U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-03-17-00 **Discipline:** Geotechnical **No. of Sheets:** 15

Project: Moab UMTRA Project

Site: Crescent Junction Disposal Site

Feature: Slope Stability of Crescent Junction Disposal Cell

Sources of Data:

1. Geotechnical Engineering Group, Inc. (GEG), 2006. Triaxial shear strength tests.
2. Golder, Inc. (Golder), 2006, Draft Technical Memorandum from James Johnson et al. to Greg Lord, S.M. Stoller, *Results of the Bench Scale Testing Program on Cover Soils and Uranium Mill Tailings from the Moab Tailings Impoundment*, Grand County, Utah, April 3.
3. Shaw E & I, Inc. (Shaw), 2006, Certificate of Analysis, Geotechnical Laboratory Results for one hundred twenty one soil samples of Moab Tailings, March 13.
4. ——, 2006, Certificate of Analysis, Geotechnical Laboratory Results for thirty seven soil samples of Moab Tailings, April 6.
5. U.S. Department of Energy (DOE), 2005. *Crescent Junction Site Characterization, Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration*, Calculation No. MOA-02-09-2005-01-09-01, September.
6. ——, 2006a. *Moab UMTRA Project, Test Pit Logs*, Calculation No. MOA-02-02-2006-1-10-00, March 15.
7. ——, 2006b. *Moab UMTRA Project, Borehole Logs*, Calculation No. MOA-02-02-2006-1-11-00, March 15.
8. ——, 2006c. *Crescent Junction Disposal Site, Geotechnical Properties of Native Materials*, Calculation No. MOA-02-03-2006-4-01-00, March 16.
9. ——, 2006d. *Moab UMTRA Project, Hydrologic Characterization-Travel Time to Uppermost (Dakota) Aquifer*, Calculation No. MOA-02-05-2006-2-13-00.

Sources of Formulae and References:

See list of references at end of calculation set

Preliminary Calc. ☐ Final Calc. ☐ Supersedes Calc. No.

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Problem Statement:

The purpose of this calculation is to assess the stability of the disposal cell at the Crescent Junction Site. Both the short-term (end-of-construction) and long-term conditions were evaluated under static and seismic conditions.

Method of Solution:

Slope stability analyses were performed using limit equilibrium methods with the aid of the computer program SLOPE/W (Geo-Slope/W 2004). The SLOPE/W program calculates factors of safety by a variety of methods. Spencer's method was used for these analyses because it considers both force equilibrium and moment equilibrium in the factor of safety calculation.

Failure surfaces represented the most likely modes of failure, including circular, non-circular, and infinite slope failure surfaces. Circular failure surface analyses were analyzed by targeting deeper, full-slope failures. Small shallow failures were not considered. In both cases, a number of failure surfaces were analyzed to find the lowest factor of safety.

In addition, the analysis of the infinite slope scenario (slope length much longer than thickness of critical layer) was conducted on the side slopes. This conservative analysis minimizes any stabilization effects of a passive resistive wedge at the base of the slope.

Assumptions:

Shear strength parameters are currently being assessed. This calculation was performed using preliminary laboratory data for recompacted alluvial and weathered shale soils and tailings material. These values are compared to published literature values for similar materials. The assumed strength parameters should be verified with laboratory results as these results become available.

Calculation:

See "Discussion."

Discussion:

Critical Conditions

Slope-stability analyses are typically conducted under scenarios that represent the critical conditions for construction and operation. For the disposal cell, these conditions include: (1) the period immediately after construction, and (2) the long-term period after cell construction.

Key factors during construction are development of excess porewater pressures in foundation, dike, tailings, or cover materials due to equipment or fill placement, or displacement of low-strength fill materials (such as slime tailings) in response to covering fill placement. These factors are not of concern for slope stability during cell construction. The foundation materials (unsaturated weathered Mancos Shale) are not susceptible to development of excess porewater pressures since they are not likely to be saturated. Tailings will be placed and compacted at optimum or slightly (up to 2 percent) wet of optimum water content. This placement procedure will minimize future settlement. Because of this placement method, it is unlikely that the tailings will become saturated or have an opportunity to develop excess porewater pressures.

Critical Geometry

The critical cross-section location used in the analysis is shown in Figure 1. It should be noted that the cell contours represent top of tailings and clean-fill dike elevations, but do not include the construction of the cover system. The profile at this location is shown in Figure 2. This section was chosen for analysis because it represents a combination of both highest slope face of the disposal cell and down-sloping natural grade.

The cell profile geometry was based on the current cell excavation plan and final cell configuration. This configuration includes excavating existing soils within the footprint of the disposal cell to a depth of approximately 18 ft. Tailings will be compacted, along with the construction of a clean-fill dike, to grades as shown on Figure 1. Tailings will be covered with approximately 9 inches of capillary break/biointrusion material (6 inches minus clean sands and gravels), approximately 13.5 ft of recompacted native alluvial and weathered Mancos Shale soils excavated from within the disposal cell footprint, and approximately 6 inches of rock mulch.

Pore Water Conditions

Site investigations (DOE 2006a, DOE 2006b, DOE 2006c) indicate that the foundation soils are dry. The shallowest water encountered in piezometer wells was at a depth of approximately 100 ft (DOE 2006d); therefore, the foundation materials are not expected to be saturated from naturally occurring ground water during construction.

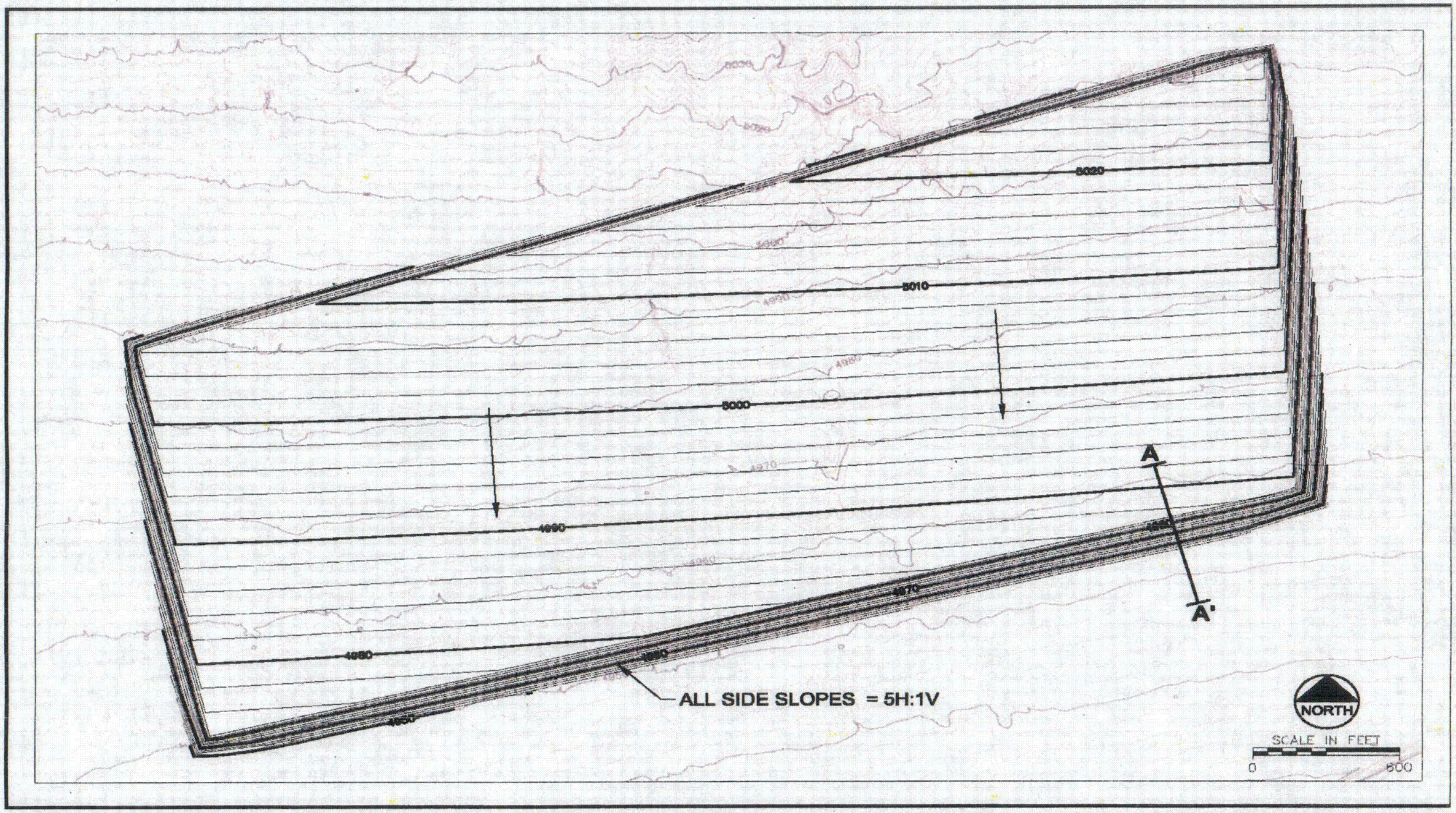
Due to the placement procedure of the tailings (placed between 2 percent dry and 2 percent wet of optimum water content and compacted to 90 percent of maximum dry density of Standard Proctor), it is unlikely that the tailings will have significant drainage of pore water. Permeability testing of the tailings is ongoing; however, estimates of the permeability of the tailings based on literature values for sandy silt tailings are 7E-5 centimeters per second (cm/sec) (Geo-Slope/W) and between 1E-5 and 1E-6 cm/sec (Keshian and Rager 1988). Packer tests performed within the weathered Mancos zone indicate the foundation materials immediately underlying the tailings have an average hydraulic conductivity of approximately 1E-4 cm/sec (DOE 2006d). Because the foundation is more permeable than the tailings, saturation within the tailings is expected to be minimal and confined to the tailings below natural grade. Due to the construction of the clean-fill dike surrounding the tailings, below-grade saturation of tailings will have minimal impact on slope stability. Therefore, potentiometric water surface within the foundation, tailings, cover, or dike material was not considered.

Material Properties

The soil properties used in the stability analyses are summarized in Table 1.

Erosion Protection

The current cell configuration requires rock mulch with a D_{50} of 2.2 inches along the 2 percent top slope of the cell to protect against erosion from action of wind and water. The south side slope requires riprap with a minimum D_{50} of 8.2 inches. This rock will have little impact on the slope stability because it is a relatively thin layer, and the rock will have relatively strong shear strength in relation to other components of the cover. Densities for the rock mulch are assumed from literature values for silty or clayey gravel and sand (Carter and Bentley 1991), and for the riprap, from typical values based on experience. Shear strength values are estimated from Figure 4.8 of NUREG/CR-4620 (Nelson et al. 1986). As the erosion protection will not be subject to excess pore water pressures, shear strength values are modeled as being the same for all three loading cases.



MFG, Inc. *consulting scientists and engineers*	**FIGURE 1** **CRITICAL SECTION FOR SLOPE STABILITY** **TOP OF TAILINGS**	Date: MAY 2006 Project: 181268 File: CELL-DESIGN..07-2

Figure 1.Critical Section for Slope Stability, Top of Tailings

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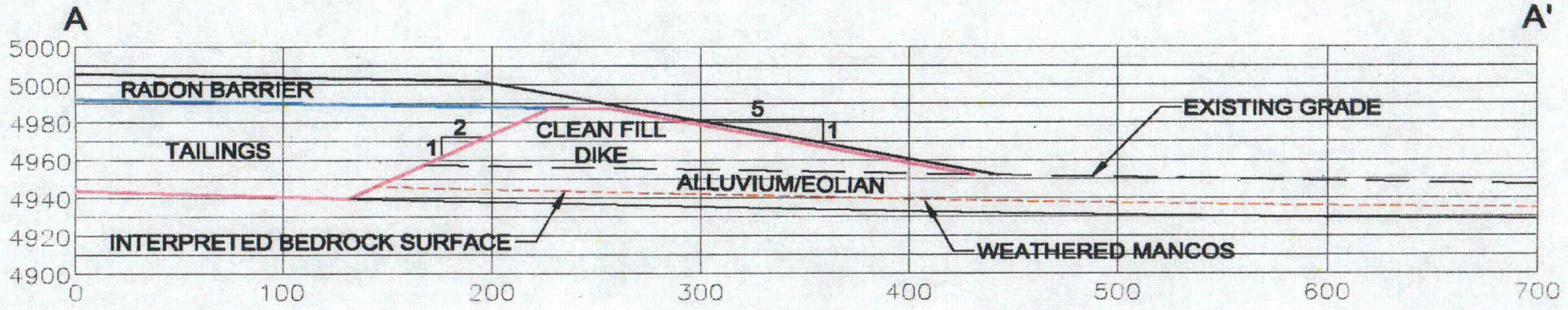

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FIGURE 2
CROSS SECTION A-A'

Date:	MAY 2006
Project:	181268
File:	CELL-DESIGN..07-2

Figure 2. Cross Section A-A'

C23

Table 1. Material Properties

Soil Layer	Description	In-Place Dry Density (pcf)	In-Place Moist Density (pcf)	In-Place Saturated Density (pcf)	Short Term		Long Term		Long-Term Seismic	
					Cohesion (psf)	Angle of Internal Friction (degrees)	Cohesion (psf)	Angle of Internal Friction (degrees)	Cohesion (psf)	Angle of Internal Friction (degrees)
Erosion Protection, Top Slope	Angular rock mulch with D_{50} = 2.2 inches	109	123	130	0	37	0	37	0	37
Erosion Protection, Side Slope	Angular riprap with D_{50} = 8.2 inches	135	135	146	0	37	0	37	0	37
Radon Barrier	On-site sheet wash and eolian soils recompacted to 85% maximum dry density from Modified Proctor	103	115	127	0	28.7	0	28.7	0	23.6
Clean-fill Dike	On-site weathered Mancos Shale recompacted to 90% maximum dry density from Modified Proctor	111	124	132	0	21	0	29	0	23.9
Tailings	Compacted to a minimum of 90% standard Proctor	98	115	125	615	0	0	32	0	27
Sheet wash/eolian soils	In-situ foundational soil outside of tailings footprint	91	97	119	0	26	0	26	0	22
Weathered Mancos Shale	In-situ foundational soil	103	114	127	0	29	0	29	0	25.7

Radon Barrier

The radon barrier consists of approximately 13.5 ft of relatively lightly recompacted native alluvial and eolian soils excavated from the disposal cell footprint. Densities are estimated based on 85 percent of the average of maximum dry densities from Modified Proctor tests performed on alluvial and eolian soils (DOE 2006c). Shear strength parameters are an average of two triaxial shear strength tests that were performed on this material (GEG 2006). Because the radon barrier will not be placed or loaded under saturated conditions, short-term shear strength parameters are estimated to be equivalent to long-term drained conditions. Under seismic loading, the shear strength parameters are estimated to be 80 percent of long-term shear strength ($\tan(\phi)_{seismic} = 0.8 \times \tan(\phi)_{long\text{-}term}$) to account for strain softening during a seismic event. Although conditions do not exist that would cause liquefaction of materials, a reduction of up to 80 percent of peak shear strength under cyclical loading is conservatively considered (Makdisi and Seed 1978) under seismic loading.

Clean-Fill Dike

A clean-fill dike will be constructed around the perimeter of the disposal cell. The height of the dike will be the same as that of the tailings, and will vary from 10 to 30 ft. The dike will be constructed from recompacted weathered Mancos Shale that is excavated from the disposal cell footprint. Densities are based on 90 percent of the average of maximum dry density from Modified Proctor tests performed on weathered Mancos Shale soils (DOE 2006c). Shear strength testing on the weathered Mancos Shale is ongoing. Two triaxial shear strength tests have been performed to date. One test result indicates cohesion of 96 pounds per square foot (psf) and an effective angle of internal friction of 31 degrees. The second test indicates cohesion of 240 psf and an effective angle of internal friction of 2 degrees (GEG 2006). This second test is considered suspect and indicative of unconsolidated, undrained conditions rather than effective shear strength. A triaxial shear strength test performed on recompacted weathered Mancos Shale for the Uranium Mill Tailings Remedial Action Project Site in Grand Junction indicates effective shear strength parameters similar to the first triaxial shear strength test (90 psf cohesion and an angle of internal friction of 28 degrees (DOE 1991). Literature values for remolded clays with a plasticity index of 11 (average value for weathered shale from DOE 2006c) indicate approximately 28 degrees (Bowles 1988). The average of these three values (29 degrees) is used in this analysis. Shear strength parameters of the weathered shale should be updated as additional laboratory test results become available. For short-term analyses, total shear strength parameters from one triaxial shear strength test, ignoring strength from cohesion are used. The total strength parameter (angle of internal friction of 21 degrees) is similar to the total strength parameters for recompacted weathered Mancos Shale at the Grand Junction Site (angle of internal friction of 20 degrees). Under seismic loading, the shear strength parameters are estimated to be 80 percent of long-term shear strength to account for strain softening during a seismic event. The strain-softening approach is used to account for some loss in strength under high strain. An undrained shear strength approach is not considered appropriate because the dike is not expected to be saturated.

Tailings

Tailings will be relocated from the current site in Moab. During the relocation process, tailings will be mixed such that fine-grained particles (slimes) will be combined with coarse-grained particles (sands). The resulting material will consist of transitional tailings, or a mixture of approximately equal portions of sands and slimes. The tailings will be moisture conditioned and compacted in maximum 12-inch loose lifts within the disposal cell. Densities of the tailings are based on 90 percent of the average of maximum dry density from Standard Proctor tests on transitional tailings (Golder 2006). Shear strength testing on the tailings is ongoing. Literature values for hydraulically placed uranium mill tailings indicate that an effective angle of internal friction of 32 degrees is appropriate for preliminary estimates of the strength of sand/slime mixtures (Keshian and Rager 1988). For short-term, the shear strength of the tailings is estimated based on the average of unconfined compressive strength tests performed on undisturbed samples of the tailings sampled from the current site in Moab (Shaw 2006). This is considered a conservative approach because the tailings in Moab that were tested for unconfined compressive strength were predominately slimes and have been hydraulically placed. In contrast, the relocated tailing at the Crescent Junction Site will be mixed in such a manner that percent slimes placed will be minimal.

The tailings will also be compacted, thereby increasing the density and shear strength above that currently seen at the Moab Site. Because the tailings will be placed at close to optimum moisture content and compacted, they are not expected to be saturated. Under seismic loading, the shear strength parameters are estimated to be 80 percent of long-term shear strength to account for strain softening during a seismic event. The strain-softening approach is used to account for some loss in strength under high strain during cyclical loading. An undrained shear strength approach is not considered appropriate because the dike is not expected to be saturated.

Alluvial/Eolian Soil and Weathered Mancos Shale

The native soils outside the footprint of the disposal cell are modeled to check against failures that may incorporate foundation materials. The densities of the alluvial/eolian soils and the weathered Mancos Shale are based on average dry densities measured from respective liner samples taken during the field investigation (DOE 2006c). Shear strength parameters for the alluvial/eolian soils are modeled as being 90 percent of the recompacted shear strength of the same material to reflect lower shear strength due to less compaction. The in-situ weathered shale has essentially the same dry density as the recompacted samples and is therefore estimated to have similar shear strength parameters.

Seismic Coefficient

As per the *Site and Regional Seismicity – Results of Maximum Credible Earthquake Estimation and Peak Horizontal Acceleration* (DOE 2005), the predicted peak horizontal acceleration (PGA) is estimated to be 0.22 g. In accordance with guidance given in the Technical Approach Document (TAD) (DOE 1989), the seismic coefficient for a pseudostatic analysis is equivalent to 1/2 of PGA (0.11 g) for end-of-construction analyses, and is equivalent to 2/3 of PGA (0.15 g) for the long-term analyses.

Stability Criteria

The required safety factors as given in the TAD are as follows:

Loading Condition	Minimum Factor of Safety
End-of-construction:	
Static	1.3
Psuedostatic (kh=0.11 g)	1.0
Long-term:	
Static	1.5
Psuedostatic (kh=0.15 g)	1.0

Results from Stability Analyses

Based on the input parameters outlined previously, critical failure surfaces and the associated factor of safety are shown in Figures 3 through 6. The following results were approximated for the stability analyses:

Loading Condition	Results of Analysis
End-of-construction:	
Static	1.9
Psuedostatic (kh=0.11g)	1.2
Infinite Slope (Static)	1.9
Infinite Slope (Pseudostatic)	1.2
Long-term:	
Static	2.5
Pseudostatic (kh=0.15 g)	1.2
Infinite Slope (Static)	2.8
Infinite Slope (Pseudostatic)	1.2

Name: short-term seismic.gsz

Comments: End-of-Construction

Comments: End-of-ConstructionHorz Seismic Load: 0.11

Material #: 1	Description: Radon Barrier	Wt: 115	Cohesion: 0	Phi: 28.7
Material #: 2	Description: Clean-Fill Dike	Wt: 124	Cohesion: 0	Phi: 21
Material #: 3	Description: Tailings	Wt: 115	Cohesion: 615	
Material #: 4	Description: Alluvium/Eolian	Wt: 97	Cohesion: 0	Phi: 26
Material #: 5	Description: Weathered Mancos	Wt: 114	Cohesion: 0	Phi: 29
Material #: 6	Description: Competent Mancos	Wt: 120	Cohesion: 2000	Phi: 29

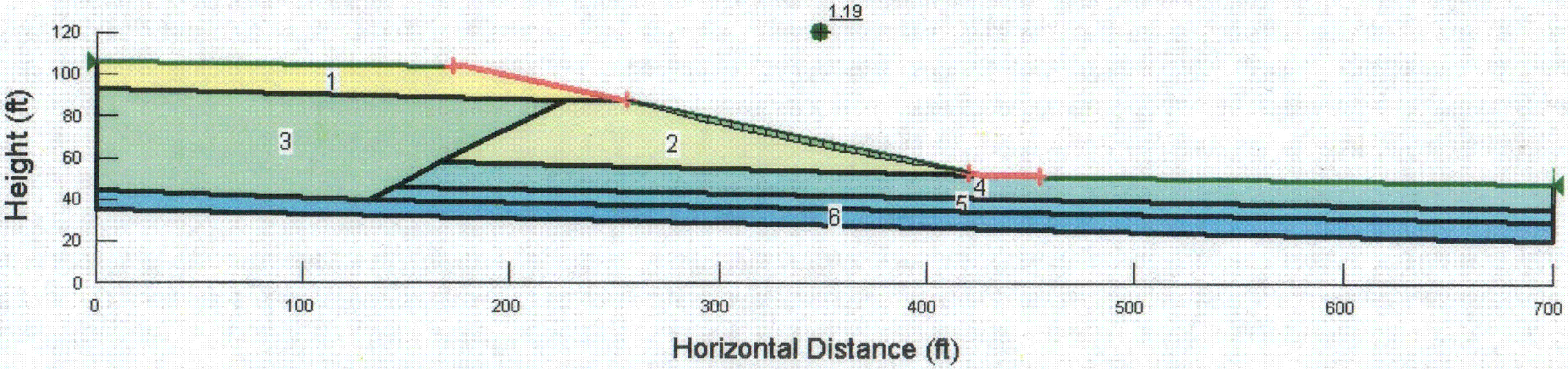

Figure 3. Short-Term Seismic

C24

Name: short-term static.gsz

Comments: End-of-Construction

Comments: End-of-ConstructionHorz Seismic Load: 0

Material #: 1 Description: Radon Barrier Wt: 115 Cohesion: 0 Phi: 28.7
Material #: 2 Description: Clean-Fill Dike Wt: 124 Cohesion: 0 Phi: 21
Material #: 3 Description: Tailings Wt: 115 Cohesion: 615
Material #: 4 Description: Alluvium/Eolian Wt: 97 Cohesion: 0 Phi: 26
Material #: 5 Description: Weathered Mancos Wt: 114 Cohesion: 0 Phi: 29
Material #: 6 Description: Competent Mancos Wt: 120 Cohesion: 2000 Phi: 29

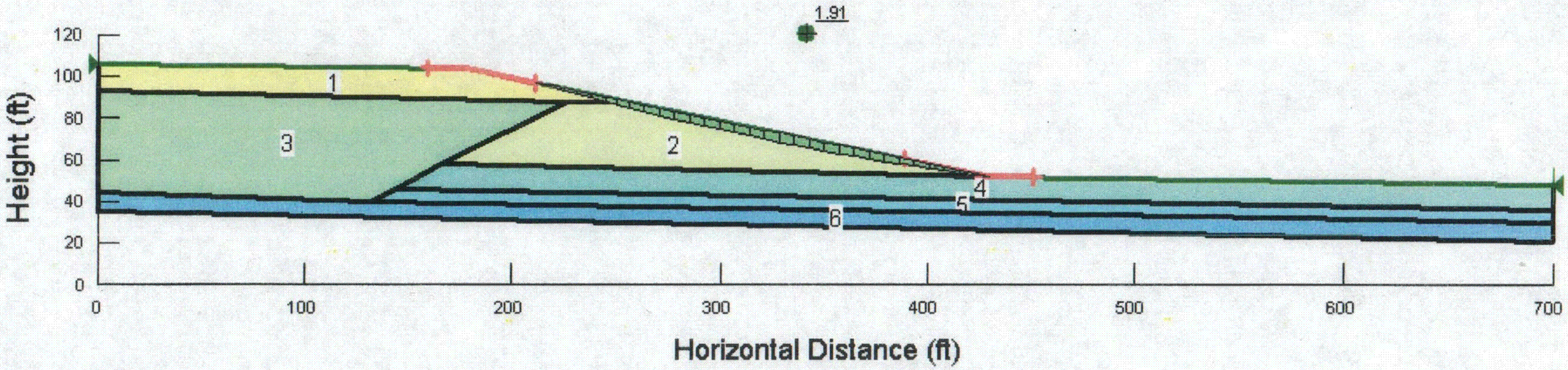

Figure 4. Short-Term Static

C25

Name: long-term seismic.gsz

Comments: Long-term

Comments: Long-termHorz Seismic Load: 0.15

Material #: 1	Description: Radon Barrier	Wt: 115	Cohesion: 0	Phi: 23.6
Material #: 2	Description: Clean-Fill Dike	Wt: 124	Cohesion: 0	Phi: 23.9
Material #: 3	Description: Tailings	Wt: 115	Cohesion: 0	Phi: 27
Material #: 4	Description: Alluvium/Eolian	Wt: 97	Cohesion: 0	Phi: 22
Material #: 5	Description: Weathered Mancos	Wt: 114	Cohesion: 0	Phi: 25.7
Material #: 6	Description: Competent Mancos	Wt: 120	Cohesion: 2000	Phi: 29

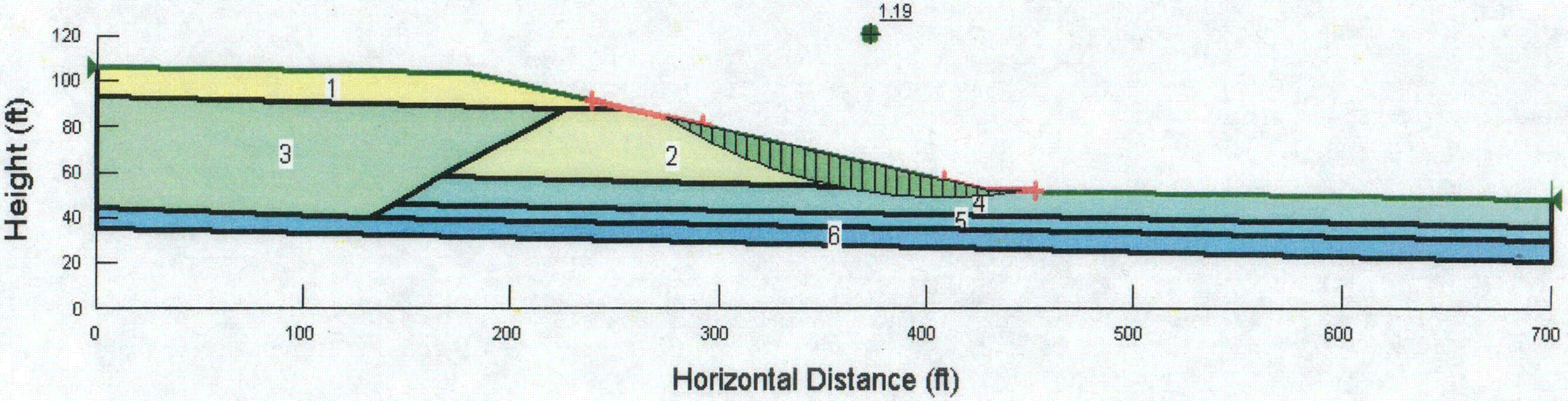

Figure 5. Long-Term Seismic

C26

Name: long-term static.gsz

Comments: Long-term

Comments: Long-termHorz Seismic Load: 0

Material #: 1 Description: Radon Barrier Wt: 115 Cohesion: 0 Phi: 28.7
Material #: 2 Description: Clean-Fill Dike Wt: 124 Cohesion: 0 Phi: 29
Material #: 3 Description: Tailings Wt: 115 Cohesion: 0 Phi: 32
Material #: 4 Description: Alluvium/Eolian Wt: 97 Cohesion: 0 Phi: 26
Material #: 5 Description: Weathered Mancos Wt: 114 Cohesion: 0 Phi: 29
Material #: 6 Description: Competent Mancos Wt: 120 Cohesion: 2000 Phi: 29

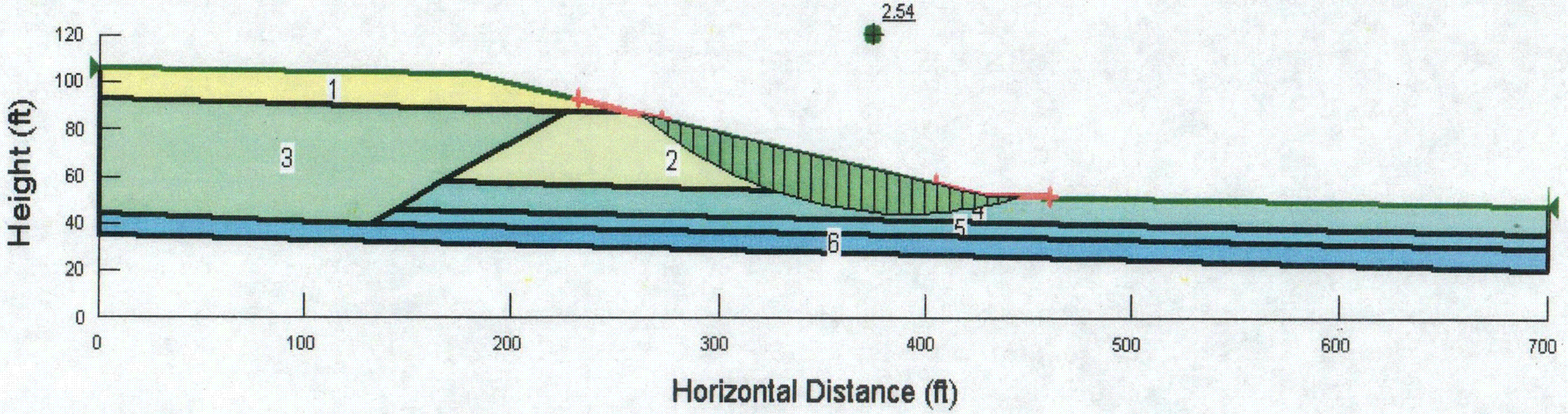

Figure 6. Long-Term Static

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Conclusion and Recommendations:

Based on results of geologic literature review, the Crescent Junction Site appears to be suitable for disposal of the Moab uranium mill tailings and contaminated material. Based on this information, and in conjunction with findings of field investigations, this site is deemed suitable for the intended use.

Computer Source:

Geo-Slope/W International, LTD, 2004. SLOPE/W version 6.19, Calgary, Alberta, Canada.

References:

Bowles, J.E. 1988. Foundation Analysis and Design, Fourth Edition, McGraw-Hill, Inc.

Carter, M., and S. P. Bentley, 1991. *Correlations of Soil Properties*, Pentech Press.

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——, 1991. *Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Grand Junction, Colorado.*

Keshian, B., and R. E. Rager, 1988. "Geotechnical Properties of Hydraulically Placed Uranium Mill Tailings in Hydraulic Fill Structures," ed. By D. J. A. Van Zyl and S. G. Vick, *Geotechnical Special Publication No. 21*, American Society of Civil Engineers.

Makdisi, F.I., and Seed, H.B., 1978. "Simplified Procedure for Estimating Dam and Embankment Earthquake-Induced Deformations". Journal of the Geotechnical Engineering Division, ASCE, Vol. 104, No. GT7, July.

Nelson, J.D., S.R. Abt, R.L. Volpe, D. van Zyl, N.E. Hinkle, W.P. Staub, 1986. Methodologies for Evaluating Long-Term Stabilization Design of Uranium Mill Tailings Impoundments, NUREG/CR-4620, U.S. Nuclear Regulatory Commission (NRC), June.

U.S. Nuclear Regulatory Commission (NRC), 1993. *Final Standard Review Plan for the Review and Remedial Action of Inactive Mill Tailings Sites under Title 1 of the Uranium Mill Tailings Radiation Control Act*, June.

Appendix A

Infinite Slope Analysis

Client:	U.S. Department of Energy	Job No. 181268	Page: 1 of 2
Project:	Disposal Cell	Date: 5/19/06	Date Checked: 5/19/06
Detail:	Slope Stability, Seismic Analyses for Infinite Slope	Computed by: MV	Checked by: CLS

Problem Statement:

Calculate the Factor of Safety assuming infinite slope failure. Analyze side slope at 5H:1V. Critical surface is at the clean-fill dike around the perimeter of the disposal cell. Average properties of borrow material for Mancos Shale soils are LL = 28 and PI = 11. Assume that under moderate loading conditions (10 to 30 feet of material), soils force failure. Use long-term, static friction angle of 29 degrees (average of 31 degrees from one triaxial test, 28 degrees from correlated values to PI value, and 29 degrees from similar material used at the UMTRA Site in Grand Junction), long-term pseudostatic friction angle of 23.9 degrees (80 percent reduction in strength), and short-term friction angle of 21 degrees (total stress parameter from one triaxial test).

Solution:

Use the following equation

$$FS = \frac{\tan(\phi)}{\tan[\beta + \arctan(k_h)]}$$

where FS= Factor of Safety
ϕ= friction angle of clean fill dike
β= slope angle of cover=arctan (1/5)
k_h=horizontal seismic coefficient (g)

For static, short-term conditions, k_h=0.0 g and ϕ=21 degrees:

$$FS = \frac{\tan(21)}{\tan\left[\arctan(\frac{1}{5}) + \arctan(0.0)\right]} = 1.92$$

For pseudostatic, short-term conditions, k_h=0.11 g and ϕ=21 degrees:

$$FS = \frac{\tan(21)}{\tan\left[\arctan(\frac{1}{5}) + \arctan(0.11)\right]} = 1.21$$

For static, long-term conditions, k_h=0.0 g and ϕ=29 degrees:

$$FS = \frac{\tan(29)}{\tan\left[\arctan(\frac{1}{5}) + \arctan(0.0)\right]} = 2.77$$

For pseudostatic, long-term conditions, k_h=0.15g and ϕ=23.9 degrees:

$$FS = \frac{\tan(23.9)}{\tan\left[\arctan(\frac{1}{5}) + \arctan(0.15)\right]} = 1.23$$

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-03-16-00 **Discipline: Engineering Design** **No. of Sheets: 3**

Project: **Moab UMTRA Project**

Site: **Crescent Junction Disposal Site, Disposal Cell Design**

Feature:
Settlement, Cracking, and Liquefaction Analysis

Sources of Data:

Calculation No. MOA-02-09-2005-01-09-1; *Site and Regional Seismicity – Results of Literature Research*, 2005. U.S. Department of Energy, Grand Junction, Colorado, November.

Caterpillar, Inc., 1996. Caterpillar Performance Handbook, Caterpillar, Inc., Peoria, Illinois, October.

Golder Associates, 2006. Results of Bench Scale Testing (Draft). April 3.

Keshian, B. and R. Rager, 1988. "Geotechnical Properties of Hydraulically-Placed Uranium Mill Tailings," Hydraulic Fill Structures, Geotechnical Special Publication No. 21, ASCE, pp. 227-254.

Shaw E & I Inc., 2006. Geotechnical test results on tailings samples. March 13.

Sources of Formulae and References:

Caldwell, J. and C. Reith, 1993. Principles and Practice of Waste Encapsulation, Lewis Publishers.

Day, R.W. Geotechnical and Foundation Engineering, McGraw-Hill.

Holtz, R.D. and W.D. Kovacs, 1981. An Introduction to Geotechnical Engineering, Prentice-Hall, Inc.

Larson, N. and B. Keshian, 1988. "Prediction of Strains in Earthen Covers," Hydraulic Fill Structures, Geotechnical Special Publication No. 21, ASCE, pp. 367-388.

Preliminary Calc. ☐ **Final Calc.** ☐ **Supersedes Calc. No.**

Author: Alan Strachan 12 Jun 06 **Checked by:**
Name Date Name Date

Approved by: Toby E Elmer 6/13/06
Name Date Name Date

William M Smith 6-13-06
Name Date

Reviewed by: Brady B Burn 6-12-06
Name Date

Problem Statement:

Evaluate (1) the potential for post-construction tailings settlement, (2) the potential for cover cracking, and (3) the potential for liquefaction under seismic loading conditions.

Method of Solution:

See "Discussion."

Assumptions:

- Tailings and wastes will be placed at approximately 98 pounds per cubic foot (pcf), 12 percent to 15 percent gravimetric moisture content (90 percent of average Standard Proctor maximum dry density, and within percent of optimum moisture content).
- Tailings and waste will be placed in thin lifts, compacted, and placed to an ultimate thickness of 38 feet (ft).
- Peak horizontal ground acceleration is 0.22 g (See Calculation MOA-02-09-2005-01-09-1; *Site and Regional Seismicity – Results of Literature Research*).

Calculation:

See attached sheets.

Discussion:

The calculations outline the analyses of (1) post-construction tailings settlement, (2) the impact of differential tailings settlement on cover performance (specifically cover cracking), and (3) the potential for tailings liquefaction.

Tailings Settlement

Typical settlement analyses are conducted for uranium tailings reclamation planning, because tailings will settle to varying amounts due to the stress changes from reclamation activity. These stress changes can be caused by: (1) the weight of construction equipment; (2) the loading due to the reclamation cover; and (3) lowering of the zone of saturation in the tailings. These changes have a larger effect with reclamation of tailings deposited as a slurry. In this case, the tailings will be placed in the repository as an unsaturated material, spread in lifts, and rolled with conventional construction equipment. Other Title I sites with relocated tailings have been evaluated for post-construction settlement, and areas of concern for differential settlement are transition zones between tailings and embankment materials or subsoils or zones between tailings and contaminated soils (such as described in Larson and Keshian 1988).

Since tailings characterization testing (including consolidation testing) has not been completed, analysis of tailings settlement is based on the anticipated method of placement and cover system loads on the tailings, as well as published data on uranium tailings characteristics.

Analysis of settlement was made on a preliminary basis by comparing the loading of construction equipment to the subsequent loading of tailings and cover. For a layer of tailings at the bottom of the cell, the vertical loading of tailings and cover would be approximately 5,700 pounds per square foot (psf). This is approximately 4,300 psf for the tailings and 1,400 psf for the cover (38 ft of tailings at 98 pcf and 15 percent water content and 13 ft of cover at 103 pcf and 7 percent water content). For a layer of tailings at the top of the cell, the vertical loading would be approximately 1,400 psf.

Since a large compactor is planned to roll the tailings (such as a Cat 815 or 825), the ground pressure (or vertical loading under the wheels) would be as much as 9,000 psf (Caterpillar, Inc. 1996). Therefore, the transient loading of the compaction equipment would impart a vertical stress on each lift of tailings that is larger than the vertical stress from subsequent tailings and cover placement. There may be some effects due to the transient loading over a small area compared with a uniform load over the entire tailings surface, but minimal additional settlement due to cover placement would be expected.

Settlement of the tailings was evaluated to check the magnitude of primary and secondary settlement of the tailings due to the loading of subsequent tailings and cover materials. From data in Keshian and Rager (1988) on Title I tailings samples, the compression index (C_c) for remolded, mixed tailings ranged from 0.01 to 0.1, and the secondary compression index (C_α) ranged from 0.003 to 0.01. By evaluating stresses at the mid-point of the 38-ft thick zone to compacted tailings, the primary settlement of the 38-ft thick zone of tailings would range from approximately 0.05 to 0.5 ft. Due to the construction schedule, settlement of one area of tailings (due to subsequent tailings placement) may be nearly complete by the time cover construction is started. The secondary settlement (over a 1,000-year period) would range from approximately 0.4 to 1.4 ft (using the procedure outlined in Larson and Keshian 1988).

In the event that downward migration of pore water in the tailings creates a saturated zone at the bottom of the compacted tailings, this would be a post-construction effect, and gradual dissipation of pore water pressures over the design period would not significantly change the void ratio of these tailings.

The multi-year construction schedule for the disposal cell provides significant time for tailings drying and settlement prior to cover placement. Tailings will be placed in regions of the cell in lifts, compacted, and covered with interim cover. These regions will subsequently be covered with the soil cover system. The relatively thick cover is believed to be sufficiently thick to accommodate differential settlement without detrimental effects. This was evaluated by the calculations described below.

Cover Cracking

Cover cracking was evaluated by comparison of allowable strain for the cover materials with maximum calculated strain due to differential settlement in the cover. The area of the cell with the highest anticipated differential settlement (and associated largest horizontal strain) is inside the perimeter embankment.

The allowable strain for the cover materials was calculated using the equation in Caldwell and Reith (1993) based on soil plasticity index:

$$e_f = 0.05 + 0.003\,PI$$

where e_f = soil tensile strain at failure (in percent)
PI = plasticity index of the cover soil

For the UMTRCA cover, with a weathered Mancos shale radon barrier with a PI of 10, the maximum allowable strain is approximately 0.08 percent. For the alternative cover with slopewash soils with a plasticity index of 5 or less, the maximum allowable strain is approximately 0.06 percent. These allowable strain values are consistent with the allowable strains presented in Larson and Keshian (1988) for similar cover soils.

The differential settlement of tailings along the perimeter embankment would be zero near the embankment crest to as much as 1.9 ft at the inside edge of the cell excavation (conservatively adding primary and secondary settlement). This amount of differential settlement over the inside embankment slope distance (76 ft) is equivalent to a horizontal tensile strain of approximately 0.03 percent. This calculated strain is lower than the allowable tensile strain for the soil, indicating acceptable cover performance.

Liquefaction

Although the tailings will be placed in the repository in an unsaturated condition, downward migration of porewater or inclusion of meteoric water may create zones in the tailings with saturated conditions. The potential liquefaction of saturated zones of the tailings was checked with standard procedures outlined in Day (1999), based on the classic paper by Seed and Idriss (1971). This involves comparison of the seismic stress ratio due to the design seismic event with the seismic stress ratio that would cause liquefaction of the tailings at a specific depth of analysis.

Calculations were made at the top and bottom of the tailings. The stress ratio due to the seismic event was calculated from the peak estimated acceleration at the ground surface of 0.22g. The stress ratio required for liquefaction was based a conservatively estimated relative density of the tailings of 50 percent, based on a tailings compaction at 90 percent of Standard Proctor density (using a correlation in Holtz and Kovacs 1981). For this relative density and two depths of analysis, the stress ratio required to cause liquefaction was higher than the seismic stress ratio, indicating that if the tailings were to become saturated, the tailings would not liquefy under peak seismic ground acceleration conditions.

Conclusion and Recommendations:

- The cover for the repository should not undergo significant settlement due to (1) the placement characteristics (density and moisture content of the tailings), and (2) the compaction energies applied by the equipment used to place the material. Due to the multi-year construction schedule and dry site climate, considerable tailings settlement would be expected before the cover is constructed over the cell.
- In the event of differential settlement of tailings, an analysis of cover cracking shows that the maximum calculated tensile stresses in the cover due to differential settlement are less than the allowable stresses in the cover. In addition, the cover thickness (roughly 10 to 14 ft for the UMTRCA and alternative cover designs) would allow some cracking without affecting the performance of the entire cover system.
- Tailings liquefaction is not likely because of the placement of unsaturated tailings in the cell (as described above), the density that the tailings will achieve with placement in lifts and rolling with construction equipment, and the fines content of the tailings. In the event of zones of tailings becoming saturated, the calculated stress ratio required to cause liquefaction of the tailings is higher than the seismic stress ratio for all of the cases considered.

Computer Source:

Not applicable.

Appendix A

Liquefaction Analysis

consulting scientists and engineers

CLIENT

PROJECT

DETAIL LIQUEFACTION ANAL.

JOB NO 181268

DATE 18May06

COMPUTED BY CLS

DATE CHECKED

CHECKED BY

Seismic shear stress ratio (SSR)* caused by earthquake

$$SSR = 0.65\ r_d \left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{vc}}{\sigma_{vc}'}\right)$$

a_{max} = peak accel estimated at ground surface

for Crescent Valley, a_{max}/g = 0.22

σ_{vo} = total vertical stress at the depth of analysis

σ_{vc}' = vertical effective stress at the depth of analysis

r_d = depth reduction factor = $1 - 0.012z$

z = depth (m) below ground surface ~~near the~~ at the depth of analysis

at mid-point in the tailings, 13' cover, 20' tailings

cover 103, ~~.5~~ 7
tails 98 . 15

σ_{vo} = $103(1+0.07) \cdot 13$ = 1433 psf
$+ 98(1+0.15) \cdot 20$ 2254 psf } 3687 psf * $\frac{1\ kPa}{20.885\ psf}$ = 177 kPa

$\sigma_{vc}' = \sigma_{vc}$

$r_d = 1 - 0.012\left(\frac{\cancel{13+20}\ 10.0}{3.28}\right) = \cancel{0.604}\ 0.88$

$SSR = 0.65(\cancel{0.604}\ 0.88)(0.22)(1.0) = \cancel{0.086}\ 0.126$

53/3.28

for z = 53, $r_d = 1 - 0.012(53)$
= ~~0.364~~
= 0.806

* Day (1999) Geotechnical and Foundation Engineering, McGraw-Hill, NY.

Seismic shear stress ratio that will cause liquefaction*

$(N_1)_{60} = (100/\sigma_{vo}')^{0.5} N_{60}$, then SSR from Fig 11.8

for tailings placed in cell, using a conservative average blow count of 10 (relative density of 35%),

$(N_1)_{60} = (100/177)^{0.5} \cdot 10 = 0.75 \cdot 10 = 7.5$

from Figure 11.8 : $(N_1)_{60} = 7.5$, 20% fines, SSR = 0.15

SSR caused by earthquake < SSR that will cause liquefaction
0.126 ~~0.086~~ < 0.15

checking at base of tailings :

$\sigma_{vo} = 1433 + 98(1+0.15) \cdot 40 = 5941$ psf $= 284$ kPa

$(N_1)_{60} = (100/284)^{0.5} \cdot 10 = 0.593 \cdot 10 = 5.93$

from Figure 11.8 : $(N_1)_{60} = 5.9$, 20% fines, SSR = 0.12

SSR = 0.65 (~~0.364~~ 0.806)(0.22)(1.0) = ~~0.052~~ 0.115

SSR caused by earthquake < SSR that will cause liquefaction
0.115 ~~0.05~~ < 0.12

checking at base of tailings with N of 20

$(N_1)_{60} = (100/284)^{0.5} \cdot 20 = 12$

from Figure 11.8 : $(N_1)_{60} = 12$, 20% fines, SSR = 0.20

SSR caused by earthquake < SSR that will cause liquefaction
0.115 < 0.20

*Day (1999)

FIGURE 11.1 Building collapse caused by the 1994 Northridge, California, earthquake.

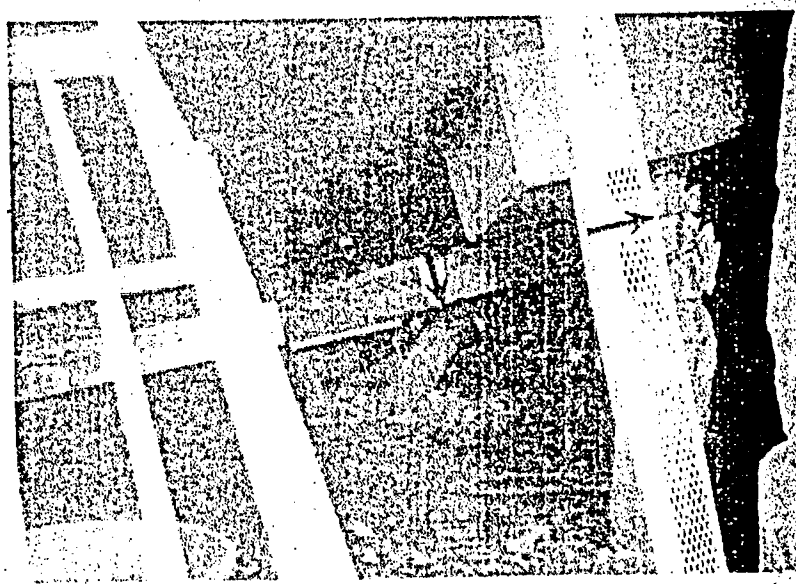

FIGURE 11.2 View inside the collapsed first floor parking garage (arrows point to columns).

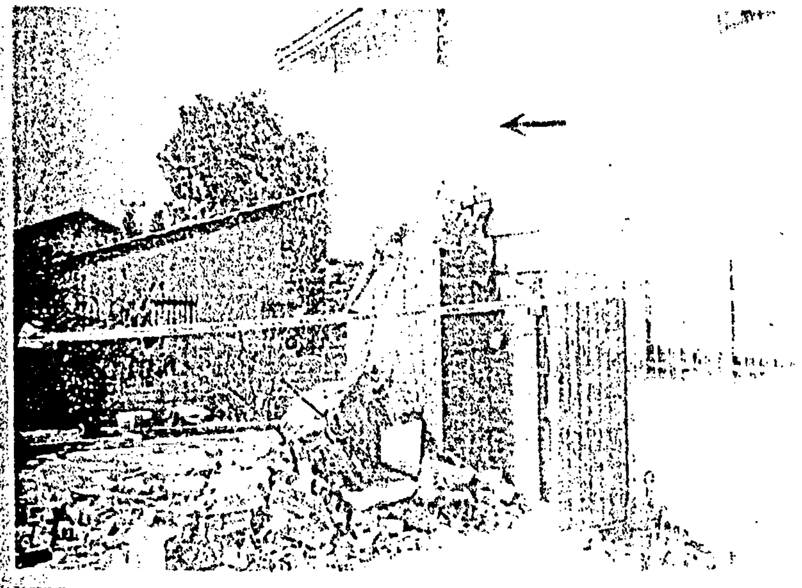

FIGURE 11.3 Collapse of brick chimney, 1994 Northridge, California, earthquake.

two primary types of damage have developed: (1) longitudinal cracks at the top of the dam and (2) crest settlement. In the case of the Sheffield Dam, a complete failure did occur, probably due to liquefaction of the very loose and saturated lower portion of the embankment (Sherard et al., 1963).

11.2 EARTHQUAKES

A structure can be damaged by many different earthquake effects. Examples previously provided include a lack of shear resistance (Figs. 11.1 and 11.2) and poor construction practices (Fig. 11.3). The purpose of the following sections is to provide a brief summary of the common earthquake effects that need to be considered by the geotechnical engineer.

11.2.1 Fault and Ground Rupture Zone

Surface fault rupture caused by the earthquake is important because it has caused severe damage to buildings, bridges, dams, tunnels, canals, and underground utilities (Lawson et al., 1908; Ambraseys, 1960; Duke, 1960; California Department of Water Resources, 1967; Bonilla, 1970; Steinbrugge, 1970). Fault displacement is defined as the relative movement of the two sides of a fault, measured in a specific direction (Bonilla, 1970). Figure 11.4 shows the displacement of rock strata caused by the Carmel Valley Fault, located at Torry Pines, California.

Examples of very large surface fault rupture are the 11 m (35 ft) of vertical displacement in the Assam earthquake of 1897 (Oldham, 1899) and the 9 m (29 ft) of horizontal

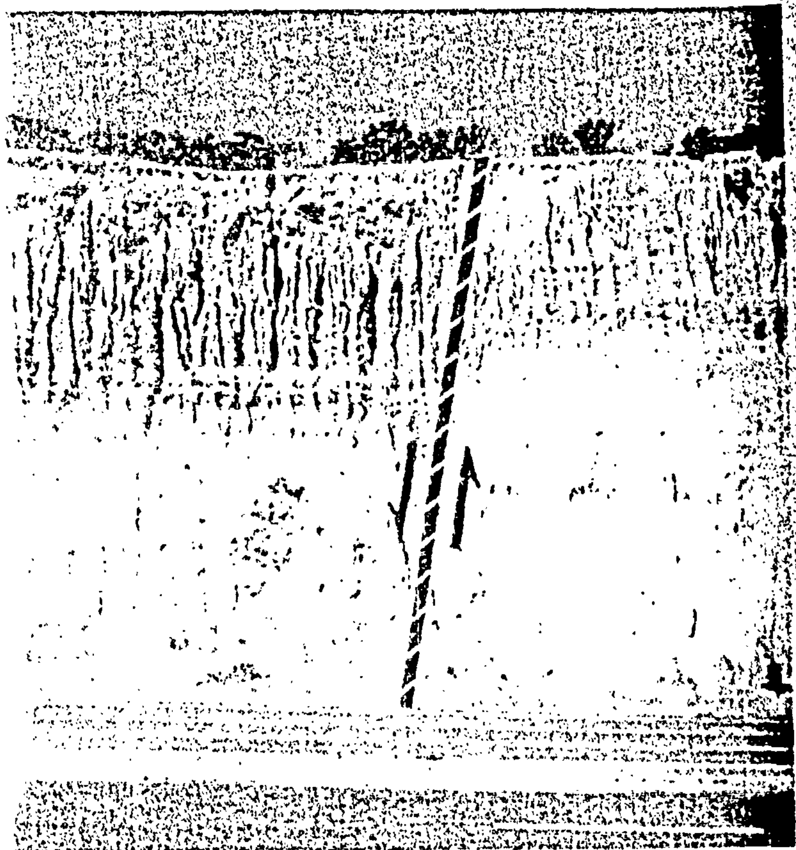

FIGURE 11.4 Carmel Valley Fault, located at Torry Pines, California.

movement during the Gobi-Altai earthquake of 1957 (Florensov and Solonenko, 1965). The length of the fault rupture can be quite significant. For example, the estimated length of surface faulting in the 1964 Alaskan earthquake varied from 600 to 720 km (Savage and Hastie, 1966; Housner, 1970).

A recent (geologically speaking) earthquake caused the fault rupture shown in Fig. 11.5. The fault is located at the base of the Black Mountains, in California. The vertical fault displacement caused by the earthquake is the vertical distance between the two arrows in Fig. 11.5. The fault displacement occurred in an alluvial fan being deposited at the base of the Black Mountains. Most structures would be unable to accommodate the huge vertical displacement shown in Fig. 11.5.

In addition to fault rupture, there can also be ground rupture away from the main trace of the fault. These ground cracks could be caused by many different factors, such as movement of subsidiary faults, auxiliary movement that branches off from the main fault trace, or ground rupture caused by the differential or lateral movement of underlying soil deposits. For example, Fig. 11.6 shows ground rupture during the 1994 Northridge,

California, earthquake. The direction of the ground shear movement shown in Fig. 11.6 is toward the northwest. The ground movement sheared both the concrete patio and adjacent pool and knocked the house off its foundation.

Since most structures will be unable to resist the shear movement associated with surface faulting and ground rupture, one design approach is to simply restrict construction in the active fault shear zone. The best individual to determine the location and width of the active fault shear zone is the engineering geologist. Seismic study maps, such as the *State of California Special Studies Zones Maps* (1982), which were developed as part of the Alquist-Priolo Special Studies Zones Act, delineate the approximate location of active fault traces that require special geologic studies. These maps also indicate the approximate locations of historic fault offsets, which are indicated by year of earthquake-associated event, as well as the locations of ongoing fault displacement due to fault creep. There are many other geologic references, such as the cross section shown in Fig. 4.2, that can be used to identify active shear fault zones. Trenches, such as shown in Figs. 4.20 and 4.21, can be excavated across the fault zone to more accurately identify the width of the active fault shear zone. Critical structures, such as essential transportation routes (see Sec. 2.2) that must cross the active shear fault zones, will need special designs to resist the earthquake forces induced by ground rupture.

11.2.2 Liquefaction

The typical subsurface condition that is susceptible to liquefaction is a loose or very loose sand that has been newly deposited or placed, with a groundwater table near ground surface. During an earthquake, the ground shaking causes the loose sand to contract, resulting in an increase in pore water pressure. Because the seismic shaking occurs so quickly, the

FIGURE 11.5 Fault rupture at the base of the Black Mountains (arrows indicate the amount of vertical displacement caused by the earthquake).

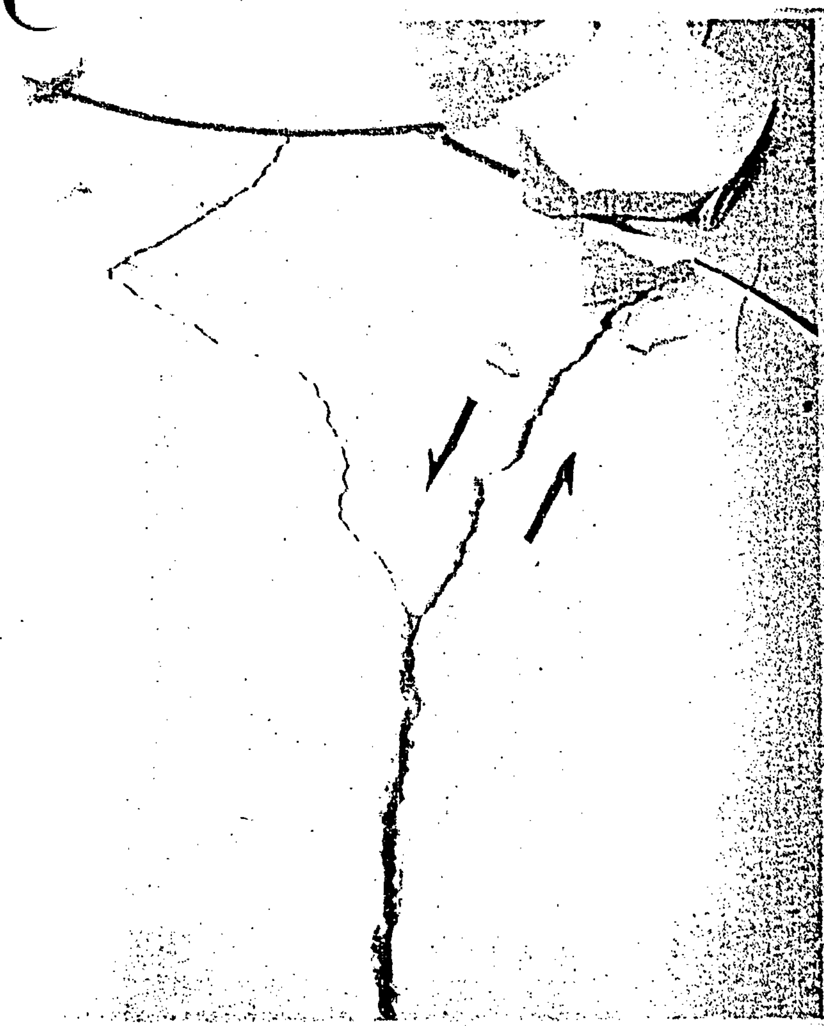

FIGURE 11.6 Ground rupture, 1994 Northridge, California, earthquake.

cohesionless soil is subjected to an undrained loading (total stress analysis). The increase in pore water pressure causes an upward flow of water to the ground surface, where it emerges in the form of mud spouts or sand boils. The development of high pore water pressures due to the ground shaking (i.e., the effective stress becomes zero) and the upward flow of water may turn the sand into a liquefied condition, which has been termed *liquefaction*. Structures on top of the loose sand deposit that has liquefied during an earthquake will sink or fall over, and buried tanks will float to the surface when the loose sand liquefies (Seed, 1970).

Liquefaction can also cause lateral movement of slopes and create flow slides (Ishihara, 1993). Seed (1970) states:

If liquefaction occurs in or under a sloping soil mass, the entire mass will flow or translate laterally to the unsupported side in a phenomenon termed a flow slide. Such slides also develop in loose, saturated, cohesionless materials during earthquakes and are reported at Chile (1960), Alaska (1964), and Niigata (1964).

An example of lateral movement of liquefied sand is shown in Fig. 11.7 (from Kerwin and Stone, 1997). This damage occurred to a marine facility at Redondo Beach King Harbor during the 1994 Northridge, California, earthquake. The 5.5 m (18 ft) of horizontal displacement was caused by the liquefaction of an offshore sloping fill mass that was constructed as a part of the marine facility.

There can also be liquefaction of seams of loose saturated sands within a slope. This can cause the entire slope to move laterally along the liquefied layer at the base. These types of gross slope failures caused by liquefied seams of soil caused extensive damage during the 1964 Alaskan earthquake (Shannon and Wilson, Inc., 1964; Hansen, 1965). It has been observed that slope movement of this type typically results in little damage to structures located on the main slide mass, but buildings located in the graben area are subjected to large differential settlements and are often completely destroyed (Seed, 1970).

Main Factors for Liquefaction of Cohesionless Soil. There are many factors that govern the liquefaction process. The most important factors are as follows:

1. *Earthquake intensity and duration.* In order to have liquefaction of soil, there must be ground shaking. The character of the ground motion, such as acceleration and frequency content, determines the shear strains that cause the contraction of the soil particles and the development of excess pore water pressures leading to liquefaction. The most common

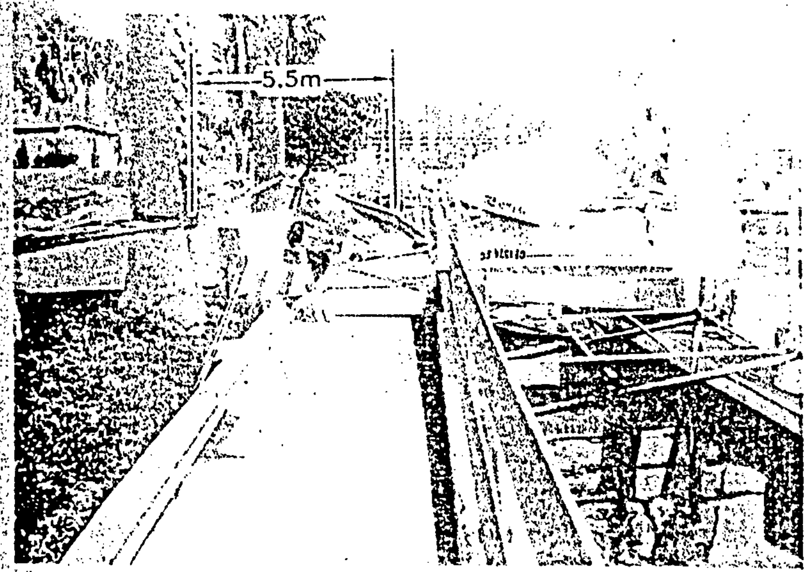

FIGURE 11.7 Damage to marine facility, 1994 Northridge, California, earthquake. *(From Kerwin and Stone, 1997; reprinted with permission from the American Society of Civil Engineers.)*

cause of liquefaction is the seismic energy released during an earthquake. The potential for liquefaction increases as the earthquake intensity and duration increase. Sites located near the epicenter of major earthquakes will be subjected to the largest intensity and duration of ground shaking (i.e., higher number of applications of cyclic shear strain). Besides earthquakes, other conditions can cause liquefaction, such as subsurface blasting.

2. *Groundwater table.* The condition most conducive to liquefaction is a near-surface groundwater table. Unsaturated soil located above the groundwater table will not liquefy.

3. *Soil type.* The soil types susceptible to liquefaction are nonplastic (cohesionless) soils. Seed et al. (1983) state that, on the basis of both laboratory testing and field performance, the great majority of clayey soils will not liquefy during earthquakes.

An approximate listing of cohesionless soils from least to most resistant to liquefaction are clean sands, nonplastic silty sands, nonplastic silt, and gravels. There could be numerous exceptions to this sequence. For example, Ishihara (1985, 1993) describes the case of tailings derived from the mining industry that were essentially composed of ground-up rocks and were classified as rock flour. Ishihara (1985, 1993) states that the rock flour in a water-saturated state did not possess significant cohesion and behaved as if it were a clean sand. These tailings were shown to exhibit as low a resistance to liquefaction as clean sand.

4. *Soil relative density D_r.* Cohesionless soils in a very loose relative density state are susceptible to liquefaction, while the same soil in a very dense relative density state will not liquefy. Very loose nonplastic soils will contract during the seismic shaking which will cause the development of excess pore water pressures. Very dense soils will dilate during seismic shaking and are not susceptible to liquefaction.

5. *Particle size gradation.* Poorly graded nonplastic soils tend to form more unstable particle arrangements and are more susceptible to liquefaction than well-graded soils.

6. *Placement conditions.* Hydraulic fills (fill placed under water) tend to be more susceptible to liquefaction because of the loose and segregated soil structure created by the soil particles falling through water.

7. *Drainage conditions.* If the excess pore water pressure can quickly dissipate, the soil may not liquefy. Thus gravel drains or gravel layers can reduce the liquefaction potential of adjacent soil.

8. *Confining pressures.* The greater the confining pressure, the less susceptible the soil is to liquefaction. Conditions that can create a higher confining pressure are a deeper groundwater table, soil that is located at a deeper depth below ground surface, and a surcharge pressure applied at ground surface. Case studies have shown that the possible zone of liquefaction usually extends from the ground surface to a maximum depth of about 15 m (50 ft). Deeper soils generally do not liquefy because of the higher confining pressures.

9. *Aging.* Newly deposited soils tend to be more susceptible to liquefaction than old deposits of soil. Older soil deposits may already have been subjected to seismic shaking or the soil particles may have deformed or been compressed into more stable arrangements.

Liquefaction Analysis. The most common type of analysis to determine the liquefaction potential is to use the standard penetration test (SPT) or the cone penetration test (CPT) (Seed et al., 1985; Stark and Olson, 1995). The analysis is based on the simplified method proposed by Seed and Idriss (1971). The method of analysis is as follows:

1. *Seismic shear stress ratio (SSR) caused by the earthquake.* The first step in the liquefaction analysis is to determine the seismic shear stress ratio (SSR). The seismic shear stress ratio induced by the earthquake at any point in the ground is estimated as follows (Seed and Idriss, 1971):

$$\text{SSR} = 0.65\, r_d \left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{v0}}{\sigma'_{v0}}\right) \tag{11.1}$$

where SSR = seismic shear stress ratio (dimensionless parameter)

a_{max} = peak acceleration measured or estimated at the ground surface of the site (m/s²)

g = acceleration of gravity (9.81 m/s²)*

σ_{v0} = total vertical stress at a particular depth where the liquefaction analysis is being performed (kPa) (in order to calculate the total vertical stress, the total unit weight γ_t of the soil layers must be known)

σ'_{v0} = vertical effective stress at that same depth in the soil deposit where σ_{v0} was calculated (kPa) (in order to calculate the vertical effective stress, the location of the groundwater table must be known).

The term r_d = depth reduction factor, which can be estimated in the upper 10 m of soil as (Kayen et al., 1992):

$$r_d = 1 - (0.012)(z) \tag{11.2}$$

where z = depth in meters below the ground surface where the liquefaction analysis is being performed (i.e., the same depth used to calculate σ_{v0} and σ'_{v0})

2. *Seismic shear stress ratio that will cause liquefaction of the soil.* The second step is to determine the seismic shear stress ratio (SSR) that will cause liquefaction of the *in situ* soil. Figure 11.8 presents a chart that can be used to determine the seismic shear stress ratio (SSR) that will cause liquefaction of the *in situ* soil. In order to use this chart, the results of the standard penetration test (SPT) must be expressed in terms of the SPT $(N_1)_{60}$ value. In liquefaction analysis, the SPT N_{60} value [Eq. (4.3)] is corrected for the overburden pressure. When a correction is applied to the SPT N_{60} value to account for the effect of overburden pressure, these values are referred to as SPT $(N_1)_{60}$ values. The procedure consists of multiplying the N_{60} value by a correction C_N in order to calculate the SPT $(N_1)_{60}$ value, or:

$$(N_1)_{60} = C_N N_{60} = (100/\sigma'_{v0})^{0.5} N_{60} \tag{11.3}$$

where $(N_1)_{60}$ = standard penetration N-value corrected for both field testing procedures and overburden pressure

C_N = correction factor to account for the overburden pressure [as indicated in Eq. (11.3), C_N is approximately equal to $(100/\sigma'_{v0})^{0.5}$, where σ'_{v0} is the vertical effective stress in kPa]

N_{60} = standard penetration N-value corrected for testing procedures [note that N_{60} is calculated by using Eq. (4.3)]

Once the corrected SPT $(N_1)_{60}$ has been calculated, Fig. 11.8 can be used to determine the seismic shear stress ratio (SSR) that will cause liquefaction of the *in situ* soil. Note that Fig. 11.8 is for a projected earthquake of 7.5 magnitude. The figure also has different curves that are to be used according to the percent fines in the soil. For a given $(N_1)_{60}$ value,

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*Usually the engineering geologist will determine the peak acceleration at the ground surface at the site from fault, seismicity, and attenuation studies. Typically the engineering geologist provides a peak ground acceleration in the form of a_{max}/g = a constant. For example, the engineering geologist may determine that the peak ground surface acceleration at a site is $a_{max}/g = 0.1$, in which case the value of 0.1 (dimensionless) is substituted into Eq. (11.1) in place of a_{max}/g.

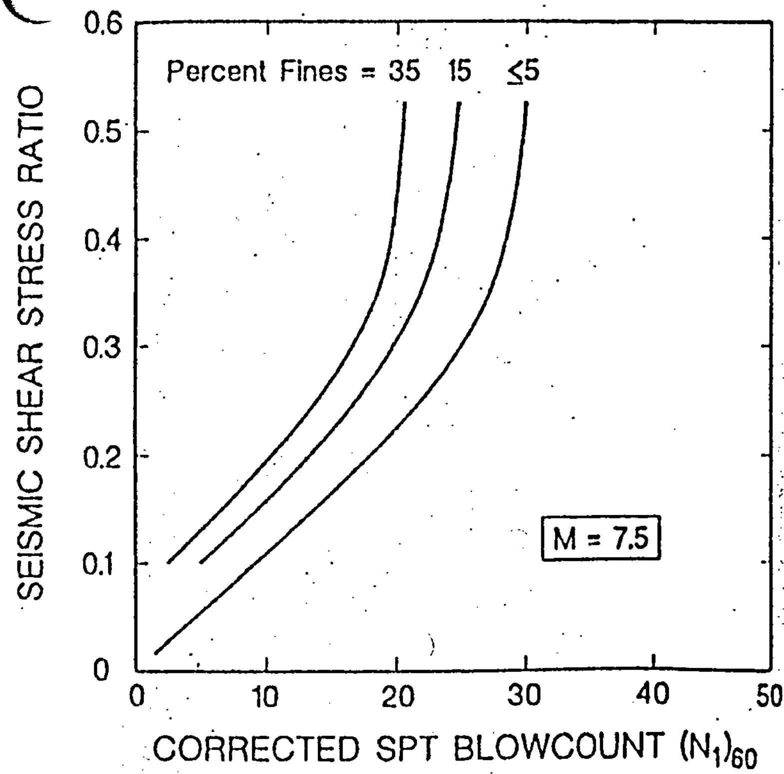

FIGURE 11.8 Relationship between seismic shear stress ratio (SSR) triggering liquefaction and $(N_1)_{60}$ values for clean and silty sands for $M = 7.5$ earthquakes. (*After Seed and DeAlba, 1986; reproduced from: Stark and Olson, 1995; reprinted with permission of the American Society of Civil Engineers.*)

soils with more fines have a higher seismic shear stress ratio (SSR) that will cause liquefaction of the *in situ* soil.

Figure 11.9 presents a chart for clean sands (5 percent or less fines) and different magnitude earthquakes. The magnitude 7.5 curve in Fig. 11.9 is similar to the magnitude 7.5 curve for 5 percent or less fines in Fig. 11.8.

3. *Compare seismic shear stress ratios.* The final step in the liquefaction analysis is to compare the seismic shear stress ratio (SSR) values. If the SSR value from Eq. (11.1) is greater than the SSR value obtained from either Fig. 11.8 or Fig. 11.9, then liquefaction could occur during the earthquake, and vice versa.

Example. It is planned to construct a building on a cohesionless soil deposit (fines less than 5 percent). There is a nearby major active fault and the engineering geologist has determined that the peak ground acceleration (a_{max}) = 0.4g. Assume the site conditions are the same as stated in Prob. 18 (Chap. 6), i.e., a level ground surface with the groundwater table located 1.5 m below ground surface and the standard penetration test performed at a depth of 3 m. If the earthquake magnitude (M) = 7.5, will the saturated clean sand located at a depth of 3 m below ground surface liquefy during the anticipated earthquake?

Solution. From Prob. 18 (Chap. 6), σ'_{v0} = 43 kPa and N_{60} = 5. Using the total unit weights from Prob. 18 (Chap. 6), σ_{v0} = 58 kPa. Since z = 3 m, r_d = 0.96. Using the following values:

$r_d = 0.96$

$a_{max}/g = 0.4$

$(\sigma_{v0}/\sigma'_{v0}) = (58/43) = 1.35$

and inserting the above values into Eq. (11.1), we find the seismic shear stress ratio (SSR) caused by the earthquake is 0.34.

The next step is to determine the seismic shear stress ratio (SSR) that will cause liquefaction of the *in situ* soil. From Prob. 18 (Chap. 6), the *N*-value corrected for field testing procedures (N_{60}) = 5. Using Eq. (11.3) with σ'_{v0} = 43 kPa and N_{60} = 5, we find

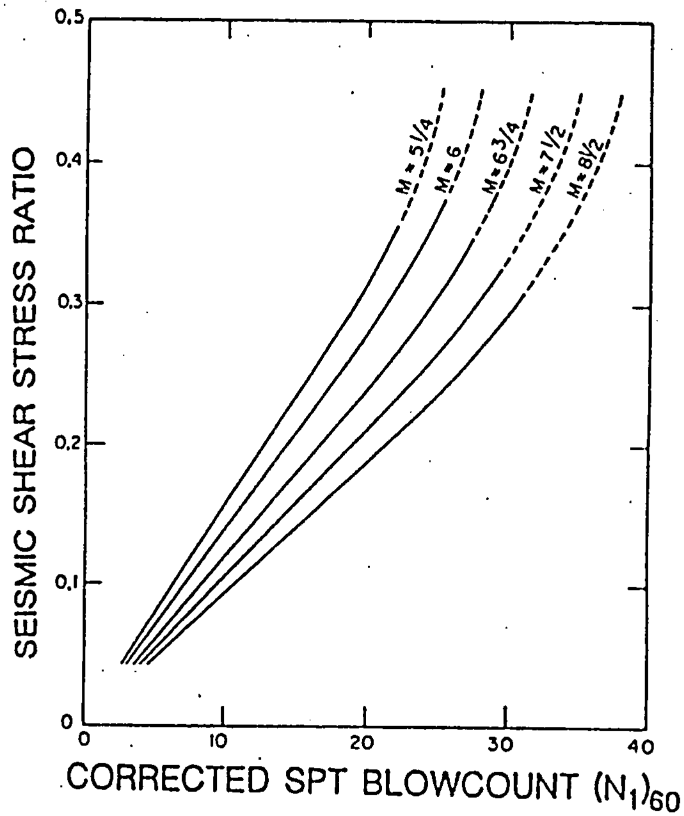

FIGURE 11.9 Relationship between seismic shear stress ratio (SSR) triggering liquefaction and $(N_1)_{60}$ values for clean sand for different magnitude earthquakes. (*After Seed et al., 1983; reprinted with permission of the American Society of Civil Engineers.*)

$(N_1)_{60}$ = 8. Entering Fig. 11.8 with $(N_1)_{60}$ = 8 and intersecting the curve labeled ≤ 5% fines, the seismic shear stress ratio (SSR) that will cause liquefaction of the *in situ* soil at a depth of 3 m = 0.08.

The final step is to compare the SSR caused by the earthquake (SSR = 0.34) with the SSR that will cause liquefaction of the *in situ* soil (SSR = 0.08). From a comparison of the SSR values, it is probable that during the earthquake the *in situ* sand located at a depth of 3 m below ground surface will liquefy.

In the above liquefaction analysis, there are many different equations and corrections that are applied to the seismic shear stress ratio (SSR). For example, there are four different corrections (E_m, C_b, C_r, and σ'_{v0}) that are applied to the SPT *N*-value in order to calculate the $(N_1)_{60}$ value. All of these different equations and various corrections may provide the engineer with a sense of high accuracy, when in fact, the entire analysis is only a gross approximation. The analysis should be treated as such and engineering experience and judgment are essential in the final determination of whether or not a site has liquefaction potential.

11.2.3 Slope Movement and Settlement

Besides liquefaction of loose saturated sands, other soil conditions can result in slope movement or settlement during an earthquake. For example, Grantz et al. (1964) describe an interesting case of ground vibrations from the 1964 Alaskan earthquake that caused 0.8 m (2.6 ft) of alluvium settlement. Other loose soils, such as cohesionless sand and gravel, will also be susceptible to settlement due to the ground vibrations from earthquakes.

Slopes having a low factor of safety can experience large horizontal movement during an earthquake. Types of slopes most susceptible to movement during earthquakes include those slopes composed of soil that loses shear strength with strain (such as sensitive soil) and ancient landslides that can become reactivated by seismic forces (Day and Poland, 1996).

11.2.4 Translation and Rotation

An unusual effect caused by earthquakes is translation and rotation of objects. For example, Fig. 11.10 shows a photograph of a brick mailbox that rotated and translated (moved laterally) during the Northridge earthquake. The initial position in Fig. 11.10 refers to the pre-earthquake position of the mailbox.

Earthquakes have caused the rotation of other movable objects, such as grave markers (Athanasopoulos, 1995; Yegian et al., 1994). According to Athanasopoulos (1995), such objects will rotate in such a manner as to be aligned with the strong component of the earthquake. Besides rotation, translation (lateral movement) can also occur during an earthquake. The objects will tend to move in the same direction as the propagation of energy waves, i.e., in a direction away from the epicenter of the earthquake.

11.3 ESTIMATING EARTHQUAKE GROUND MOVEMENT

Often the geotechnical engineer will be required to estimate the amount of foundation displacement caused by earthquake-induced soil movement. For example, the *Uniform*

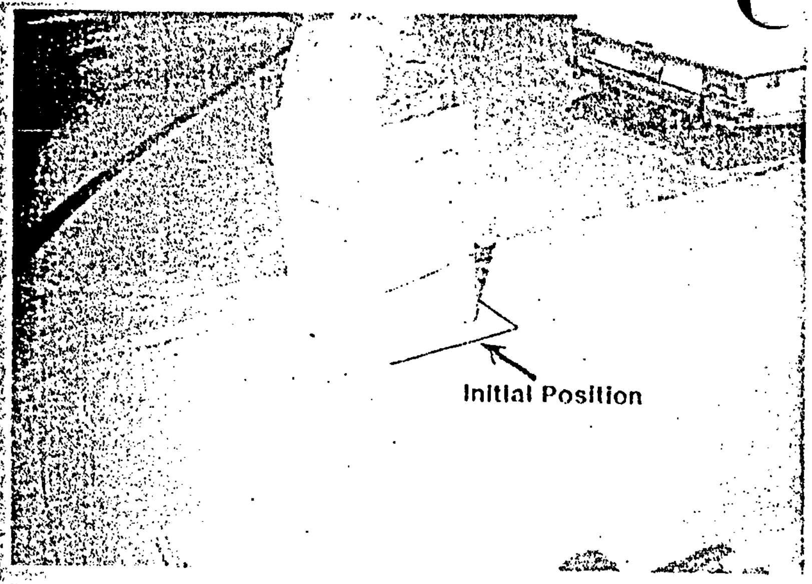

FIGURE 11.10 Rotation of brick mailbox, 1994 Northridge, California, earthquake.

Building Code (1997), which is the building code required for construction in California, states (code provision submitted by the author, adopted in May 1994):

> The potential for soil liquefaction and soil strength loss during earthquakes shall be evaluated during the geotechnical investigation. The geotechnical report shall assess potential consequences of any liquefaction and soil strength loss, including estimation of differential settlement, lateral movement or reduction in foundation soil-bearing capacity, and discuss mitigating measures. Such measures shall be given consideration in the design of the building and may include, but are not limited to, ground stabilization, selection of appropriate foundation type and depths, selection of appropriate structural systems to accommodate anticipated displacement or any combination of these measures.

The intent of this building code requirement is to obtain an approximate estimate of the foundation displacement caused by the earthquake induced soil movement. In terms of accuracy of the calculations used to determine the earthquake induced soil movement, Tokimatsu and Seed (1984) conclude:

> It should be recognized that, even under static loading conditions, the error associated with the estimation of settlement is on the order of ±25 to 50%. It is therefore reasonable to expect less accuracy in predicting settlements for the more complicated conditions associated with earthquake loadin.... In the application of the methods, it is essential to check that the final results are reasonable in light of available experience.

Pseudostatic Approach. A vast majority of foundation and earthwork designs are based on the pseudostatic approach (Coduto, 1994). This method ignores the cyclic nature of earthquakes and treats them as if they apply an additional static force upon the slope, retaining wall, or foundation element. For example, as will be discussed in Sec. 15.3, a common

GEOTECHNICAL AND FOUNDATION ENGINEERING

Design and Construction

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Appendix B

Loading Due to Construction Equipment

CLIENT	JOB NO 181263	PAGE	OF
PROJECT	DATE 16 MAY 06	DATE CHECKED	
DETAIL	COMPUTED BY CLS	CHECKED BY	

consulting scientists and engineers

LOADING DUE TO CONSTRUCTION EQUIPMENT (Cat., 1996)*

1. Dozer tracking

DGM XL — Weight 33,[illegible] lb
Ground contact area 4743 in² = 32.94 ft²
Loading pressure = 33,[illegible] / 32.94 = 1.0[illegible]
6.99×144 = 1,0[illegible] psf

DGM LGP — Weight [illegible]
Ground contact area [illegible] in² = 57.05 ft²
Loading pressure = [illegible] / 57.05 = 638 psf
4.40×144 = 634 psf

D7 G — [illegible] 1267 psf

D8 R — [illegible].47×144 = 1941 psf

2. Compactors

815 F — Weight 45,934 lb
Drum width 33.5 in
Drum diameter 24 in — Drum Circumference = πD = 75.4 in
Feet per row 12 — Rows 5
Feet in contact 2
End [illegible] 18" — 5·2 = 10 feet in contact
4×10×18" = 180 in × 4 = 720 in² = 5 ft²

Ground pressure 45934/5 = 9187 psf

LOADING DUE TO TAILINGS & COVER

At bottom of [illegible]: tailings thickness 38' — tailings density = 98 (1 + 0.15) = 112.7 pcf
cover thickness 13' — cover density = 103 (1 + 0.07) = 110.2 pcf

Stress at bottom of cell: 112.7·38 + 110.2·13 = 4282.6 + 1432.6 = 5715.2 psf

Stress at top of tailings: 110.2·13 = 1432.6 psf

STRESSES ON TAILINGS — by [illegible] and [illegible]
[illegible]

*Caterpillar Inc. (Cat) 1996. Caterpillar Performance Handbook.

Track-Type Tractors | Specifications

MODEL	D5E▶		D6M XL		D6M LGP		D6G	
Flywheel Power, Power Shift	78 kW	105 hp	104 kW	140 hp	104 kW	140 hp	116 kW	155 hp
Operating Weight, Power Shift	—		*15 050 kg	33,200 lb	16 500 kg	36,400 lb	15 432 kg	34,028 lb
Direct Drive	*11 7[illegible] kg	25,800 lb	—		—		—	
Engine Model	3306		3116		3116		3306	
Rated Engine RPM, Power Shift	1750		2200		2200		1900	
Direct Drive	—		—		—			
No. of Cylinders	6		6		6		6	
Bore	121 mm	4.75	105 mm	4.1"	105 mm	4.1"	121 mm	4.75"
Stroke	152 mm	6"	127 mm	5.0"	127 mm	5.0"	152 mm	6"
Displacement	10.5 L	638 in³	6.6 L	403 in³	6.6 L	403 in³	10.5 L	638 in³
Track Rollers (Each Side)	6		7		8		7	
Width of Standard Track Shoe	457 mm	18"	600 mm	24"	860 mm	34"	508 mm	20"
Length of Track on Ground	2.21 m	87"	2.55 m	100"	3.08 m	121"	2.67 m	105"
Ground Contact Area (W/Std. Shoes)	2.05 m²	3154 in²	3.06 m²	4743 in²	5.30 m²	8217 in²	2.72 m²	4216 in²
Track Gauge	1.52 m	60"	1.89 m	74"	2.16 m	85"	1.88 m	74"
GENERAL DIMENSIONS								
Height (Stripped Top)**	1.9[illegible] m	6'6"	2.30 m	7'6.5"	2.41 m	7'11"	2.10 m	6'11"
Height (To Top of ROPS Canopy)	—		3.02 m	9'11"	3.14 m	10'4"	—	
Height (To Top of ROPS)	2.95 m	9'8"	—		—		3.20 m	10'5"
Height (To Top of Cab ROPS)	—		3.06 m	10'1"	3.19 m	10'6"	—	
Overall Length (With P Blade)***	—		4.80 m	15'9"	5.37 m	17'8"	—	
(Without Blade)	—		3.74 m	12'3"	4.15 m	13'7"	—	
Overall Length (With S Blade)	—		4.92 m	16'2"	—		5.00 m	16'4"
(Without Blade)	3.88 m	12'8"	3.74 m	12'3"	4.15 m	13'7"	3.94 m	12'9"
Width (Over Trunnion)	—		3.19 m	10'6"	—		—	
Width (W/O Trunnion — Std. Shoes)	2.03 m	6'8"	2.49 m	8'2"	3.02 m	9'11"	2.39 m	7'10"
Ground Clearance	277 mm	10.9"	424 mm	16.7"	538 mm	21.2"	310 mm	12.2"
Blade Types and Widths								
Straight	—		—		—		3.20m	10'6"
Angle	3.34 m	10'11"	—		—		3.90m	12'9"
Semi-U	—		3.17 m	10'6"	—		3.20m	10'6"
"P" Straight	—		—		—		—	
Power Angle & Tilt†	—		3.27 m	10'9"	4.08 m	13'5"	—	
Fuel Tank Refill Capacity	295 L	78 U.S. gal	311 L	82.2 U.S. gal	311 L	82.2 U.S. gal	300 L	80 U.S. gal

* Operating Weight includes ROPS canopy, operator, lubricants, coolant, full fuel tank, hydraulic controls and fluids, straight dozer with tilt (UPAT on D5M LGP and D6M) rigid drawbar, front towing device, engine enclosures, and suspension seat.
** Height (stripped top) — without ROPS canopy, exhaust, precleaner, seat back or other easily removed encumbrances.
*** UPAT blade on D6M LGP and D6M
† SU blade on D6M
▶ Built for Domestic only

GROUND PRESSURES

Pressures computed from operating weights given earlier in this section in the specifications tables.

MODEL	SHOE WIDTH		CONTACT AREA		GROUND PRESSURE	
	mm	in	m²	in²	kPa	psi
D3C Series III	356	14	1.35	2097	52	7.2
◄	406	16	1.54	2396	44.5	6.45
D3C XL Series III	406	16	1.67	2589	42.5	6.16
D3C LGP Series III	635	25	2.61	4045	28.6	4.15
D4C Series III	406	16	1.67	2589	42.4	6.15
D4C XL Series III	457	18	2.02	3132	36.2	5.25
D4C LGP Series III	635	25	2.61	4045	30	4.2
D5C Series III	457	18	1.97	3038	41	6.0
D5C XL Series III	508	20	2.36	3648	35	5.1
D5C LGP Series III	660	26	2.83	4389	30.3	4.4
D5M XL ◄	510	20	2.44	3775	48	6.83
	560	22	2.67	4146	44	6.22
D5M LGP	610	24	3.18	4922	40	5.64
◄	760	30	3.96	6133	32	4.53
	770	30	4.01	6213	31	4.47
D5E	406	16	1.77	2745	62	9.00
◄	457	18	1.99	3085	55	7.98
D6M XL	560	22	2.89	4427	52	7.49
◄	600	24	3.06	4743	48	6.99
D6M LGP	710	28	4.38	6783	37	5.36
◄	860	34	5.30	8217	31	4.43
	865	34	5.33	8264	30	4.40
D6G	457	18	2.43	3766	60	8.70
◄	508	20	2.71	4200	54	7.83
	560	22	2.98	4619	49	7.10
	610	24	3.25	5040	45	6.54
D6H Series II ◄	560	22	2.92	4518	61	8.82
	610	24	3.18	4930	56	8.14

◄ Standard Shoe

MODEL	SHOE WIDTH		CONTACT AREA		GROUND PRESSUR	
	mm	in	m²	in²	kPa	psi
D6H XL ◄	560	22	3.16	4888	60	8.60
Series II	610	24	3.44	5332	55	7.93
D6H XL (IG) Series II	762	30	4.3	6696	44	6.50
D6H XR ◄	560	22	3.08	4770	60	8.6
Series II	610	24	3.36	5203	56	8.0
D6H LGP	760	30	4.93	7662	41	5.8
Series II ◄	915	36	5.93	9194	35	4.9
	1000	39	6.49	9961	32	4.5
D7G ◄	508	20	2.76	4280	73	10.6
◄	559	22	3.04	4708	66	9.6
	610	24	3.31	5136	60	8.8
D7H Series II	510	20	2.94	4560	82	11.7
◄	560	22	3.24	5016	75	10.6
	610	24	3.53	5472	69	9.8
	660	26	3.82	5928	64	9.1
D7H XR Series II	560	22	3.43	5315	71.5	10.1
◄	610	24	3.75	5808	65.9	9.
	660	26	4.06	6282	61.2	8.
D7H LGP	760	30	4.8	7504	54	7.
Series II	915	36	5.82	9029	46	6.
D8R ◄	560	22	3.59	5565	101.1	14.
	610	24	3.91	6062	92.8	13.
	660	26	4.23	6559	85.9	12.
	710	28	4.55	7056	79.7	11.
D8R LGP*	965	38	6.2	9576	58.6	8.
D9R	560	22	3.86	6009	121.1	17.
◄	610	24	4.24	6569	110.8	16.
	685	27	4.74	7374	98.7	14
	760	30	5.26	8194	88.8	12
D10R ◄	610	24	4.73	7326	136.4	19
	710	28	5.50	8527	117.1	17
	860	31.5	6.66	10,328	96.7	14
D11R ◄	710	28	6.31	9781	152.8	22
	810	32	7.20	11,159	133.9	19
	915	36	8.13	12,605	118.6	17

◄ Standard shoe *Offered as a Custom Product

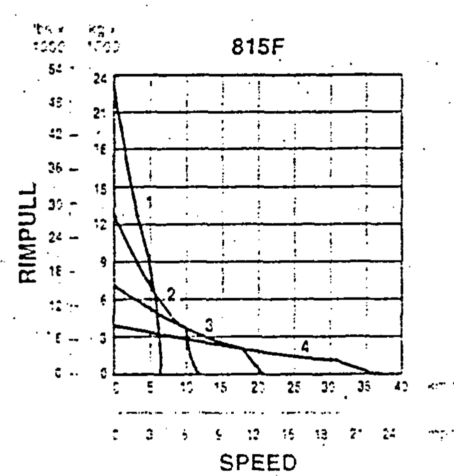
NOTE: Ground contact area = width of track sh × length of track on ground × 2.

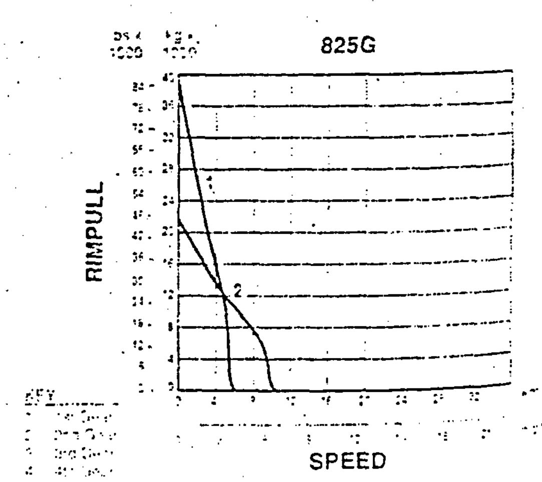
$$\text{Ground pressure} = \frac{\text{operating weigh}}{\text{ground contact ar}}$$

Soil Compactors | Specifications
- Rimpull

MODEL	815F		825G	
Flywheel Power	164 kW	220 hp	235 kW	315 hp
Operating Weight*	20 679 kg	45,934 lb	31 740 kg	69,828 lb
Engine Model	3306 DITA		3406C DITA	
Rated Engine RPM	2200		2100	
No. Cylinders	6		6	
Displacement	10.5 L	638 in³	14.6 L	893 in³
Speeds:				
Forward	4		2	
Reverse	4		2	
Turning Circle with Blade	12.6 m	41'5"	14.6 m	48'0"
Fuel Tank Refill Capacity	464 L	122.6 U.S. gal	630 L	166.5 U.S. gal
TAMPING FOOT WHEELS:				
Each Drum Width	978 mm	38.5"	1125 mm	44.3"
Diameters, over feet	1.42 m	55.9"	1.68 m	66"
over drum	1.03 m	40.5"	1.29 m	51"
Feet per Wheel	60		65	
Feet per Row	12		13	
Rows of Feet	5		5	
Foot Length	198 mm	7.8"	220 mm	8.7"
End Area Per Foot	116 cm²	18 in²	183 cm²	28.4 in²
Width of Two Pass Coverage	4.35 m	14'3"	4.88 m	16'0"
GENERAL DIMENSIONS:				
Height (top of ROPS)	3.34 m	11'0"	3.74 m	12'3"
Height (stripped top)**	2.39 m	7'10"	2.65 m	8'8"
Wheel Base	3.35 m	11'0"	3.70 m	12'2"
Overall Length with Dozer	6.82 m	22'5"	8.24 m	27'1"
Width over Drums	3.24 m	10'8"	3.65 m	12'0"
Ground Clearance	423 mm	1'5"	355 mm	1'2"
STRAIGHT BULLDOZER:				
Width	3.76 m	12'4"	4.61 m	15'2"
Height	8.60 m	2'10"	[illegible] m	3'3"

*Operating Weight includes coolant, lubricants, bulldozer, hydraulics, ROPS canopy, full fuel tank and operator.
**Height (stripped top) — without ROPS, exhaust, seat back or other easily removed encumbrances.





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U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-08-2005-2-08-01 **Discipline:** Hydrology **No. of Sheets:** 3

Project: Moab Project

Site: Crescent Junction Site Characterization

Feature:

Site Drainage—Hydrology Parameters
[Calculation Set 1 per Mod P]

Sources of Data:

Sources of Formulae and References:

3. U.S. Department of Energy, Technical Approach Document, Revision II, UMTRA-DOE/AL 050424.0002, December 1989.

Preliminary Calc. ☐ **Final Calc.** ☐ **Supersedes Calc. No. MOA-02-08-2005-2-08-00**

Author: Mark Kautsky 11-17-05
Name Date

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Name Date

Approved by: John E. Elmer 11-17-05
Name Date

Name Date

Name Date

Name Date

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-08-2005-2-08-00 **Discipline: Hydrology** **No. of Sheets: 3**

Project: **Moab Project**

Site: **Crescent Junction Site Characterization**

Feature:

Site Drainage—Hydrology Parameters
[Calculation Set 1 per Mod P]

Sources of Data:

The design storm information was downloaded from the NOAA website:
http://hdsc.nws.noaa.gov/hdsc/pfds/sa/ut_pfds.html.

Point precipitation frequency estimates were drawn directly from http://hdsc.nws.noaa.gov/cgi-bin/hdsc/buildout.perl?type=pf&series=pd&units=us&statename=UTAH&stateabv=ut&study=sa&season=All&intype=3&plat=&plon=&liststation=THOMPSON+++++++++++++++++UT+%2C+42-8705&slat=38.96&slon=-109.8&mlat=40.051&mlon=-108.490&elev=0&xy0=lat&xy1=-lon&xy2=lat&xy3=-lon&xy4=lat&xy5=-lon&xy6=lat&xy7=-lon&xy8=lat&xy9=-lon&xy10=lat&xy11=-lon&xy12=lat&xy13=-lon&xy14=lat&xy15=-lon&xy16=lat&xy17=-lon&xy18=lat&xy19=-lon&xy20=lat&xy21=-lon&xy22=lat&xy23=-lon

Sources of Formulae and References:

1. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, NOAA Atlas 14: Precipitation-Frequency Atlas of the United States, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah), 2004.
2. U. S. Department of Commerce, Environmental Science Service Administration, Weather Bureau, "Hydrometerological Report No. 49. Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainage" Sept. 1977

Preliminary Calc. ☐ **Final Calc.** ☐ **Supersedes Calc. No.**

Author:	Mark Kautsky (Name)	9-9-05 (Date)	**Checked by:**	Toby Wright (Name)	9/7/05 (Date)
Approved by:	John Elmer (Name)	9-12-05 (Date)		Greg Smith (Name)	9/8/05 (Date)
				Name	Date
				Name	Date

Problem Statement

To determine the hydrometeorological characteristics of the Crescent Junction site, Utah, at 38.96° North, 109.80° West, elevation 4,950 feet amsl for the following designs during and after remedial action:

A. During remedial action at the disposal site:

1. 10-year, 60-minute storm to size ditches and erosion protection

2. 10-year, 24-hour storm to size wastewater retention basins

3. 25-year, 60-minute storm to size emergency spillway of the basins

B. After remedial action at the disposal site:

1. PMP storm intensity and duration to size ditches and design erosion protection for ditches and embankment

Method of Solution

For remedial action at the disposal site, look up point-precipitation frequency estimates on NOAA website and download the results.

For post-remedial action at the disposal site, use HMR No. 49 to calculate PMP storm intensity for general storm PMP and the local-storm PMP. Select most intense storm for design purposes.

Assumptions

Standard procedures used to calculate design storms and PMP will be protective of human life, infrastructure, and environment.

Calculation

During remedial action, rainfall will be determined from the NOAA precipitation-frequency atlas for Utah (Ref 1).

The design storm information was downloaded from the NOAA website: http://hdsc.nws.noaa.gov/hdsc/pfds/sa/ut_pfds.html.

Point precipitation frequency estimates were drawn directly from http://hdsc.nws.noaa.gov/cgi-bin/hdsc/buildout.perl?type=pf&series=pd&units=us&statename=UTAH&stateabv=ut&study=sa&season=All&intype=3&plat=&plon=&liststation=THOMPSON++++++++++++++++UT+%2C+42-8705&slat=38.96&slon=-109.8&mlat=40.051&mlon=-108.490&elev=0&xy0=lat&xy1=-lon&xy2=lat&xy3=-lon&xy4=lat&xy5=-lon&xy6=lat&xy7=-lon&xy8=lat&xy9=-lon&xy10=lat&xy11=-lon&xy12=lat&xy13=-lon&xy14=lat&xy15=-lon&xy16=lat&xy17=-lon&xy18=lat&xy19=-lon&xy20=lat&xy21=-lon&xy22=lat&xy23=-lon. The data from this website are presented in Appendix A. The design-storm data are presented in Table 1.

After remediation, rainfall will be determined for the Crescent Junction disposal site from the general storm PMP or the local-storm PMP, whichever is more severe, according to HMR49 (Ref. 2). The watershed areas of the proposed diversion ditch (if required), and the proposed tailings site are each less than 10 mi^2; therefore, no depth-area correction is required for the PMP. The basin area of the Crescent Wash drainage is 22 mi^2; therefore a depth-area correction of 98% is required to compute the general storm PMP. The minimum site elevation for the project is approximately 4,950 ft amsl. The wet season of the site is from July to October. The general storm PMP and the local-storm PMP are calculated as shown in Appendix B. The maximum general-storm PMP, which occurs during the month of August, has an estimated maximum intensity of 4.7 inches in 6 hours. A comparison of the general-storm and the local-storm PMPs indicates that the intensity of the local-storm PMP, which carries an estimated depth of 7.4 inches in 6 hours, exceeds the intensity of the general-storm PMP; consequently, the local-storm PMP should be used for engineering design purposes in accordance with Section 4.1.3 of the Technical Approach Document (DOE 1989). The estimated precipitation depths for the local-storm PMP are presented in Table 2.

Discussion:

Not applicable

Conclusions and Recommendations:

Table 1. Summary of Design Storm Data for the Crescent Junction, Utah Site

Recurrence Interval (years)	Rainfall Inches for Duration Hours	
	60 minute	24 hour
10	0.8 inches	1.63 inches
25	1.07 inches	

Table 2. Estimated Precipitation Depths For Local-Storm PMP, Crescent Junction, Utah Site

Hourly Increments	First Hour	Second Hour	Third Hour				Fourth Hour	Fifth Hour	Sixth Hour
PMP Depths (inches)	0.1	0.3	6.0				0.7	0.2	0.1
Third-Hour Component Depths (inches)			4.3	0.8	0.6	0.3			

Computer Source:

Not applicable

Appendix A
Point Precipitation Frequency Estimates
From NOAA Atlas 14

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 38.96 N 109.8 W 4954 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003

Extracted: Thu Jul 7 2005

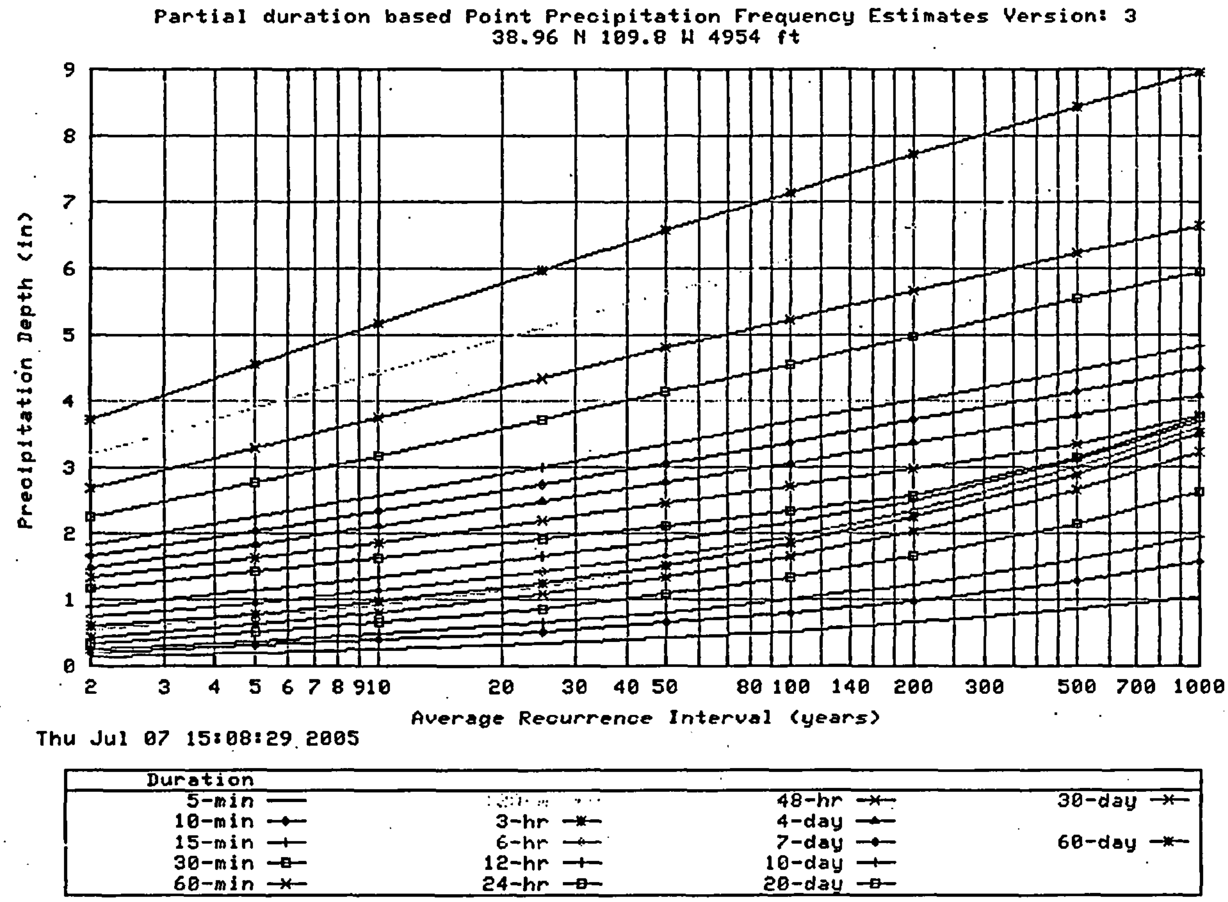
Confidence Limits | Seasonality | Location Maps | Other Info. | Grids | Maps | Help | Docs

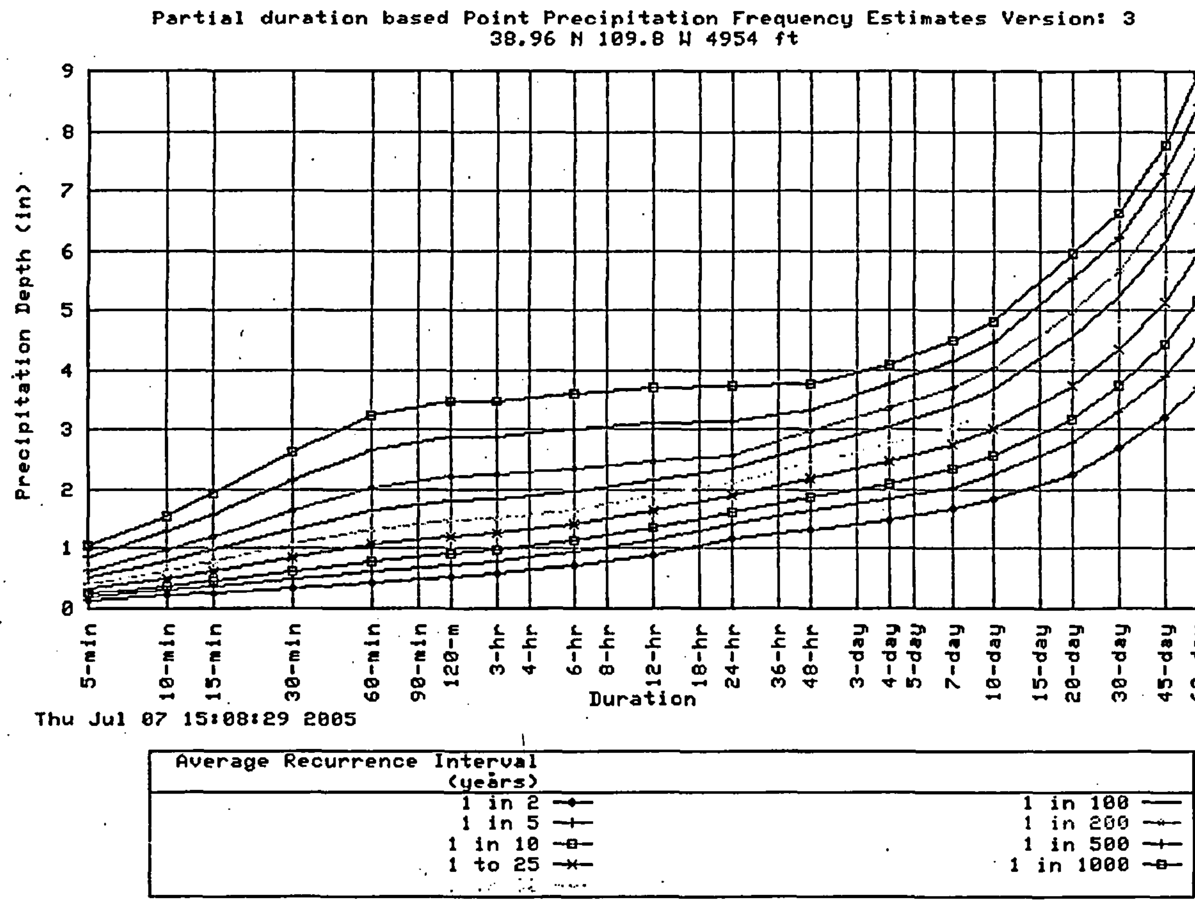
Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.14	0.21	0.26	0.35	0.44	0.53	0.59	0.73	0.89	1.16	1.34	1.49	1.66	1.83	2.25	2.70	3.19	3.71
5	0.20	0.30	0.38	0.51	0.62	0.73	0.79	0.94	1.15	1.42	1.64	1.83	2.03	2.24	2.77	3.29	3.89	4.54
10	0.25	0.39	0.48	0.65	0.80	0.91	0.97	1.13	1.36	1.63	1.87	2.10	2.33	2.57	3.18	3.75	4.42	5.16
25	0.34	0.52	0.64	0.87	1.07	1.21	1.26	1.42	1.65	1.91	2.20	2.47	2.75	3.01	3.73	4.34	5.12	5.97
50	0.42	0.65	0.80	1.08	1.34	1.49	1.52	1.66	1.90	2.12	2.45	2.76	3.05	3.34	4.14	4.79	5.64	6.56
100	0.53	0.80	0.99	1.33	1.65	1.82	1.84	1.95	2.16	2.35	2.71	3.05	3.38	3.68	4.56	5.23	6.15	7.14
200	0.65	0.98	1.22	1.64	2.03	2.23	2.25	2.35	2.47	2.58	2.98	3.36	3.71	4.01	4.97	5.66	6.64	7.71
500	0.84	1.28	1.59	2.15	2.65	2.88	2.89	3.00	3.11	3.15	3.34	3.77	4.15	4.47	5.54	6.22	7.28	8.43
1000	1.03	1.57	1.94	2.62	3.24	3.49	3.50	3.60	3.69	3.73	3.77	4.09	4.50	4.82	5.95	6.63	7.75	8.95

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.


Partial duration based Point Precipitation Frequency Estimates Version: 3
38.96 N 109.8 W 4954 ft
Precipitation Depth (in)
0
1
2
3
4
5
6
7
8
9
2
3
4
5
6
7
8
9
10
20
30
40
50
80
100
140
200
300
500
700
1000
Average Recurrence Interval (years)
Thu Jul 07 15:08:29 2005
Duration
5-min
10-min
15-min
30-min
60-min
3-hr
6-hr
12-hr
24-hr
48-hr
4-day
7-day
10-day
20-day
30-day
60-day



Confidence Limits -

*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.16	0.25	0.30	0.41	0.51	0.60	0.66	0.82	1.00	1.25	1.43	1.61	1.80	1.99	2.46	2.92	3.45	4.02
5	0.23	0.35	0.43	0.58	0.72	0.83	0.88	1.06	1.27	1.52	1.74	1.96	2.19	2.42	3.02	3.56	4.19	4.89
10	0.29	0.44	0.55	0.74	0.92	1.03	1.09	1.28	1.50	1.75	1.99	2.24	2.51	2.77	3.45	4.06	4.76	5.55
25	0.40	0.60	0.75	1.00	1.24	1.38	1.43	1.60	1.85	2.06	2.35	2.65	2.96	3.25	4.04	4.71	5.51	6.41
50	0.50	0.76	0.94	1.26	1.56	1.71	1.73	1.90	2.12	2.32	2.63	2.95	3.29	3.62	4.50	5.20	6.08	7.08
100	0.62	0.94	1.16	1.56	1.94	2.11	2.13	2.25	2.46	2.59	2.94	3.28	3.66	4.01	4.99	5.71	6.65	7.74
200	0.77	1.17	1.45	1.95	2.41	2.61	2.63	2.75	2.86	2.87	3.26	3.65	4.05	4.41	5.47	6.22	7.21	8.41
500	1.02	1.55	1.93	2.60	3.21	3.47	3.49	3.58	3.67	3.70	3.71	4.15	4.62	4.96	6.15	6.91	7.97	9.27
1000	1.27	1.94	2.40	3.24	4.01	4.28	4.30	4.37	4.42	4.47	4.51	4.58	5.08	5.43	6.69	7.42	8.55	9.96

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

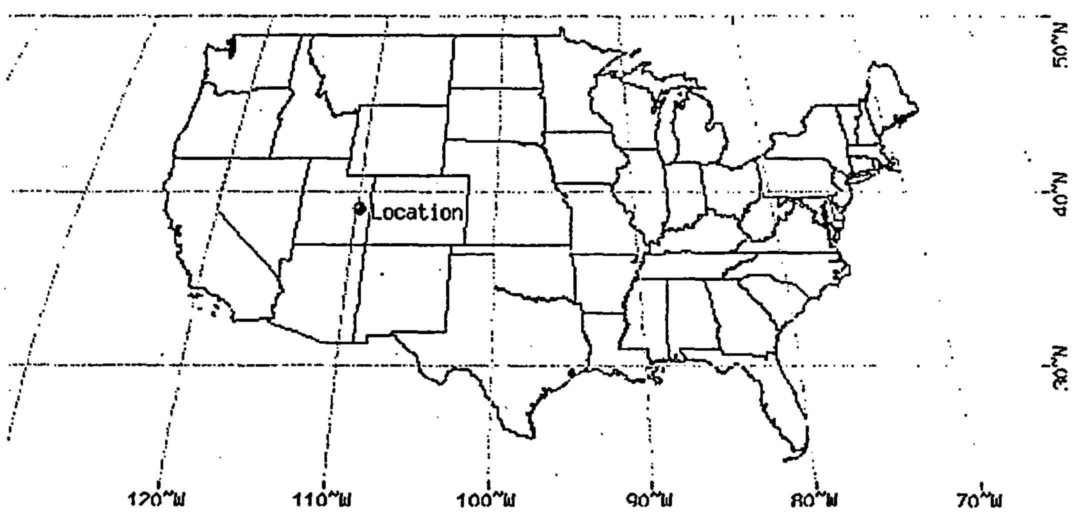
*** Lower bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

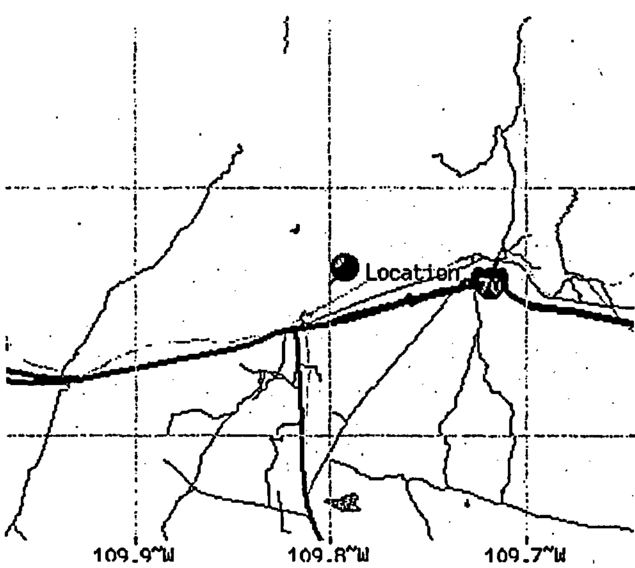
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.12	0.19	0.23	0.31	0.39	0.47	0.53	0.66	0.81	1.09	1.26	1.40	1.56	1.71	2.08	2.50	2.94	3.44
5	0.17	0.26	0.33	0.44	0.54	0.65	0.70	0.85	1.03	1.33	1.53	1.70	1.89	2.08	2.56	3.03	3.58	4.19
10	0.22	0.33	0.41	0.55	0.69	0.79	0.86	1.01	1.21	1.52	1.75	1.95	2.16	2.38	2.91	3.44	4.07	4.76
25	0.29	0.44	0.54	0.73	0.91	1.03	1.09	1.25	1.47	1.78	2.04	2.27	2.52	2.76	3.40	3.98	4.67	5.47
50	0.35	0.53	0.66	0.89	1.10	1.24	1.29	1.44	1.67	1.97	2.25	2.51	2.77	3.04	3.75	4.36	5.12	5.98
100	0.42	0.64	0.80	1.07	1.33	1.48	1.54	1.66	1.88	2.17	2.46	2.74	3.02	3.30	4.09	4.71	5.53	6.45
200	0.50	0.76	0.94	1.27	1.57	1.75	1.82	1.96	2.12	2.35	2.66	2.98	3.27	3.55	4.41	5.05	5.91	6.88
500	0.62	0.94	1.17	1.58	1.95	2.16	2.25	2.43	2.61	2.64	2.92	3.27	3.59	3.87	4.83	5.46	6.39	7.42
1000	0.73	1.11	1.37	1.85	2.29	2.51	2.63	2.85	3.06	3.09	3.12	3.49	3.81	4.10	5.12	5.74	6.73	7.80

* The lower bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are less than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.

Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Maps -





These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server.

Please read disclaimer for more information.

LEGEND

State
County
Indian Resv
Lake/Pond/Ocean
Street
Expressway
Highway
Connector
Stream
Military Area
National Park
Other Park
City
County

Scale 1:228583
0 2 4 6 8 10 km
0 2 4 6 8 mi
*average--true scale depends on monitor resolution

Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to our documentation.

Using the National Climatic Data Center's (NCDC) station search engine, locate other climate stations within:

+/-30 minutes ...OR... +/-1 degree of this location (38.96/-109.8). Digital ASCII data can be obtained directly from NCDC.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the Western Regional Climate Center's state-specific SNOTEL station maps.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910
(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Appendix B
General-Storm and Local-Storm PMP Estimates

General Storm PMP Computation
July

Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage Crescent Junction Disposal Site Elev 5000 Area less than 1 mi^2 (km^2)
Latitude 38°57'50"N (38.96°N) Longitude ___ of basin center 109° 48'00" W (109.80°W)
Month July

Step	6	12	18	24	48	72	
A. Convergence PMP							
1. Drainage average value from one of figures 2.5 to 2.16 11.5 in. (~~mm~~)							
2. Reduction for barrier-elevation [fig. 2.18] 50 %							
3. Barrier-elevation reduced PMP [step 1 X step 2] 5.8 in. (~~mm~~)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].	69	86	94	100	115	121	%
5. Convergence PMP for indicated durations [steps 3 X 4]	4.0	5.0	5.4	5.8	6.7	7.0	in. (~~mm~~)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	4.0	1.0	0.4	0.4	0.9	0.3	in. (~~mm~~)
7. Areal reduction [select from figs. 2.28 and 2.29]	95	98	98	100	100	100	%
8. Areally reduced PMP [step 6 X step 7]	3.8	1.0	0.4	0.4	0.9	0.3	in. (~~mm~~)
9. Drainage average PMP [accumulated values of step 8]	3.8	4.8	5.2	5.6	6.5	6.8	in. (~~mm~~)
B. Orographic PMP							
1. Drainage average orographic index from figure 3.11a to d. 2.0 in. (~~mm~~)							
2. Areal reduction [figure 3.20] 98 %							
3. Adjustment for month [one of figs. 3.12 to 3.17] 99 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3] 1.94 in. (~~mm~~)							
5. Durational variation [table 3.4]	30	57	80	100	157	185	%
6. Orographic PMP for given durations [steps 4 X 5]	0.6	1.1	1.6	2.0	3.1	3.7	in. (~~mm~~)
C. Total PMP							
1. Add steps A9 and B6	4.4	5.9	6.8	7.6	9.6	10.5	in. (~~mm~~)
2. PMP for other durations from smooth curve fitted to plot of computed data.							
3. Comparison with local-storm PMP (see sec. 6.3).							

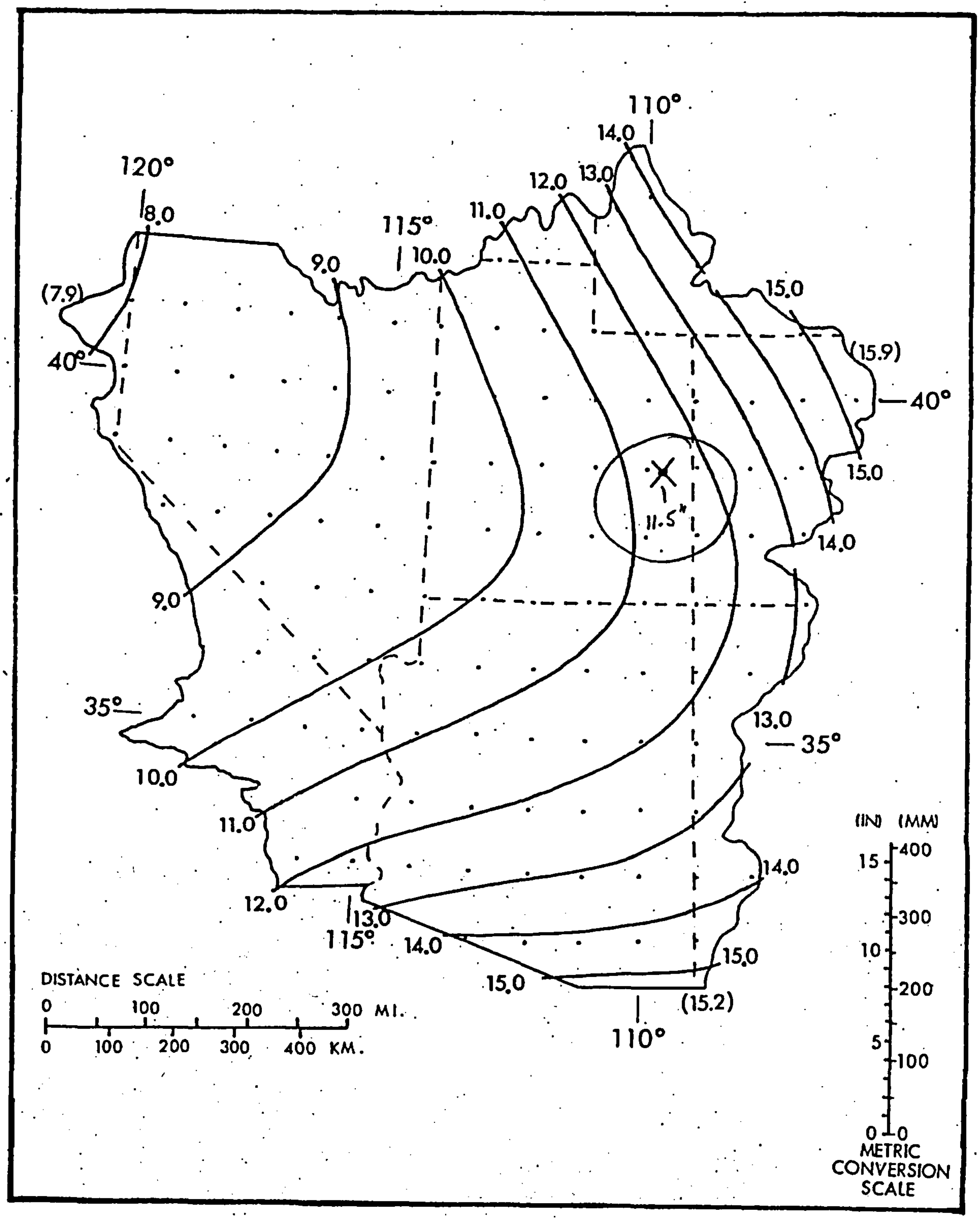


Figure 2.11.--1000-mb (100-kPa) 24-hr convergence PMP (inches) for 10 mi2 (26 km2) for July. Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

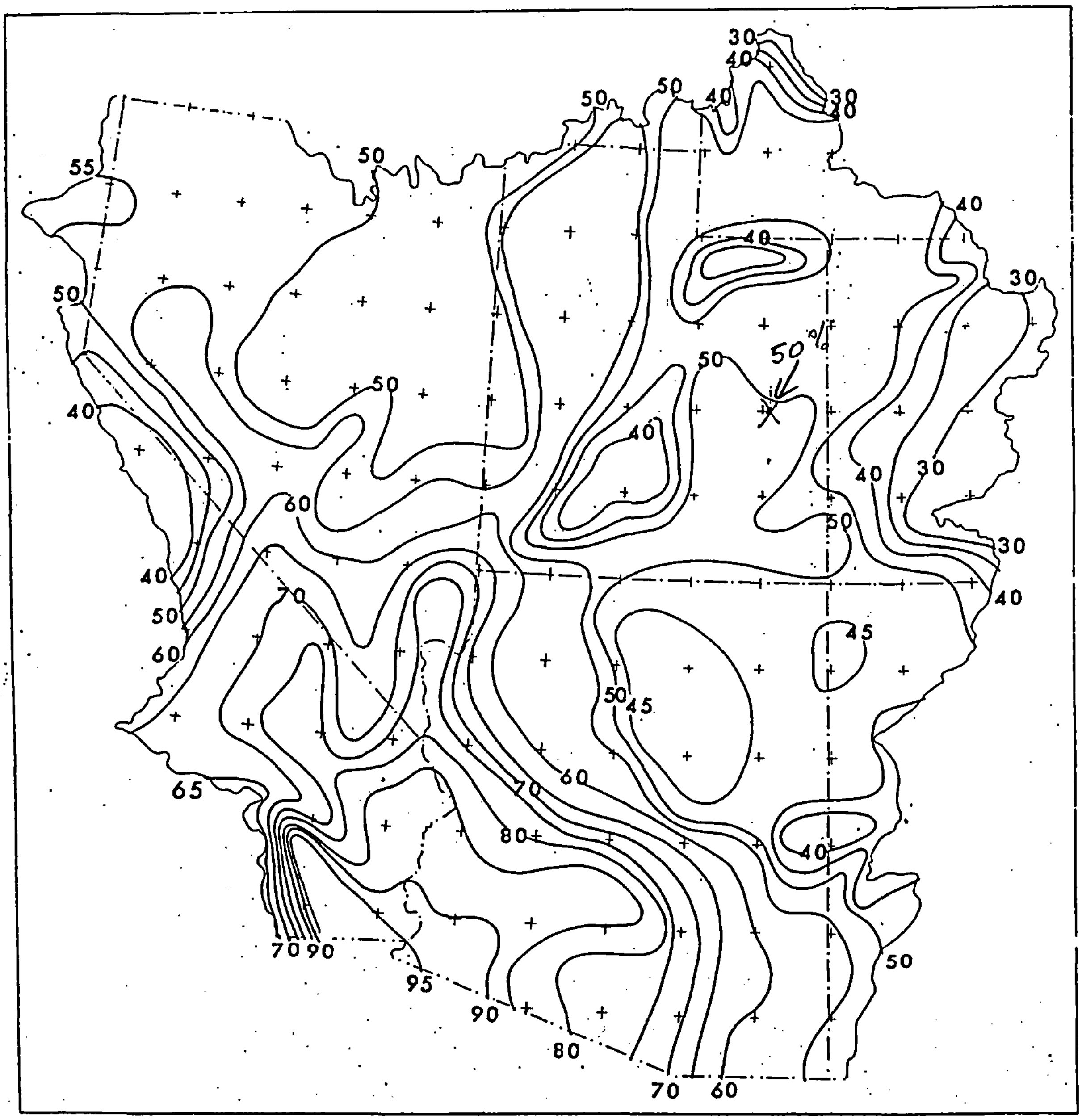


Figure 2.18.--Percent of 1000-mb (100-kPa) convergence PMP resulting from effective elevation and barrier considerations. Isolines drawn for every five percent.

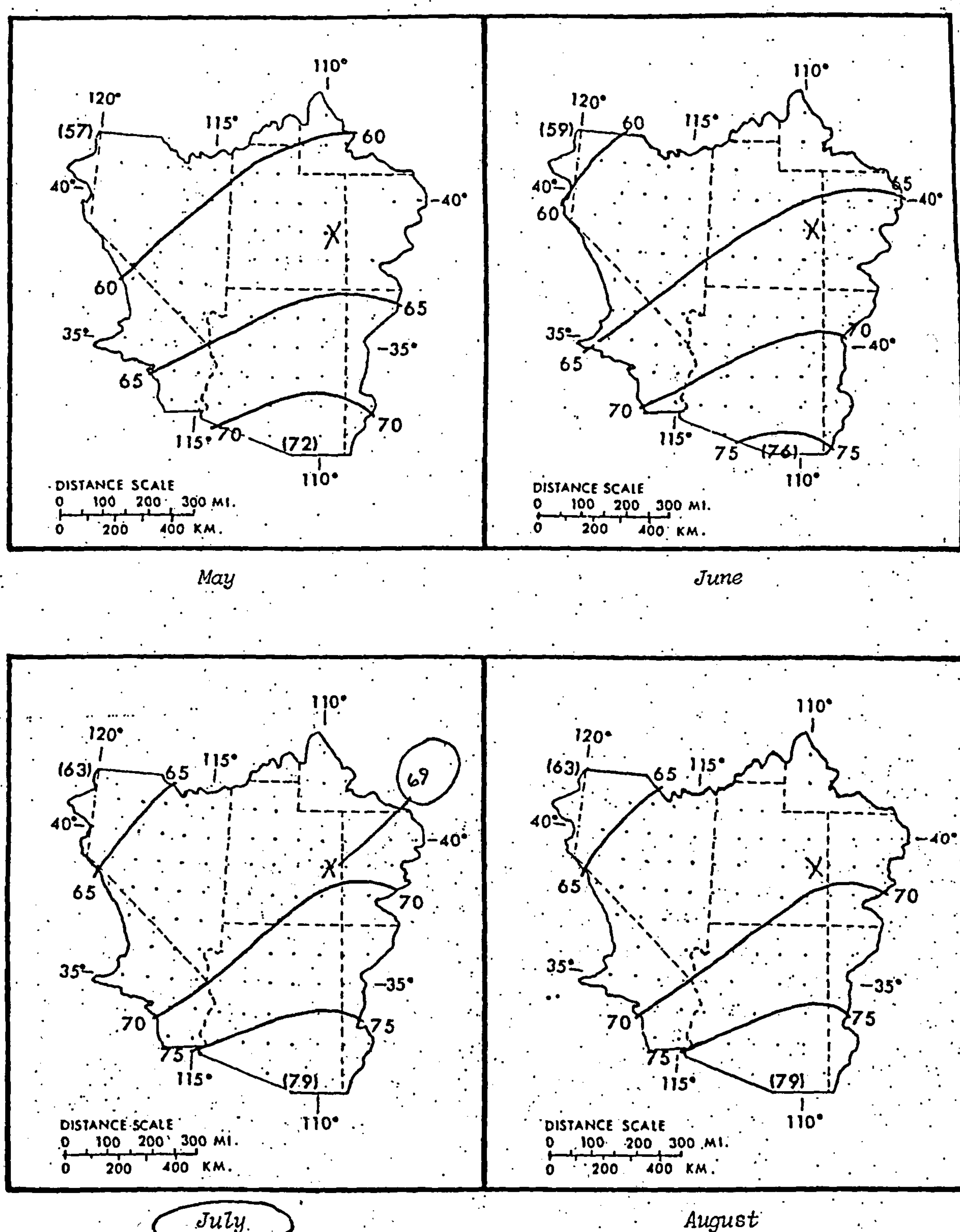


Figure 2.26.--Regional variation of 6/24-hr ratios by month (percent). Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

July PMP

For the range of 6/24-hr ratios included in figures 2.25 to 2.27, depth-duration values in percent of 24-hr amounts are found in table 2.7. The regional ratio maps, and the depth-duration curves presented in figure 2.20 were used in adjusting the major storm data to 24-hr amounts listed in table 2.1.

Table 2.7.--Durational variation of convergence PMP (in percent of 24-hr amount).

Duration (Hrs)					
6	12	18	24	48	72
50	76	90	100	129	150
51	77	90	100	128	148
52	77	90	100	127	146
53	77	91	100	127	144
54	78	91	100	126	142
55	78	91	100	125	140
56	79	91	100	124	138
57	79	92	100	123	137
58	80	92	100	122	135
59	80	92	100	121	134
60	81	92	100	120	132
61	81	92	100	120	131
62	82	93	100	119	129
63	82	93	100	118	128
64	83	93	100	117	126
65	84	93	100	117	125

Duration (Hrs)					
6	12	18	24	48	72
66	84	93	100	116	124
67	85	94	100	116	123
68	85	94	100	115	122
69	86	94	100	115	121
70	87	94	100	114	120
71	87	95	100	114	119
72	88	95	100	113	118
73	88	95	100	113	118
74	89	95	100	112	117
75	89	96	100	112	116
76	90	96	100	111	115
77	90	96	100	110	114
78	91	96	100	110	114
79	92	97	100	109	113
80	92	97	100	109	113

Note: For use, enter first column (6 hr) with 6/24-hr ratio from figures 2.25 to 2.27.

2.5 Areal Reduction for Basin Size

For operational use, basin average values of convergence PMP are needed rather than 10-mi^2 (26-km^2) values. Preferably, the method for reducing 10-mi^2 (26-km^2) values to basin average rainfalls should be derived from depth-area relations of storms in the region. However, all general storms in the region include large proportions of orographic precipitation.

Our solution was to use generalized depth-area relations developed for PMP estimates within bordering zones in the Central and Eastern United States (Riedel et. al. 1956). The smoothed areal variations adopted for the Southwestern States are shown in figures 2.28 and 2.29 for each month or a combination of months where differences are insignificant.

Figures 2.28 and 2.29 give depth-area relations that reduce 10-mi^2 (26-km^2) convergence PMP for basin sizes up to 5,000 mi^2 (12,950 km^2) for each month. Areal variations are given for the 4 greatest (1st to 4th) 6-hr PMP increments. After the 4th increment no reduction for basin size is required. Application of these figures will become clear through consideration of an example of PMP computation in chapter 6.

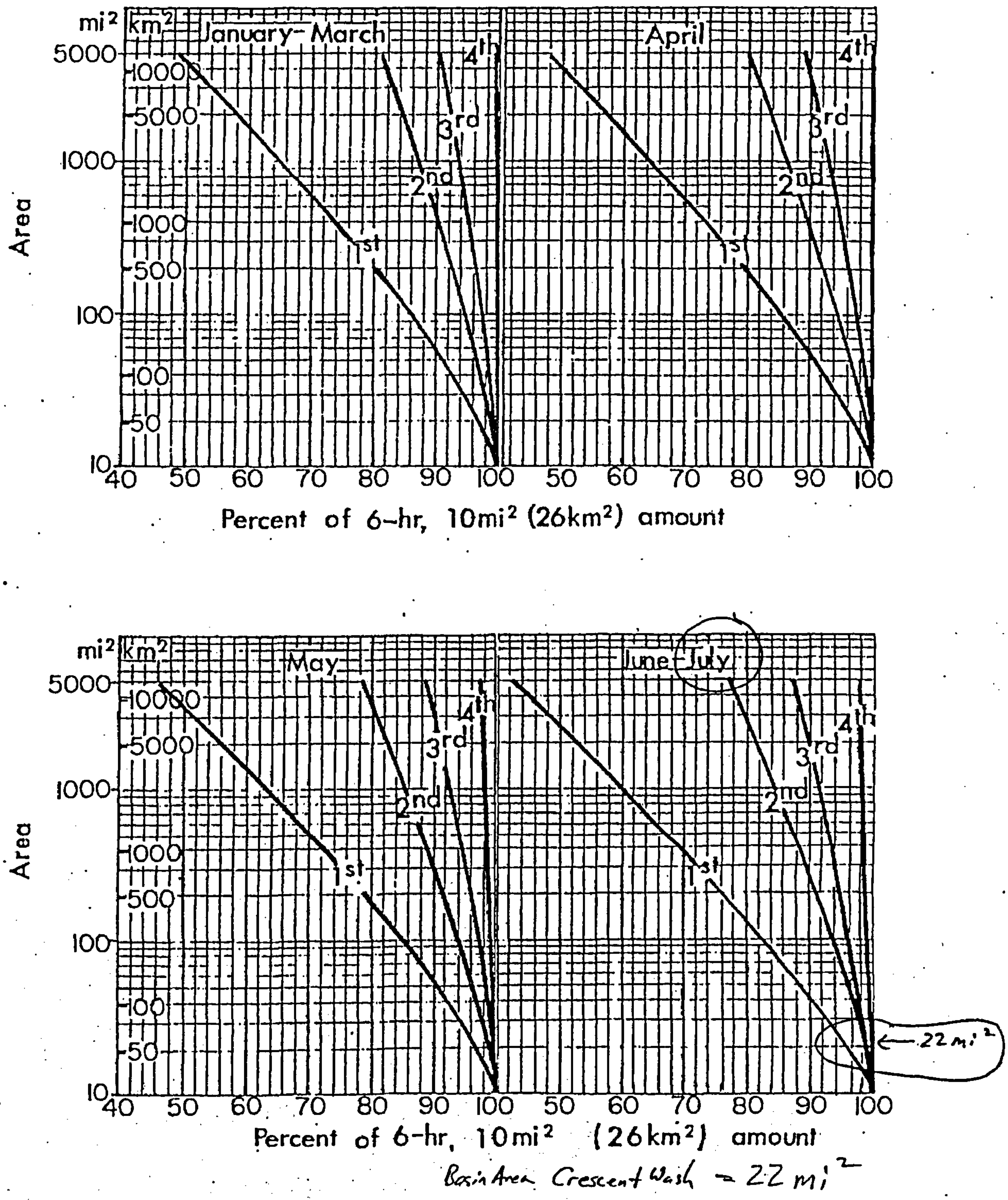
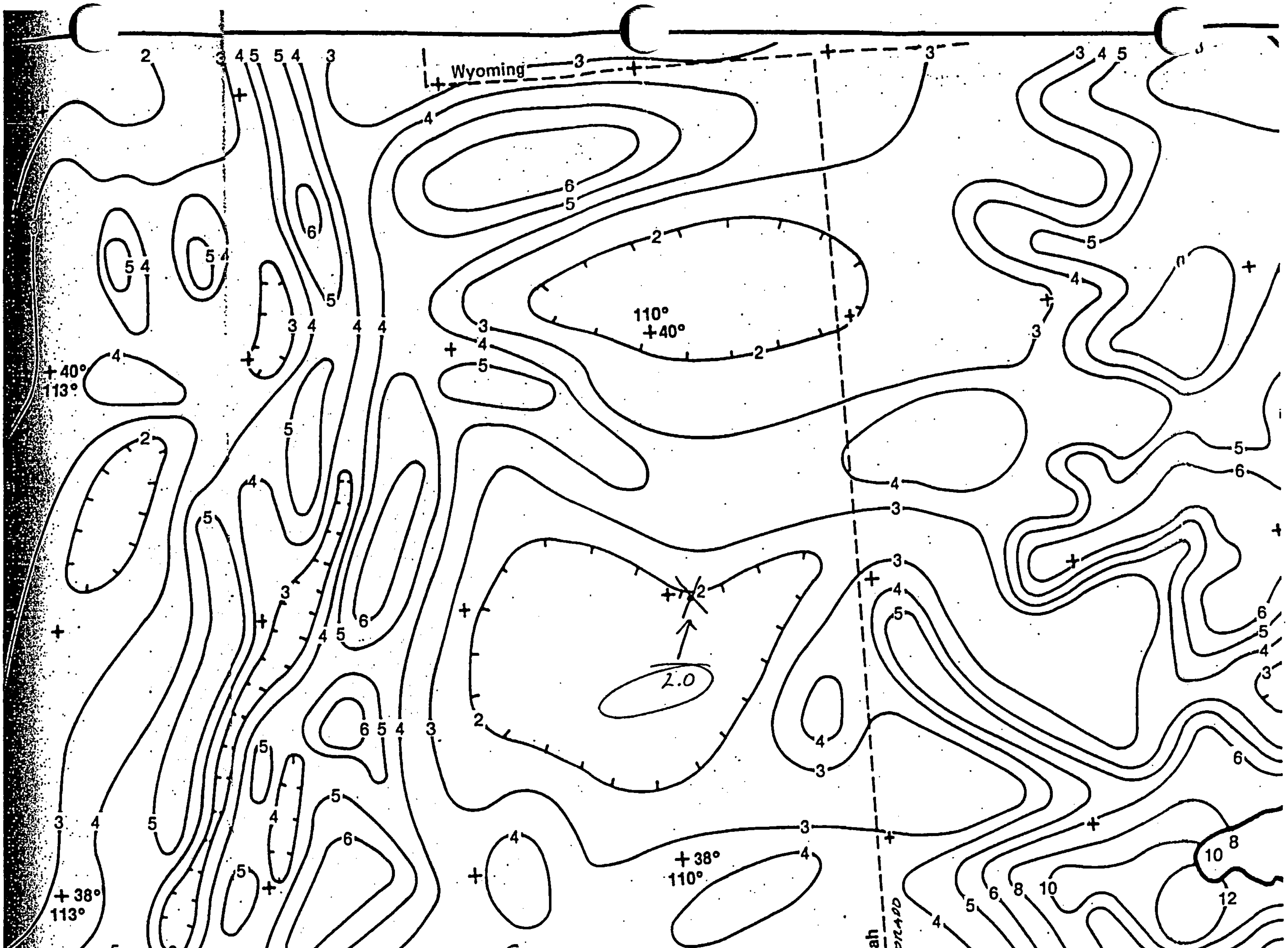


Figure 2.28--*Depth-area variation for convergence PMP for first to fourth 6-hr increments.*



(Fig 3.11 b)

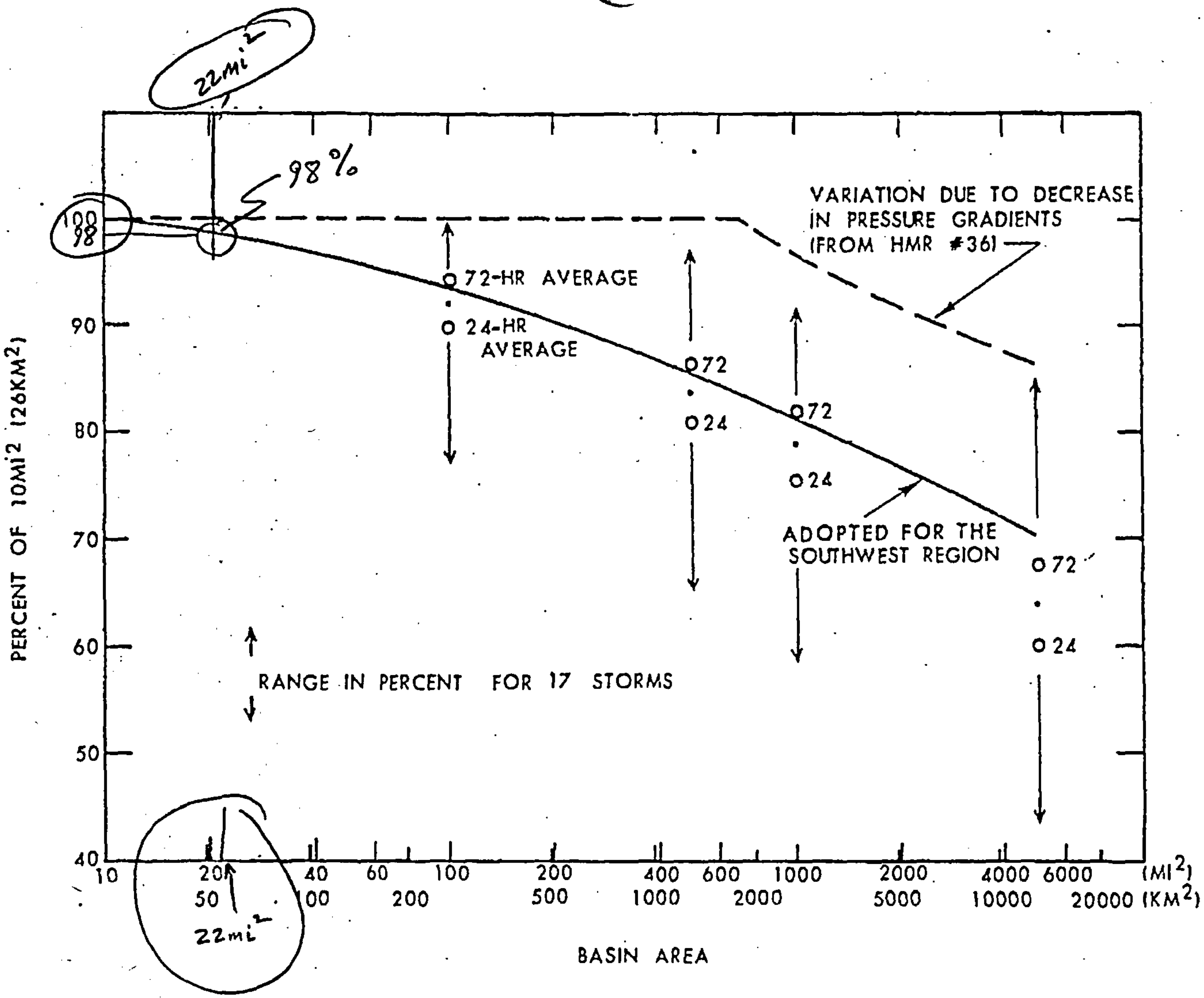
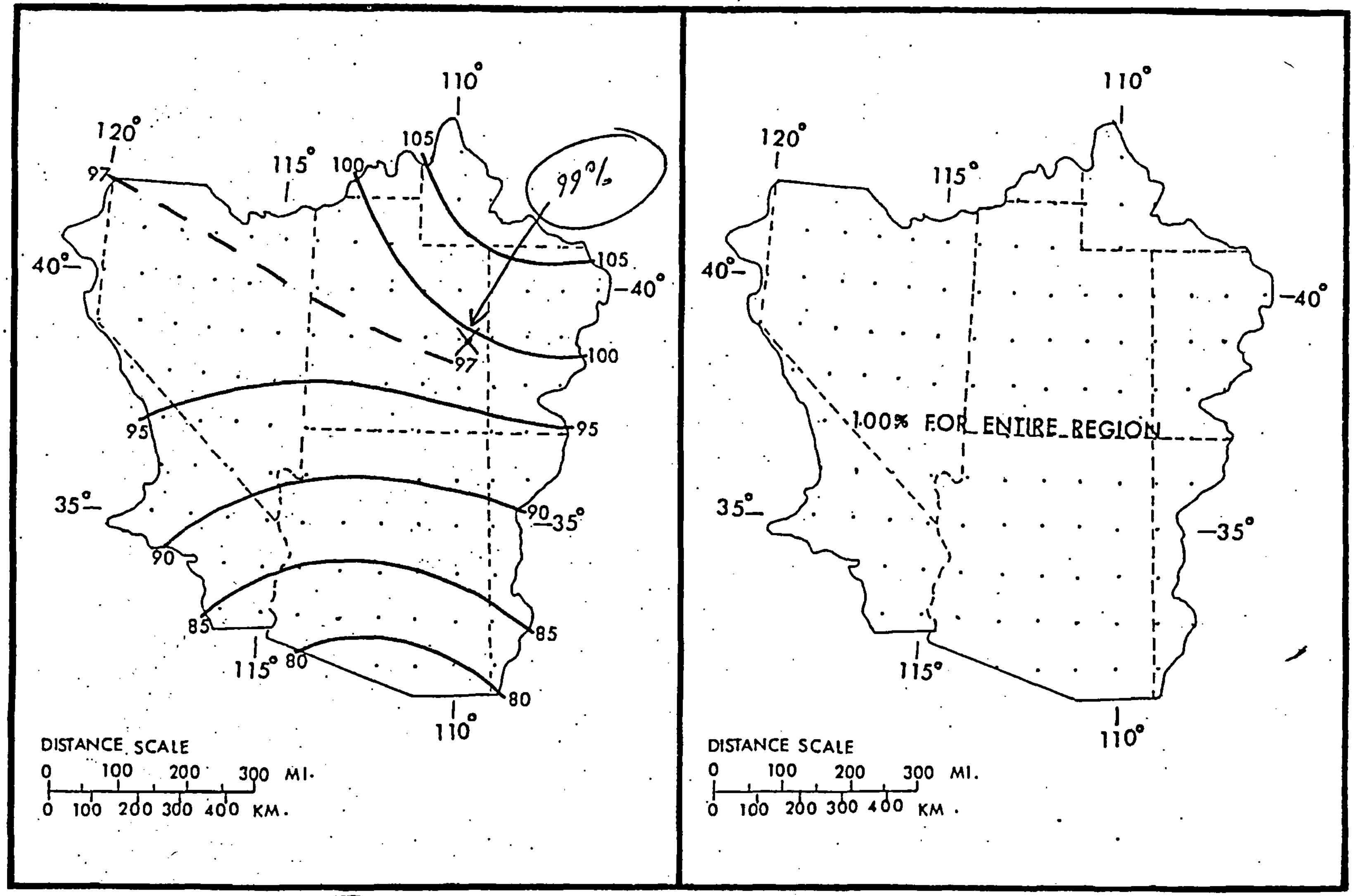


Figure 3.20.--Variation of orographic PMP with basin size.



July

August

Figure 3.15.--Seasonal variation in 10-mi^2 (26-km^2) 24-hr orographic PMP for the study region (in percent of values in figure 3.11).

Table 3.9.--Durational variation of orographic PMP

Latitude °N	Percent of 24-hr value					
	6 hr	12	18	24	48	72
42	28	55	79	100	161	190
41	29	56	79	100	160	189
40	30	57	80	100	159	187
39	30	57	80	100	157	185
38	31	58	81	100	155	182
37	32	59	81	100	152	177
36	33	60	82	100	149	172
35	34	61	82	100	146	167
34	35	62	83	100	143	162
33	36	63	84	100	139	157
32	37	64	84	100	135	152
31	39	66	85	100	132	146

4. LOCAL-STORM PMP FOR THE SOUTHWESTERN REGION AND CALIFORNIA

4.1 Introduction

This chapter provides generalized estimates of local or thunderstorm probable maximum precipitation. By "generalized" is meant that mapped values are given from which estimates of PMP may be determined for any selected drainage.

4.1.1 Region of Interest

Local-storm PMP was not included in the "Interim Report, Probable Maximum Precipitation in California" (HMR No. 36). During the formulation of the present study, we decided that the local-storm part of the study should include California west of the Sierra Nevada. It was also noted that PMP for summer thunderstorms was not considered west of the Cascade Divide in the Northwestern Region (HMR No. 43). As stated in the latter report, "No summer thunderstorms have been reported there (west of the Divide) of an intensity of those to the east, for which the moisture source is often the Gulf of Mexico or Gulf of California. The Cascade Divide offers an additional barrier to such moisture inflows to coastal areas where, in addition, the Pacific Ocean to the west has a stabilizing influence on the air to hinder the occurrence of intense summer local storms." Therefore, it was necessary to establish some continuation of the Cascade Divide into California so that the local-storm PMP definition would have continuity between the two regions.

The stabilizing influence of the Pacific air is at times interrupted by the warm moist tropical air from the south pushing into California, although it is difficult to determine where the limit of southerly flow occurs. General storms having the tropical characteristic of excessive thunderstorm rains are observed as far north as the northern end of the Sacramento Valley. Thus, a northern boundary has been selected for this study, excluding that portion of

General Storm PMP Computation
August

Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage Crescent Junction Disposal Site (Elev 5000) Area less than 1 mi^2 (km^2)
Latitude 38°57'50"N (38.96°N), Longitude ___ of basin center 109°48'00"W (109.80°W)
Month August

Step			Duration (hrs) 6	12	18	24	48	72	
A. Convergence PMP									
1. Drainage average value from one of figures 2.5 to 2.16	12.6	in. (~~mm~~)							
2. Reduction for barrier-elevation [fig. 2.18]	50 %								
3. Barrier-elevation reduced PMP [step 1 X step 2]	6.3	in. (~~mm~~)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].			69	86	94	100	115	121	%
5. Convergence PMP for indicated durations [steps 3 X 4]			4.3	5.4	5.9	6.3	7.2	7.6	in. (~~mm~~)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]			4.3	1.1	0.5	0.4	0.9	0.4	in. (~~mm~~)
7. Areal reduction [select from figs. 2.28 and 2.29]			95	100	100	100	100	100	%
8. Areally reduced PMP [step 6 X step 7]			4.1	1.1	0.5	0.4	0.9	0.4	in. (~~mm~~)
9. Drainage average PMP [accumulated values of step 8]			4.1	5.2	5.7	6.1	7.0	7.4	in. (~~mm~~)
B. Orographic PMP									
1. Drainage average orographic index from figure 3.11a to d.	2.0	in. (~~mm~~)							
2. Areal reduction [figure 3.20]	98 %								
3. Adjustment for month [one of figs. 3.12 to 3.17]	100%								
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	1.96	in. (~~mm~~)							
5. Durational variation [table 3.9]			30	57	80	100	157	185	%
6. Orographic PMP for given durations [steps 4 X 5]			0.6	1.1	1.6	2.0	3.1	3.7	in. (~~mm~~)
C. Total PMP									
1. Add steps A9 and B6			4.7	6.3	7.3	8.1	10.1	11.1	in. (~~mm~~)
2. PMP for other durations from smooth curve fitted to plot of computed data.									
3. Comparison with local-storm PMP (see sec. 6.3).									

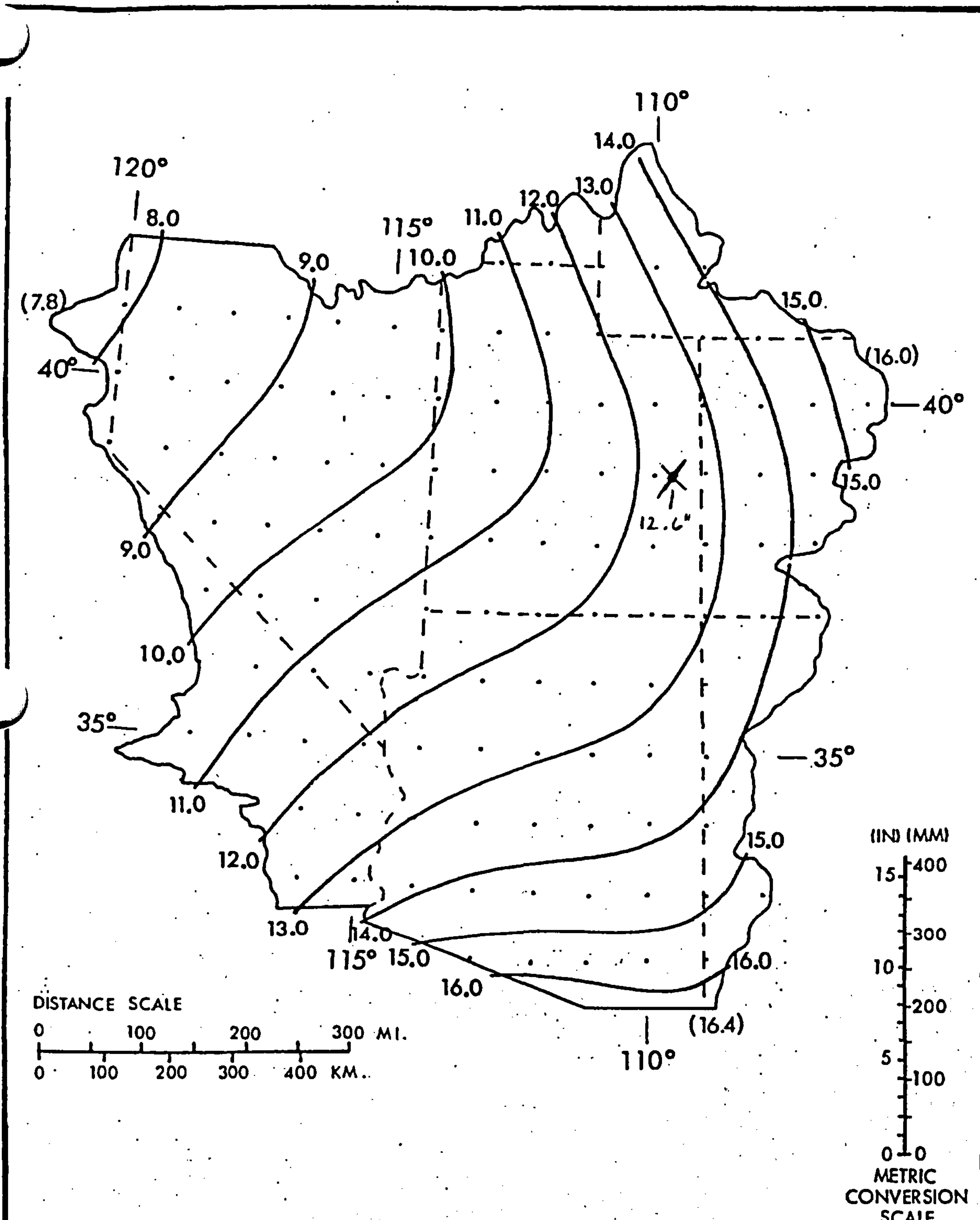


Figure 2.12.--1000-mb (100-kPa) 24-hr convergence PMP (inches) for 10 mi^2 (26 km^2) for August. Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

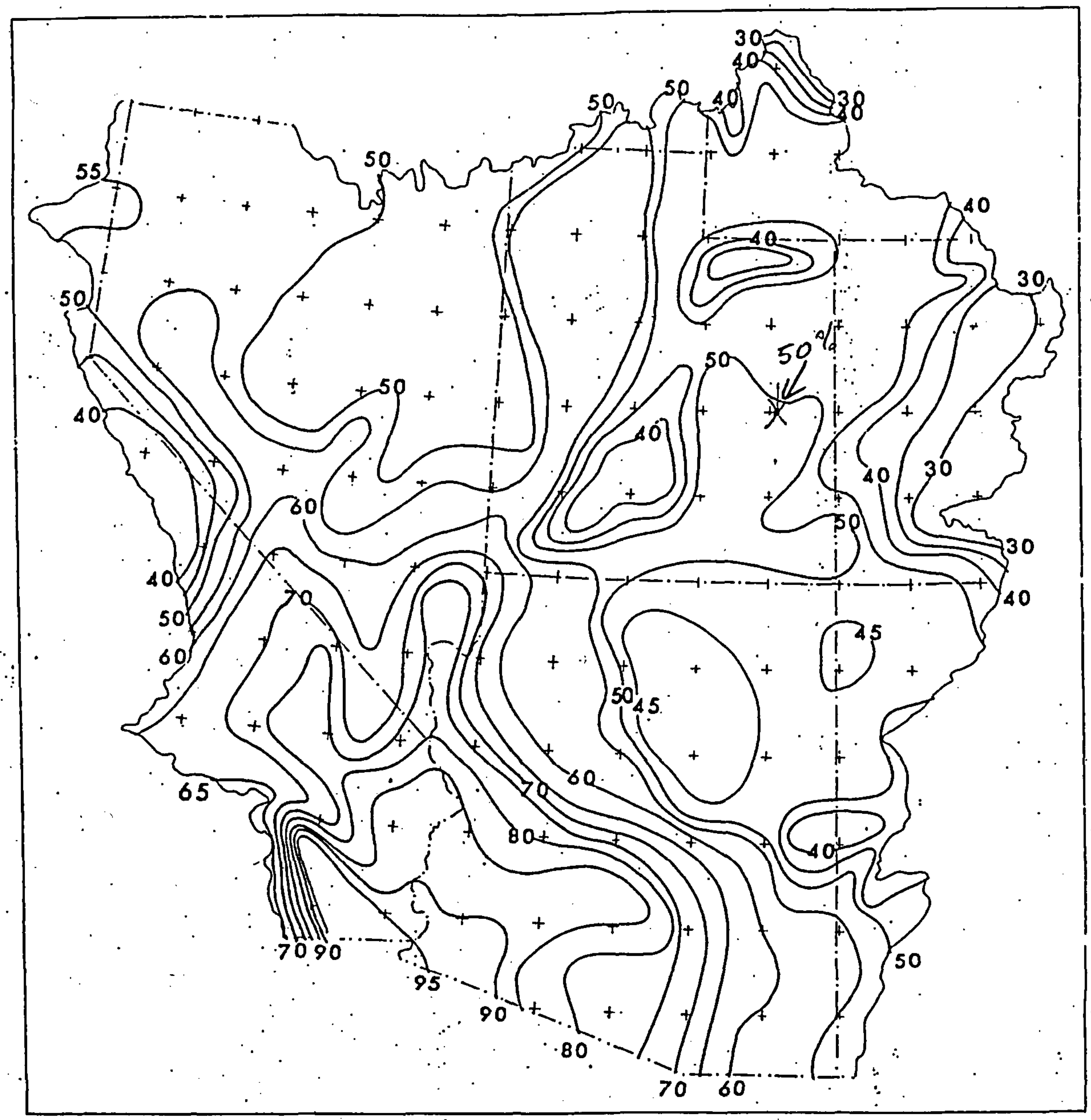


Figure 2.18.--Percent of 1000-mb (100-kPa) convergence PMP resulting from effective elevation and barrier considerations. Isolines drawn for every five percent.

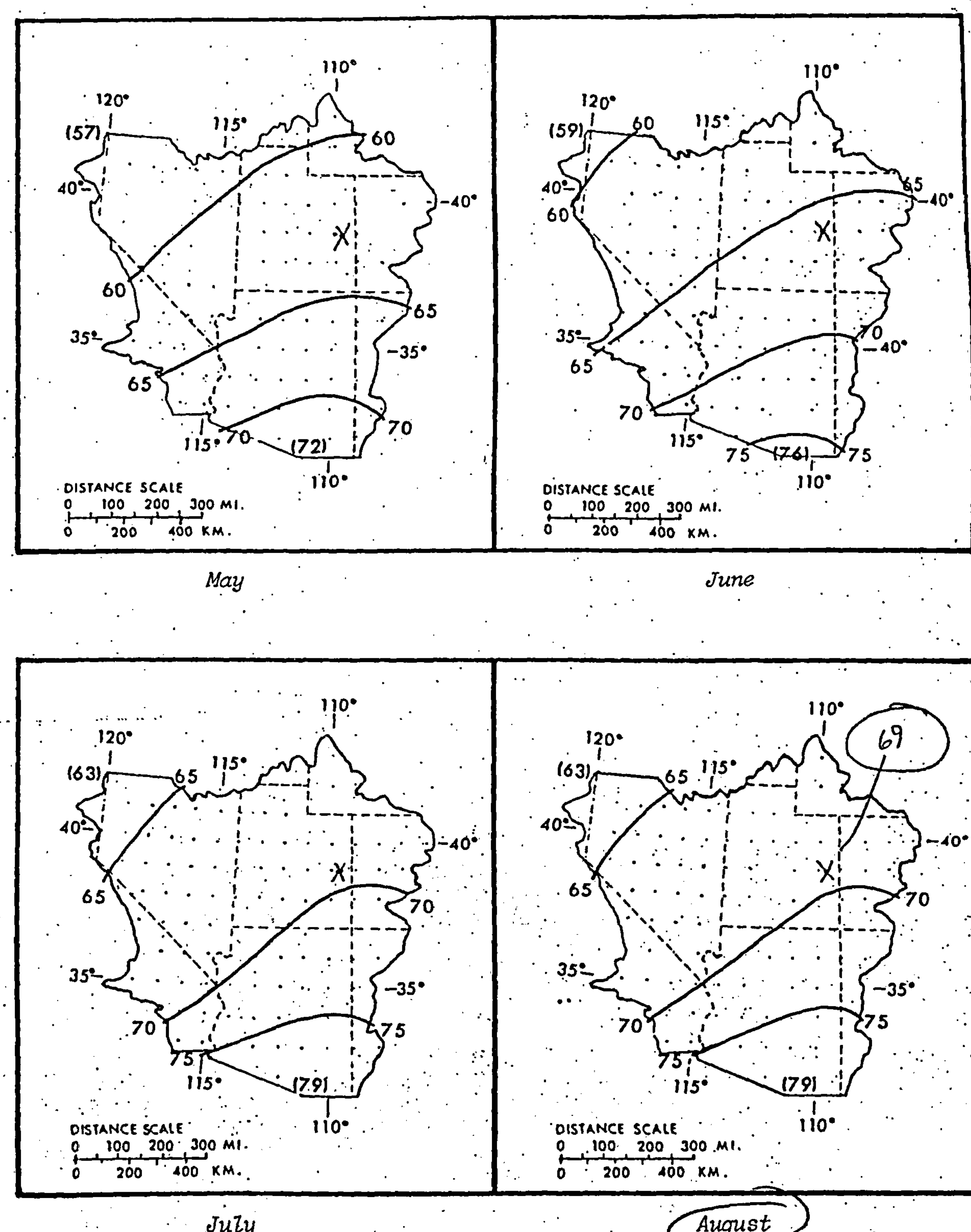


Figure 2.26.--Regional variation of 6/24-hr ratios by month (percent). Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

For the range of 6/24-hr ratios included in figures 2.25 to 2.27, depth-duration values in percent of 24-hr amounts are found in table 2.7. The regional ratio maps, and the depth-duration curves presented in figure 2.20 were used in adjusting the major storm data to 24-hr amounts listed in table 2.1.

Table 2.7.--Durational variation of convergence PMP (in percent of 24-hr amount).

Duration (Hrs)					
6	12	18	24	48	72
50	76	90	100	129	150
51	77	90	100	128	148
52	77	90	100	127	146
53	77	91	100	127	144
54	78	91	100	126	142
55	78	91	100	125	140
56	79	91	100	124	138
57	79	92	100	123	137
58	80	92	100	122	135
59	80	92	100	121	134
60	81	92	100	120	132
61	81	92	100	120	131
62	82	93	100	119	129
63	82	93	100	118	128
64	83	93	100	117	126
65	84	93	100	117	125
66	84	93	100	116	124
67	85	94	100	116	123
68	85	94	100	115	122
69	86	94	100	115	121
70	87	94	100	114	120
71	87	95	100	114	119
72	88	95	100	113	118
73	88	95	100	113	118
74	89	95	100	112	117
75	89	96	100	112	116
76	90	96	100	111	115
77	90	96	100	110	114
78	91	96	100	110	114
79	92	97	100	109	113
80	92	97	100	109	113

Note: For use, enter first column (6 hr) with 6/24-hr ratio from figures 2.25 to 2.27.

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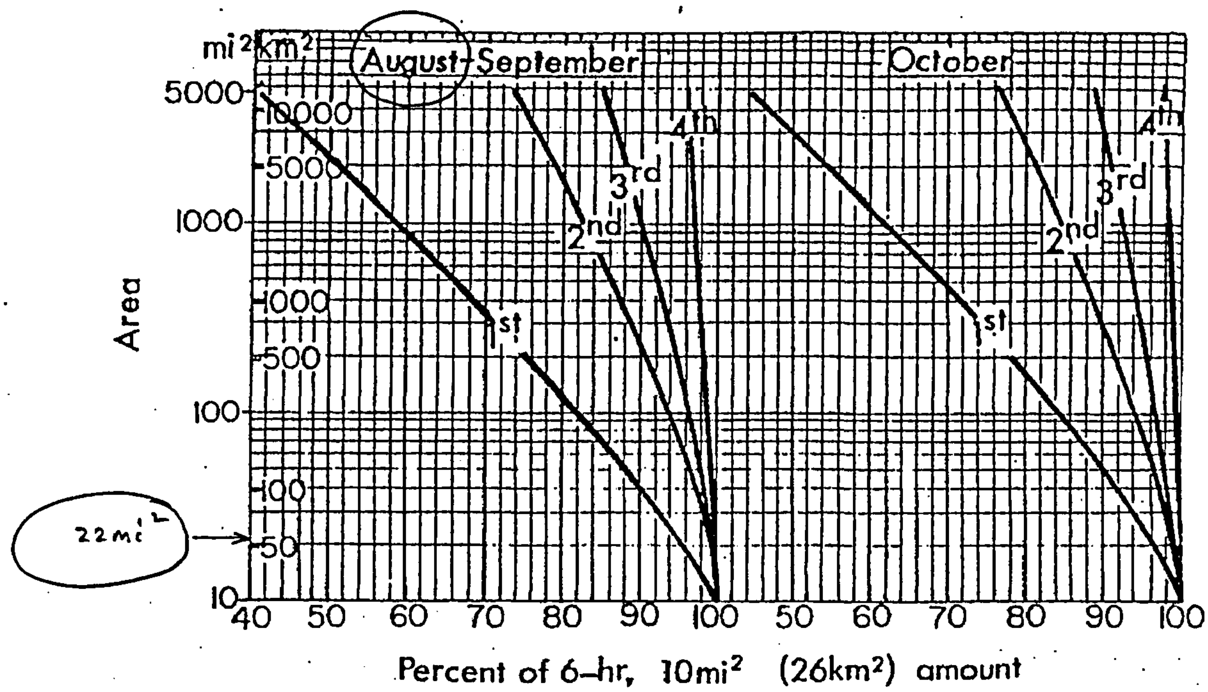


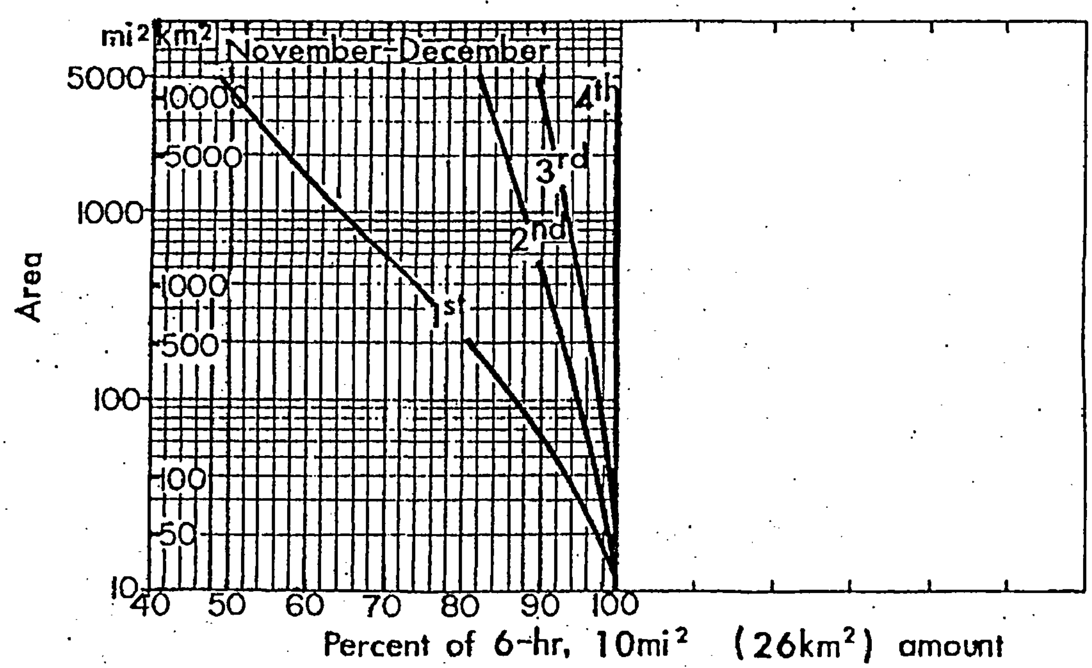
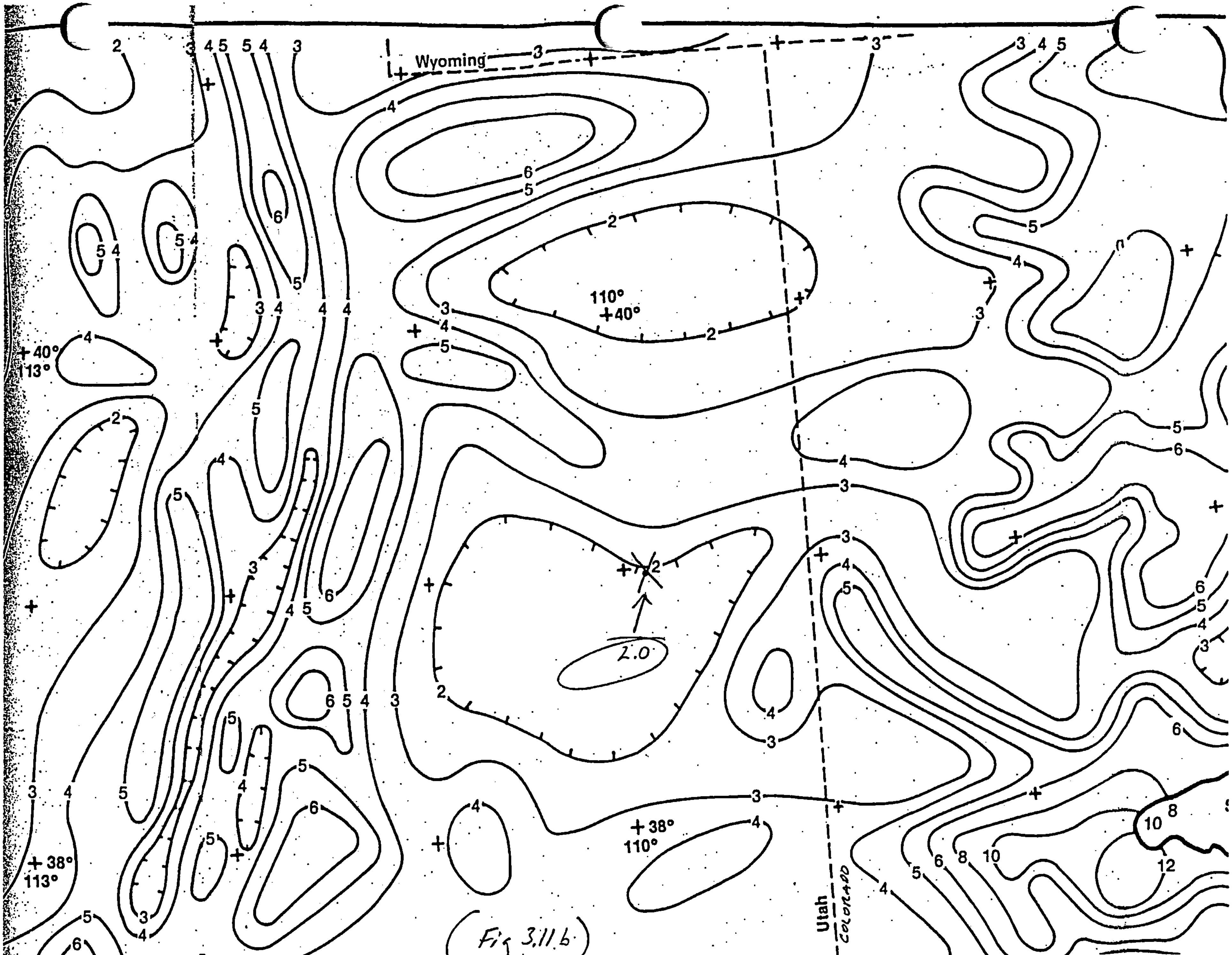


Figure 2.29.--Depth-area variation for convergence PMP for first to fourth 6-hr increments.



(Fig 3.11.b)

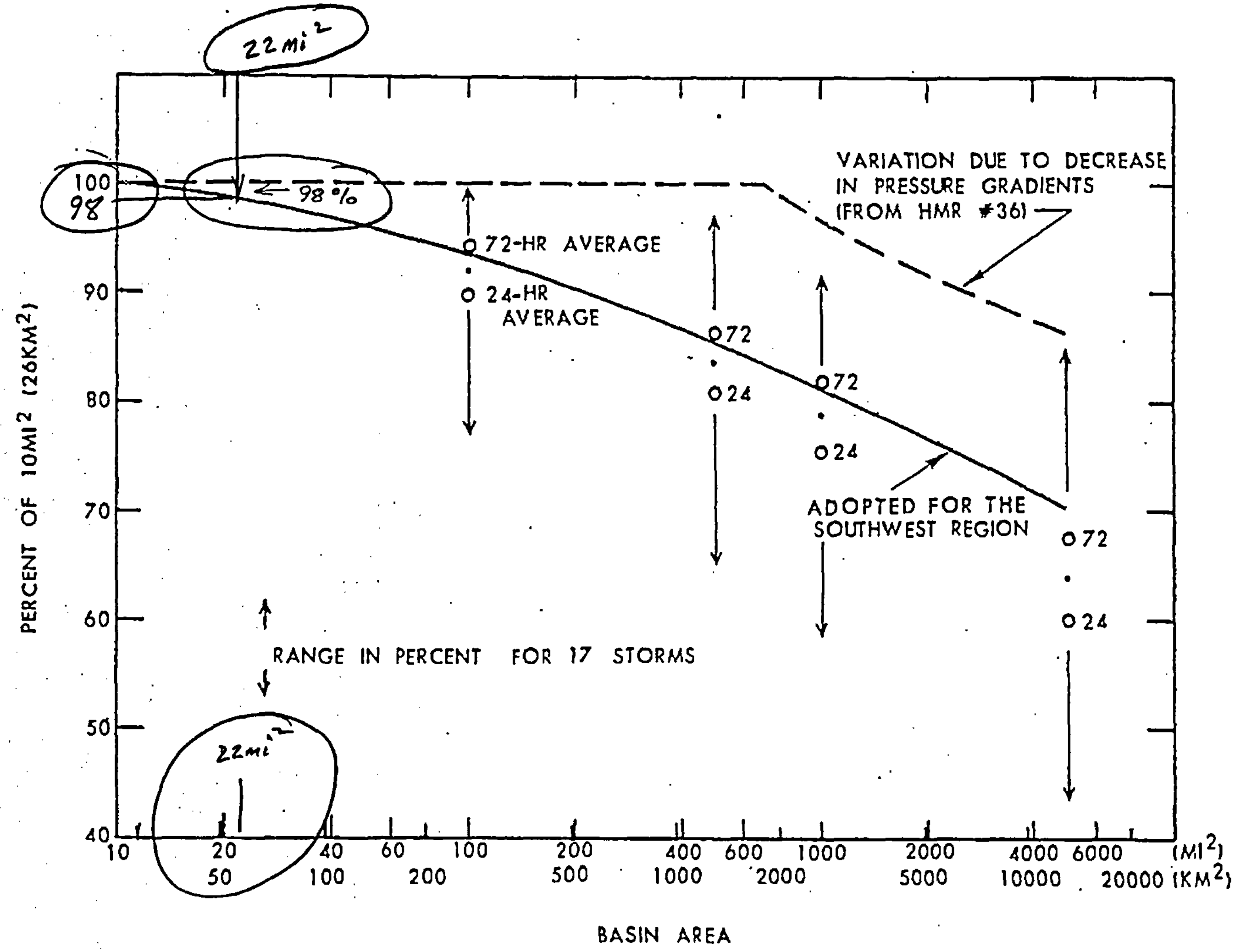


Figure 3.20.--Variation of orographic PMP with basin size.

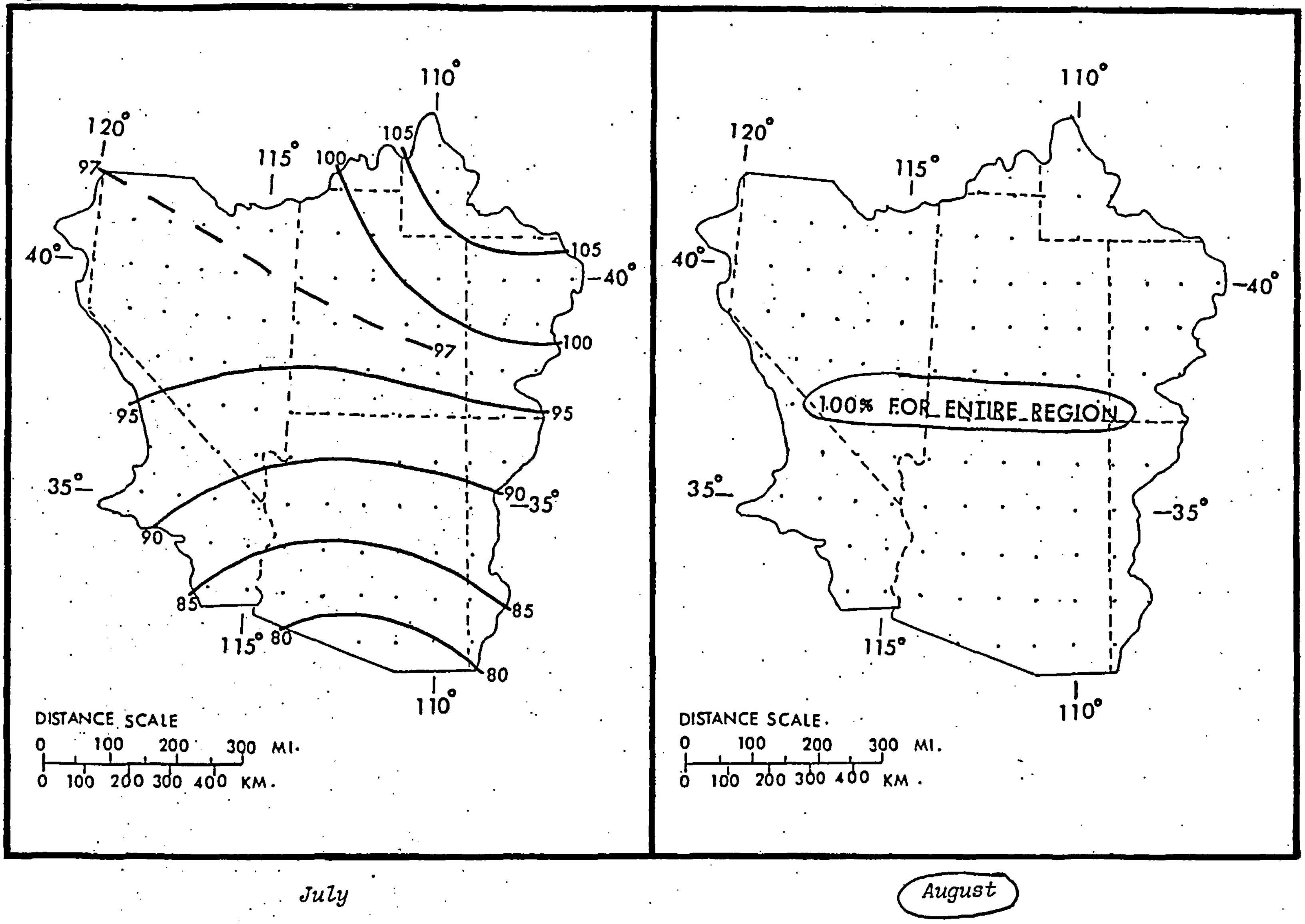


Figure 3.15.--Seasonal variation in 10-mi^2 (26-km^2) 24-hr orographic PMP for the study region (in percent of values in figure 3.11).

Table 3.9.--Durational variation of orographic PMP

Latitude °N	Percent of 24-hr value					
	6 hr	12	18	24	48	72
42	28	55	79	100	161	190
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4. LOCAL-STORM PMP FOR THE SOUTHWESTERN REGION AND CALIFORNIA

4.1 Introduction

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The stabilizing influence of the Pacific air is at times interrupted by the warm moist tropical air from the south pushing into California, although it is difficult to determine where the limit of southerly flow occurs. General storms having the tropical characteristic of excessive thunderstorm rains are observed as far north as the northern end of the Sacramento Valley. Thus, a northern boundary has been selected for this study, excluding that portion of

General Storm PMP Computation
September

Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage Crescent Junction Disposal Site Area less than 1 mi^2 (~~km^2~~)
Latitude 38°57'50" N, Longitude ___ of basin center 109°48'00" W
(38.96°N) (109.80°W)
Month September

Step			6	12	18	24	48	72	
			Duration (hrs)						
A.	**Convergence PMP**								
1.	Drainage average value from one of figures 2.5 to 2.16	12.4 in. (~~mm~~)							
2.	Reduction for barrier-elevation [fig. 2.18]	50 %							
3.	Barrier-elevation reduced PMP [step 1 X step 2]	6.2 in. (~~mm~~)							
4.	Durational variation [figs. 2.25 to 2.27 and table 2.7].		69	86	94	100	115	121	%
5.	Convergence PMP for indicated durations [steps 3 X 4]		4.3	5.3	5.8	6.2	7.1	7.5	in. (~~mm~~)
6.	Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]		4.3	1.0	0.5	0.4	0.9	0.4	in. (~~mm~~)
7.	Areal reduction [select from figs. 2.28 and 2.29]		95	100	100	100	100	100	%
8.	Areally reduced PMP [step 6 X step 7]		4.1	1.0	0.5	0.4	0.9	0.4	in. (~~mm~~)
9.	Drainage average PMP [accumulated values of step 8]		4.1	5.1	5.6	6.0	6.9	7.3	in. (~~mm~~)
B.	**Orographic PMP**								
1.	Drainage average orographic index from figure 3.11a to d.	2.0 in. (~~mm~~)							
2.	Areal reduction [figure 3.20]	98 %							
3.	Adjustment for month [one of figs. 3.12 to 3.17]	100 %							
4.	Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	1.96 in. (~~mm~~)							
5.	Durational variation [table 3.6]		30	57	80	100	157	185	%
6.	Orographic PMP for given durations [steps 4 X 5]		0.6	1.1	1.6	2.0	3.1	3.7	in. (~~mm~~)
C.	**Total PMP**								
1.	Add steps A9 and B6		4.7	6.2	7.2	8.0	10.0	11.0	in. (~~mm~~)
2.	PMP for other durations from smooth curve fitted to plot of computed data.								
3.	Comparison with local-storm PMP (see sec. 6.3).								

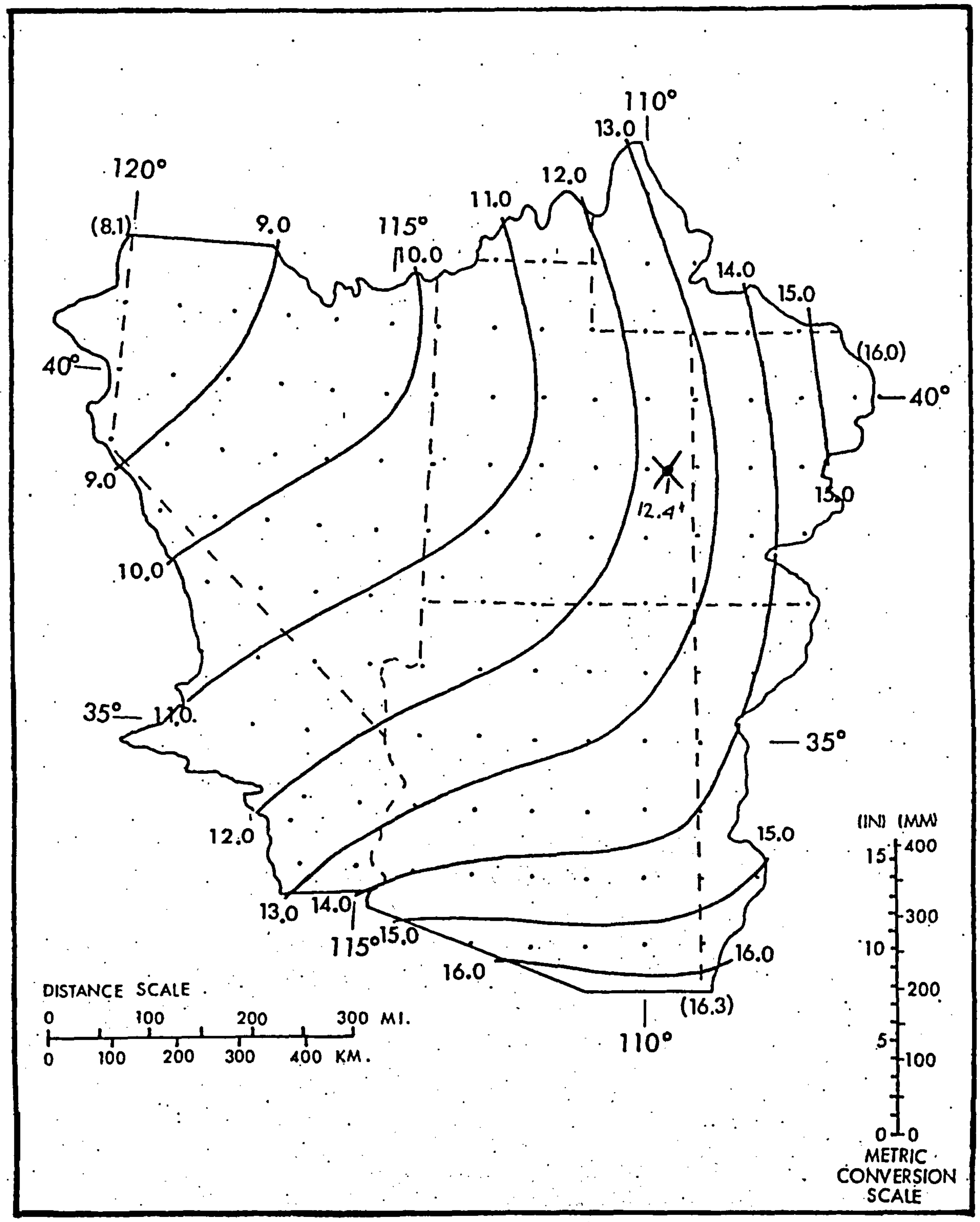

Figure 2.13.--1000-mb (100-kPa) 24-hr convergence PMP (inches) for 10 mi² (26 km²) for September. Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

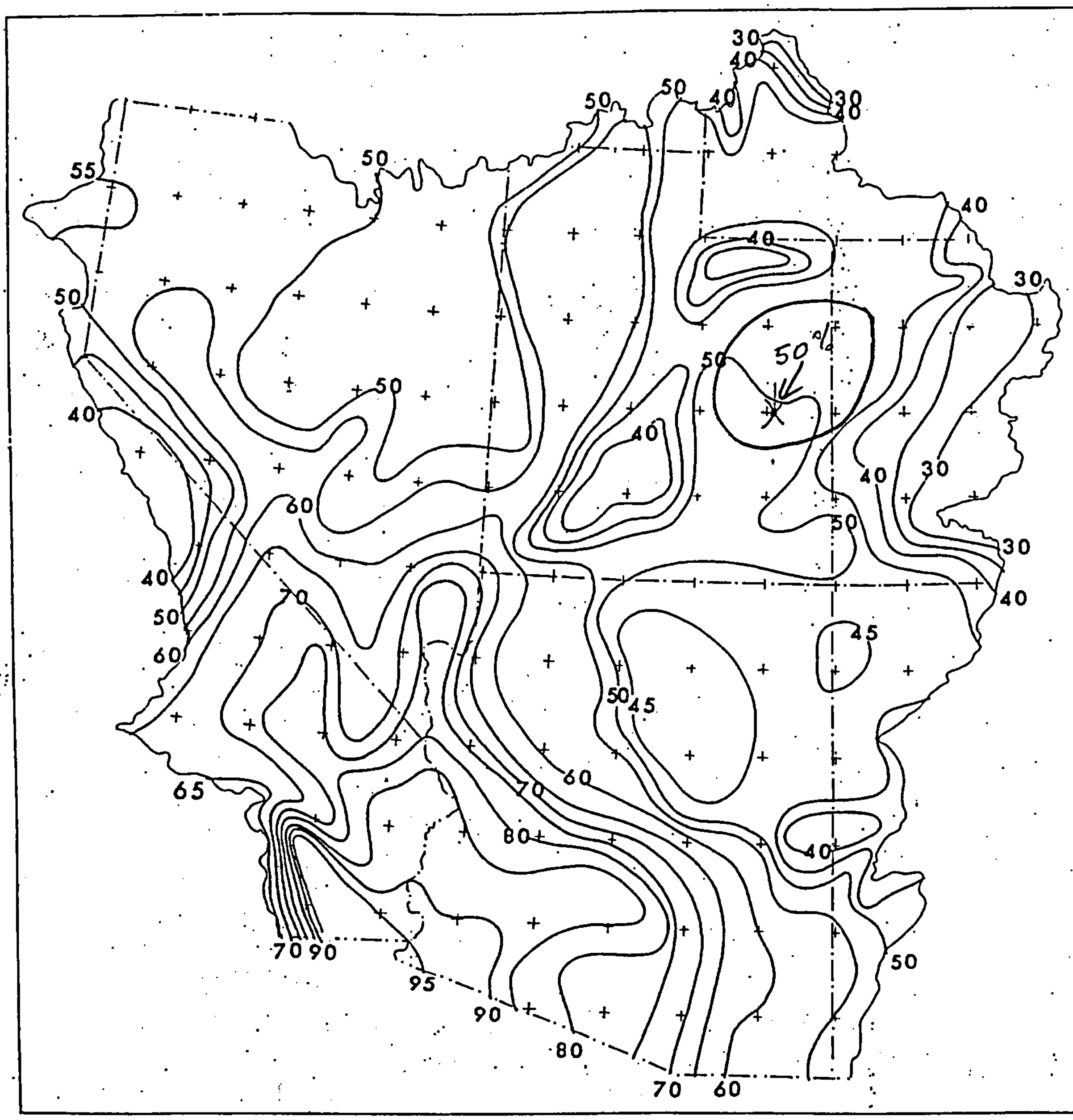

Figure 2.18.--Percent of 1000-mb (100-kPa) convergence PMP resulting from effective elevation and barrier considerations. Isolines drawn for every five percent.

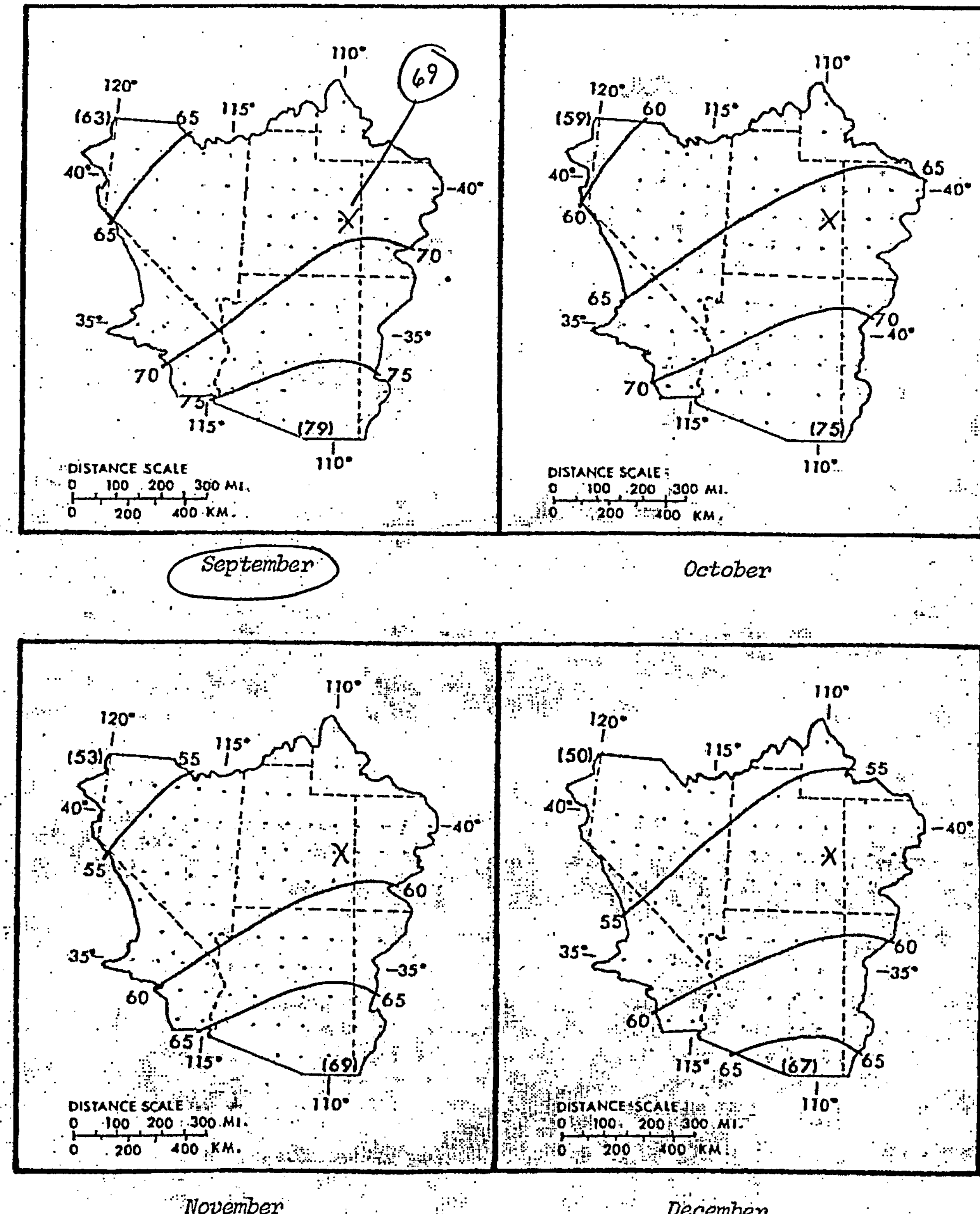

Figure 2.27.--Regional variation of 6/24-hr ratios by month (percent). Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

For the range of 6/24-hr ratios included in figures 2.25 to 2.27, depth-duration values in percent of 24-hr amounts are found in table 2.7. The regional ratio maps, and the depth-duration curves presented in figure 2.20 were used in adjusting the major storm data to 24-hr amounts listed in table 2.1.

Table 2.7.--Durational variation of convergence PMP (in percent of 24-hr amount).

Duration (Hrs)						Duration (Hrs)					
6	12	18	24	48	72	6	12	18	24	48	72
50	76	90	100	129	150	66	84	93	100	116	124
51	77	90	100	128	148	67	85	94	100	116	123
52	77	90	100	127	146	68	85	94	100	115	122
53	77	91	100	127	144	69	86	94	100	115	121
54	78	91	100	126	142						
55	78	91	100	125	140	70	87	94	100	114	120
56	79	91	100	124	138	71	87	95	100	114	119
57	79	92	100	123	137	72	88	95	100	113	118
58	80	92	100	122	135	73	88	95	100	113	118
59	80	92	100	121	134	74	89	95	100	112	117
						75	89	96	100	112	116
60	81	92	100	120	132	76	90	96	100	111	115
61	81	92	100	120	131	77	90	96	100	110	114
62	82	93	100	119	129	78	91	96	100	110	114
63	82	93	100	118	128	79	92	97	100	109	113
64	83	93	100	117	126						
65	84	93	100	117	125	80	92	97	100	109	113

Note: For use, enter first column (6 hr) with 6/24-hr ratio from figures 2.25 to 2.27.

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For operational use, basin average values of convergence PMP are needed rather than 10-mi^2 (26-km^2) values. Preferably, the method for reducing 10-mi^2 (26-km^2) values to basin average rainfalls should be derived from depth-area relations of storms in the region. However, all general storms in the region include large proportions of orographic precipitation.

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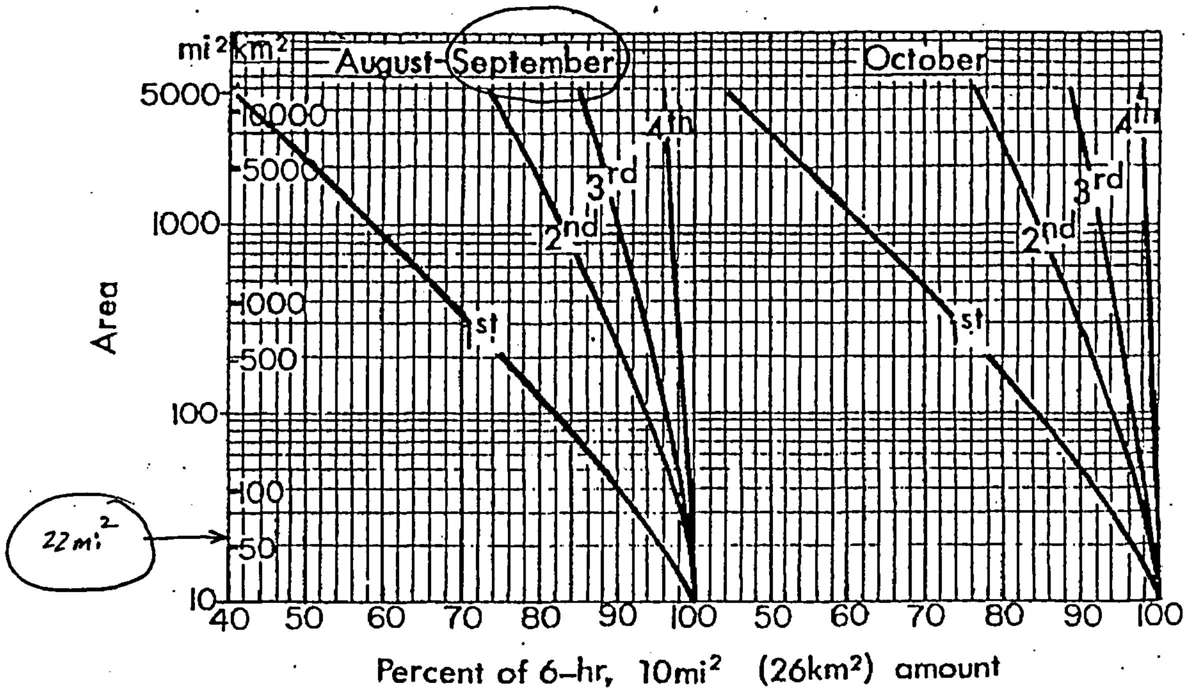


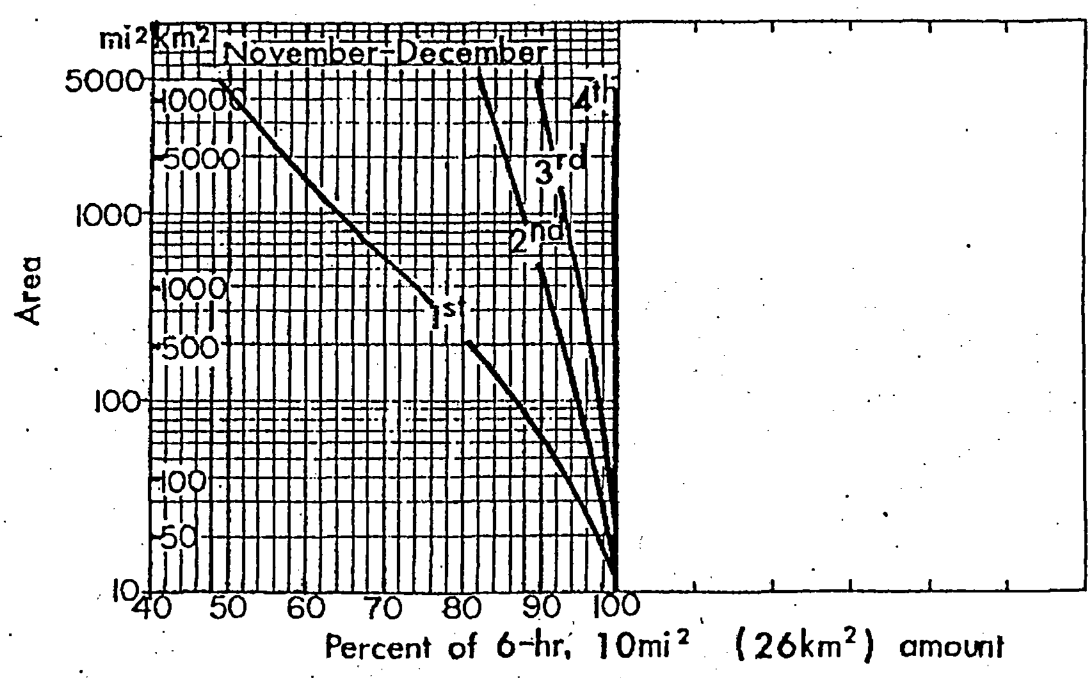
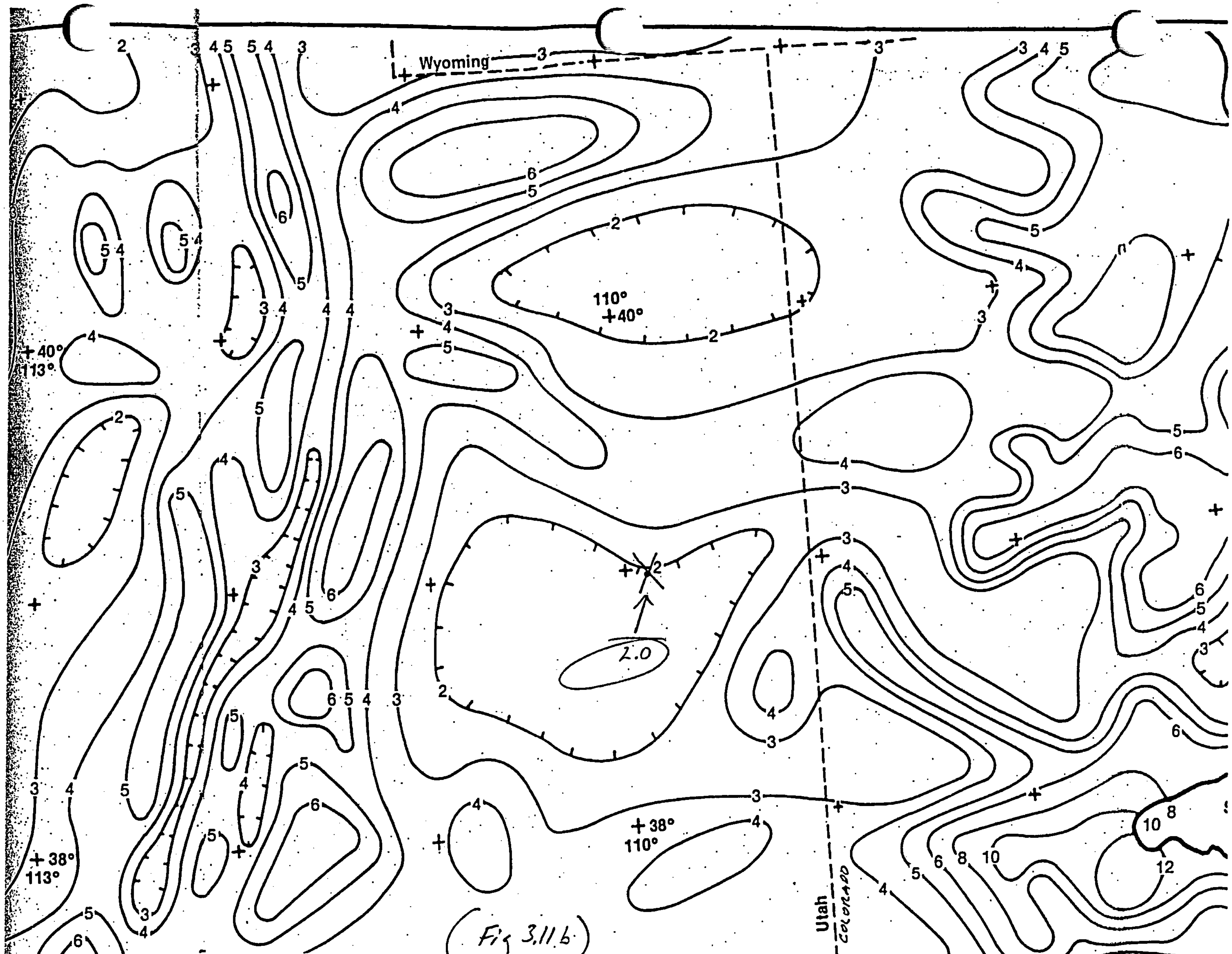
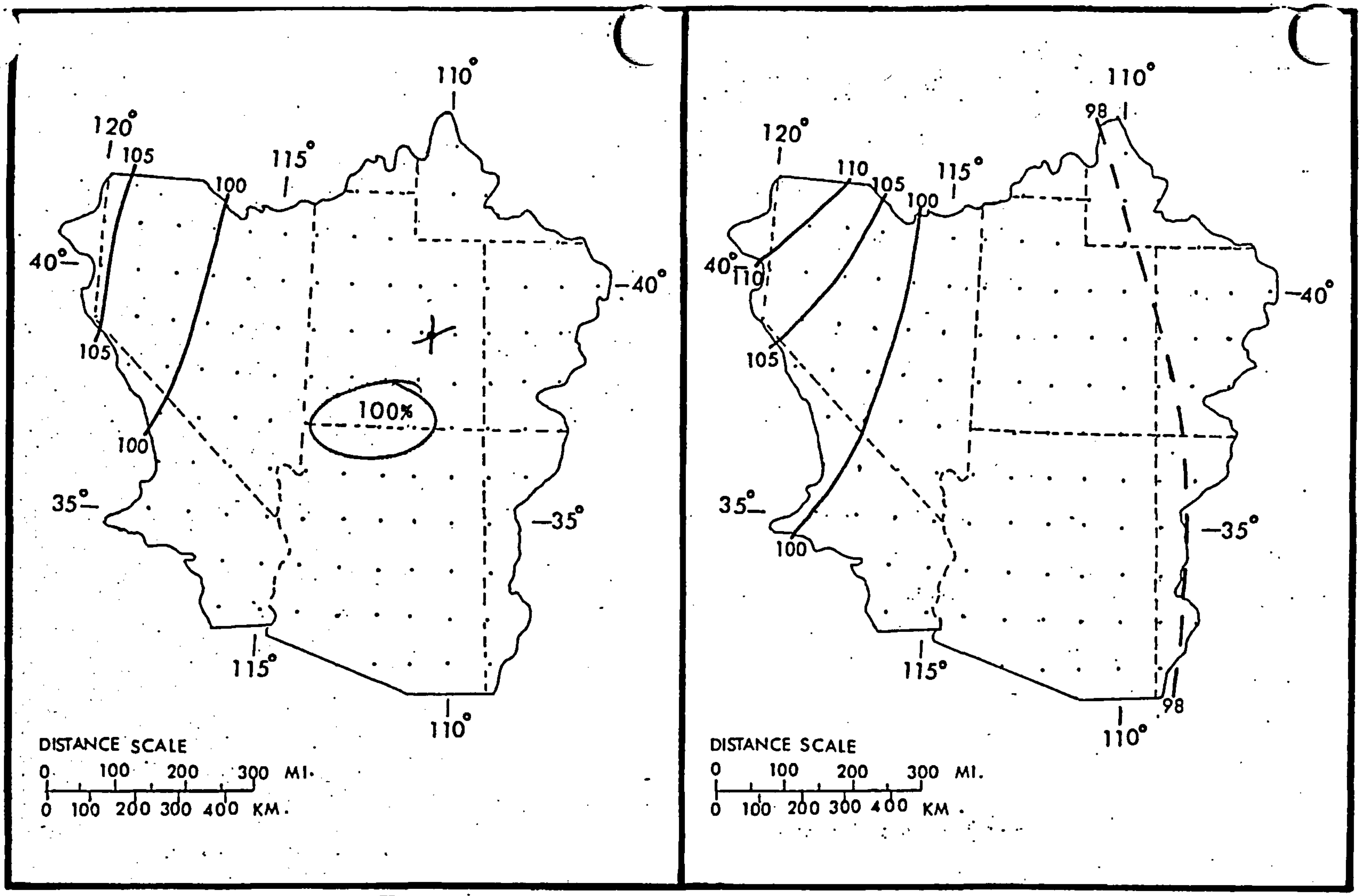


Figure 2.29.--Depth-area variation for convergence PMP for first to fourth 6-hr increments.



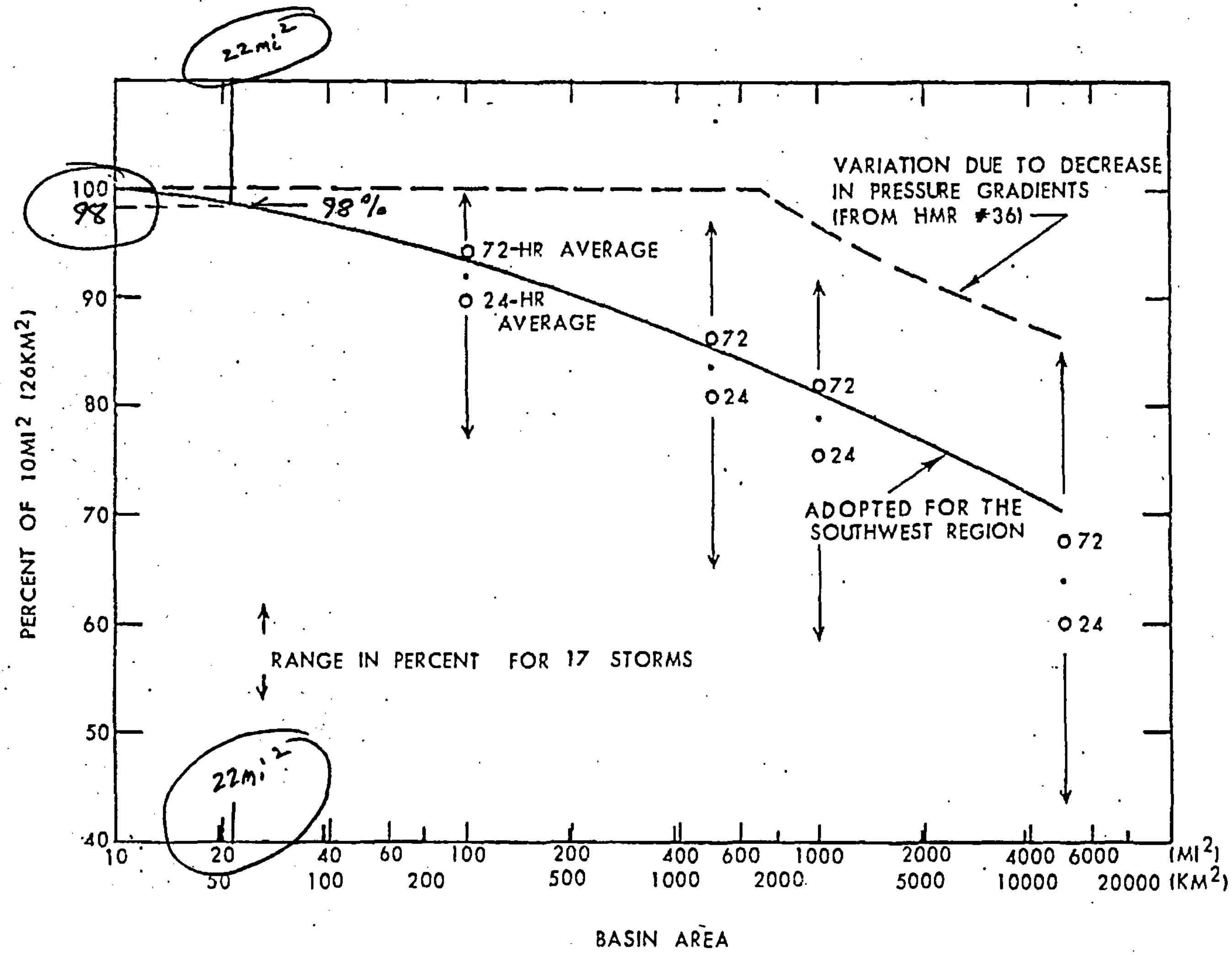
(Fig 3.11.b)



September

October

Figure 3.16.--Seasonal variation in 10-mi² (26-km²) 24-hr orographic PMP for the study region (in percent of values in figure 3.11).



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Latitude 38°57'50"N, Longitude ___ of basin center 109°48'00"W
(38.96°N) (109.80°W)

Month October

Step		Duration (hrs) 6	12	18	24	48	72	
A. Convergence PMP								
1. Drainage average value from one of figures 2.5 to 2.16	11.6 in. (~~mm~~)							
2. Reduction for barrier-elevation [fig. 2.18]	50 %							
3. Barrier-elevation reduced PMP [step 1 X step 2]	5.8 in. (~~mm~~)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].		67	85	94	100	116	123	%
5. Convergence PMP for indicated durations [steps 3 X 4]		3.9	4.9	5.5	5.8	6.7	7.1	in. (~~mm~~)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]		3.9	1.0	0.6	0.3	0.9	0.4	in. (~~mm~~)
7. Areal reduction [select from figs. 2.28 and 2.29]		96	99	99	100	100	100	%
8. Areally reduced PMP [step 6 X step 7]		3.7	1.0	0.6	0.3	0.9	0.4	in. (~~mm~~)
9. Drainage average PMP [accumulated values of step 8]		3.7	4.7	5.3	5.6	6.5	6.9	in. (~~mm~~)
B. Orographic PMP								
1. Drainage average orographic index from figure 3.11a to d.	2.0 in. (~~mm~~)							
2. Areal reduction [figure 3.20]	98 %							
3. Adjustment for month [one of figs. 3.12 to 3.17]	98 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	1.92 in. (~~mm~~)							
5. Durational variation [table 3.9]		30	57	80	100	157	185	%
6. Orographic PMP for given durations [steps 4 X 5]		0.6	1.1	1.5	1.9	3.0	3.6	in. (~~mm~~)
C. Total PMP								
1. Add steps A9 and B6		4.3	5.8	6.8	7.5	9.5	10.5	in. (~~mm~~)
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3. Comparison with local-storm PMP (see sec. 6.3).								

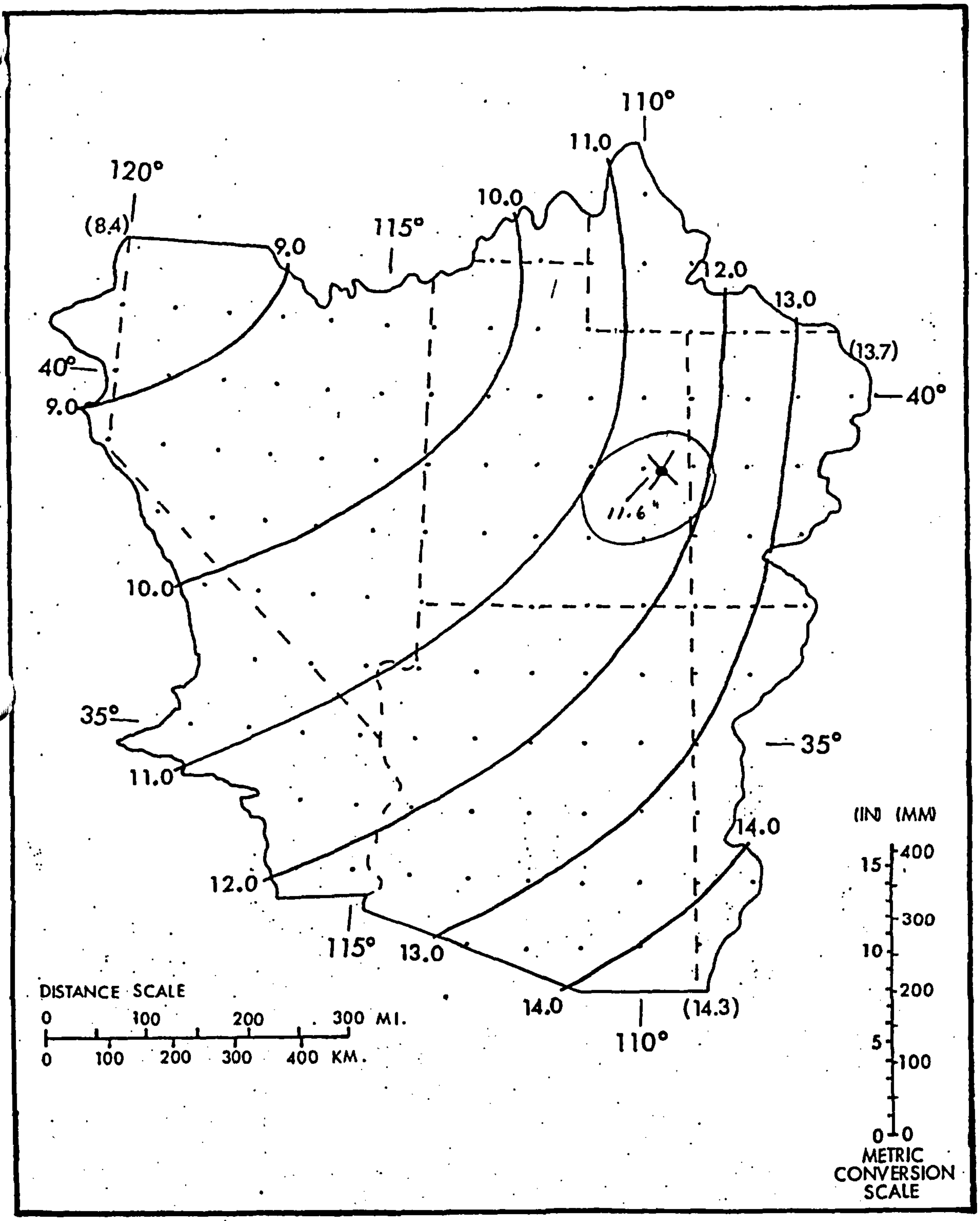
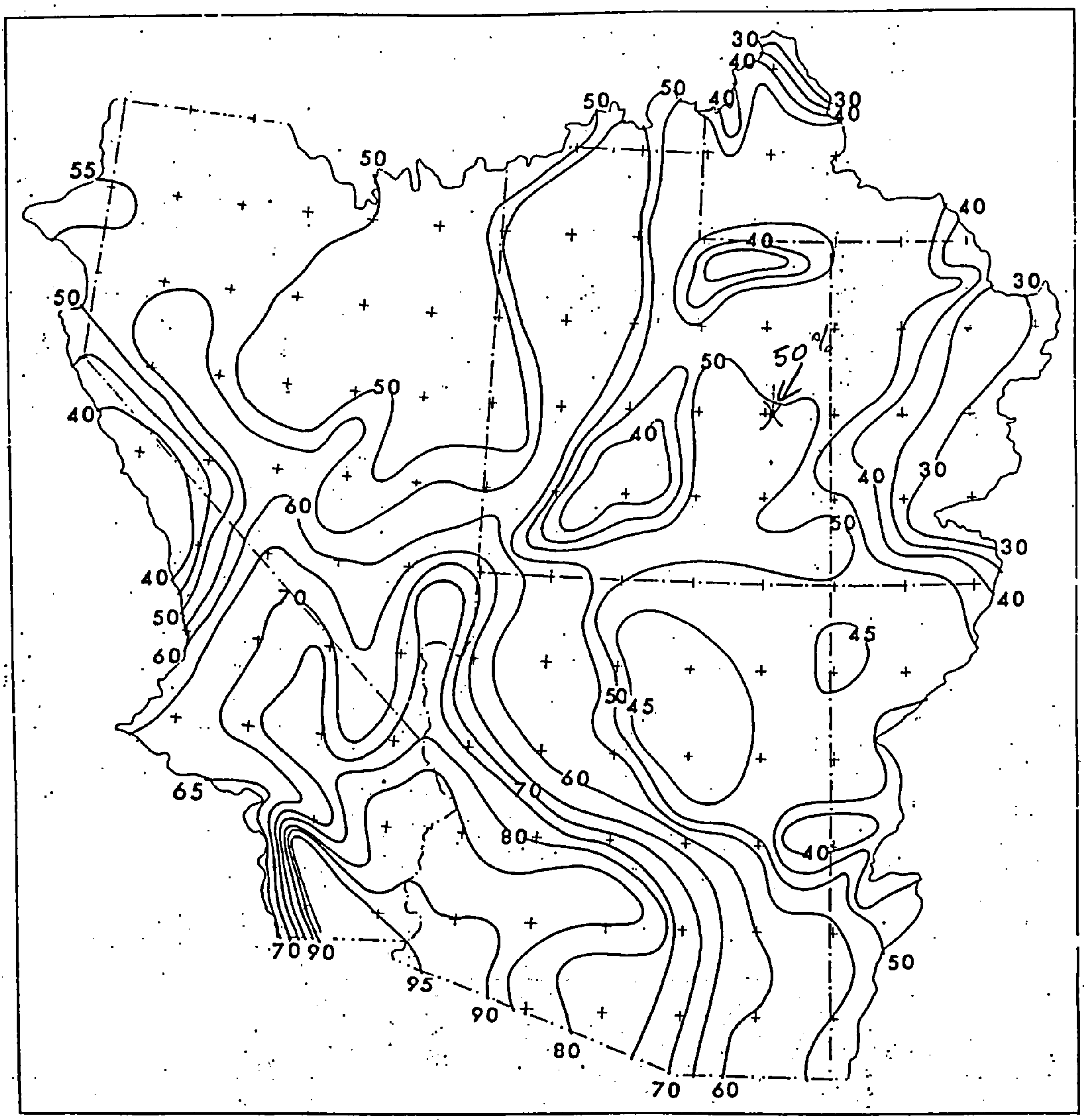


Figure 2.14.--1000-mb (100-kPa) 24-hr convergence PMP (inches) for 10 mi^2 (26 km^2) for October. Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.



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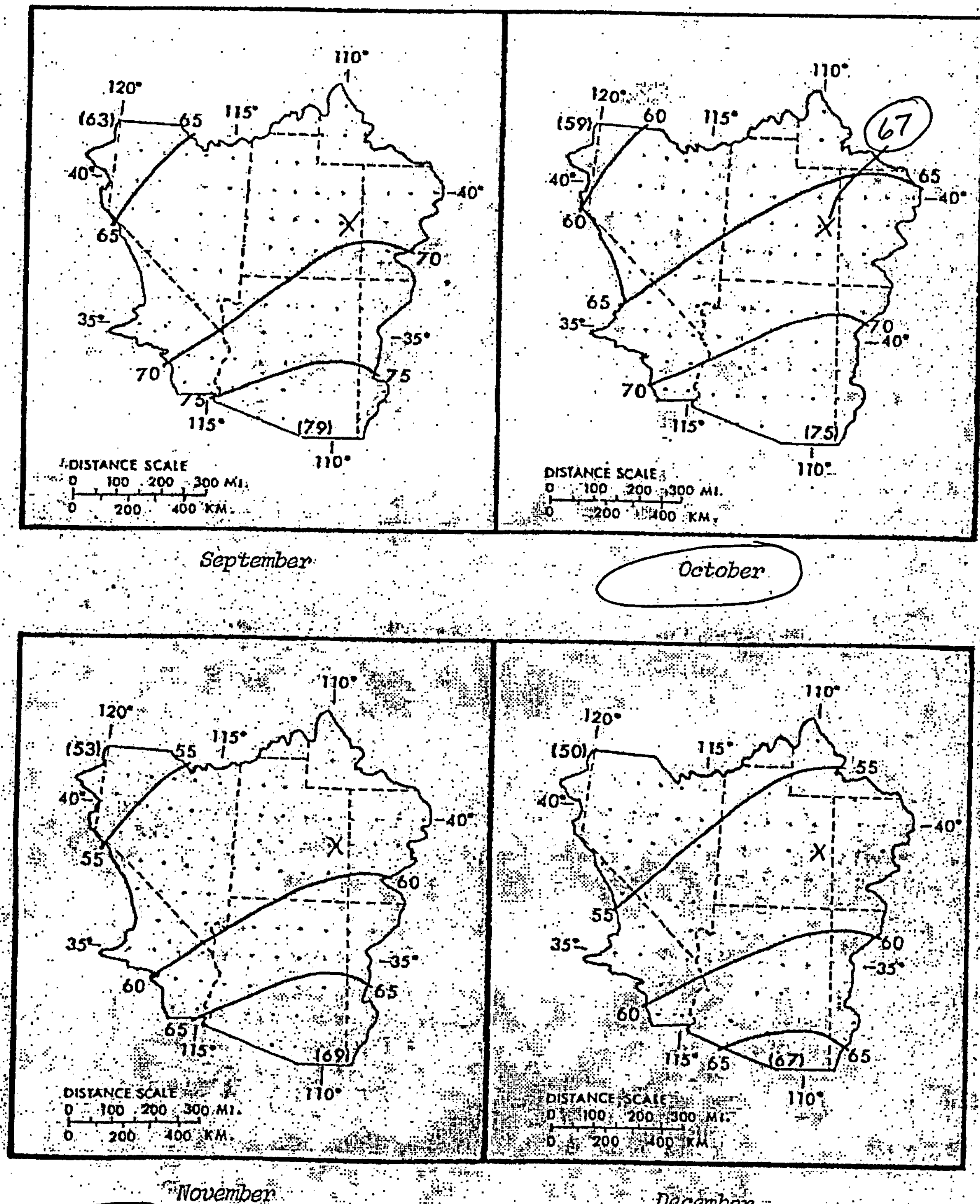

Figure 2.27.—*Regional variation of 6/24-hr ratios by month (percent). Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.*

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71	87	95	100	114	119
72	88	95	100	113	118
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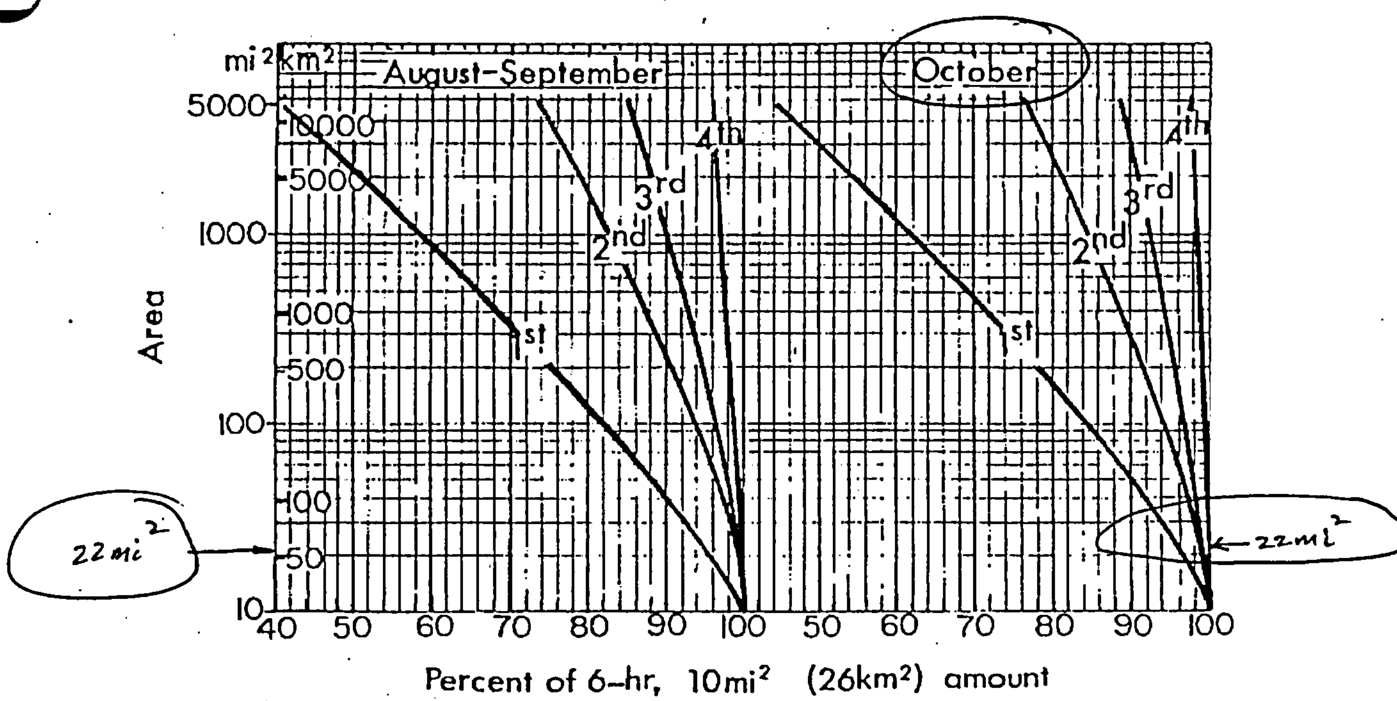


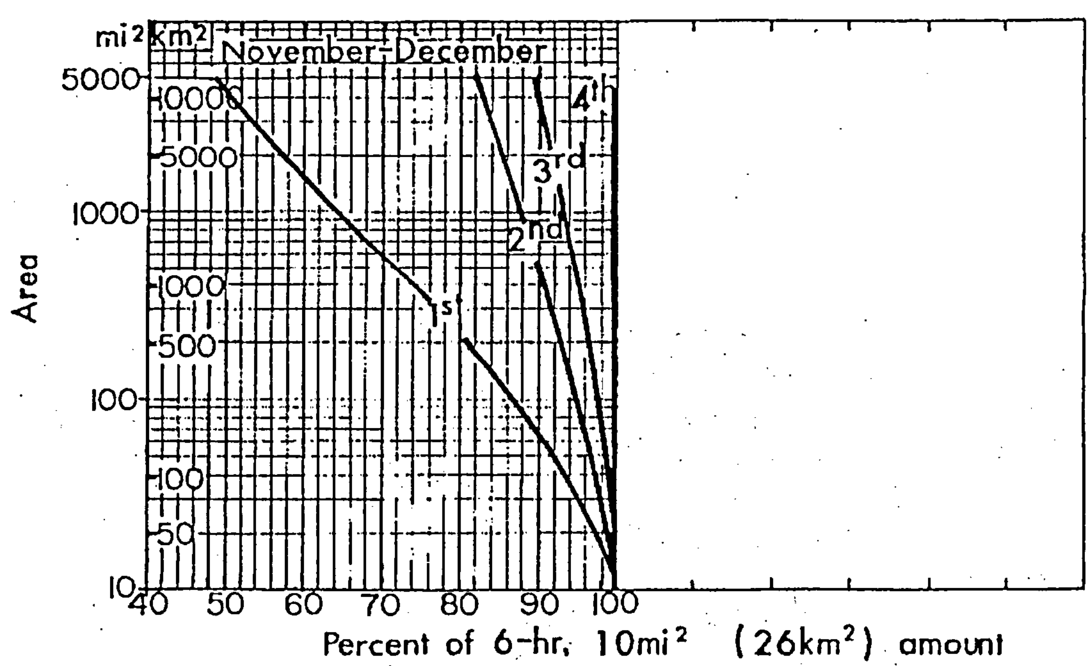
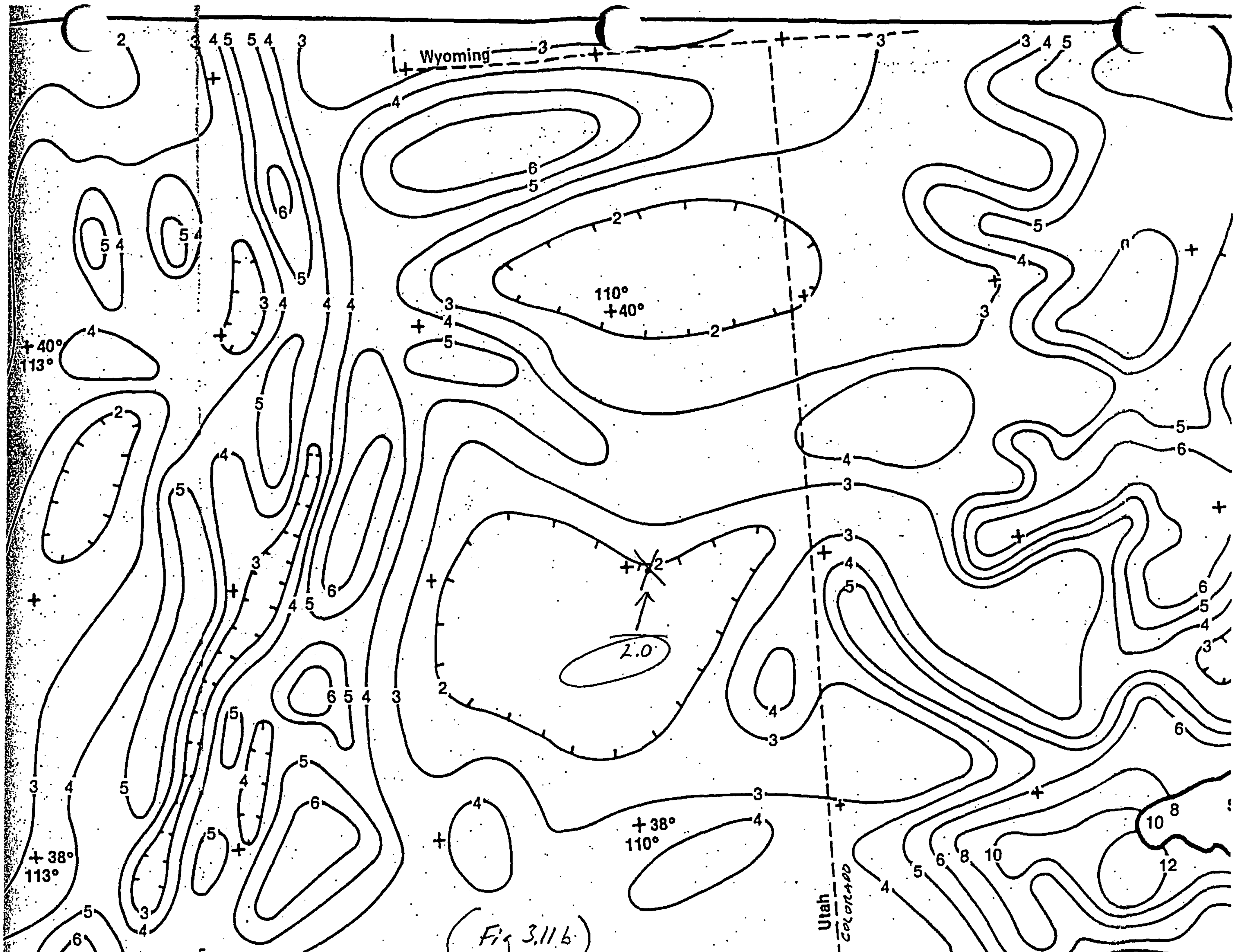


Figure 2.29--*Depth-area variation for convergence PMF for first to fourth 6-hr increments.*



(Fig 3.11.b)

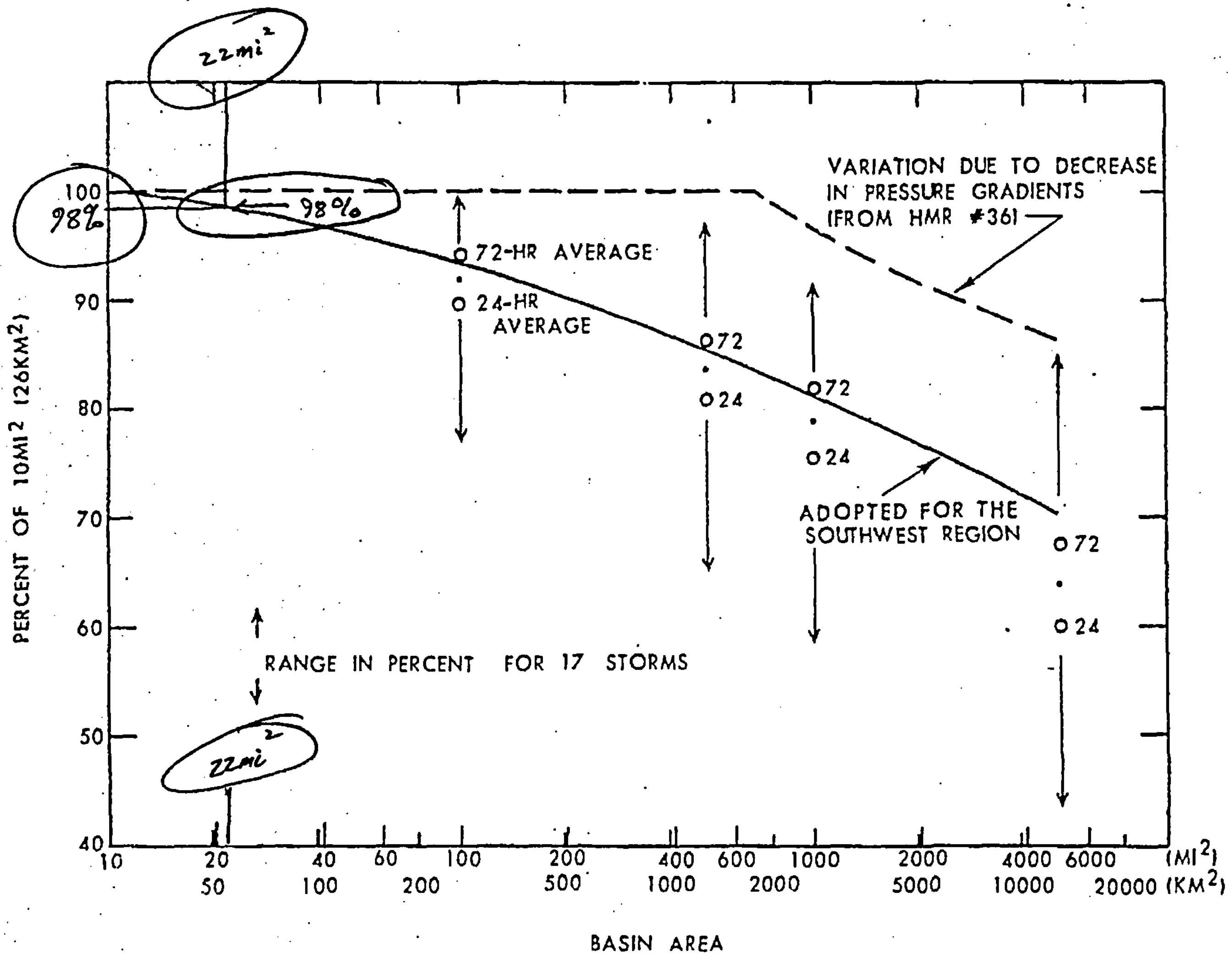
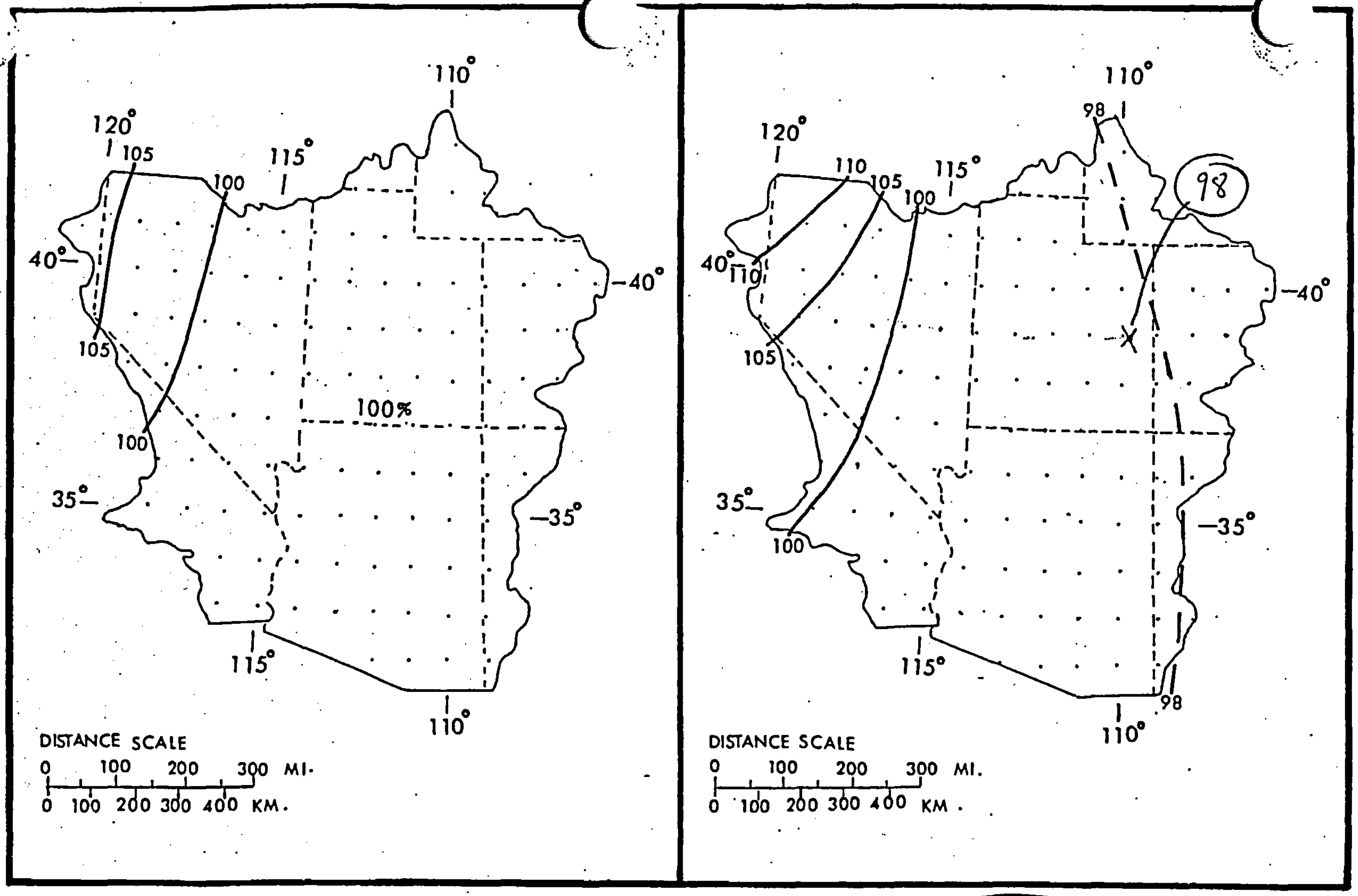


Figure 3.20.--Variation of orographic PMP with basin size.



September *October*

Figure 3.16.--*Seasonal variation in 10-mi² (26-km²) 24-hr orographic PMP for the study region (in percent of values in figure 3.11).*

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This chapter provides generalized estimates of local or thunderstorm probable maximum precipitation. By "generalized" is meant that mapped values are given from which estimates of PMP may be determined for any selected drainage.

4.1.1 Region of Interest

Local-storm PMP was not included in the "Interim Report, Probable Maximum Precipitation in California" (HMR No. 36). During the formulation of the present study, we decided that the local-storm part of the study should include California west of the Sierra Nevada. It was also noted that PMP for summer thunderstorms was not considered west of the Cascade Divide in the Northwestern Region (HMR No. 43). As stated in the latter report, "No summer thunderstorms have been reported there (west of the Divide) of an intensity of those to the east, for which the moisture source is often the Gulf of Mexico or Gulf of California... The Cascade Divide offers an additional barrier to such moisture inflows to coastal areas where, in addition, the Pacific Ocean to the west has a stabilizing influence on the air to hinder the occurrence of intense summer local storms." Therefore, it was necessary to establish some continuation of the Cascade Divide into California so that the local-storm PMP definition would have continuity between the two regions.

The stabilizing influence of the Pacific air is at times interrupted by the warm moist tropical air from the south pushing into California, although it is difficult to determine where the limit of southerly flow occurs. General storms having the tropical characteristic of excessive thunderstorm rains are observed as far north as the northern end of the Sacramento Valley. Thus, a northern boundary has been selected for this study, excluding that portion of

Local Storm PMP Computation

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area less than 1 mi^2 ~~(km^2)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00"W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

	Duration (hr)									
	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	86	93	97	100	107	109	110	110	110	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~
6. Areal reduction [fig. 4.9].	61	67	71	73	76	78	80	81	82	%
7. Areal reduced PMP [steps 5 X 6].	4.3	5.1	5.7	6.0	6.7	6.9	7.2	7.3	7.4	in. ~~(mm)~~
8. Incremental PMP [successive subtraction in step 7].				6.0	0.7	0.2	0.3	0.1	0.1	in. ~~(mm)~~
	4.3	0.8	0.6	0.3	} 15-min. increments					

9. Time sequence of incremental PMP according to: HMR No. 5

   Hourly increments [table 4.7]. 0.1 0.3 6.0 0.7 0.2 0.1 in. ~~(mm)~~

   Four largest 15-min. increments [table 4.8]. 4.3 0.8 0.6 0.3 in. ~~(mm)~~

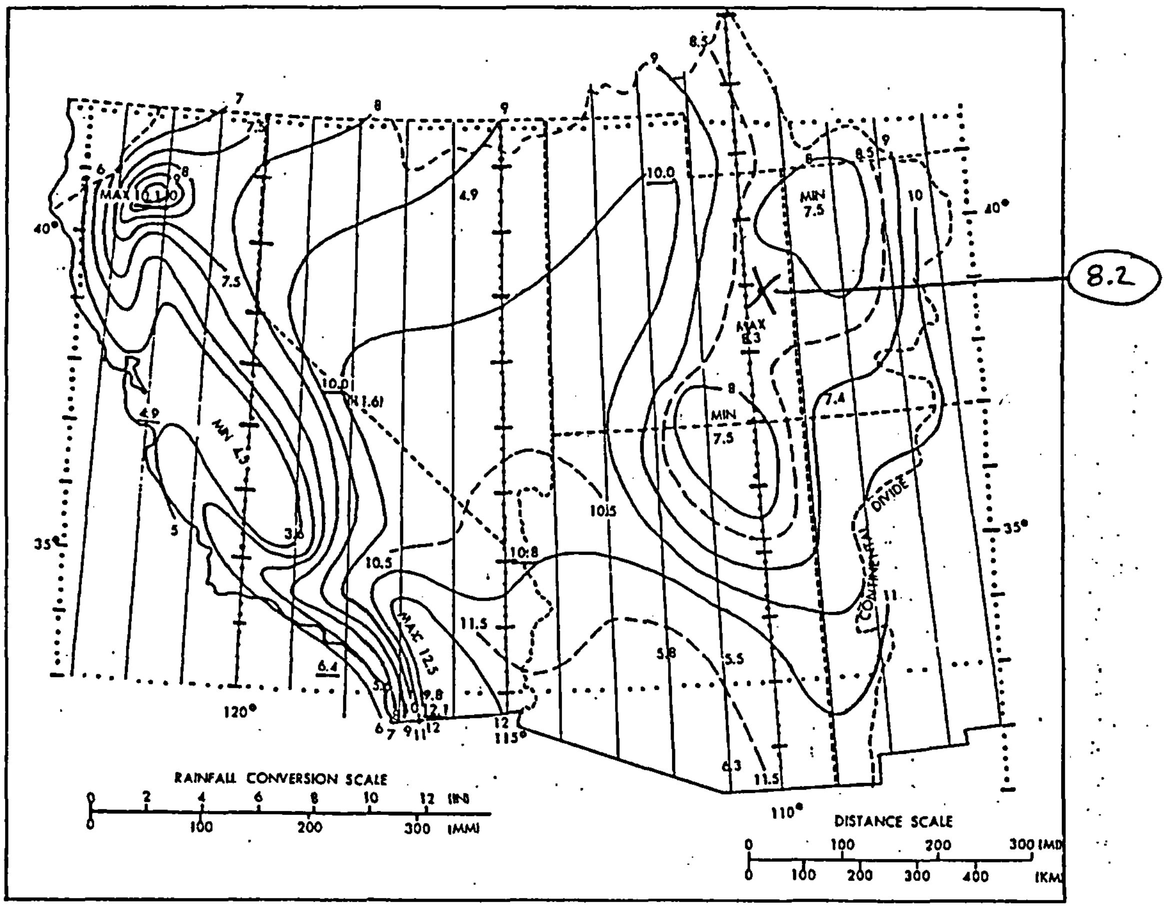

Figure 4.5--Local-storm PMP for 1 mi^2 *(2.6 km*^{2}*) 1 hr. Directly applicable for locations between sea level and 5000 ft (1524 m). Elevation adjustment must be applied for locations above 5000 ft.*

events. In contrast to figure 4.4, figure 4.5 maintains a maximum between these two locations. There is no known meteorological basis for a different solution. The analysis suggests that in the northern portion of the region maximum PMP occurs between the Sierra Nevada on the west and the Wasatch range on the east.

A discrete maximum (> 10 inches, 254 mm) occurs at the north end of the Sacramento Valley in northern California because the northward-flowing moist air is increasingly channeled and forced upslope. Support for this PMP center comes from the Newton, Kennett, and Red Bluff storms (fig. 4.1). Although the analysis in this region appears to be an extension of the broad maximum through the center of the Southwestern Region, it does not indicate the direction of moist inflow. The pattern has evolved primarily as a result of attempts to tie plotted maxima into a reasonable picture while considering inflow directions, terrain effects, and moisture potential.

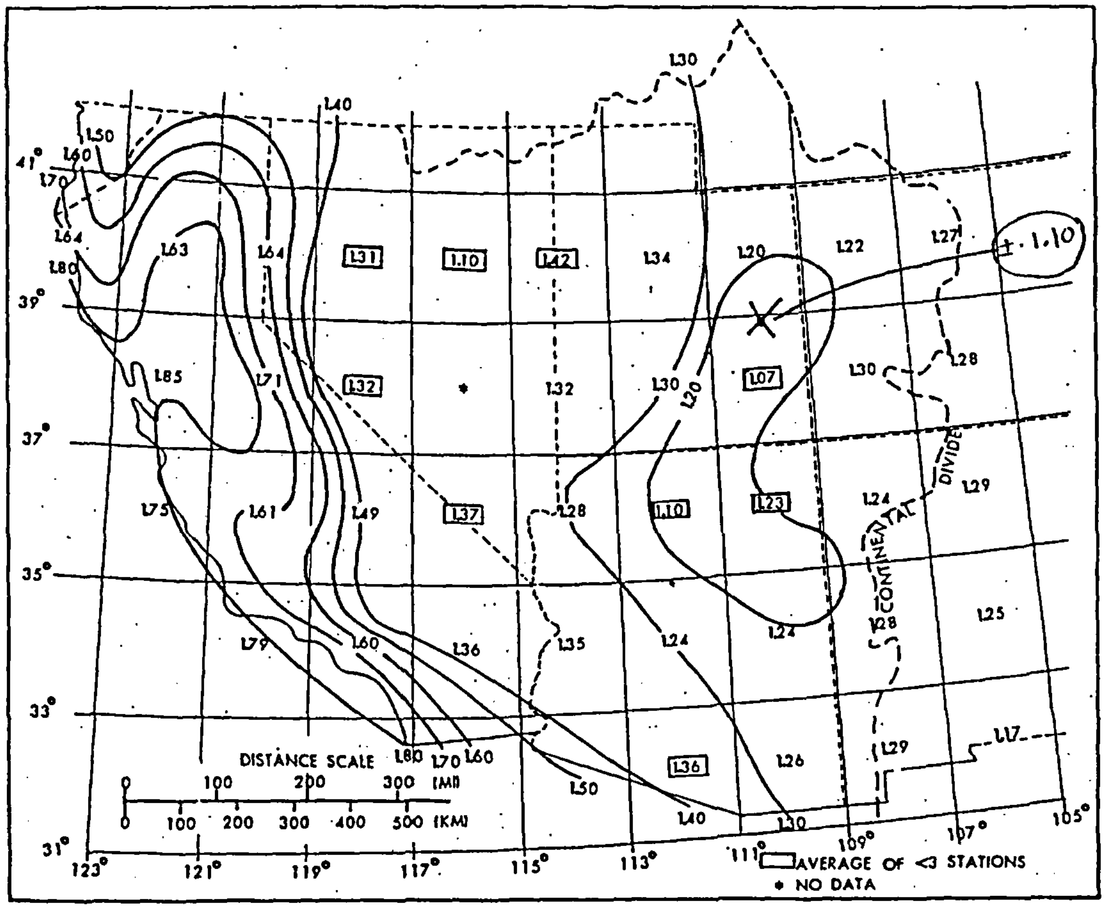

Figure 4.7--*Analysis of 6/1-hr ratios of averaged maximum station data (plotted at midpoints of a 2° latitude-longitude grid).*

establish the basic depth-duration curve, then structure a variable set of depth-duration curves to cover the range of 6/1-hr ratios that are needed.

Three sets of data were considered for obtaining a base relation (see table 4.3 for depth-duration data).

a. An average of depth-duration relations from each of 17 greatest 3-hr rains from summer storms (1940-49) in Utah (U. S. Weather Bureau 1951b) and in unpublished tabulations for Nevada and Arizona (1940-63). The 3-hr amounts ranged from 1 to 3 inches (25 to 76 mm) in these events.

b. An average depth-duration relation from 14 of the most extreme short-duration storms listed in Storm Rainfall (U. S. Army, Corps of Engineers 1945-). These storms come from Eastern and Central States and have 3-hr amounts of 5 to 22 inches (127 to 559 mm).

ratios than storms with high 3/1-hr ratios. The geographical distribution of 15-min to 1-hr ratios also were inversely correlated with magnitudes of the 6/1-hr ratios of figure 4.7. For example, Los Angeles and San Diego (high 6/1-hr ratios) have low 15-min to 1-hr ratios (approximately 0.60) whereas the 15-min to 1-hr ratios in Arizona and Utah (low 6/1-hr ratios) were generally higher (approximately 0.75).

Depth-duration relations for durations less than 1 hour were then smoothed to provide a family of curves consistent with the relations determined for 1 to 6 hours, as shown in figure 4.3. Adjustment was necessary to some of the curves to provide smoother relations through the common point at 1 hour.

We believe we were justified in reducing the number of the curves shown in figure 4.3 for durations less than 1 hour, letting one curve apply to a range of 6/1-hr ratios. The corresponding curves have been indicated by letter designators, A-D, on figure 4.3. As an example, for any 6-hr amount between 115% and 135% of 1-hr, 1-mi^2 (2.6-km^2) PMP, the associated values for durations less than 1 hour are obtained from the curve designated as "B".

Table 4.4 lists durational variations in percent of 1-hr PMP for selected 6/1-hr rain ratios. These values were interpolated from figure 4.3.

To determine 6-hr PMP for a basin, use figure 4.3 (or table 4.4) and the geographical distribution of 6/1-hr ratios given in figure 4.7.

Table 4.4.--Durational variation of 1-mi^2 (2.6-km^2) local-storm PMP in percent of 1-hr PMP (see figure 4.3)

6/1-hr	Duration (hr)								
ratio	1/4	1/2	3/4	1	2	3	4	5	6
1.1	86	93	97	100	107	109	110	110	110
1.2	74	89	95	100	110	115	118	119	120
1.3	74	89	95	100	114	121	125	128	130
1.4	63	83	93	100	118	126	132	137	140
1.5	63	83	93	100	121	132	140	145	150
1.6	43	70	87	100	124	138	147	154	160
1.8	43	70	87	100	130	149	161	171	180
2.0	43	70	87	100	137	161	175	188	200

4.5 Depth-Area Relation

We have thus far developed local-storm PMP for an area of 1 mi^2 (2.6 km^2). To apply PMP to a basin, we need to determine how 1-mi^2 (2.6-km^2) PMP should decrease with increasing area. We have adopted depth-area relations based on rainfalls in the Southwest and from consideration of a model thunderstorm.

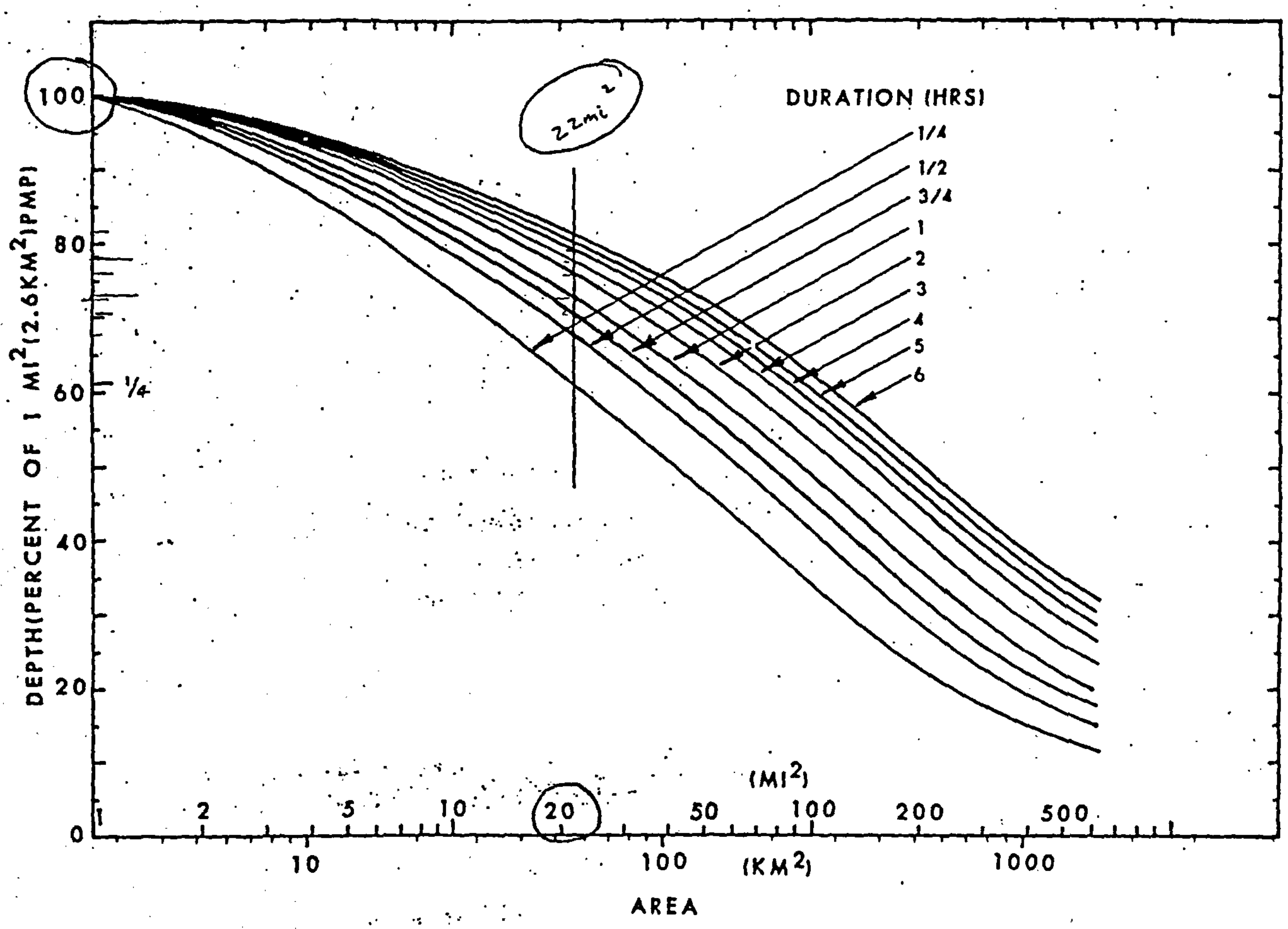

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

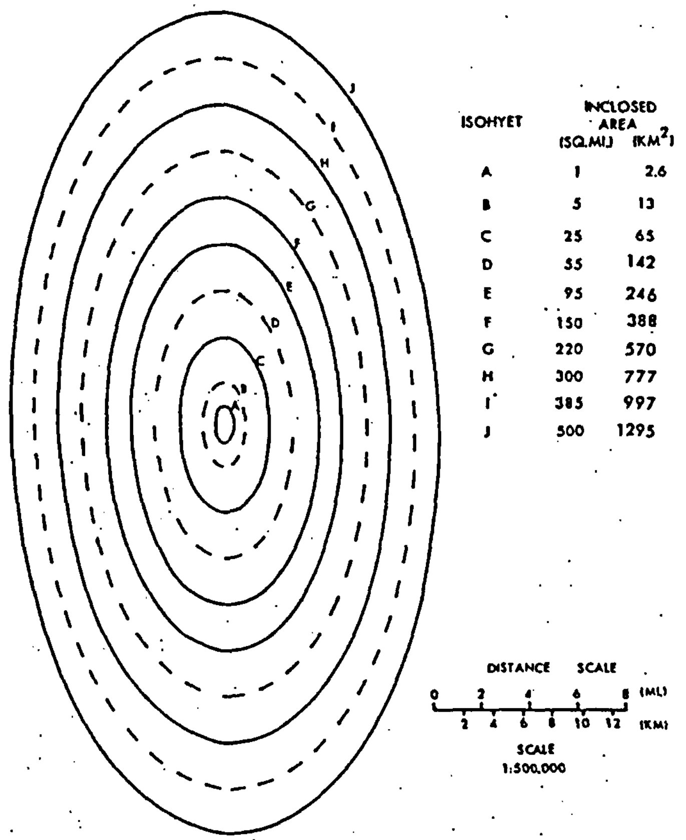

Figure 4.10.--Idealized local-storm isohyetal pattern.

storm period. The sequence of hourly incremental PMP for the Southwest 6-hr thunderstorm in accord with this study is presented in column 2 of table 4.7. A small variation from this sequence is given in Engineering Manual 1110-2-1411 (U. S. Army, Corps of Engineers 1965). The latter, listed in column 3 of table 4.7, places greater incremental amounts somewhat more toward the end of the 6-hr storm period. In application, the choice of either of these distributions is left to the user since one may prove to be more critical in a specific case than the other.

Table 4.7.--Time sequence for hourly incremental PMP in 6-hr storm

Increment	HMR No. 5[1] Sequence Position	EM1110-2-1411[2] Sequence Position
Largest hourly amount	Third	Fourth
2nd largest	Fourth	Third
3rd largest	Second	Fifth
4th largest	Fifth	Second
5th largest	First	Last
least	Last	First

[1]U. S. Weather Bureau 1947.
[2]U. S. Corps of Engineers 1952.

Also of importance is the sequence of the four 15-min incremental PMP values. We recommend a time distribution, table 4.8, giving the greatest intensity in the first 15-min interval (U.S. Weather Bureau 1947). This is based on data from a broad geographical region. Additional support for this time distribution is found in the reports of specific storms by Keppell (1963) and Osborn and Renard (1969).

Table 4.8.--Time sequence for 15-min incremental PMP within 1 hr.

Increment	Sequence Position
Largest 15-min amount	First
2nd largest	Second
3rd largest	Third
least	Last

4.8 Seasonal Distribution

The time of the year when local-storm PMP is most likely is of interest. Guidance was obtained from analysis of the distribution of maximum 1-hr thunderstorm events through the warm season at the recording stations in Utah, Arizona, and in southern California (south of 37°N and east of the Sierra Nevada ridgeline). The period of record used was for 1940-72 with an average record length for the stations considered of 27 years. The month with the one greatest thunderstorm rainfall for the period of record at each station was noted. The totals of these events for each month, by States, are shown in table 4.9.

Table 4.9.--Seasonal distribution of thunderstorm rainfalls.

(The maximum event at each of 108 stations, period of record 1940-72.)

	Month						
	M	J	J	A	S	O	No. of Cases
Utah	1	5	9	14	5		34
Arizona		4	16	19	4		43
S. Calif.*		14	10	7			31
No. of cases/mo.	1	23	35	40	9	0	

*South of 37°N and east of Sierra Nevada ridgeline.

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-5-08-00 | Discipline: Geotechnical | No. of Sheets: 6

Project: Moab UMTRA Project

Site: Crescent Junction Disposal Site

Feature:
Crescent Junction Site Hydrology Report

Sources of Data:

Sources of Formulae and References:

See "References."

Preliminary Calc. ☐ Final Calc. ☐ Supersedes Calc. No.

Author: ________ Name ________ Date

Checked by: ________ for ________ 6-9-06
Name Date

________ 6-9-06
Name Date

________ 6-10-06
Name Date

____
Name Date

Approved by: ________ 6-9-06
Name Date

Problem Statement:

Peak runoff flow rates are determined at specific locations in the vicinity of the Crescent Junction Site for the following storms:

- 25-year, 24-hour storm,
- 100-year, 24-hour storm,
- Probable Maximum Precipitation (PMP), Local Storm.

The 25-year, 24-hour storm is determined for sizing culverts and swales along the access road and Trailer Staging Area. These facilities will be in-place for approximately 25-years to facilitate the placement of the disposal cell. The 100-year flood is used to size the detention facility at the Trailer Staging Area, in compliance with Grand County drainage regulations. A separate drainage report for submittal to the County is being prepared with detention basin calculations. 100-year flows are also generated to compare existing versus "developed" conditions at key drainage points located downhill from the disposal cell. This includes flows at West Kendall Wash at the Railroad crossing located immediately south of the southwest corner of the disposal cell, Kendall Wash at the I-70 crossing and Crescent Wash at the I-70 crossing immediately west of Kendall Wash. The PMF is calculated for use in design of facilities associated with the disposal cell. This includes the PMF for the cell drainage facilities to control run-on and run-off. Major drainages are shown on Figure 1. Sub-basins and proposed-conditions basins are shown in detail on the Master Drainage Plan (Plan), appended to this report.

Method of Solution:

Calculations for runoff hydrographs, routing reaches, and combination of hydrographs for all basins greater than 20 acres are determined using the U.S. Army Corps of Engineers' Hydrologic Modeling System (HEC-HMS) Version 3.0.1. Within this computer model, the following runoff and routing methods are used:

- NRCS classification of the soils within the project site is Type B (Toddler-Ravola-Glenton) described as well draining sands and sandy loams, with a range of final infiltration rates of 4 to 8 mm per hour (.16 to .31 inches per hour). The Bureau of Reclamation also recommends .3 to .15 inches per hour (USBR) as the minimum infiltration rates for B soils. For the purpose of this analysis use 0.3 inches per hour in the existing undisturbed watershed and 0.15 inches per hour for the cell site.
- SCS CN values for B soils with sparse vegetation use 70.
- Manning's N value, K_n, representing the hydraulic characteristics of the drainage network, varies with flow (see discussion in Section 4.2), use 0.042 for the PMF and 0.054 for the 25-year and 100-year flow.

For the PMF:

- Loss Method in existing watershed– Initial loss of 0.0 inches, constant loss of 0.3 inches per hour.
- Loss Method for the disposal cell – Initial loss of 0.0 inches, constant loss of 0.15 inches per hour.
- Transform Method – User-specified unit hydrograph.
- Baseflow Method – None.
- Routing Reaches – Kinematic wave.
- Meteorology Model – PMP calculations, no evapotranspiration, no snowmelt.

For the 25-year and 100-year, 24 hour storms:

- Loss Method in existing watershed – SCS CN method with Initial loss of .86 inches based on CN of 70 and constant loss of 0.3 inches per hour.
- Loss Method for the disposal cell- SCS CN method with Initial loss of .86 inches based on CN of 70 and constant loss of 0.15 inches per hour
- Transform Method – User-specified unit hydrograph.
- Baseflow Method – None.
- Routing Reaches – Kinematic wave.
- Meteorology Model – Precipitation from NOAA Atlas 14, no evapotranspiration, no snowmelt.

Note that for basins less than 20 acres that do not require PMF determination, runoff is calculated using the Rational Method.

Assumptions:

Standard methods were used to calculate the runoff to the design points for the specific frequency storms.

Calculations:

Basin Delineation

Drainage basins are delineated based on locations of bridges/culverts or other points of concentration. There are four major basins encompassing the study area: Crescent Wash, Basin 1, Basin 2, and Basin 3. These major basins are shown on Figure 1. Seven sub-basins within the major basins are created due to the re-routing of flows around the disposal cell and the access road. These sub-basins are shown on the Plan.

The disposal cell will be isolated from run-on with the construction of a diversion channel, labeled as "North Ditch" on the Plan. These flows, which are ultimately tributary to West Kendall Wash, will be routed to the west past the Disposal Site, and then south in the "West Ditch", back into West Kendall Wash. Runoff from the cell will be diverted to the west at the south toe of the disposal cell, and confluence with the West Ditch at Design Point 4 as shown on the Plan.

User-Specified Unit Hydrograph

The methodology for determining the unit hydrograph is detailed in *Design of Small Dams* (USBR 1987) using the dimensionless unit hydrograph data for the Colorado Plateau regions of Southern California, Nevada, Utah, Arizona, and western Colorado and New Mexico. Basins in this arid region are generally typified by sparse vegetation, fairly well defined drainage networks, and terrain varying from rolling to very rugged in the more mountainous areas. The unit hydrograph lag time is defined as:

$$L_g = C(LL_{ca}/S^{.5})$$

where:

L_g = unit hydrograph lag time, hours

The USBR defines the unit hydrograph lag time as the time from the midpoint of the unit rainfall excess to the time that 50 percent of the volume of unit runoff from the drainage basin has passed the concentration point (USBR).

C = constant=26K_n

K_n = average Manning's n value representing the hydraulic characteristics of the drainage basin. K_n is a function of the magnitude of the flows and normally decreases with increasing discharge. K_n values for the PMF are based on recommendations from *Design of Small Dams* (USBR), which suggests the lowest value representative of the region be used. A regional K_n value of 0.042 represents the lower limit of the accepted range for PMF determination and is typical of the usual desert terrain. For other storm events a higher value is appropriate. Based on the *Design of Small Dams* the Colorado Plateau regions K_n range from 0.042 to 0.070. A value of 0.054 is selected for the 25-year and 100-year storm events, representing an area of Utah that is relatively close proximity to the project site on the White River (Table 3 *Design of Small Dams (USBR)*.

L = the length of the longest watercourse from the point of concentration to the boundary of the drainage basin,

L_{ca} = the length along the longest watercourse from the point of concentration to a point opposite the centroid of the drainage basin,

S = the overall slope of the longest watercourse (along *L*),

Hydrologic parameters and spreadsheets are used to create the basin-specific unit hydrographs for use by the HEC-HMS models and are presented in Appendix A.

Frequency Storms

Design storm information is provided by *Crescent Junction Site Characterization – Site Drainage Hydrology Parameters* (DOE 2005), which calculates the local storm PMP for storms of <1 mi^2 and 22 mi^2. This analysis also includes determination of storms in basins covering 1.4, 2.7, 3.5, 9, and 15 mi^2. Thus additional depth-duration models are developed so that the size of the storm is equivalent to the drainage area contributing to the design point. Calculations are included in Appendix B.

The depth-duration relationships for all of the modeled storms are summarized in Table 1.

Table 1. Depth-Duration for Modeled Storms

Precipitation Depth (inches) for Specified Duration								
Storm Event	**5 min**	**15 min**	**1 hr**	**2 hr**	**3 hr**	**6 hr**	**12 hr**	**24 hr**
25-yr, 24-hr	0.34	0.64	1.07	1.21	1.26	1.42	1.65	1.91
100-yr, 24-hr	0.53	0.99	1.65	1.82	1.84	1.95	2.16	2.35
200-yr, 24-hr	0.65	1.22	2.03	2.23	2.25	2.35	2.47	2.58
PMP – Local								
<1 mi^2	4.5	7.1	8.2	8.8	8.9	9.0		
1.4 mi^2	4.3	6.8	8.0	8.6	8.7	8.9		
2.7 mi^2	4.1	6.5	7.9	8.4	8.5	8.7		
3.5 mi^2	4.0	6.2	7.6	8.3	8.5	8.6		
9 mi^2	3.4	5.4	6.9	7.6	7.7	8.0		
15 mi^2	3.0	4.8	6.4	7.0	7.2	7.7		
22 mi^2	2.7	4.3	6.0	6.7	6.9	7.4		

Routing Reaches

Reach routing is performed in the HEC-HMS modeling using kinematic wave to route hydrographs along ditches and between design points. Design parameters and input are summarized in Appendix B.

HEC-HMS Results

The HEC-HMS model is used to determine hydrographs at the specific design points for each of the four storm events. Model output is provided in Appendix C and summarized in Table 2. For basins less than 20 acres that do not require PMF determination, runoff is calculated using the Rational Method. Rational Method calculations are presented in Appendix D.

Conclusions and Recommendations:

The peak flow rates at each of the design points are summarized in Table 2.

Table 2. Peak Flow Rates, Major Storm Events

Design Point	Area	Peak Flow Rate (cfs)		
	(mi^2)	25-yr, 24-hr	100-yr, 24-hr	PMP - Local
Crescent Wash at RR Bridge and I-70 Existing and Proposed	22.56	2,975	5,983	45,197
Basin 1 at RR Bridge (Design Point 6)	2.63			
Existing conditions		-	2,135	21,288
Proposed conditions		-	2,210	21,322
Basin 2 at RR Bridge Existing and Proposed	8.96	1,726	3,453	29,869
Basins 1, 2, and 3 at I-70 CMP	15.09			
Existing conditions		-	5,109	40,835
Proposed conditions		-	5,098	40,871
Proposed Drainage Facilities				
North Ditch	0.52	291	-	5,859
West Ditch (Design Point 4)	0.52	291	-	5,859
Design Point 5	0.90	448	-	8,722
Existing Culvert (Design Point 3)	0.17	75	147	1,488
Culvert C1*	0.09	42	-	-
Culvert C2*	0.05	9	-	-
Culvert C3*	0.02	4	-	-
Culvert C4*	0.10	18	-	-
Culvert C5	1.25	611	-	-
Culvert C6*	0.05	9	-	-
Culvert C7*	0.41	239	-	-

Discussion:

Parameters used to calculate the 25-year and 100-year flows are checked using gaged data available for Crescent Wash through the USGS. Two sets of information are available. The first includes 10 years of gaging information (USGSb), which indicates the highest flow on record of 4,160 cfs in1965. The second is a flood-frequency analysis performed by the USGS (Vaill 2000) indicating a 100-year event with a peak discharge of 6,460 cfs. Due to the limited amount of data, this information is considered only a relative check for order of magnitude compared to the computations; however, the results of this analysis are within 3 percent of the USGS results, when adjusted for drainage area. Several additional gaged sites were also checked for peak flows per square mile. Sites selected for comparison are similar in elevation and size and are in similar environmental conditions as the project site. Peak flows were calculated by the USGS using Log-Pearson Type III probability distribution (Vaill 2000). See Appendix E for a detailed discussion and comparison of flows.

References:

U.S. Army Corps of Engineers (USACE). *HEC-HMS Hydrologic Modeling System*, Version 3.0.1, Hydrologic Engineering Center, Davis, California.

U.S. Geological Survey (USGS), 1999. *The National Flood-Frequency Program-Methods for Estimating Flood Magnitude and Frequency in Rural Areas in Utah*, Reston, Virginia, September.

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Vaill, J.E., 2000. *Analysis of the Magnitude and Frequency of Floods in Colorado*. Water-Resources Investigations Report 99-4190, prepared in cooperation with the Colorado Department of Transportation and the Bureau of Land Management by U.S. Geological Survey. Denver, Colorado.

Appendix A

Unit Hydrographs

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Crescent Wash-10, 25, 100, 200 Existing Conditions

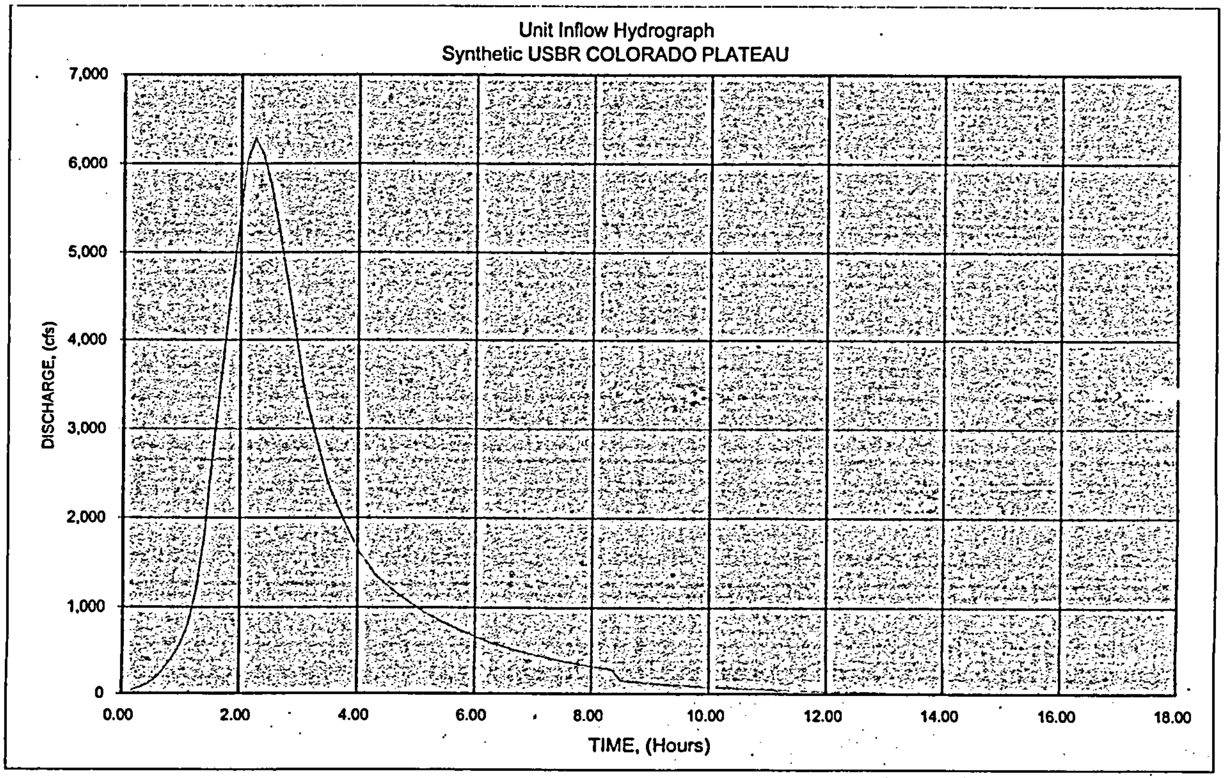
Drainage Area =	22.56 sq. miles	Lg+D/2 =	2.79 Hours
Basin Slope =	209 ft./mile	Basin Factor =	6.63
L =	13.56 mi., Length of Watercourse	V' =	606.64 cfs/Day
Lca =	7.07 mi., Distance to Centroid	Qs =	217.6 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated: Lag Time, Lg = 2.62 Hours — Unit Duration, D = 28.59 minutes; Calculated Timestep = 8.36 minutes

Data to be used in Analysis Unit Duration, D = 20 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	25	47	64	83	104	138	180	241	313	391
UI	497	612	749	945	1178	1552	1979	2526	3048	3554
UI	4073	4576	5027	5502	5994	6176	6265	6156	5984	5764
UI	5485	5187	4845	4503	4160	3794	3450	3204	2979	2774
UI	2569	2377	2241	2111	1987	1876	1766	1657	1564	1489
UI	1414	1342	1294	1246	1200	1157	1115	1075	1037	1002
UI	968	935	908	879	849	823	798	771	745	720
UI	696	673	651	628	605	587	571	550	531	512
UI	497	482	467	452	437	423	409	396	383	370
UI	358	346	334	323	314	305	296	286	276	267
UI	258	251	241	233	225	218	211	204	196	190
UI	184	179	174	168	163	157	151	147	143	139
UI	134	129	125	121	117	113	109	105	102	99
UI	96	92	89	87	84	81	79	76	74	72

UI	70	66	63	61	59	58	57	54	52	51
UI	49	48	47	46	44	43	42	40	39	38
UI	36	35	34	33	33	32	29	27	26	26
UI	26	24	14							
UI										
UI										
UI										
UI										

USBR calculated unitgraph peak = 6291 Interpolated Peak = 6265

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.14	8.4	0.19	41	305.0	8.50	510.2	0.66	144
10.0	0.28	16.7	0.32	70	310.0	8.64	518.5	0.63	137
15.0	0.42	25.1	0.48	104	315.0	8.78	526.9	0.59	128
20.0	0.56	33.5	0.74	161	320.0	8.92	535.3	0.56	122
25.0	0.70	41.8	1.21	263	325.0	9.06	543.6	0.53	115
30.0	0.84	50.2	1.81	394	330.0	9.20	552.0	0.50	109
35.0	0.98	58.5	2.63	572	335.0	9.34	560.4	0.47	102
40.0	1.12	66.9	3.68	801	340.0	9.48	568.7	0.45	98
45.0	1.25	75.3	5.47	1,190	345.0	9.62	577.1	0.42	91
50.0	1.39	83.6	8.41	1,830	350.0	9.76	585.4	0.40	87
55.0	1.53	92.0	12.61	2,744	355.0	9.90	593.8	0.38	83
60.0	1.67	100.4	16.50	3,590	360.0	10.04	602.2	0.36	78
65.0	1.81	108.7	20.50	4,461	365.0	10.18	610.5	0.34	74
70.0	1.95	117.1	23.97	5,216	370.0	10.32	618.9	0.33	72
75.0	2.09	125.5	27.75	6,038	375.0	10.45	627.3	0.30	65
80.0	2.23	133.8	28.91	6,291	380.0	10.59	635.6	0.28	61
85.0	2.37	142.2	28.07	6,108	385.0	10.73	644.0	0.27	59
90.0	2.51	150.5	26.38	5,740	390.0	10.87	652.4	0.26	57
95.0	2.65	158.9	24.18	5,262	395.0	11.01	660.7	0.24	52
100.0	2.79	167.3	21.55	4,689	400.0	11.15	669.1	0.23	50
105.0	2.93	175.6	18.92	4,117	405.0	11.29	677.4	0.22	48
110.0	3.07	184.0	16.08	3,499	410.0	11.43	685.8	0.21	46
115.0	3.21	192.4	14.19	3,088	415.0	11.57	694.2	0.20	44
120.0	3.35	200.7	12.61	2,744	420.0	11.71	702.5	0.19	41
125.0	3.48	209.1	11.04	2,402	425.0	11.85	710.9	0.18	39
130.0	3.62	217.5	9.99	2,174	430.0	11.99	719.3	0.17	37
135.0	3.76	225.8	9.04	1,967	435.0	12.13	727.6	0.16	35
140.0	3.90	234.2	8.20	1,784	440.0	12.27	736.0	0.15	33
145.0	4.04	242.5	7.36	1,602	445.0	12.41	744.4	0.15	33
150.0	4.18	250.9	6.78	1,475	450.0	12.55	752.7	0.13	28
155.0	4.32	259.3	6.20	1,349	455.0	12.68	761.1	0.12	26
160.0	4.46	267.6	5.83	1,269	460.0	12.82	769.4	0.12	26
165.0	4.60	276.0	5.47	1,190	465.0	12.96	777.8	0.11	24
170.0	4.74	284.4	5.15	1,121	470.0	13.10	786.2		
175.0	4.88	292.7	4.84	1,053	475.0	13.24	794.5		
180.0	5.02	301.1	4.57	994	480.0	13.38	802.9		
185.0	5.16	309.5	4.31	938	485.0	13.52	811.3		
190.0	5.30	317.8	4.10	892	490.0	13.66	819.6		
195.0	5.44	326.2	3.87	842	495.0	13.80	828.0		
200.0	5.58	334.5	3.68	801	500.0	13.94	836.4		
205.0	5.72	342.9	3.47	755	505.0	14.08	844.7		
210.0	5.85	351.3	3.28	714	510.0	14.22	853.1		
215.0	5.99	359.6	3.10	675	515.0	14.36	861.4		
220.0	6.13	368.0	2.93	638	520.0	14.50	869.8		
225.0	6.27	376.4	2.75	598	525.0	14.64	878.2		
230.0	6.41	384.7	2.63	572	530.0	14.78	886.5		
235.0	6.55	393.1	2.47	537	535.0	14.91	894.9		
240.0	6.69	401.5	2.33	507	540.0	15.05	903.3		
245.0	6.83	409.8	2.22	483	545.0	15.19	911.6		
250.0	6.97	418.2	2.10	457	550.0	15.33	920.0		
255.0	7.11	426.5	1.99	433	555.0	15.47	928.4		
260.0	7.25	434.9	1.88	409	560.0	15.61	936.7		
265.0	7.39	443.3	1.78	387	565.0	15.75	945.1		
270.0	7.53	451.6	1.68	366	570.0	15.89	953.4		
275.0	7.67	460.0	1.59	346	575.0	16.03	961.8		
280.0	7.81	468.4	1.50	326	580.0	16.17	970.2		
285.0	7.95	476.7	1.43	311	585.0	16.31	978.5		
290.0	8.08	485.1	1.36	296	590.0	16.45	986.9		
295.0	8.22	493.4	1.28	279	595.0	16.59	995.3		
300.0	8.36	501.8	1.21	263	600.0	16.73	1003.6		

NOTES : Use for models including the Crescent Wash Basin for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

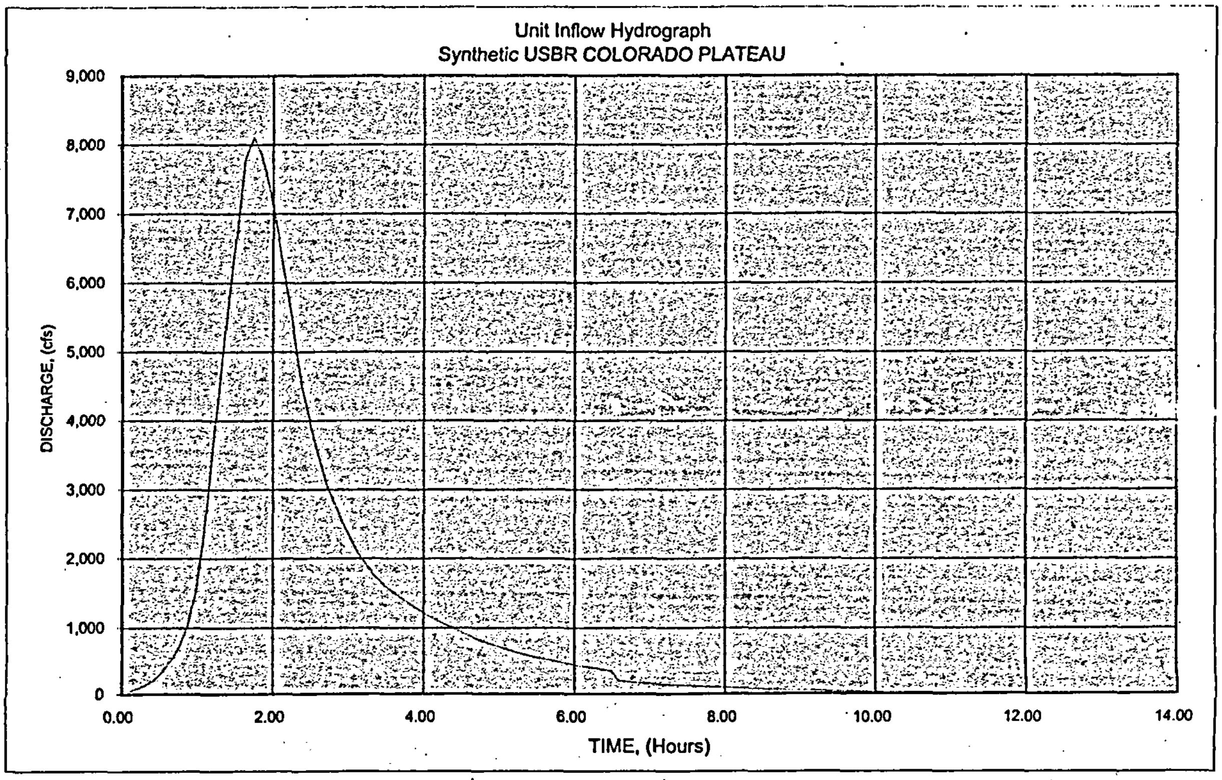
Crescent Wash-PMP Existing Conditions

Drainage Area =	22.56 sq. miles		Lg+D/2 =	2.16 Hours
Basin Slope =	209 ft./mile		Basin Factor =	6.63
L =	13.56 mi., Length of Watercourse		V' =	606.64 cfs/Day
Lca =	7.07 mi., Distance to Centroid		Qs =	280.4 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

PARAMETERS:

Calculated:	Lag Time, Lg =	2.04 Hours	Unit Duration, D =	22.24 minutes
			Calculated Timestep =	6.49 minutes

Data to be used	Unit Duration, D =	15 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph 5 **minute interval**

UI	41	73	104	140	197	289	405	545	722	944
UI	1269	1734	2374	3281	4140	4990	5840	6589	7394	7912
UI	8064	7883	7530	7096	6590	6022	5454	4852	4329	3930
UI	3589	3250	2972	2750	2545	2363	2181	2019	1894	1769
UI	1678	1599	1523	1454	1386	1324	1266	1210	1165	1116
UI	1070	1029	983	941	901	863	826	787	756	728
UI	693	663	637	612	587	563	539	516	495	473
UI	454	434	416	401	386	369	353	338	325	310
UI	296	284	273	260	248	238	230	221	212	203
UI	193	186	180	172	164	157	151	144	138	132
UI	127	121	116	112	107	103	99	95	93	86
UI	81	78	76	73	70	66	64	62	60	58
UI	56	53	51	49	47	45	43	42	40	36
UI	34	34	32	24	0					

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USBR calculated unitgraph peak = 8106 Interpolated Peak = 8064

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.11	6.5	0.19	53	305.0	6.60	396.0	0.66	185
10.0	0.22	13.0	0.32	90	310.0	6.71	402.4	0.63	177
15.0	0.32	19.5	0.48	135	315.0	6.82	408.9	0.59	165
20.0	0.43	26.0	0.74	207	320.0	6.92	415.4	0.56	157
25.0	0.54	32.5	1.21	339	325.0	7.03	421.9	0.53	149
30.0	0.65	38.9	1.81	507	330.0	7.14	428.4	0.50	140
35.0	0.76	45.4	2.63	737	335.0	7.25	434.9	0.47	132
40.0	0.87	51.9	3.68	1,032	340.0	7.36	441.4	0.45	126
45.0	0.97	58.4	5.47	1,534	345.0	7.46	447.9	0.42	118
50.0	1.08	64.9	8.41	2,358	350.0	7.57	454.4	0.40	112
55.0	1.19	71.4	12.61	3,535	355.0	7.68	460.9	0.38	107
60.0	1.30	77.9	16.50	4,626	360.0	7.79	467.4	0.36	101
65.0	1.41	84.4	20.50	5,748	365.0	7.90	473.8	0.34	95
70.0	1.51	90.9	23.97	6,720	370.0	8.01	480.3	0.33	93
75.0	1.62	97.4	27.75	7,780	375.0	8.11	486.8	0.30	84
80.0	1.73	103.9	28.91	8,106	380.0	8.22	493.3	0.28	79
85.0	1.84	110.3	28.07	7,870	385.0	8.33	499.8	0.27	76
90.0	1.95	116.8	26.38	7,396	390.0	8.44	506.3	0.26	73
95.0	2.06	123.3	24.18	6,779	395.0	8.55	512.8	0.24	67
100.0	2.16	129.8	21.55	6,042	400.0	8.65	519.3	0.23	64
105.0	2.27	136.3	18.92	5,305	405.0	8.76	525.8	0.22	62
110.0	2.38	142.8	16.08	4,508	410.0	8.87	532.3	0.21	59
115.0	2.49	149.3	14.19	3,978	415.0	8.98	538.8	0.20	56
120.0	2.60	155.8	12.61	3,535	420.0	9.09	545.3	0.19	53
125.0	2.70	162.3	11.04	3,095	425.0	9.20	551.7	0.18	50
130.0	2.81	168.8	9.99	2,801	430.0	9.30	558.2	0.17	48
135.0	2.92	175.3	9.04	2,535	435.0	9.41	564.7	0.16	45
140.0	3.03	181.8	8.20	2,299	440.0	9.52	571.2	0.15	42
145.0	3.14	188.2	7.36	2,064	445.0	9.63	577.7	0.15	42
150.0	3.25	194.7	6.78	1,901	450.0	9.74	584.2	0.13	36
155.0	3.35	201.2	6.20	1,738	455.0	9.84	590.7	0.12	34
160.0	3.46	207.7	5.83	1,635	460.0	9.95	597.2	0.12	34
165.0	3.57	214.2	5.47	1,534	465.0	10.06	603.7	0.11	31
170.0	3.68	220.7	5.15	1,444	470.0	10.17	610.2		
175.0	3.79	227.2	4.84	1,357	475.0	10.28	616.7		
180.0	3.89	233.7	4.57	1,281	480.0	10.39	623.1		
185.0	4.00	240.2	4.31	1,208	485.0	10.49	629.6		
190.0	4.11	246.7	4.10	1,150	490.0	10.60	636.1		
195.0	4.22	253.2	3.87	1,085	495.0	10.71	642.6		
200.0	4.33	259.6	3.68	1,032	500.0	10.82	649.1		
205.0	4.44	266.1	3.47	973	505.0	10.93	655.6		
210.0	4.54	272.6	3.28	920	510.0	11.03	662.1		
215.0	4.65	279.1	3.10	869	515.0	11.14	668.6		
220.0	4.76	285.6	2.93	821	520.0	11.25	675.1		
225.0	4.87	292.1	2.75	771	525.0	11.36	681.6		
230.0	4.98	298.6	2.63	737	530.0	11.47	688.1		
235.0	5.08	305.1	2.47	693	535.0	11.58	694.5		
240.0	5.19	311.6	2.33	653	540.0	11.68	701.0		
245.0	5.30	318.1	2.22	622	545.0	11.79	707.5		
250.0	5.41	324.6	2.10	589	550.0	11.90	714.0		
255.0	5.52	331.0	1.99	558	555.0	12.01	720.5		
260.0	5.63	337.5	1.88	527	560.0	12.12	727.0		
265.0	5.73	344.0	1.78	499	565.0	12.22	733.5		
270.0	5.84	350.5	1.68	471	570.0	12.33	740.0		
275.0	5.95	357.0	1.59	446	575.0	12.44	746.5		
280.0	6.06	363.5	1.50	421	580.0	12.55	753.0		
285.0	6.17	370.0	1.43	401	585.0	12.66	759.5		
290.0	6.27	376.5	1.36	381	590.0	12.77	765.9		
295.0	6.38	383.0	1.28	359	595.0	12.87	772.4		
300.0	6.49	389.5	1.21	339	600.0	12.98	778.9		

NOTES : Use for models including the Crescent Wash Basin for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin 1-10, 25, 100, 200 Existing Conditions

Drainage Area =	2.63 sq. miles	Lg+D/2 =	0.79 Hours
Basin Slope =	356 ft./mile	Basin Factor =	0.13
L =	2.92 mi., Length of Watercourse	V' =	70.72 cfs/Day
Lca =	0.87 mi., Distance to Centroid	Qs =	89.2 * q, cfs
Kn =	0.056 -, Ave. Weighted Manning's n		

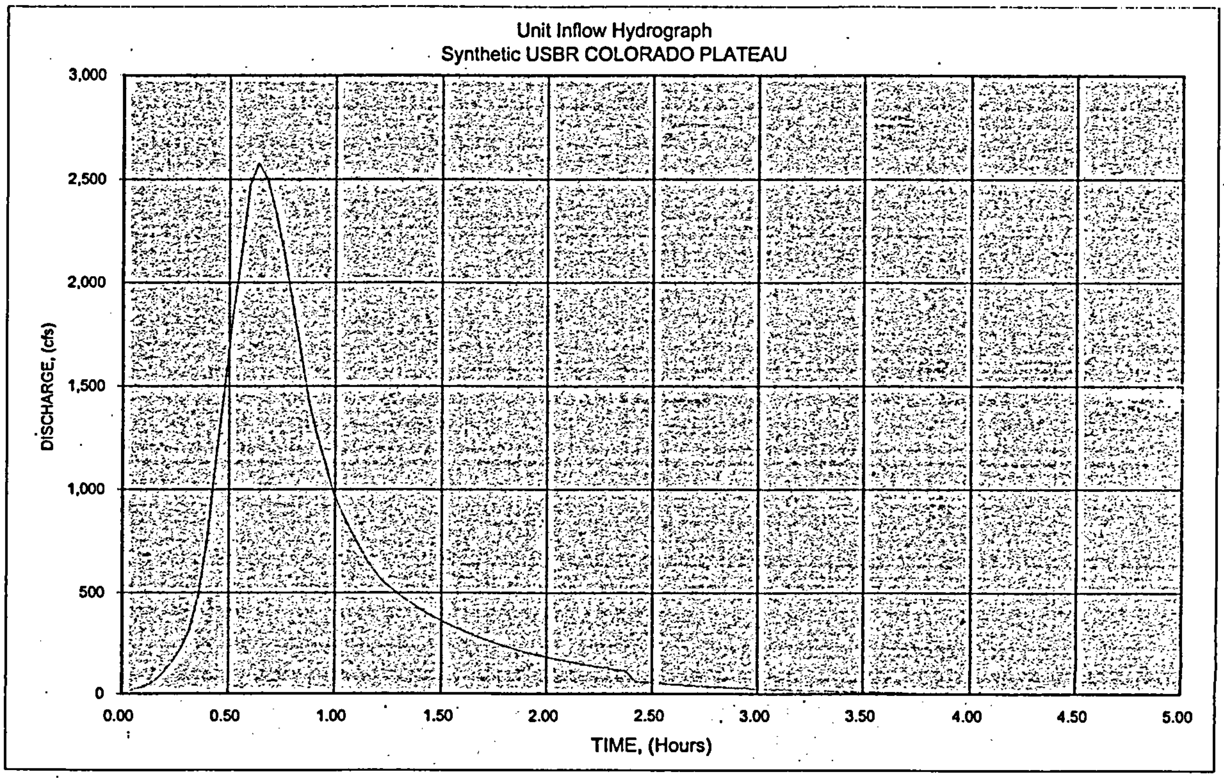
PARAMETERS:

Calculated: Lag Time, Lg = 0.75 Hours Unit Duration, D = 8.20 minutes

Calculated Timestep = 2.38 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	30	75	184	393	941	1690	2378	2517	2173	1683
UI	1249	964	782	634	536	470	414	369	329	292
UI	259	231	204	183	163	145	129	115	103	91
UI	80	72	64	58	51	45	41	36	32	29
UI	25	23	20	18	16	15	13	11	10	
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USBR calculated unitgraph peak = 2578 Interpolated Peak = 2517

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.04	2.4	0.19	17	305.0	2.42	145.1	0.66	59
10.0	0.08	4.8	0.32	29	310.0	2.46	147.5	0.63	56
15.0	0.12	7.1	0.48	43	315.0	2.50	149.9	0.59	53
20.0	0.16	9.5	0.74	66	320.0	2.54	152.2	0.56	50
25.0	0.20	11.9	1.21	108	325.0	2.58	154.6	0.53	47
30.0	0.24	14.3	1.81	161	330.0	2.62	157.0	0.50	45
35.0	0.28	16.7	2.63	235	335.0	2.66	159.4	0.47	42
40.0	0.32	19.0	3.68	328	340.0	2.70	161.8	0.45	40
45.0	0.36	21.4	5.47	488	345.0	2.74	164.1	0.42	37
50.0	0.40	23.8	8.41	750	350.0	2.78	166.5	0.40	36
55.0	0.44	26.2	12.61	1,125	355.0	2.81	168.9	0.38	34
60.0	0.48	28.5	16.50	1,472	360.0	2.85	171.3	0.36	32
65.0	0.52	30.9	20.50	1,828	365.0	2.89	173.7	0.34	30
70.0	0.56	33.3	23.97	2,138	370.0	2.93	176.0	0.33	29
75.0	0.59	35.7	27.75	2,475	375.0	2.97	178.4	0.30	27
80.0	0.63	38.1	28.91	2,578	380.0	3.01	180.8	0.28	25
85.0	0.67	40.4	28.07	2,504	385.0	3.05	183.2	0.27	24
90.0	0.71	42.8	26.38	2,353	390.0	3.09	185.5	0.26	23
95.0	0.75	45.2	24.18	2,157	395.0	3.13	187.9	0.24	21
100.0	0.79	47.6	21.55	1,922	400.0	3.17	190.3	0.23	21
105.0	0.83	50.0	18.92	1,687	405.0	3.21	192.7	0.22	20
110.0	0.87	52.3	16.08	1,434	410.0	3.25	195.1	0.21	19
115.0	0.91	54.7	14.19	1,266	415.0	3.29	197.4	0.20	18
120.0	0.95	57.1	12.61	1,125	420.0	3.33	199.8	0.19	17
125.0	0.99	59.5	11.04	985	425.0	3.37	202.2	0.18	16
130.0	1.03	61.8	9.99	891	430.0	3.41	204.6	0.17	15
135.0	1.07	64.2	9.04	806	435.0	3.45	207.0	0.16	14
140.0	1.11	66.6	8.20	731	440.0	3.49	209.3	0.15	13
145.0	1.15	69.0	7.36	656	445.0	3.53	211.7	0.15	13
150.0	1.19	71.4	6.78	605	450.0	3.57	214.1	0.13	12
155.0	1.23	73.7	6.20	553	455.0	3.61	216.5	0.12	11
160.0	1.27	76.1	5.83	520	460.0	3.65	218.8	0.12	11
165.0	1.31	78.5	5.47	488	465.0	3.69	221.2	0.11	10
170.0	1.35	80.9	5.15	459	470.0	3.73	223.6		
175.0	1.39	83.3	4.84	432	475.0	3.77	226.0		
180.0	1.43	85.6	4.57	408	480.0	3.81	228.4		
185.0	1.47	88.0	4.31	384	485.0	3.85	230.7		
190.0	1.51	90.4	4.10	366	490.0	3.89	233.1		
195.0	1.55	92.8	3.87	345	495.0	3.92	235.5		
200.0	1.59	95.2	3.68	328	500.0	3.96	237.9		
205.0	1.63	97.5	3.47	309	505.0	4.00	240.3		
210.0	1.67	99.9	3.28	293	510.0	4.04	242.6		
215.0	1.70	102.3	3.10	276	515.0	4.08	245.0		
220.0	1.74	104.7	2.93	261	520.0	4.12	247.4		
225.0	1.78	107.0	2.75	245	525.0	4.16	249.8		
230.0	1.82	109.4	2.63	235	530.0	4.20	252.2		
235.0	1.86	111.8	2.47	220	535.0	4.24	254.5		
240.0	1.90	114.2	2.33	208	540.0	4.28	256.9		
245.0	1.94	116.6	2.22	198	545.0	4.32	259.3		
250.0	1.98	118.9	2.10	187	550.0	4.36	261.7		
255.0	2.02	121.3	1.99	177	555.0	4.40	264.0		
260.0	2.06	123.7	1.88	168	560.0	4.44	266.4		
265.0	2.10	126.1	1.78	159	565.0	4.48	268.8		
270.0	2.14	128.5	1.68	150	570.0	4.52	271.2		
275.0	2.18	130.8	1.59	142	575.0	4.56	273.6		
280.0	2.22	133.2	1.50	134	580.0	4.60	275.9		
285.0	2.26	135.6	1.43	128	585.0	4.64	278.3		
290.0	2.30	138.0	1.36	121	590.0	4.68	280.7		
295.0	2.34	140.3	1.28	114	595.0	4.72	283.1		
300.0	2.38	142.7	1.21	108	600.0	4.76	285.5		

NOTES : Use for models including Basin 1 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

Basin 1-PMP Existing Conditions

Drainage Area =	2.63 sq. miles	Lg+D/2 =	0.61 Hours
Basin Slope =	356 ft./mile	Basin Factor =	0.13
L =	2.92 mi., Length of Watercourse	V' =	70.72 cfs/Day
Lca =	0.87 mi., Distance to Centroid	Qs =	116.9 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

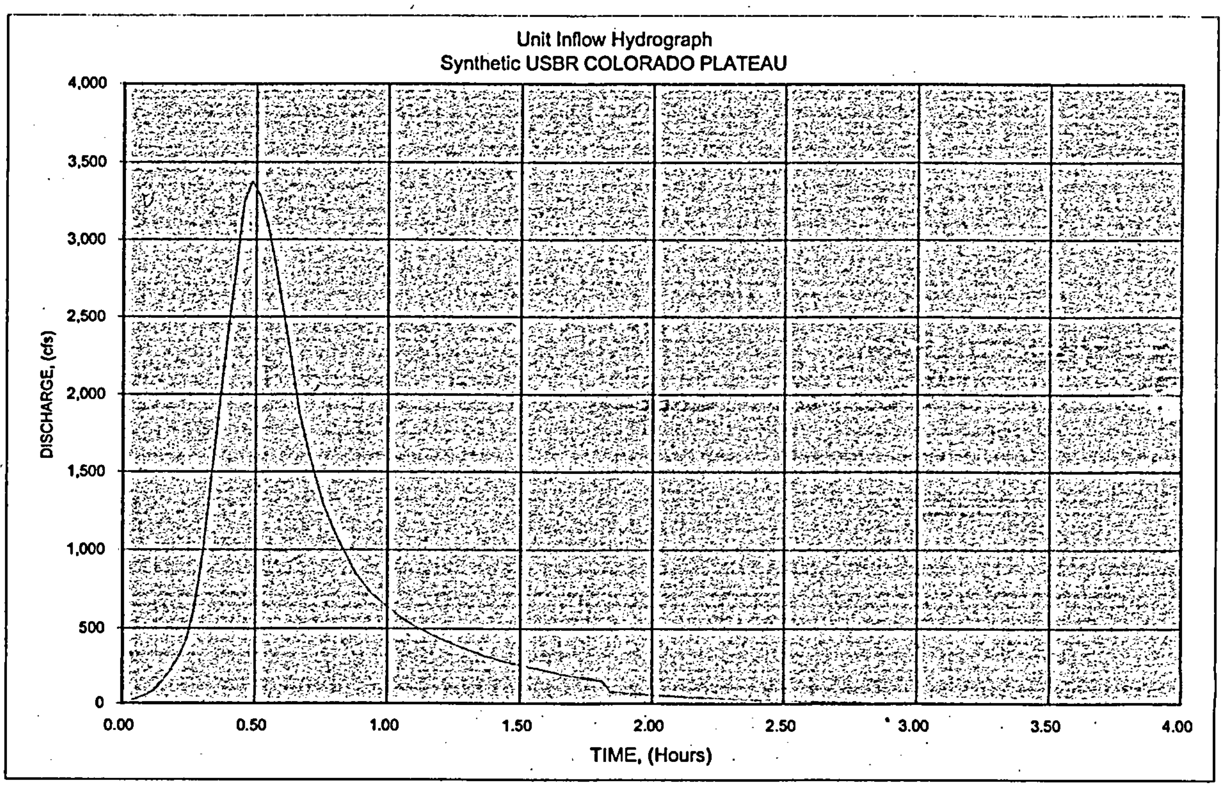
PARAMETERS:

Calculated: Lag Time, Lg = 0.56 Hours — Unit Duration, D = 6.15 minutes; Calculated Timestep = 1.82 minutes

Data to be used in Analysis

Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	52	177	485	1482	2709	3327	2740	1872	1329	1003
UI	772	637	540	464	399	341	292	251	216	185
UI	160	137	117	100	87	75	64	55	47	41
UI	34	30	26	23	19	17	14			
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USBR calculated unitgraph peak = 3379 Interpolated Peak = 3327

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.8	0.19	22	305.0	1.85	110.7	0.66	77
10.0	0.06	3.6	0.32	37	310.0	1.88	112.6	0.63	74
15.0	0.09	5.4	0.48	56	315.0	1.91	114.4	0.59	69
20.0	0.12	7.3	0.74	86	320.0	1.94	116.2	0.56	65
25.0	0.15	9.1	1.21	141	325.0	1.97	118.0	0.53	62
30.0	0.18	10.9	1.81	212	330.0	2.00	119.8	0.50	58
35.0	0.21	12.7	2.63	307	335.0	2.03	121.6	0.47	55
40.0	0.24	14.5	3.68	430	340.0	2.06	123.4	0.45	53
45.0	0.27	16.3	5.47	639	345.0	2.09	125.3	0.42	49
50.0	0.30	18.2	8.41	983	350.0	2.12	127.1	0.40	47
55.0	0.33	20.0	12.61	1,474	355.0	2.15	128.9	0.38	44
60.0	0.36	21.8	16.50	1,928	360.0	2.18	130.7	0.36	42
65.0	0.39	23.6	20.50	2,396	365.0	2.21	132.5	0.34	40
70.0	0.42	25.4	23.97	2,801	370.0	2.24	134.3	0.33	39
75.0	0.45	27.2	27.75	3,243	375.0	2.27	136.1	0.30	35
80.0	0.48	29.0	28.91	3,379	380.0	2.30	138.0	0.28	33
85.0	0.51	30.9	28.07	3,281	385.0	2.33	139.8	0.27	32
90.0	0.54	32.7	26.38	3,083	390.0	2.36	141.6	0.26	30
95.0	0.57	34.5	24.18	2,826	395.0	2.39	143.4	0.24	28
100.0	0.61	36.3	21.55	2,519	400.0	2.42	145.2	0.23	27
105.0	0.64	38.1	18.92	2,211	405.0	2.45	147.0	0.22	26
110.0	0.67	39.9	16.08	1,879	410.0	2.48	148.9	0.21	25
115.0	0.70	41.8	14.19	1,658	415.0	2.51	150.7	0.20	23
120.0	0.73	43.6	12.61	1,474	420.0	2.54	152.5	0.19	22
125.0	0.76	45.4	11.04	1,290	425.0	2.57	154.3	0.18	21
130.0	0.79	47.2	9.99	1,168	430.0	2.60	156.1	0.17	20
135.0	0.82	49.0	9.04	1,057	435.0	2.63	157.9	0.16	19
140.0	0.85	50.8	8.20	958	440.0	2.66	159.7	0.15	18
145.0	0.88	52.6	7.36	860	445.0	2.69	161.6	0.15	18
150.0	0.91	54.5	6.78	792	450.0	2.72	163.4	0.13	15
155.0	0.94	56.3	6.20	725	455.0	2.75	165.2	0.12	14
160.0	0.97	58.1	5.83	681	460.0	2.78	167.0	0.12	14
165.0	1.00	59.9	5.47	639	465.0	2.81	168.8	0.11	13
170.0	1.03	61.7	5.15	602	470.0	2.84	170.6		
175.0	1.06	63.5	4.84	566	475.0	2.87	172.5		
180.0	1.09	65.4	4.57	534	480.0	2.90	174.3		
185.0	1.12	67.2	4.31	504	485.0	2.93	176.1		
190.0	1.15	69.0	4.10	479	490.0	2.97	177.9		
195.0	1.18	70.8	3.87	452	495.0	3.00	179.7		
200.0	1.21	72.6	3.68	430	500.0	3.03	181.5		
205.0	1.24	74.4	3.47	406	505.0	3.06	183.3		
210.0	1.27	76.2	3.28	383	510.0	3.09	185.2		
215.0	1.30	78.1	3.10	362	515.0	3.12	187.0		
220.0	1.33	79.9	2.93	342	520.0	3.15	188.8		
225.0	1.36	81.7	2.75	321	525.0	3.18	190.6		
230.0	1.39	83.5	2.63	307	530.0	3.21	192.4		
235.0	1.42	85.3	2.47	289	535.0	3.24	194.2		
240.0	1.45	87.1	2.33	272	540.0	3.27	196.1		
245.0	1.48	89.0	2.22	259	545.0	3.30	197.9		
250.0	1.51	90.8	2.10	245	550.0	3.33	199.7		
255.0	1.54	92.6	1.99	233	555.0	3.36	201.5		
260.0	1.57	94.4	1.88	220	560.0	3.39	203.3		
265.0	1.60	96.2	1.78	208	565.0	3.42	205.1		
270.0	1.63	98.0	1.68	196	570.0	3.45	206.9		
275.0	1.66	99.8	1.59	186	575.0	3.48	208.8		
280.0	1.69	101.7	1.50	175	580.0	3.51	210.6		
285.0	1.72	103.5	1.43	167	585.0	3.54	212.4		
290.0	1.75	105.3	1.36	159	590.0	3.57	214.2		
295.0	1.79	107.1	1.28	150	595.0	3.60	216.0		
300.0	1.82	108.9	1.21	141	600.0	3.63	217.8		

NOTES : Use for models including Basin 1 for the PMP Local event

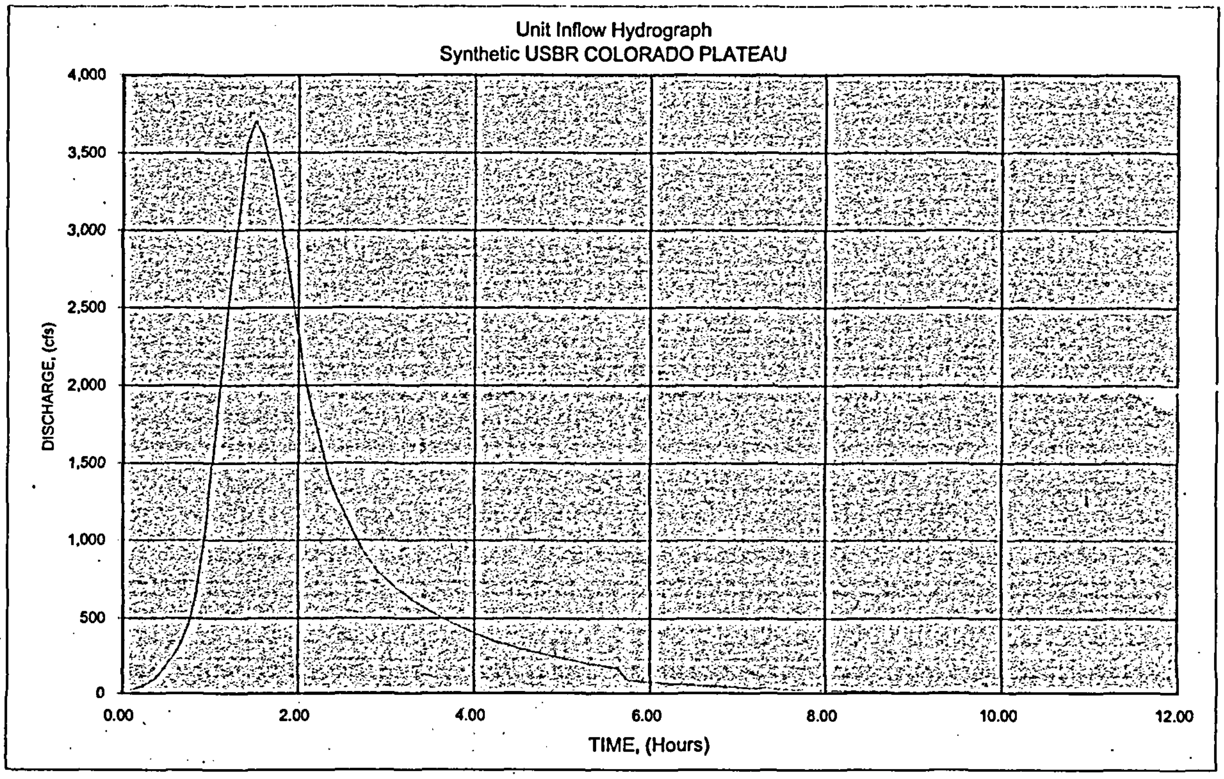
COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin 2-10, 25, 100, 200 Existing Conditions

Drainage Area =	8.96 sq. miles	Lg+D/2 =	1.88 Hours
Basin Slope =	283 ft./mile	Basin Factor =	1.97
L =	7.67 mi., Length of Watercourse	V' =	240.93 cfs/Day
Lca =	4.31 mi., Distance to Centroid	Qs =	128.2 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:
Calculated: Lag Time, Lg = 1.75 Hours Unit Duration, D = 19.14 minutes
Calculated Timestep = 5.64 minutes

Data to be used in Analysis Unit Duration, D = 15 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	22	37	55	80	121	180	254	350	469	671
UI	985	1423	1879	2327	2761	3163	3568	3700	3615	3439
UI	3206	2928	2629	2323	2021	1808	1628	1450	1319	1207
UI	1106	1011	924	858	793	751	710	673	637	604
UI	574	546	522	496	474	450	428	407	388	368
UI	349	335	317	301	288	274	262	249	237	226
UI	214	204	194	186	178	169	160	153	146	138
UI	131	125	119	113	108	103	99	94	88	85
UI	81	77	73	70	67	63	60	58	54	52
UI	50	47	45	43	41	38	36	35	34	32
UI	30	29	28	27	26	24	23	22	21	20
UI	19	18	16	15	15	14	4			
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USBR calculated unitgraph peak = 3706 Interpolated Peak = 3700

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.09	5.6	0.19	24	305.0	5.73	344.0	0.66	85
10.0	0.19	11.3	0.32	41	310.0	5.83	349.6	0.63	81
15.0	0.28	16.9	0.48	62	315.0	5.92	355.2	0.59	76
20.0	0.38	22.6	0.74	95	320.0	6.01	360.9	0.56	72
25.0	0.47	28.2	1.21	155	325.0	6.11	366.5	0.53	68
30.0	0.56	33.8	1.81	232	330.0	6.20	372.2	0.50	64
35.0	0.66	39.5	2.63	337	335.0	6.30	377.8	0.47	60
40.0	0.75	45.1	3.68	472	340.0	6.39	383.4	0.45	58
45.0	0.85	50.7	5.47	701	345.0	6.48	389.1	0.42	54
50.0	0.94	56.4	8.41	1,078	350.0	6.58	394.7	0.40	51
55.0	1.03	62.0	12.61	1,616	355.0	6.67	400.4	0.38	49
60.0	1.13	67.7	16.50	2,115	360.0	6.77	406.0	0.36	46
65.0	1.22	73.3	20.50	2,628	365.0	6.86	411.6	0.34	44
70.0	1.32	78.9	23.97	3,073	370.0	6.95	417.3	0.33	42
75.0	1.41	84.6	27.75	3,557	375.0	7.05	422.9	0.30	38
80.0	1.50	90.2	28.91	3,706	380.0	7.14	428.6	0.28	36
85.0	1.60	95.9	28.07	3,598	385.0	7.24	434.2	0.27	35
90.0	1.69	101.5	26.38	3,381	390.0	7.33	439.8	0.26	33
95.0	1.79	107.1	24.18	3,099	395.0	7.42	445.5	0.24	31
100.0	1.88	112.8	21.55	2,762	400.0	7.52	451.1	0.23	29
105.0	1.97	118.4	18.92	2,425	405.0	7.61	456.7	0.22	28
110.0	2.07	124.1	16.08	2,061	410.0	7.71	462.4	0.21	27
115.0	2.16	129.7	14.19	1,819	415.0	7.80	468.0	0.20	26
120.0	2.26	135.3	12.61	1,616	420.0	7.89	473.7	0.19	24
125.0	2.35	141.0	11.04	1,415	425.0	7.99	479.3	0.18	23
130.0	2.44	146.6	9.99	1,281	430.0	8.08	484.9	0.17	22
135.0	2.54	152.2	9.04	1,159	435.0	8.18	490.6	0.16	21
140.0	2.63	157.9	8.20	1,051	440.0	8.27	496.2	0.15	19
145.0	2.73	163.5	7.36	943	445.0	8.36	501.9	0.15	19
150.0	2.82	169.2	6.78	869	450.0	8.46	507.5	0.13	17
155.0	2.91	174.8	6.20	795	455.0	8.55	513.1	0.12	15
160.0	3.01	180.4	5.83	747	460.0	8.65	518.8	0.12	15
165.0	3.10	186.1	5.47	701	465.0	8.74	524.4	0.11	14
170.0	3.20	191.7	5.15	660	470.0	8.83	530.1		
175.0	3.29	197.4	4.84	620	475.0	8.93	535.7		
180.0	3.38	203.0	4.57	586	480.0	9.02	541.3		
185.0	3.48	208.6	4.31	552	485.0	9.12	547.0		
190.0	3.57	214.3	4.10	526	490.0	9.21	552.6		
195.0	3.67	219.9	3.87	496	495.0	9.30	558.2		
200.0	3.76	225.6	3.68	472	500.0	9.40	563.9		
205.0	3.85	231.2	3.47	445	505.0	9.49	569.5		
210.0	3.95	236.8	3.28	420	510.0	9.59	575.2		
215.0	4.04	242.5	3.10	397	515.0	9.68	580.8		
220.0	4.14	248.1	2.93	376	520.0	9.77	586.4		
225.0	4.23	253.7	2.75	353	525.0	9.87	592.1		
230.0	4.32	259.4	2.63	337	530.0	9.96	597.7		
235.0	4.42	265.0	2.47	317	535.0	10.06	603.4		
240.0	4.51	270.7	2.33	299	540.0	10.15	609.0		
245.0	4.61	276.3	2.22	285	545.0	10.24	614.6		
250.0	4.70	281.9	2.10	269	550.0	10.34	620.3		
255.0	4.79	287.6	1.99	255	555.0	10.43	625.9		
260.0	4.89	293.2	1.88	241	560.0	10.53	631.6		
265.0	4.98	298.9	1.78	228	565.0	10.62	637.2		
270.0	5.07	304.5	1.68	215	570.0	10.71	642.8		
275.0	5.17	310.1	1.59	204	575.0	10.81	648.5		
280.0	5.26	315.8	1.50	192	580.0	10.90	654.1		
285.0	5.36	321.4	1.43	183	585.0	11.00	659.7		
290.0	5.45	327.1	1.36	174	590.0	11.09	665.4		
295.0	5.54	332.7	1.28	164	595.0	11.18	671.0		
300.0	5.64	338.3	1.21	155	600.0	11.28	676.7		

NOTES : Use for models including Basin 2 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

Basin 2-PMP Existing Conditions

Drainage Area =	8.96 sq. miles	Lg+D/2 =	1.45	Hours
Basin Slope =	283 ft./mile	Basin Factor =	1.97	
L =	7.67 mi., Length of Watercourse	V' =	240.93	cfs/Day
Lca =	4.31 mi., Distance to Centroid	Qs =	166.4	* q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

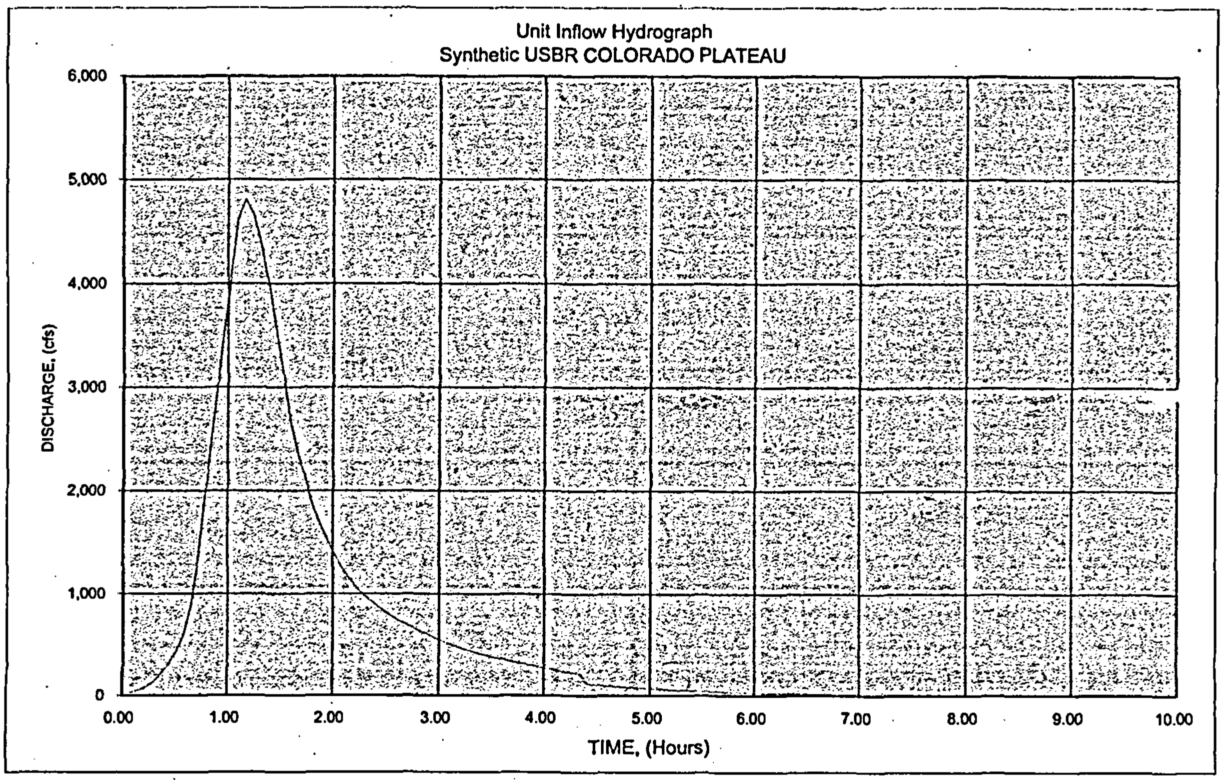
PARAMETERS:

Calculated: Lag Time, Lg = 1.36 Hours   Unit Duration, D = 14.89 minutes

Calculated Timestep = 4.34 minutes

Data to be used in Analysis Unit Duration, D = 10 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	35	61	99	170	277	425	629	1012	1650	2428
UI	3185	3880	4594	4794	4596	4237	3775	3272	2738	2356
UI	2054	1781	1587	1417	1256	1135	1027	956	890	830
UI	775	724	683	640	602	564	528	495	461	437
UI	407	381	360	338	317	297	278	261	245	232
UI	217	203	191	178	167	157	146	138	130	123
UI	114	108	101	95	89	83	78	74	68	65
UI	61	57	55	49	46	44	41	39	37	35
UI	33	31	29	27	25	25	21	20	19	8
UI										
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USBR calculated unitgraph peak = 4810 Interpolated Peak = 4794

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.07	4.3	0.19	32	305.0	4.42	265.0	0.66	110
10.0	0.14	8.7	0.32	53	310.0	4.49	269.3	0.63	105
15.0	0.22	13.0	0.48	80	315.0	4.56	273.7	0.59	98
20.0	0.29	17.4	0.74	123	320.0	4.63	278.0	0.56	93
25.0	0.36	21.7	1.21	201	325.0	4.71	282.4	0.53	88
30.0	0.43	26.1	1.81	301	330.0	4.78	286.7	0.50	83
35.0	0.51	30.4	2.63	438	335.0	4.85	291.1	0.47	78
40.0	0.58	34.8	3.68	612	340.0	4.92	295.4	0.45	75
45.0	0.65	39.1	5.47	910	345.0	5.00	299.7	0.42	70
50.0	0.72	43.4	8.41	1,399	350.0	5.07	304.1	0.40	67
55.0	0.80	47.8	12.61	2,098	355.0	5.14	308.4	0.38	63
60.0	0.87	52.1	16.50	2,745	360.0	5.21	312.8	0.36	60
65.0	0.94	56.5	20.50	3,411	365.0	5.29	317.1	0.34	57
70.0	1.01	60.8	23.97	3,988	370.0	5.36	321.5	0.33	55
75.0	1.09	65.2	27.75	4,617	375.0	5.43	325.8	0.30	50
80.0	1.16	69.5	28.91	4,810	380.0	5.50	330.2	0.28	47
85.0	1.23	73.8	28.07	4,670	385.0	5.57	334.5	0.27	45
90.0	1.30	78.2	26.38	4,389	390.0	5.65	338.8	0.26	43
95.0	1.38	82.5	24.18	4,023	395.0	5.72	343.2	0.24	40
100.0	1.45	86.9	21.55	3,586	400.0	5.79	347.5	0.23	38
105.0	1.52	91.2	18.92	3,148	405.0	5.86	351.9	0.22	37
110.0	1.59	95.6	16.08	2,676	410.0	5.94	356.2	0.21	35
115.0	1.67	99.9	14.19	2,361	415.0	6.01	360.6	0.20	33
120.0	1.74	104.3	12.61	2,098	420.0	6.08	364.9	0.19	32
125.0	1.81	108.6	11.04	1,837	425.0	6.15	369.2	0.18	30
130.0	1.88	112.9	9.99	1,662	430.0	6.23	373.6	0.17	28
135.0	1.95	117.3	9.04	1,504	435.0	6.30	377.9	0.16	27
140.0	2.03	121.6	8.20	1,364	440.0	6.37	382.3	0.15	25
145.0	2.10	126.0	7.36	1,225	445.0	6.44	386.6	0.15	25
150.0	2.17	130.3	6.78	1,128	450.0	6.52	391.0	0.13	22
155.0	2.24	134.7	6.20	1,032	455.0	6.59	395.3	0.12	20
160.0	2.32	139.0	5.83	970	460.0	6.66	399.7	0.12	20
165.0	2.39	143.4	5.47	910	465.0	6.73	404.0	0.11	18
170.0	2.46	147.7	5.15	857	470.0	6.81	408.3		
175.0	2.53	152.0	4.84	805	475.0	6.88	412.7		
180.0	2.61	156.4	4.57	760	480.0	6.95	417.0		
185.0	2.68	160.7	4.31	717	485.0	7.02	421.4		
190.0	2.75	165.1	4.10	682	490.0	7.10	425.7		
195.0	2.82	169.4	3.87	644	495.0	7.17	430.1		
200.0	2.90	173.8	3.68	612	500.0	7.24	434.4		
205.0	2.97	178.1	3.47	577	505.0	7.31	438.8		
210.0	3.04	182.5	3.28	546	510.0	7.38	443.1		
215.0	3.11	186.8	3.10	516	515.0	7.46	447.4		
220.0	3.19	191.1	2.93	488	520.0	7.53	451.8		
225.0	3.26	195.5	2.75	458	525.0	7.60	456.1		
230.0	3.33	199.8	2.63	438	530.0	7.67	460.5		
235.0	3.40	204.2	2.47	411	535.0	7.75	464.8		
240.0	3.48	208.5	2.33	388	540.0	7.82	469.2		
245.0	3.55	212.9	2.22	369	545.0	7.89	473.5		
250.0	3.62	217.2	2.10	349	550.0	7.96	477.9		
255.0	3.69	221.5	1.99	331	555.0	8.04	482.2		
260.0	3.76	225.9	1.88	313	560.0	8.11	486.5		
265.0	3.84	230.2	1.78	296	565.0	8.18	490.9		
270.0	3.91	234.6	1.68	280	570.0	8.25	495.2		
275.0	3.98	238.9	1.59	265	575.0	8.33	499.6		
280.0	4.05	243.3	1.50	250	580.0	8.40	503.9		
285.0	4.13	247.6	1.43	238	585.0	8.47	508.3		
290.0	4.20	252.0	1.36	226	590.0	8.54	512.6		
295.0	4.27	256.3	1.28	213	595.0	8.62	516.9		
300.0	4.34	260.6	1.21	201	600.0	8.69	521.3		

NOTES : Use for models including Basin 2 for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

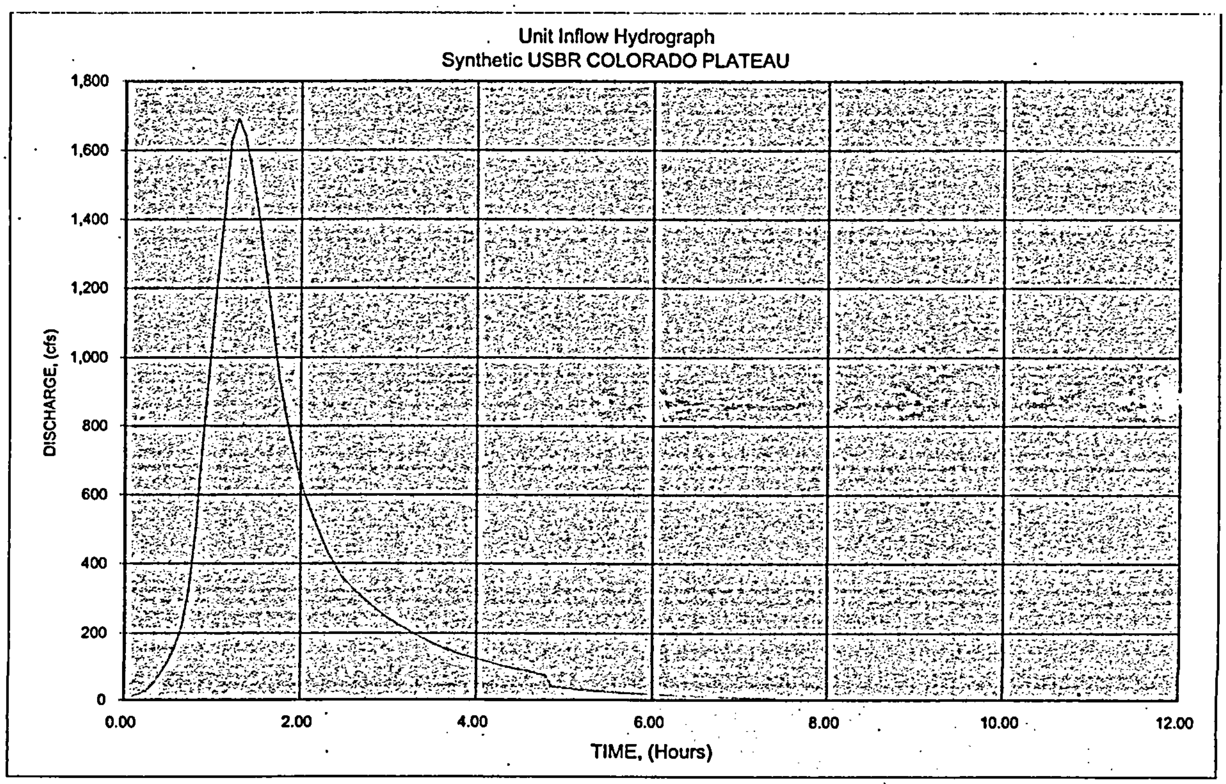
Basin 3-10, 25, 100, 200 Existing Conditions

Drainage Area =	3.47 sq. miles	Lg+D/2 =	1.59 Hours
Basin Slope =	57.1 ft./mile	Basin Factor =	1.15
L =	4.73 mi., Length of Watercourse	V' =	93.31 cfs/Day
Lca =	1.83 mi., Distance to Centroid	Qs =	58.6 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	1.47 Hours	Unit Duration, D =	16.02 minutes
			Calculated Timestep =	4.78 minutes

Data to be used	Unit Duration, D =	15 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph 5 **minute Interval**

UI	11	20	30	48	79	119	174	254	392	606
UI	854	1096	1322	1546	1672	1657	1566	1438	1281	1120
UI	947	830	733	640	577	520	468	421	386	355
UI	332	311	292	275	258	244	231	218	206	194
UI	183	172	161	154	144	136	129	122	115	108
UI	102	96	91	86	82	77	72	69	64	61
UI	57	54	51	48	46	43	40	38	36	34
UI	32	30	29	27	26	24	23	22	20	20
UI	18	17	16	15	14	13	13	12	12	11
UI	10	10	9	9	8	7	7	7	3	
UI										
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USBR calculated unitgraph peak = 1693 Interpolated Peak = 1672

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.08	4.8	0.19	11	305.0	4.86	291.6	0.66	39
10.0	0.16	9.6	0.32	19	310.0	4.94	296.4	0.63	37
15.0	0.24	14.3	0.48	28	315.0	5.02	301.1	0.59	35
20.0	0.32	19.1	0.74	43	320.0	5.10	305.9	0.56	33
25.0	0.40	23.9	1.21	71	325.0	5.18	310.7	0.53	31
30.0	0.48	28.7	1.81	106	330.0	5.26	315.5	0.50	29
35.0	0.56	33.5	2.63	154	335.0	5.34	320.3	0.47	28
40.0	0.64	38.2	3.68	216	340.0	5.42	325.0	0.45	26
45.0	0.72	43.0	5.47	320	345.0	5.50	329.8	0.42	25
50.0	0.80	47.8	8.41	492	350.0	5.58	334.6	0.40	23
55.0	0.88	52.6	12.61	738	355.0	5.66	339.4	0.38	22
60.0	0.96	57.4	16.50	966	360.0	5.74	344.2	0.36	21
65.0	1.04	62.1	20.50	1,200	365.0	5.82	348.9	0.34	20
70.0	1.12	66.9	23.97	1,404	370.0	5.90	353.7	0.33	19
75.0	1.20	71.7	27.75	1,625	375.0	5.98	358.5	0.30	18
80.0	1.27	76.5	28.91	1,693	380.0	6.05	363.3	0.28	16
85.0	1.35	81.3	28.07	1,644	385.0	6.13	368.1	0.27	16
90.0	1.43	86.0	26.38	1,545	390.0	6.21	372.8	0.26	15
95.0	1.51	90.8	24.18	1,416	395.0	6.29	377.6	0.24	14
100.0	1.59	95.6	21.55	1,262	400.0	6.37	382.4	0.23	13
105.0	1.67	100.4	18.92	1,108	405.0	6.45	387.2	0.22	13
110.0	1.75	105.2	16.08	942	410.0	6.53	392.0	0.21	12
115.0	1.83	109.9	14.19	831	415.0	6.61	396.7	0.20	12
120.0	1.91	114.7	12.61	738	420.0	6.69	401.5	0.19	11
125.0	1.99	119.5	11.04	647	425.0	6.77	406.3	0.18	11
130.0	2.07	124.3	9.99	585	430.0	6.85	411.1	0.17	10
135.0	2.15	129.1	9.04	529	435.0	6.93	415.9	0.16	9
140.0	2.23	133.8	8.20	480	440.0	7.01	420.6	0.15	9
145.0	2.31	138.6	7.36	431	445.0	7.09	425.4	0.15	9
150.0	2.39	143.4	6.78	397	450.0	7.17	430.2	0.13	8
155.0	2.47	148.2	6.20	363	455.0	7.25	435.0	0.12	7
160.0	2.55	153.0	5.83	341	460.0	7.33	439.8	0.12	7
165.0	2.63	157.7	5.47	320	465.0	7.41	444.5	0.11	6
170.0	2.71	162.5	5.15	302	470.0	7.49	449.3		
175.0	2.79	167.3	4.84	283	475.0	7.57	454.1		
180.0	2.87	172.1	4.57	268	480.0	7.65	458.9		
185.0	2.95	176.9	4.31	252	485.0	7.73	463.7		
190.0	3.03	181.6	4.10	240	490.0	7.81	468.5		
195.0	3.11	186.4	3.87	227	495.0	7.89	473.2		
200.0	3.19	191.2	3.68	216	500.0	7.97	478.0		
205.0	3.27	196.0	3.47	203	505.0	8.05	482.8		
210.0	3.35	200.8	3.28	192	510.0	8.13	487.6		
215.0	3.43	205.5	3.10	182	515.0	8.21	492.4		
220.0	3.51	210.3	2.93	172	520.0	8.29	497.1		
225.0	3.59	215.1	2.75	161	525.0	8.37	501.9		
230.0	3.66	219.9	2.63	154	530.0	8.44	506.7		
235.0	3.74	224.7	2.47	145	535.0	8.52	511.5		
240.0	3.82	229.4	2.33	136	540.0	8.60	516.3		
245.0	3.90	234.2	2.22	130	545.0	8.68	521.0		
250.0	3.98	239.0	2.10	123	550.0	8.76	525.8		
255.0	4.06	243.8	1.99	117	555.0	8.84	530.6		
260.0	4.14	248.6	1.88	110	560.0	8.92	535.4		
265.0	4.22	253.3	1.78	104	565.0	9.00	540.2		
270.0	4.30	258.1	1.68	98	570.0	9.08	544.9		
275.0	4.38	262.9	1.59	93	575.0	9.16	549.7		
280.0	4.46	267.7	1.50	88	580.0	9.24	554.5		
285.0	4.54	272.5	1.43	84	585.0	9.32	559.3		
290.0	4.62	277.2	1.36	80	590.0	9.40	564.1		
295.0	4.70	282.0	1.28	75	595.0	9.48	568.8		
300.0	4.78	286.8	1.21	71	600.0	9.56	573.6		

NOTES : Use for models including Basin 3 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin 3-PMP Existing Conditions

Drainage Area =	3.47 sq. miles	Lg+D/2 =	1.23 Hours
Basin Slope =	57.1 ft./mile	Basin Factor =	1.15
L =	4.73 mi., Length of Watercourse	V' =	93.31 cfs/Day
Lca =	1.83 mi., Distance to Centroid	Qs =	76.1 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

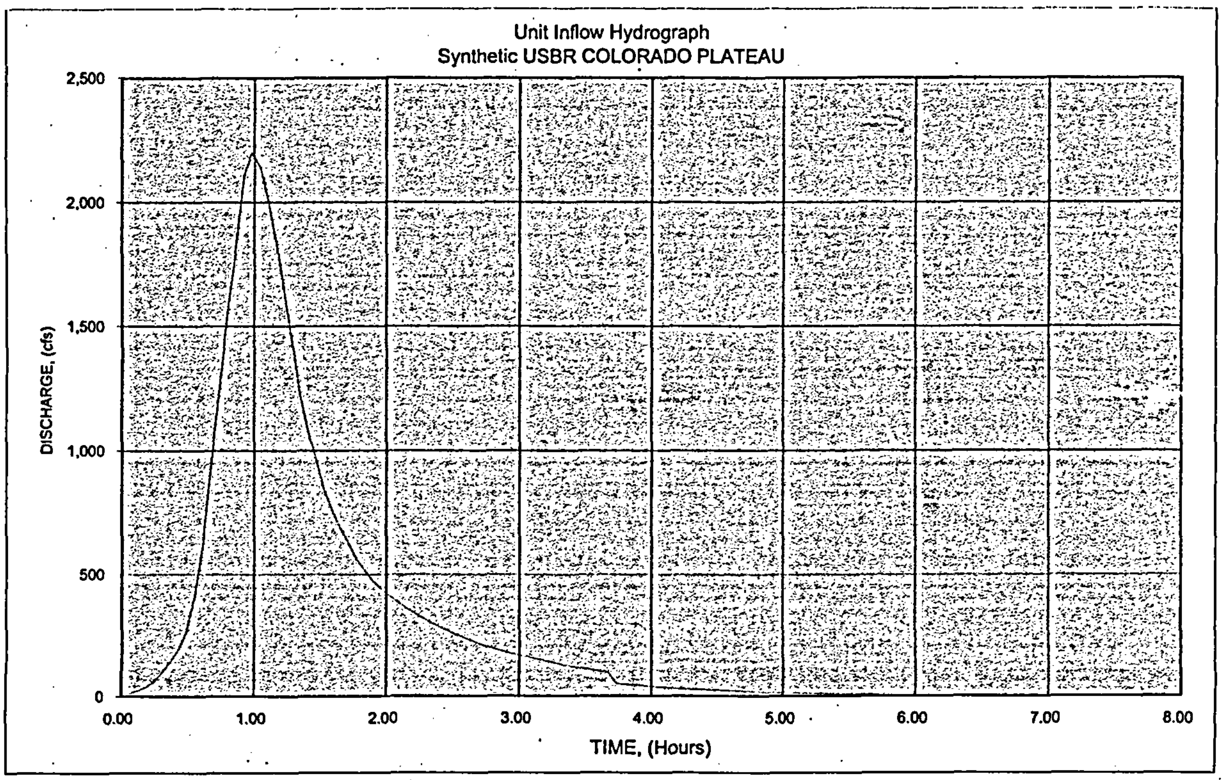
PARAMETERS:

Calculated: Lag Time, Lg = 1.14 Hours Unit Duration, D = 12.46 minutes

Calculated Timestep = 3.68 minutes

Data to be used in Analysis Unit Duration, D = 10 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute Interval**

UI	18	33	59	112	188	302	533	922	1330	1720
UI	2102	2181	2050	1833	1561	1276	1066	903	773	675
UI	588	520	464	426	392	361	334	311	288	267
UI	248	229	211	197	182	169	157	146	135	125
UI	116	108	101	93	86	80	74	68	64	59
UI	55	51	48	44	41	38	35	32	30	28
UI	26	24	22	21	19	18	17	16	15	14
UI	13	11	11	9	9	5				
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USBR calculated unitgraph peak = 2201 Interpolated Peak = 2181

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.06	3.7	0.19	14	305.0	3.74	224.2	0.66	50
10.0	0.12	7.4	0.32	24	310.0	3.80	227.9	0.63	48
15.0	0.18	11.0	0.48	37	315.0	3.86	231.6	0.59	45
20.0	0.25	14.7	0.74	56	320.0	3.92	235.3	0.56	43
25.0	0.31	18.4	1.21	92	325.0	3.98	239.0	0.53	40
30.0	0.37	22.1	1.81	138	330.0	4.04	242.6	0.50	38
35.0	0.43	25.7	2.63	200	335.0	4.11	246.3	0.47	36
40.0	0.49	29.4	3.68	280	340.0	4.17	250.0	0.45	34
45.0	0.55	33.1	5.47	417	345.0	4.23	253.7	0.42	32
50.0	0.61	36.8	8.41	640	350.0	4.29	257.3	0.40	30
55.0	0.67	40.4	12.61	960	355.0	4.35	261.0	0.38	29
60.0	0.74	44.1	16.50	1,256	360.0	4.41	264.7	0.36	27
65.0	0.80	47.8	20.50	1,561	365.0	4.47	268.4	0.34	26
70.0	0.86	51.5	23.97	1,825	370.0	4.53	272.0	0.33	25
75.0	0.92	55.1	27.75	2,113	375.0	4.60	275.7	0.30	23
80.0	0.98	58.8	28.91	2,201	380.0	4.66	279.4	0.28	21
85.0	1.04	62.5	28.07	2,137	385.0	4.72	283.1	0.27	21
90.0	1.10	66.2	26.38	2,009	390.0	4.78	286.7	0.26	20
95.0	1.16	69.8	24.18	1,841	395.0	4.84	290.4	0.24	18
100.0	1.23	73.5	21.55	1,641	400.0	4.90	294.1	0.23	18
105.0	1.29	77.2	18.92	1,441	405.0	4.96	297.8	0.22	17
110.0	1.35	80.9	16.08	1,224	410.0	5.02	301.4	0.21	16
115.0	1.41	84.6	14.19	1,081	415.0	5.09	305.1	0.20	15
120.0	1.47	88.2	12.61	960	420.0	5.15	308.8	0.19	14
125.0	1.53	91.9	11.04	841	425.0	5.21	312.5	0.18	14
130.0	1.59	95.6	9.99	761	430.0	5.27	316.2	0.17	13
135.0	1.65	99.3	9.04	688	435.0	5.33	319.8	0.16	12
140.0	1.72	102.9	8.20	624	440.0	5.39	323.5	0.15	11
145.0	1.78	106.6	7.36	560	445.0	5.45	327.2	0.15	11
150.0	1.84	110.3	6.78	516	450.0	5.51	330.9	0.13	10
155.0	1.90	114.0	6.20	472	455.0	5.58	334.5	0.12	9
160.0	1.96	117.6	5.83	444	460.0	5.64	338.2	0.12	9
165.0	2.02	121.3	5.47	417	465.0	5.70	341.9	0.11	8
170.0	2.08	125.0	5.15	392	470.0	5.76	345.6		
175.0	2.14	128.7	4.84	369	475.0	5.82	349.2		
180.0	2.21	132.3	4.57	348	480.0	5.88	352.9		
185.0	2.27	136.0	4.31	328	485.0	5.94	356.6		
190.0	2.33	139.7	4.10	312	490.0	6.00	360.3		
195.0	2.39	143.4	3.87	295	495.0	6.07	363.9		
200.0	2.45	147.0	3.68	280	500.0	6.13	367.6		
205.0	2.51	150.7	3.47	264	505.0	6.19	371.3		
210.0	2.57	154.4	3.28	250	510.0	6.25	375.0		
215.0	2.63	158.1	3.10	236	515.0	6.31	378.6		
220.0	2.70	161.8	2.93	223	520.0	6.37	382.3		
225.0	2.76	165.4	2.75	209	525.0	6.43	386.0		
230.0	2.82	169.1	2.63	200	530.0	6.49	389.7		
235.0	2.88	172.8	2.47	188	535.0	6.56	393.4		
240.0	2.94	176.5	2.33	177	540.0	6.62	397.0		
245.0	3.00	180.1	2.22	169	545.0	6.68	400.7		
250.0	3.06	183.8	2.10	160	550.0	6.74	404.4		
255.0	3.12	187.5	1.99	152	555.0	6.80	408.1		
260.0	3.19	191.2	1.88	143	560.0	6.86	411.7		
265.0	3.25	194.8	1.78	136	565.0	6.92	415.4		
270.0	3.31	198.5	1.68	128	570.0	6.98	419.1		
275.0	3.37	202.2	1.59	121	575.0	7.05	422.8		
280.0	3.43	205.9	1.50	114	580.0	7.11	426.4		
285.0	3.49	209.5	1.43	109	585.0	7.17	430.1		
290.0	3.55	213.2	1.36	104	590.0	7.23	433.8		
295.0	3.61	216.9	1.28	97	595.0	7.29	437.5		
300.0	3.68	220.6	1.21	92	600.0	7.35	441.1		

NOTES : Use for models including Basin 3 for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

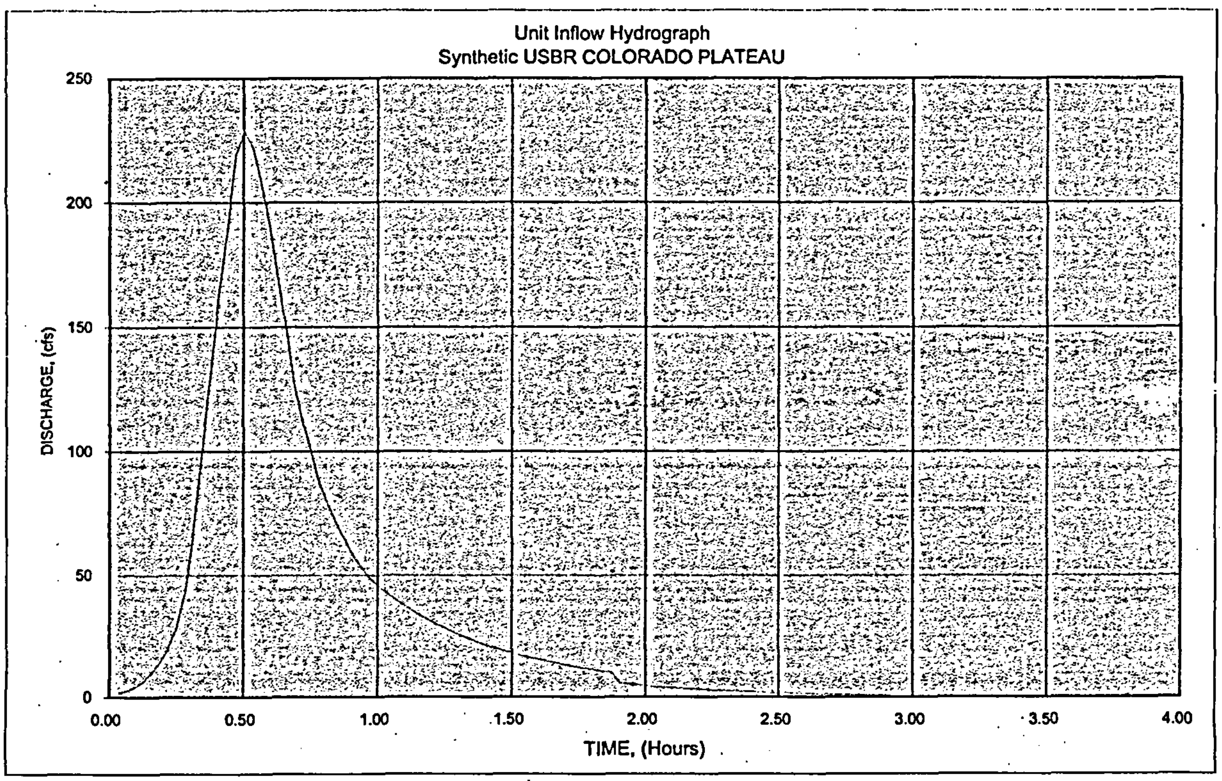
Design Point 1-10, 25, 100, 200 Existing Conditions

Drainage Area =	0.1839 sq. miles	Lg+D/2 =	0.63 Hours
Basin Slope =	70.74 ft./mile	Basin Factor =	0.07
L =	1.13 mi., Length of Watercourse	V' =	4.95 cfs/Day
Lca =	0.52 mi., Distance to Centroid	Qs =	7.9 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.58 Hours	Unit Duration, D =	6.36 minutes
			Calculated Timestep =	1.88 minutes

Data to be used	Unit Duration, D =	5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	3	11	29	89	171	229	197	142	100	74
UI	57	46	39	34	29	25	21	18	16	14
UI	12	10	9	8	7	6	5	4	4	3
UI	3	2	2	2	2	1	1	1	0	
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USBR calculated unitgraph peak = 229 Interpolated Peak = 229

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.9	0.19	2	305.0	1.91	114.4	0.66	5
10.0	0.06	3.8	0.32	3	310.0	1.94	116.3	0.63	5
15.0	0.09	5.6	0.48	4	315.0	1.97	118.1	0.59	5
20.0	0.13	7.5	0.74	6	320.0	2.00	120.0	0.56	4
25.0	0.16	9.4	1.21	10	325.0	2.03	121.9	0.53	4
30.0	0.19	11.3	1.81	14	330.0	2.06	123.8	0.50	4
35.0	0.22	13.1	2.63	21	335.0	2.09	125.6	0.47	4
40.0	0.25	15.0	3.68	29	340.0	2.13	127.5	0.45	4
45.0	0.28	16.9	5.47	43	345.0	2.16	129.4	0.42	3
50.0	0.31	18.8	8.41	67	350.0	2.19	131.3	0.40	3
55.0	0.34	20.6	12.61	100	355.0	2.22	133.1	0.38	3
60.0	0.38	22.5	16.50	131	360.0	2.25	135.0	0.36	3
65.0	0.41	24.4	20.50	162	365.0	2.28	136.9	0.34	3
70.0	0.44	26.3	23.97	190	370.0	2.31	138.8	0.33	3
75.0	0.47	28.1	27.75	220	375.0	2.34	140.6	0.30	2
80.0	0.50	30.0	28.91	229	380.0	2.38	142.5	0.28	2
85.0	0.53	31.9	28.07	222	385.0	2.41	144.4	0.27	2
90.0	0.56	33.8	26.38	209	390.0	2.44	146.3	0.26	2
95.0	0.59	35.6	24.18	191	395.0	2.47	148.1	0.24	2
100.0	0.63	37.5	21.55	170	400.0	2.50	150.0	0.23	2
105.0	0.66	39.4	18.92	150	405.0	2.53	151.9	0.22	2
110.0	0.69	41.3	16.08	127	410.0	2.56	153.8	0.21	2
115.0	0.72	43.1	14.19	112	415.0	2.59	155.6	0.20	2
120.0	0.75	45.0	12.61	100	420.0	2.63	157.5	0.19	2
125.0	0.78	46.9	11.04	87	425.0	2.66	159.4	0.18	1
130.0	0.81	48.8	9.99	79	430.0	2.69	161.3	0.17	1
135.0	0.84	50.6	9.04	72	435.0	2.72	163.1	0.16	1
140.0	0.88	52.5	8.20	65	440.0	2.75	165.0	0.15	1
145.0	0.91	54.4	7.36	58	445.0	2.78	166.9	0.15	1
150.0	0.94	56.3	6.78	54	450.0	2.81	168.8	0.13	1
155.0	0.97	58.1	6.20	49	455.0	2.84	170.6	0.12	1
160.0	1.00	60.0	5.83	46	460.0	2.88	172.5	0.12	1
165.0	1.03	61.9	5.47	43	465.0	2.91	174.4	0.11	1
170.0	1.06	63.8	5.15	41	470.0	2.94	176.3		
175.0	1.09	65.6	4.84	38	475.0	2.97	178.1		
180.0	1.13	67.5	4.57	36	480.0	3.00	180.0		
185.0	1.16	69.4	4.31	34	485.0	3.03	181.9		
190.0	1.19	71.3	4.10	32	490.0	3.06	183.8		
195.0	1.22	73.1	3.87	31	495.0	3.09	185.6		
200.0	1.25	75.0	3.68	29	500.0	3.13	187.5		
205.0	1.28	76.9	3.47	27	505.0	3.16	189.4		
210.0	1.31	78.8	3.28	26	510.0	3.19	191.3		
215.0	1.34	80.6	3.10	25	515.0	3.22	193.1		
220.0	1.38	82.5	2.93	23	520.0	3.25	195.0		
225.0	1.41	84.4	2.75	22	525.0	3.28	196.9		
230.0	1.44	86.3	2.63	21	530.0	3.31	198.8		
235.0	1.47	88.1	2.47	20	535.0	3.34	200.6		
240.0	1.50	90.0	2.33	18	540.0	3.38	202.5		
245.0	1.53	91.9	2.22	18	545.0	3.41	204.4		
250.0	1.56	93.8	2.10	17	550.0	3.44	206.3		
255.0	1.59	95.6	1.99	16	555.0	3.47	208.1		
260.0	1.63	97.5	1.88	15	560.0	3.50	210.0		
265.0	1.66	99.4	1.78	14	565.0	3.53	211.9		
270.0	1.69	101.3	1.68	13	570.0	3.56	213.8		
275.0	1.72	103.1	1.59	13	575.0	3.59	215.6		
280.0	1.75	105.0	1.50	12	580.0	3.63	217.5		
285.0	1.78	106.9	1.43	11	585.0	3.66	219.4		
290.0	1.81	108.8	1.36	11	590.0	3.69	221.3		
295.0	1.84	110.6	1.28	10	595.0	3.72	223.2		
300.0	1.88	112.5	1.21	10	600.0	3.75	225.0		

NOTES : Use for models including Design Point 1 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Design Point 2-10, 25, 100, 200 Existing Conditions

Drainage Area =	0.0863 sq. miles	Lg+D/2 =	0.66 Hours
Basin Slope =	52.14 ft./mile	Basin Factor =	0.08
L =	1.04 mi., Length of Watercourse	V' =	2.32 cfs/Day
Lca =	0.59 mi., Distance to Centroid	Qs =	3.5 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

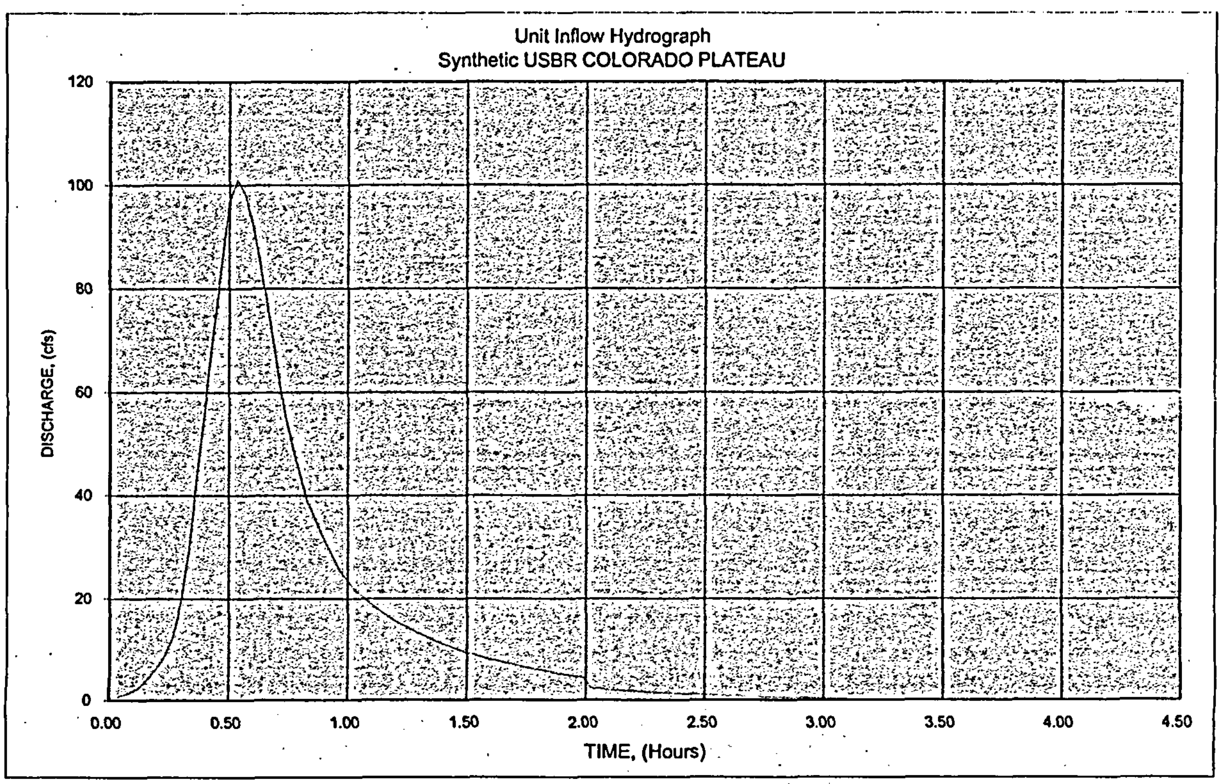
PARAMETERS:

Calculated: Lag Time, Lg = 0.62 Hours Unit Duration, D = 6.79 minutes

Calculated Timestep = 1.99 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	1	4	11	30	65	97	95	75	52	38
UI	30	23	20	17	15	13	11	10	8	7
UI	6	5	5	4	4	3	3	2	2	2
UI	2	1	1	1	1	1	1	1	1	0
UI	0									
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USBR calculated unitgraph peak = 101 Interpolated Peak = 97

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	2.0	0.19	1	305.0	2.03	121.5	0.66	2
10.0	0.07	4.0	0.32	1	310.0	2.06	123.5	0.63	2
15.0	0.10	6.0	0.48	2	315.0	2.09	125.5	0.59	2
20.0	0.13	8.0	0.74	3	320.0	2.12	127.5	0.56	2
25.0	0.17	10.0	1.21	4	325.0	2.16	129.5	0.53	2
30.0	0.20	12.0	1.81	6	330.0	2.19	131.5	0.50	2
35.0	0.23	13.9	2.63	9	335.0	2.22	133.5	0.47	2
40.0	0.27	15.9	3.68	13	340.0	2.26	135.5	0.45	2
45.0	0.30	17.9	5.47	19	345.0	2.29	137.5	0.42	1
50.0	0.33	19.9	8.41	29	350.0	2.32	139.4	0.40	1
55.0	0.37	21.9	12.61	44	355.0	2.36	141.4	0.38	1
60.0	0.40	23.9	16.50	58	360.0	2.39	143.4	0.36	1
65.0	0.43	25.9	20.50	72	365.0	2.42	145.4	0.34	1
70.0	0.46	27.9	23.97	84	370.0	2.46	147.4	0.33	1
75.0	0.50	29.9	27.75	97	375.0	2.49	149.4	0.30	1
80.0	0.53	31.9	28.91	101	380.0	2.52	151.4	0.28	1
85.0	0.56	33.9	28.07	98	385.0	2.56	153.4	0.27	1
90.0	0.60	35.9	26.38	92	390.0	2.59	155.4	0.26	1
95.0	0.63	37.8	24.18	85	395.0	2.62	157.4	0.24	1
100.0	0.66	39.8	21.55	75	400.0	2.66	159.4	0.23	1
105.0	0.70	41.8	18.92	66	405.0	2.69	161.4	0.22	1
110.0	0.73	43.8	16.08	56	410.0	2.72	163.3	0.21	1
115.0	0.76	45.8	14.19	50	415.0	2.76	165.3	0.20	1
120.0	0.80	47.8	12.61	44	420.0	2.79	167.3	0.19	1
125.0	0.83	49.8	11.04	39	425.0	2.82	169.3	0.18	1
130.0	0.86	51.8	9.99	35	430.0	2.86	171.3	0.17	1
135.0	0.90	53.8	9.04	32	435.0	2.89	173.3	0.16	1
140.0	0.93	55.8	8.20	29	440.0	2.92	175.3	0.15	1
145.0	0.96	57.8	7.36	26	445.0	2.95	177.3	0.15	1
150.0	1.00	59.8	6.78	24	450.0	2.99	179.3	0.13	0
155.0	1.03	61.8	6.20	22	455.0	3.02	181.3	0.12	0
160.0	1.06	63.7	5.83	20	460.0	3.05	183.3	0.12	0
165.0	1.10	65.7	5.47	19	465.0	3.09	185.3	0.11	0
170.0	1.13	67.7	5.15	18	470.0	3.12	187.3		
175.0	1.16	69.7	4.84	17	475.0	3.15	189.2		
180.0	1.20	71.7	4.57	16	480.0	3.19	191.2		
185.0	1.23	73.7	4.31	15	485.0	3.22	193.2		
190.0	1.26	75.7	4.10	14	490.0	3.25	195.2		
195.0	1.29	77.7	3.87	14	495.0	3.29	197.2		
200.0	1.33	79.7	3.68	13	500.0	3.32	199.2		
205.0	1.36	81.7	3.47	12	505.0	3.35	201.2		
210.0	1.39	83.7	3.28	11	510.0	3.39	203.2		
215.0	1.43	85.7	3.10	11	515.0	3.42	205.2		
220.0	1.46	87.7	2.93	10	520.0	3.45	207.2		
225.0	1.49	89.6	2.75	10	525.0	3.49	209.2		
230.0	1.53	91.6	2.63	9	530.0	3.52	211.2		
235.0	1.56	93.6	2.47	9	535.0	3.55	213.1		
240.0	1.59	95.6	2.33	8	540.0	3.59	215.1		
245.0	1.63	97.6	2.22	8	545.0	3.62	217.1		
250.0	1.66	99.6	2.10	7	550.0	3.65	219.1		
255.0	1.69	101.6	1.99	7	555.0	3.69	221.1		
260.0	1.73	103.6	1.88	7	560.0	3.72	223.1		
265.0	1.76	105.6	1.78	6	565.0	3.75	225.1		
270.0	1.79	107.6	1.68	6	570.0	3.78	227.1		
275.0	1.83	109.6	1.59	6	575.0	3.82	229.1		
280.0	1.86	111.6	1.50	5	580.0	3.85	231.1		
285.0	1.89	113.5	1.43	5	585.0	3.88	233.1		
290.0	1.93	115.5	1.36	5	590.0	3.92	235.1		
295.0	1.96	117.5	1.28	4	595.0	3.95	237.1		
300.0	1.99	119.5	1.21	4	600.0	3.98	239.0		

NOTES : Use for models including Design Point 2 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Design Point 3-10, 25, 100, 200 Existing Conditions

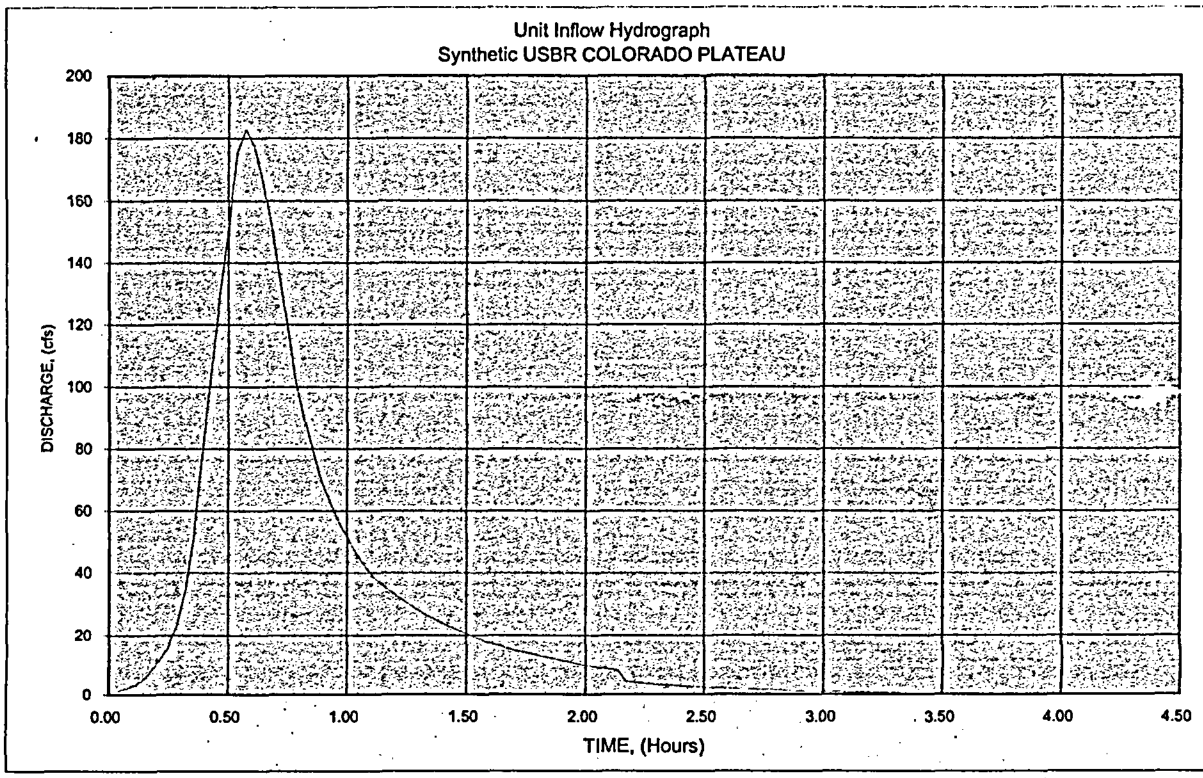
Drainage Area =	0.1675 sq. miles	Lg+D/2 =	0.71 Hours
Basin Slope =	77.56 ft./mile	Basin Factor =	0.11
L =	1.34 mi., Length of Watercourse	V' =	4.50 cfs/Day
Lca =	0.7 mi., Distance to Centroid	Qs =	6.3 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.67 Hours	Unit Duration, D =	7.31 minutes
			Calculated Timestep =	2.14 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	2	7	17	41	97	153	181	157	119	86
UI	65	51	41	35	30	27	24	21	18	16
UI	14	12	11	9	8	7	6	6	5	4
UI	4	3	3	3	2	2	2	2	1	1
UI	1	1	1	1						
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USBR calculated unitgraph peak = 183 Interpolated Peak = 181

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.04	2.1	0.19	1	305.0	2.17	130.3	0.66	4
10.0	0.07	4.3	0.32	2	310.0	2.21	132.5	0.63	4
15.0	0.11	6.4	0.48	3	315.0	2.24	134.6	0.59	4
20.0	0.14	8.5	0.74	5	320.0	2.28	136.7	0.56	4
25.0	0.18	10.7	1.21	8	325.0	2.31	138.9	0.53	3
30.0	0.21	12.8	1.81	11	330.0	2.35	141.0	0.50	3
35.0	0.25	15.0	2.63	17	335.0	2.39	143.1	0.47	3
40.0	0.28	17.1	3.68	23	340.0	2.42	145.3	0.45	3
45.0	0.32	19.2	5.47	35	345.0	2.46	147.4	0.42	3
50.0	0.36	21.4	8.41	53	350.0	2.49	149.6	0.40	3
55.0	0.39	23.5	12.61	80	355.0	2.53	151.7	0.38	2
60.0	0.43	25.6	16.50	104	360.0	2.56	153.8	0.36	2
65.0	0.46	27.8	20.50	130	365.0	2.60	156.0	0.34	2
70.0	0.50	29.9	23.97	152	370.0	2.64	158.1	0.33	2
75.0	0.53	32.0	27.75	176	375.0	2.67	160.2	0.30	2
80.0	0.57	34.2	28.91	183	380.0	2.71	162.4	0.28	2
85.0	0.61	36.3	28.07	178	385.0	2.74	164.5	0.27	2
90.0	0.64	38.5	26.38	167	390.0	2.78	166.6	0.26	2
95.0	0.68	40.6	24.18	153	395.0	2.81	168.8	0.24	2
100.0	0.71	42.7	21.55	136	400.0	2.85	170.9	0.23	1
105.0	0.75	44.9	18.92	120	405.0	2.88	173.1	0.22	1
110.0	0.78	47.0	16.08	102	410.0	2.92	175.2	0.21	1
115.0	0.82	49.1	14.19	90	415.0	2.96	177.3	0.20	1
120.0	0.85	51.3	12.61	80	420.0	2.99	179.5	0.19	1
125.0	0.89	53.4	11.04	70	425.0	3.03	181.6	0.18	1
130.0	0.93	55.5	9.99	63	430.0	3.06	183.7	0.17	1
135.0	0.96	57.7	9.04	57	435.0	3.10	185.9	0.16	1
140.0	1.00	59.8	8.20	52	440.0	3.13	188.0	0.15	1
145.0	1.03	62.0	7.36	47	445.0	3.17	190.2	0.15	1
150.0	1.07	64.1	6.78	43	450.0	3.20	192.3	0.13	1
155.0	1.10	66.2	6.20	39	455.0	3.24	194.4	0.12	1
160.0	1.14	68.4	5.83	37	460.0	3.28	196.6	0.12	1
165.0	1.18	70.5	5.47	35	465.0	3.31	198.7	0.11	1
170.0	1.21	72.6	5.15	33	470.0	3.35	200.8		
175.0	1.25	74.8	4.84	31	475.0	3.38	203.0		
180.0	1.28	76.9	4.57	29	480.0	3.42	205.1		
185.0	1.32	79.1	4.31	27	485.0	3.45	207.2		
190.0	1.35	81.2	4.10	26	490.0	3.49	209.4		
195.0	1.39	83.3	3.87	24	495.0	3.53	211.5		
200.0	1.42	85.5	3.68	23	500.0	3.56	213.7		
205.0	1.46	87.6	3.47	22	505.0	3.60	215.8		
210.0	1.50	89.7	3.28	21	510.0	3.63	217.9		
215.0	1.53	91.9	3.10	20	515.0	3.67	220.1		
220.0	1.57	94.0	2.93	19	520.0	3.70	222.2		
225.0	1.60	96.1	2.75	17	525.0	3.74	224.3		
230.0	1.64	98.3	2.63	17	530.0	3.77	226.5		
235.0	1.67	100.4	2.47	16	535.0	3.81	228.6		
240.0	1.71	102.6	2.33	15	540.0	3.85	230.7		
245.0	1.74	104.7	2.22	14	545.0	3.88	232.9		
250.0	1.78	106.8	2.10	13	550.0	3.92	235.0		
255.0	1.82	109.0	1.99	13	555.0	3.95	237.2		
260.0	1.85	111.1	1.88	12	560.0	3.99	239.3		
265.0	1.89	113.2	1.78	11	565.0	4.02	241.4		
270.0	1.92	115.4	1.68	11	570.0	4.06	243.6		
275.0	1.96	117.5	1.59	10	575.0	4.10	245.7		
280.0	1.99	119.6	1.50	9	580.0	4.13	247.8		
285.0	2.03	121.8	1.43	9	585.0	4.17	250.0		
290.0	2.07	123.9	1.36	9	590.0	4.20	252.1		
295.0	2.10	126.1	1.28	8	595.0	4.24	254.2		
300.0	2.14	128.2	1.21	8	600.0	4.27	256.4		

NOTES : Use for models including Design Point 3 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin 1-10, 25, 100, 200 Proposed Conditions

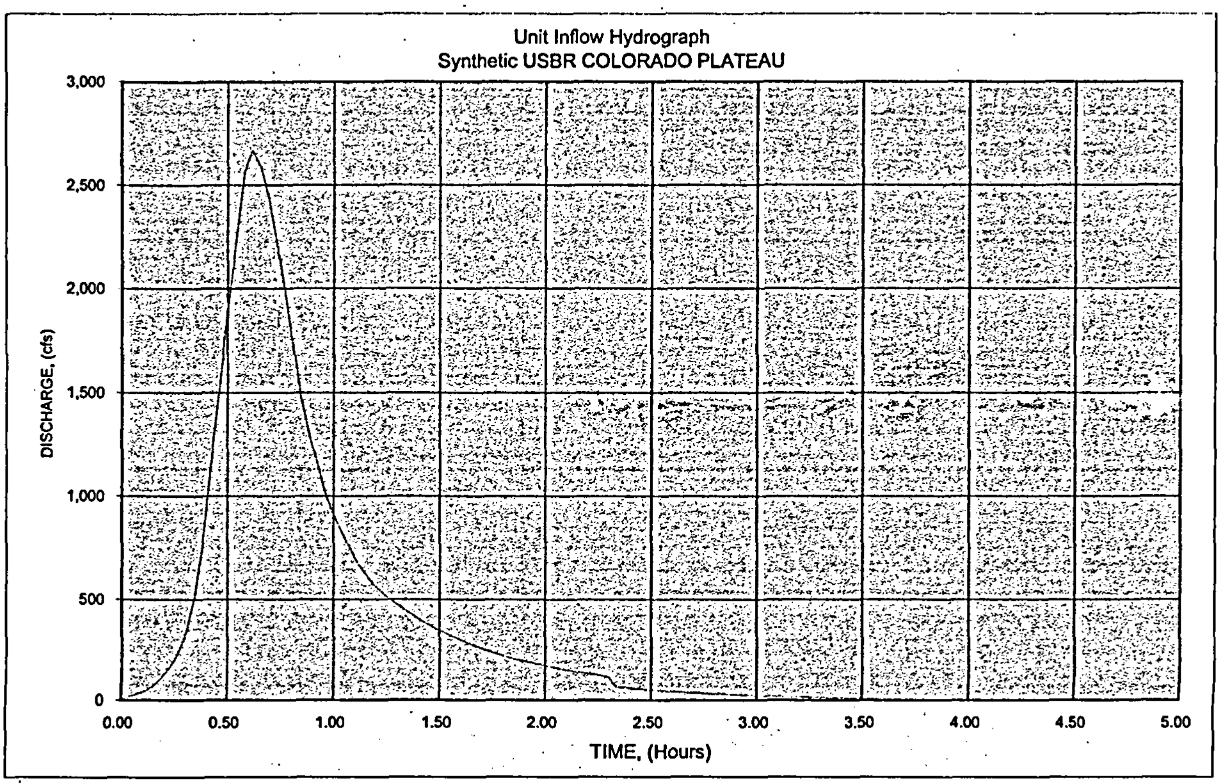
Drainage Area =	2.63 sq. miles	Lg+D/2 =	0.77 Hours
Basin Slope =	356 ft./mile	Basin Factor =	0.13
L =	2.92 mi., Length of Watercourse	V' =	70.72 cfs/Day
Lca =	0.87 mi., Distance to Centroid	Qs =	92.3 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated: Lag Time, Lg = 0.72 Hours — Unit Duration, D = 7.90 minutes; Calculated Timestep = 2.30 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	32	84	207	456	1117	1909	2586	2528	2091	1549
UI	1174	913	735	601	517	452	398	354	314	278
UI	246	217	193	172	152	135	120	107	94	83
UI	74	65	59	52	46	41	36	32	28	25
UI	22	20	18	16	14	12	11			
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USBR calculated unitgraph peak = 2669 Interpolated Peak = 2586

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.04	2.3	0.19	18	305.0	2.34	140.2	0.66	61
10.0	0.08	4.6	0.32	30	310.0	2.37	142.5	0.63	58
15.0	0.11	6.9	0.48	44	315.0	2.41	144.8	0.59	54
20.0	0.15	9.2	0.74	68	320.0	2.45	147.1	0.56	52
25.0	0.19	11.5	1.21	112	325.0	2.49	149.4	0.53	49
30.0	0.23	13.8	1.81	167	330.0	2.53	151.7	0.50	46
35.0	0.27	16.1	2.63	243	335.0	2.57	154.0	0.47	43
40.0	0.31	18.4	3.68	340	340.0	2.60	156.3	0.45	42
45.0	0.34	20.7	5.47	505	345.0	2.64	158.6	0.42	39
50.0	0.38	23.0	8.41	776	350.0	2.68	160.9	0.40	37
55.0	0.42	25.3	12.61	1,164	355.0	2.72	163.2	0.38	35
60.0	0.46	27.6	16.50	1,523	360.0	2.76	165.5	0.36	33
65.0	0.50	29.9	20.50	1,892	365.0	2.80	167.8	0.34	31
70.0	0.54	32.2	23.97	2,213	370.0	2.83	170.1	0.33	30
75.0	0.57	34.5	27.75	2,562	375.0	2.87	172.4	0.30	28
80.0	0.61	36.8	28.91	2,669	380.0	2.91	174.7	0.28	26
85.0	0.65	39.1	28.07	2,591	385.0	2.95	177.0	0.27	25
90.0	0.69	41.4	26.38	2,435	390.0	2.99	179.3	0.26	24
95.0	0.73	43.7	24.18	2,232	395.0	3.03	181.6	0.24	22
100.0	0.77	46.0	21.55	1,989	400.0	3.06	183.9	0.23	21
105.0	0.80	48.3	18.92	1,747	405.0	3.10	186.2	0.22	20
110.0	0.84	50.6	16.08	1,484	410.0	3.14	188.5	0.21	19
115.0	0.88	52.9	14.19	1,310	415.0	3.18	190.8	0.20	18
120.0	0.92	55.2	12.61	1,164	420.0	3.22	193.1	0.19	18
125.0	0.96	57.5	11.04	1,019	425.0	3.26	195.4	0.18	17
130.0	1.00	59.8	9.99	922	430.0	3.29	197.7	0.17	16
135.0	1.03	62.1	9.04	835	435.0	3.33	200.0	0.16	15
140.0	1.07	64.4	8.20	757	440.0	3.37	202.2	0.15	14
145.0	1.11	66.7	7.36	679	445.0	3.41	204.5	0.15	14
150.0	1.15	68.9	6.78	626	450.0	3.45	206.8	0.13	12
155.0	1.19	71.2	6.20	572	455.0	3.49	209.1	0.12	11
160.0	1.23	73.5	5.83	538	460.0	3.52	211.4	0.12	11
165.0	1.26	75.8	5.47	505	465.0	3.56	213.7	0.11	10
170.0	1.30	78.1	5.15	475	470.0	3.60	216.0		
175.0	1.34	80.4	4.84	447	475.0	3.64	218.3		
180.0	1.38	82.7	4.57	422	480.0	3.68	220.6		
185.0	1.42	85.0	4.31	398	485.0	3.72	222.9		
190.0	1.46	87.3	4.10	378	490.0	3.75	225.2		
195.0	1.49	89.6	3.87	357	495.0	3.79	227.5		
200.0	1.53	91.9	3.68	340	500.0	3.83	229.8		
205.0	1.57	94.2	3.47	320	505.0	3.87	232.1		
210.0	1.61	96.5	3.28	303	510.0	3.91	234.4		
215.0	1.65	98.8	3.10	286	515.0	3.95	236.7		
220.0	1.69	101.1	2.93	270	520.0	3.98	239.0		
225.0	1.72	103.4	2.75	254	525.0	4.02	241.3		
230.0	1.76	105.7	2.63	243	530.0	4.06	243.6		
235.0	1.80	108.0	2.47	228	535.0	4.10	245.9		
240.0	1.84	110.3	2.33	215	540.0	4.14	248.2		
245.0	1.88	112.6	2.22	205	545.0	4.18	250.5		
250.0	1.92	114.9	2.10	194	550.0	4.21	252.8		
255.0	1.95	117.2	1.99	184	555.0	4.25	255.1		
260.0	1.99	119.5	1.88	174	560.0	4.29	257.4		
265.0	2.03	121.8	1.78	164	565.0	4.33	259.7		
270.0	2.07	124.1	1.68	155	570.0	4.37	262.0		
275.0	2.11	126.4	1.59	147	575.0	4.41	264.3		
280.0	2.15	128.7	1.50	138	580.0	4.44	266.6		
285.0	2.18	131.0	1.43	132	585.0	4.48	268.9		
290.0	2.22	133.3	1.36	126	590.0	4.52	271.2		
295.0	2.26	135.6	1.28	118	595.0	4.56	273.5		
300.0	2.30	137.9	1.21	112	600.0	4.60	275.8		

NOTES : Use for models including Basin 1 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

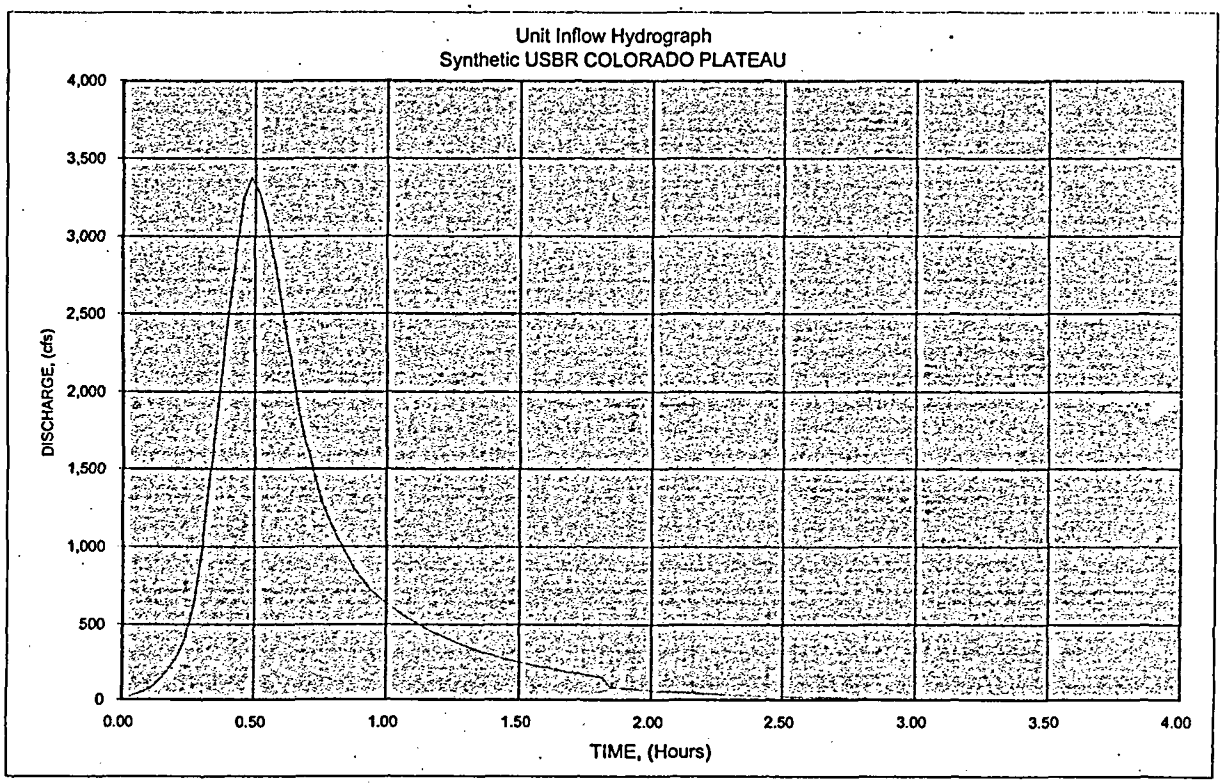
Basin 1-PMP Proposed Conditions

Drainage Area =	2.63 sq. miles		Lg+D/2 =	0.61 Hours
Basin Slope =	356 ft./mile		Basin Factor =	0.13
L =	2.92 mi., Length of Watercourse		V' =	70.72 cfs/Day
Lca =	0.87 mi., Distance to Centroid		Qs =	116.9 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

PARAMETERS:

Calculated: Lag Time, Lg = 0.56 Hours — Unit Duration, D = 6.15 minutes; Calculated Timestep = 1.82 minutes

Data to be used in Analysis
Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph — **5 minute interval**

UI	52	177	485	1482	2709	3327	2740	1872	1329	1003
UI	772	637	540	464	399	341	292	251	216	185
UI	160	137	117	100	87	75	64	55	47	41
UI	34	30	26	23	19	17	14			
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USBR calculated unitgraph peak = 3379 Interpolated Peak = 3327

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.8	0.19	22	305.0	1.85	110.7	0.66	77
10.0	0.06	3.6	0.32	37	310.0	1.88	112.6	0.63	74
15.0	0.09	5.4	0.48	56	315.0	1.91	114.4	0.59	69
20.0	0.12	7.3	0.74	86	320.0	1.94	116.2	0.56	65
25.0	0.15	9.1	1.21	141	325.0	1.97	118.0	0.53	62
30.0	0.18	10.9	1.81	212	330.0	2.00	119.8	0.50	58
35.0	0.21	12.7	2.63	307	335.0	2.03	121.6	0.47	55
40.0	0.24	14.5	3.68	430	340.0	2.06	123.4	0.45	53
45.0	0.27	16.3	5.47	639	345.0	2.09	125.3	0.42	49
50.0	0.30	18.2	8.41	983	350.0	2.12	127.1	0.40	47
55.0	0.33	20.0	12.61	1,474	355.0	2.15	128.9	0.38	44
60.0	0.36	21.8	16.50	1,928	360.0	2.18	130.7	0.36	42
65.0	0.39	23.6	20.50	2,396	365.0	2.21	132.5	0.34	40
70.0	0.42	25.4	23.97	2,801	370.0	2.24	134.3	0.33	39
75.0	0.45	27.2	27.75	3,243	375.0	2.27	136.1	0.30	35
80.0	0.48	29.0	28.91	3,379	380.0	2.30	138.0	0.28	33
85.0	0.51	30.9	28.07	3,281	385.0	2.33	139.8	0.27	32
90.0	0.54	32.7	26.38	3,083	390.0	2.36	141.6	0.26	30
95.0	0.57	34.5	24.18	2,826	395.0	2.39	143.4	0.24	28
100.0	0.61	36.3	21.55	2,519	400.0	2.42	145.2	0.23	27
105.0	0.64	38.1	18.92	2,211	405.0	2.45	147.0	0.22	26
110.0	0.67	39.9	16.08	1,879	410.0	2.48	148.9	0.21	25
115.0	0.70	41.8	14.19	1,658	415.0	2.51	150.7	0.20	23
120.0	0.73	43.6	12.61	1,474	420.0	2.54	152.5	0.19	22
125.0	0.76	45.4	11.04	1,290	425.0	2.57	154.3	0.18	21
130.0	0.79	47.2	9.99	1,168	430.0	2.60	156.1	0.17	20
135.0	0.82	49.0	9.04	1,057	435.0	2.63	157.9	0.16	19
140.0	0.85	50.8	8.20	958	440.0	2.66	159.7	0.15	18
145.0	0.88	52.6	7.36	860	445.0	2.69	161.6	0.15	18
150.0	0.91	54.5	6.78	792	450.0	2.72	163.4	0.13	15
155.0	0.94	56.3	6.20	725	455.0	2.75	165.2	0.12	14
160.0	0.97	58.1	5.83	681	460.0	2.78	167.0	0.12	14
165.0	1.00	59.9	5.47	639	465.0	2.81	168.8	0.11	13
170.0	1.03	61.7	5.15	602	470.0	2.84	170.6		
175.0	1.06	63.5	4.84	566	475.0	2.87	172.5		
180.0	1.09	65.4	4.57	534	480.0	2.90	174.3		
185.0	1.12	67.2	4.31	504	485.0	2.93	176.1		
190.0	1.15	69.0	4.10	479	490.0	2.97	177.9		
195.0	1.18	70.8	3.87	452	495.0	3.00	179.7		
200.0	1.21	72.6	3.68	430	500.0	3.03	181.5		
205.0	1.24	74.4	3.47	406	505.0	3.06	183.3		
210.0	1.27	76.2	3.28	383	510.0	3.09	185.2		
215.0	1.30	78.1	3.10	362	515.0	3.12	187.0		
220.0	1.33	79.9	2.93	342	520.0	3.15	188.8		
225.0	1.36	81.7	2.75	321	525.0	3.18	190.6		
230.0	1.39	83.5	2.63	307	530.0	3.21	192.4		
235.0	1.42	85.3	2.47	289	535.0	3.24	194.2		
240.0	1.45	87.1	2.33	272	540.0	3.27	196.1		
245.0	1.48	89.0	2.22	259	545.0	3.30	197.9		
250.0	1.51	90.8	2.10	245	550.0	3.33	199.7		
255.0	1.54	92.6	1.99	233	555.0	3.36	201.5		
260.0	1.57	94.4	1.88	220	560.0	3.39	203.3		
265.0	1.60	96.2	1.78	208	565.0	3.42	205.1		
270.0	1.63	98.0	1.68	196	570.0	3.45	206.9		
275.0	1.66	99.8	1.59	186	575.0	3.48	208.8		
280.0	1.69	101.7	1.50	175	580.0	3.51	210.6		
285.0	1.72	103.5	1.43	167	585.0	3.54	212.4		
290.0	1.75	105.3	1.36	159	590.0	3.57	214.2		
295.0	1.79	107.1	1.28	150	595.0	3.60	216.0		
300.0	1.82	108.9	1.21	141	600.0	3.63	217.8		

NOTES : Use for models including Basin 1 for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin 2-10, 25, 100, 200 Proposed Conditions

Drainage Area =	8.96 sq. miles	Lg+D/2 =	1.88 Hours
Basin Slope =	283 ft./mile	Basin Factor =	1.97
L =	7.67 mi., Length of Watercourse	V' =	240.93 cfs/Day
Lca =	4.31 mi., Distance to Centroid	Qs =	128.2 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

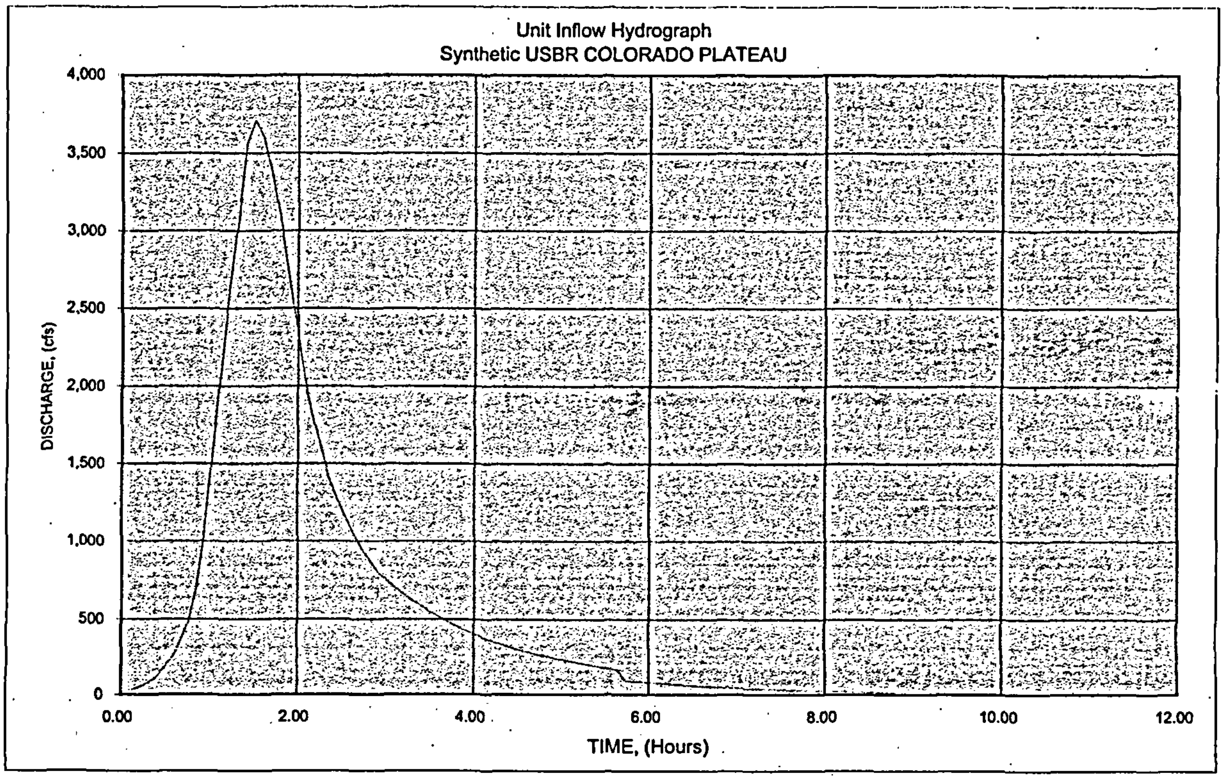
PARAMETERS:

Calculated: Lag Time, Lg = 1.75 Hours Unit Duration, D = 19.14 minutes

Calculated Timestep = 5.64 minutes

Data to be used in Analysis Unit Duration, D = 15 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	22	37	55	80	121	180	254	350	469	671
UI	985	1423	1879	2327	2761	3163	3568	3700	3615	3439
UI	3206	2928	2629	2323	2021	1808	1628	1450	1319	1207
UI	1106	1011	924	858	793	751	710	673	637	604
UI	574	546	522	496	474	450	428	407	388	368
UI	349	335	317	301	288	274	262	249	237	226
UI	214	204	194	186	178	169	160	153	146	138
UI	131	125	119	113	108	103	99	94	88	85
UI	81	77	73	70	67	63	60	58	54	52
UI	50	47	45	43	41	38	36	35	34	32
UI	30	29	28	27	26	24	23	22	21	20
UI	19	18	16	15	15	14	4			
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USBR calculated unitgraph peak = 3706 Interpolated Peak = 3700

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.09	5.6	0.19	24	305.0	5.73	344.0	0.66	85
10.0	0.19	11.3	0.32	41	310.0	5.83	349.6	0.63	81
15.0	0.28	16.9	0.48	62	315.0	5.92	355.2	0.59	76
20.0	0.38	22.6	0.74	95	320.0	6.01	360.9	0.56	72
25.0	0.47	28.2	1.21	155	325.0	6.11	366.5	0.53	68
30.0	0.56	33.8	1.81	232	330.0	6.20	372.2	0.50	64
35.0	0.66	39.5	2.63	337	335.0	6.30	377.8	0.47	60
40.0	0.75	45.1	3.68	472	340.0	6.39	383.4	0.45	58
45.0	0.85	50.7	5.47	701	345.0	6.48	389.1	0.42	54
50.0	0.94	56.4	8.41	1,078	350.0	6.58	394.7	0.40	51
55.0	1.03	62.0	12.61	1,616	355.0	6.67	400.4	0.38	49
60.0	1.13	67.7	16.50	2,115	360.0	6.77	406.0	0.36	46
65.0	1.22	73.3	20.50	2,628	365.0	6.86	411.6	0.34	44
70.0	1.32	78.9	23.97	3,073	370.0	6.95	417.3	0.33	42
75.0	1.41	84.6	27.75	3,557	375.0	7.05	422.9	0.30	38
80.0	1.50	90.2	28.91	3,706	380.0	7.14	428.6	0.28	36
85.0	1.60	95.9	28.07	3,598	385.0	7.24	434.2	0.27	35
90.0	1.69	101.5	26.38	3,381	390.0	7.33	439.8	0.26	33
95.0	1.79	107.1	24.18	3,099	395.0	7.42	445.5	0.24	31
100.0	1.88	112.8	21.55	2,762	400.0	7.52	451.1	0.23	29
105.0	1.97	118.4	18.92	2,425	405.0	7.61	456.7	0.22	28
110.0	2.07	124.1	16.08	2,061	410.0	7.71	462.4	0.21	27
115.0	2.16	129.7	14.19	1,819	415.0	7.80	468.0	0.20	26
120.0	2.26	135.3	12.61	1,616	420.0	7.89	473.7	0.19	24
125.0	2.35	141.0	11.04	1,415	425.0	7.99	479.3	0.18	23
130.0	2.44	146.6	9.99	1,281	430.0	8.08	484.9	0.17	22
135.0	2.54	152.2	9.04	1,159	435.0	8.18	490.6	0.16	21
140.0	2.63	157.9	8.20	1,051	440.0	8.27	496.2	0.15	19
145.0	2.73	163.5	7.36	943	445.0	8.36	501.9	0.15	19
150.0	2.82	169.2	6.78	869	450.0	8.46	507.5	0.13	17
155.0	2.91	174.8	6.20	795	455.0	8.55	513.1	0.12	15
160.0	3.01	180.4	5.83	747	460.0	8.65	518.8	0.12	15
165.0	3.10	186.1	5.47	701	465.0	8.74	524.4	0.11	14
170.0	3.20	191.7	5.15	660	470.0	8.83	530.1		
175.0	3.29	197.4	4.84	620	475.0	8.93	535.7		
180.0	3.38	203.0	4.57	586	480.0	9.02	541.3		
185.0	3.48	208.6	4.31	552	485.0	9.12	547.0		
190.0	3.57	214.3	4.10	526	490.0	9.21	552.6		
195.0	3.67	219.9	3.87	496	495.0	9.30	558.2		
200.0	3.76	225.6	3.68	472	500.0	9.40	563.9		
205.0	3.85	231.2	3.47	445	505.0	9.49	569.5		
210.0	3.95	236.8	3.28	420	510.0	9.59	575.2		
215.0	4.04	242.5	3.10	397	515.0	9.68	580.8		
220.0	4.14	248.1	2.93	376	520.0	9.77	586.4		
225.0	4.23	253.7	2.75	353	525.0	9.87	592.1		
230.0	4.32	259.4	2.63	337	530.0	9.96	597.7		
235.0	4.42	265.0	2.47	317	535.0	10.06	603.4		
240.0	4.51	270.7	2.33	299	540.0	10.15	609.0		
245.0	4.61	276.3	2.22	285	545.0	10.24	614.6		
250.0	4.70	281.9	2.10	269	550.0	10.34	620.3		
255.0	4.79	287.6	1.99	255	555.0	10.43	625.9		
260.0	4.89	293.2	1.88	241	560.0	10.53	631.6		
265.0	4.98	298.9	1.78	228	565.0	10.62	637.2		
270.0	5.07	304.5	1.68	215	570.0	10.71	642.8		
275.0	5.17	310.1	1.59	204	575.0	10.81	648.5		
280.0	5.26	315.8	1.50	192	580.0	10.90	654.1		
285.0	5.36	321.4	1.43	183	585.0	11.00	659.7		
290.0	5.45	327.1	1.36	174	590.0	11.09	665.4		
295.0	5.54	332.7	1.28	164	595.0	11.18	671.0		
300.0	5.64	338.3	1.21	155	600.0	11.28	676.7		

NOTES : Use for models including Basin 2 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

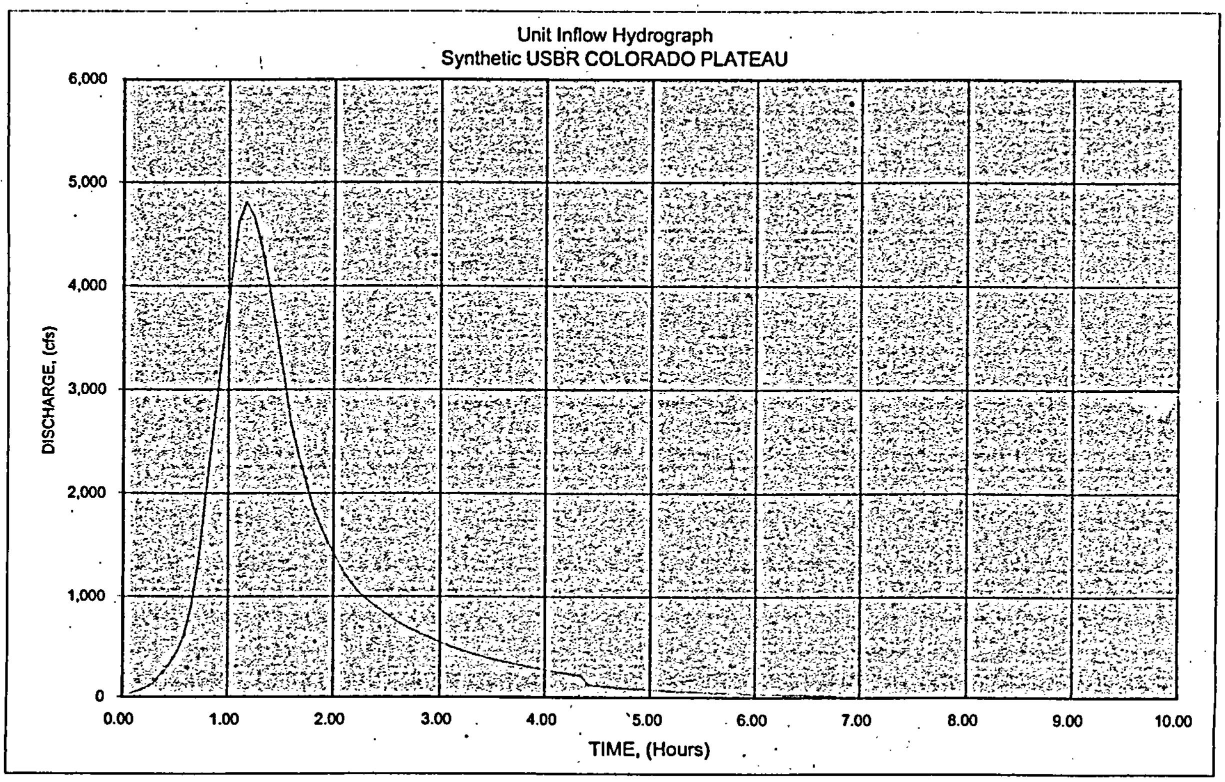
Basin 2-PMP Proposed Conditions

Drainage Area =	8.96 sq. miles	Lg+D/2 =	1.45	Hours
Basin Slope =	283 ft./mile	Basin Factor =	1.97	
L =	7.67 mi., Length of Watercourse	V' =	240.93	cfs/Day
Lca =	4.31 mi., Distance to Centroid	Qs =	166.4	* q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

PARAMETERS:

Calculated:	Lag Time, Lg =	1.36 Hours	Unit Duration, D =	14.89 minutes
			Calculated Timestep =	4.34 minutes

Data to be used	Unit Duration, D =	10 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	35	61	99	170	277	425	629	1012	1650	2428
UI	3185	3880	4594	4794	4596	4237	3775	3272	2738	2356
UI	2054	1781	1587	1417	1256	1135	1027	956	890	830
UI	775	724	683	640	602	564	528	495	461	437
UI	407	381	360	338	317	297	278	261	245	232
UI	217	203	191	178	167	157	146	138	130	123
UI	114	108	101	95	89	83	78	74	68	65
UI	61	57	55	49	46	44	41	39	37	35
UI	33	31	29	27	25	25	21	20	19	8
UI										
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USBR calculated unitgraph peak = 4810 Interpolated Peak = 4794

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.07	4.3	0.19	32	305.0	4.42	265.0	0.66	110
10.0	0.14	8.7	0.32	53	310.0	4.49	269.3	0.63	105
15.0	0.22	13.0	0.48	80	315.0	4.56	273.7	0.59	98
20.0	0.29	17.4	0.74	123	320.0	4.63	278.0	0.56	93
25.0	0.36	21.7	1.21	201	325.0	4.71	282.4	0.53	88
30.0	0.43	26.1	1.81	301	330.0	4.78	286.7	0.50	83
35.0	0.51	30.4	2.63	438	335.0	4.85	291.1	0.47	78
40.0	0.58	34.8	3.68	612	340.0	4.92	295.4	0.45	75
45.0	0.65	39.1	5.47	910	345.0	5.00	299.7	0.42	70
50.0	0.72	43.4	8.41	1,399	350.0	5.07	304.1	0.40	67
55.0	0.80	47.8	12.61	2,098	355.0	5.14	308.4	0.38	63
60.0	0.87	52.1	16.50	2,745	360.0	5.21	312.8	0.36	60
65.0	0.94	56.5	20.50	3,411	365.0	5.29	317.1	0.34	57
70.0	1.01	60.8	23.97	3,988	370.0	5.36	321.5	0.33	55
75.0	1.09	65.2	27.75	4,617	375.0	5.43	325.8	0.30	50
80.0	1.16	69.5	28.91	4,810	380.0	5.50	330.2	0.28	47
85.0	1.23	73.8	28.07	4,670	385.0	5.57	334.5	0.27	45
90.0	1.30	78.2	26.38	4,389	390.0	5.65	338.8	0.26	43
95.0	1.38	82.5	24.18	4,023	395.0	5.72	343.2	0.24	40
100.0	1.45	86.9	21.55	3,586	400.0	5.79	347.5	0.23	38
105.0	1.52	91.2	18.92	3,148	405.0	5.86	351.9	0.22	37
110.0	1.59	95.6	16.08	2,676	410.0	5.94	356.2	0.21	35
115.0	1.67	99.9	14.19	2,361	415.0	6.01	360.6	0.20	33
120.0	1.74	104.3	12.61	2,098	420.0	6.08	364.9	0.19	32
125.0	1.81	108.6	11.04	1,837	425.0	6.15	369.2	0.18	30
130.0	1.88	112.9	9.99	1,662	430.0	6.23	373.6	0.17	28
135.0	1.95	117.3	9.04	1,504	435.0	6.30	377.9	0.16	27
140.0	2.03	121.6	8.20	1,364	440.0	6.37	382.3	0.15	25
145.0	2.10	126.0	7.36	1,225	445.0	6.44	386.6	0.15	25
150.0	2.17	130.3	6.78	1,128	450.0	6.52	391.0	0.13	22
155.0	2.24	134.7	6.20	1,032	455.0	6.59	395.3	0.12	20
160.0	2.32	139.0	5.83	970	460.0	6.66	399.7	0.12	20
165.0	2.39	143.4	5.47	910	465.0	6.73	404.0	0.11	18
170.0	2.46	147.7	5.15	857	470.0	6.81	408.3		
175.0	2.53	152.0	4.84	805	475.0	6.88	412.7		
180.0	2.61	156.4	4.57	760	480.0	6.95	417.0		
185.0	2.68	160.7	4.31	717	485.0	7.02	421.4		
190.0	2.75	165.1	4.10	682	490.0	7.10	425.7		
195.0	2.82	169.4	3.87	644	495.0	7.17	430.1		
200.0	2.90	173.8	3.68	612	500.0	7.24	434.4		
205.0	2.97	178.1	3.47	577	505.0	7.31	438.8		
210.0	3.04	182.5	3.28	546	510.0	7.38	443.1		
215.0	3.11	186.8	3.10	516	515.0	7.46	447.4		
220.0	3.19	191.1	2.93	488	520.0	7.53	451.8		
225.0	3.26	195.5	2.75	458	525.0	7.60	456.1		
230.0	3.33	199.8	2.63	438	530.0	7.67	460.5		
235.0	3.40	204.2	2.47	411	535.0	7.75	464.8		
240.0	3.48	208.5	2.33	388	540.0	7.82	469.2		
245.0	3.55	212.9	2.22	369	545.0	7.89	473.5		
250.0	3.62	217.2	2.10	349	550.0	7.96	477.9		
255.0	3.69	221.5	1.99	331	555.0	8.04	482.2		
260.0	3.76	225.9	1.88	313	560.0	8.11	486.5		
265.0	3.84	230.2	1.78	296	565.0	8.18	490.9		
270.0	3.91	234.6	1.68	280	570.0	8.25	495.2		
275.0	3.98	238.9	1.59	265	575.0	8.33	499.6		
280.0	4.05	243.3	1.50	250	580.0	8.40	503.9		
285.0	4.13	247.6	1.43	238	585.0	8.47	508.3		
290.0	4.20	252.0	1.36	226	590.0	8.54	512.6		
295.0	4.27	256.3	1.28	213	595.0	8.62	516.9		
300.0	4.34	260.6	1.21	201	600.0	8.69	521.3		

NOTES : Use for models including Basin 2 for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

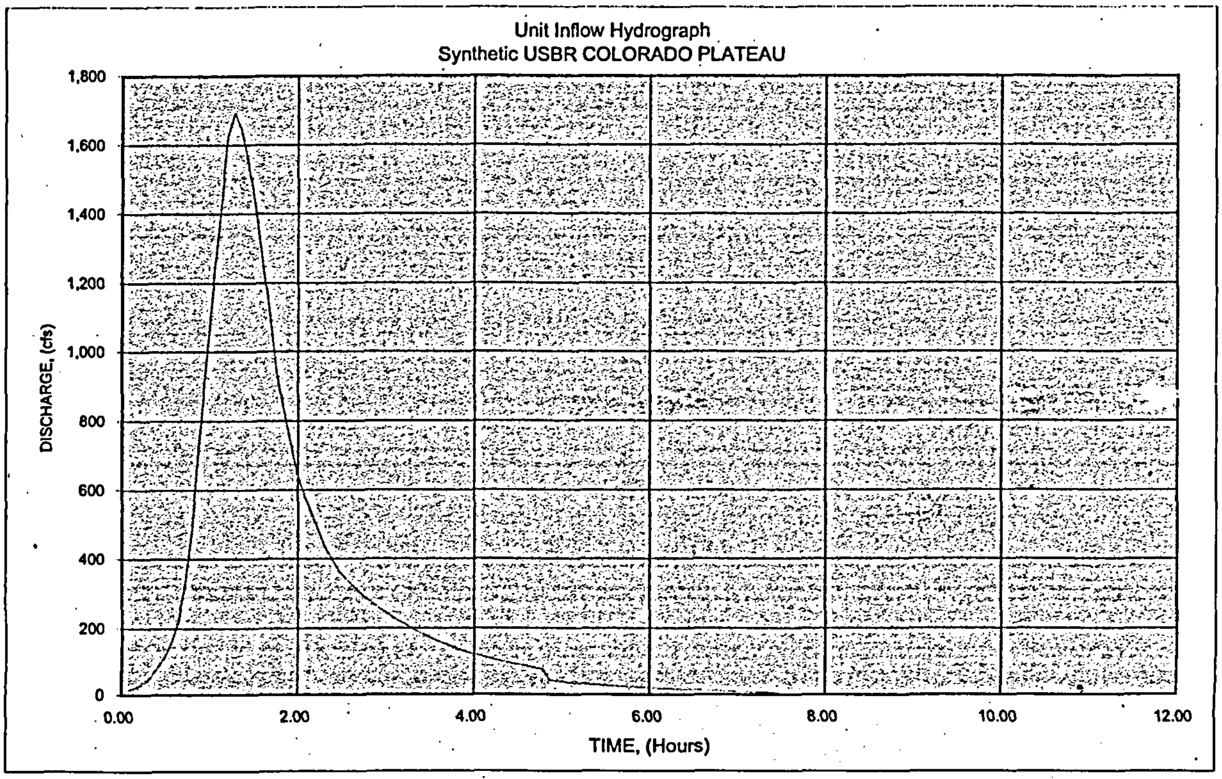
Basin 3-10, 25, 100, 200 Proposed Conditions

Drainage Area =	3.47 sq. miles	Lg+D/2 =	1.59 Hours
Basin Slope =	57.1 ft./mile	Basin Factor =	1.15
L =	4.73 mi., Length of Watercourse	V' =	93.31 cfs/Day
Lca =	1.83 mi., Distance to Centroid	Qs =	58.6 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	1.47 Hours	Unit Duration, D =	16.02 minutes
			Calculated Timestep =	4.78 minutes

Data to be used	Unit Duration, D =	15 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	11	20	30	48	79	119	174	254	392	606
UI	854	1096	1322	1546	1672	1657	1566	1438	1281	1120
UI	947	830	733	640	577	520	468	421	386	355
UI	332	311	292	275	258	244	231	218	206	194
UI	183	172	161	154	144	136	129	122	115	108
UI	102	96	91	86	82	77	72	69	64	61
UI	57	54	51	48	46	43	40	38	36	34
UI	32	30	29	27	26	24	23	22	20	20
UI	18	17	16	15	14	13	13	12	12	11
UI	10	10	9	9	8	7	7	7	3	
UI										
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USBR calculated unitgraph peak = 1693 Interpolated Peak = 1672

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.08	4.8	0.19	11	305.0	4.86	291.6	0.66	39
10.0	0.16	9.6	0.32	19	310.0	4.94	296.4	0.63	37
15.0	0.24	14.3	0.48	28	315.0	5.02	301.1	0.59	35
20.0	0.32	19.1	0.74	43	320.0	5.10	305.9	0.56	33
25.0	0.40	23.9	1.21	71	325.0	5.18	310.7	0.53	31
30.0	0.48	28.7	1.81	106	330.0	5.26	315.5	0.50	29
35.0	0.56	33.5	2.63	154	335.0	5.34	320.3	0.47	28
40.0	0.64	38.2	3.68	216	340.0	5.42	325.0	0.45	26
45.0	0.72	43.0	5.47	320	345.0	5.50	329.8	0.42	25
50.0	0.80	47.8	8.41	492	350.0	5.58	334.6	0.40	23
55.0	0.88	52.6	12.61	738	355.0	5.66	339.4	0.38	22
60.0	0.96	57.4	16.50	966	360.0	5.74	344.2	0.36	21
65.0	1.04	62.1	20.50	1,200	365.0	5.82	348.9	0.34	20
70.0	1.12	66.9	23.97	1,404	370.0	5.90	353.7	0.33	19
75.0	1.20	71.7	27.75	1,625	375.0	5.98	358.5	0.30	18
80.0	1.27	76.5	28.91	1,693	380.0	6.05	363.3	0.28	16
85.0	1.35	81.3	28.07	1,644	385.0	6.13	368.1	0.27	16
90.0	1.43	86.0	26.38	1,545	390.0	6.21	372.8	0.26	15
95.0	1.51	90.8	24.18	1,416	395.0	6.29	377.6	0.24	14
100.0	1.59	95.6	21.55	1,262	400.0	6.37	382.4	0.23	13
105.0	1.67	100.4	18.92	1,108	405.0	6.45	387.2	0.22	13
110.0	1.75	105.2	16.08	942	410.0	6.53	392.0	0.21	12
115.0	1.83	109.9	14.19	831	415.0	6.61	396.7	0.20	12
120.0	1.91	114.7	12.61	738	420.0	6.69	401.5	0.19	11
125.0	1.99	119.5	11.04	647	425.0	6.77	406.3	0.18	11
130.0	2.07	124.3	9.99	585	430.0	6.85	411.1	0.17	10
135.0	2.15	129.1	9.04	529	435.0	6.93	415.9	0.16	9
140.0	2.23	133.8	8.20	480	440.0	7.01	420.6	0.15	9
145.0	2.31	138.6	7.36	431	445.0	7.09	425.4	0.15	9
150.0	2.39	143.4	6.78	397	450.0	7.17	430.2	0.13	8
155.0	2.47	148.2	6.20	363	455.0	7.25	435.0	0.12	7
160.0	2.55	153.0	5.83	341	460.0	7.33	439.8	0.12	7
165.0	2.63	157.7	5.47	320	465.0	7.41	444.5	0.11	6
170.0	2.71	162.5	5.15	302	470.0	7.49	449.3		
175.0	2.79	167.3	4.84	283	475.0	7.57	454.1		
180.0	2.87	172.1	4.57	268	480.0	7.65	458.9		
185.0	2.95	176.9	4.31	252	485.0	7.73	463.7		
190.0	3.03	181.6	4.10	240	490.0	7.81	468.5		
195.0	3.11	186.4	3.87	227	495.0	7.89	473.2		
200.0	3.19	191.2	3.68	216	500.0	7.97	478.0		
205.0	3.27	196.0	3.47	203	505.0	8.05	482.8		
210.0	3.35	200.8	3.28	192	510.0	8.13	487.6		
215.0	3.43	205.5	3.10	182	515.0	8.21	492.4		
220.0	3.51	210.3	2.93	172	520.0	8.29	497.1		
225.0	3.59	215.1	2.75	161	525.0	8.37	501.9		
230.0	3.66	219.9	2.63	154	530.0	8.44	506.7		
235.0	3.74	224.7	2.47	145	535.0	8.52	511.5		
240.0	3.82	229.4	2.33	136	540.0	8.60	516.3		
245.0	3.90	234.2	2.22	130	545.0	8.68	521.0		
250.0	3.98	239.0	2.10	123	550.0	8.76	525.8		
255.0	4.06	243.8	1.99	117	555.0	8.84	530.6		
260.0	4.14	248.6	1.88	110	560.0	8.92	535.4		
265.0	4.22	253.3	1.78	104	565.0	9.00	540.2		
270.0	4.30	258.1	1.68	98	570.0	9.08	544.9		
275.0	4.38	262.9	1.59	93	575.0	9.16	549.7		
280.0	4.46	267.7	1.50	88	580.0	9.24	554.5		
285.0	4.54	272.5	1.43	84	585.0	9.32	559.3		
290.0	4.62	277.2	1.36	80	590.0	9.40	564.1		
295.0	4.70	282.0	1.28	75	595.0	9.48	568.8		
300.0	4.78	286.8	1.21	71	600.0	9.56	573.6		

NOTES : Use for models including Basin 3 for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin 3-PMP Proposed Conditions

Drainage Area =	3.47 sq. miles	Lg+D/2 =	1.23 Hours
Basin Slope =	57.1 ft./mile	Basin Factor =	1.15
L =	4.73 mi., Length of Watercourse	V' =	93.31 cfs/Day
Lca =	1.83 mi., Distance to Centroid	Qs =	76.1 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

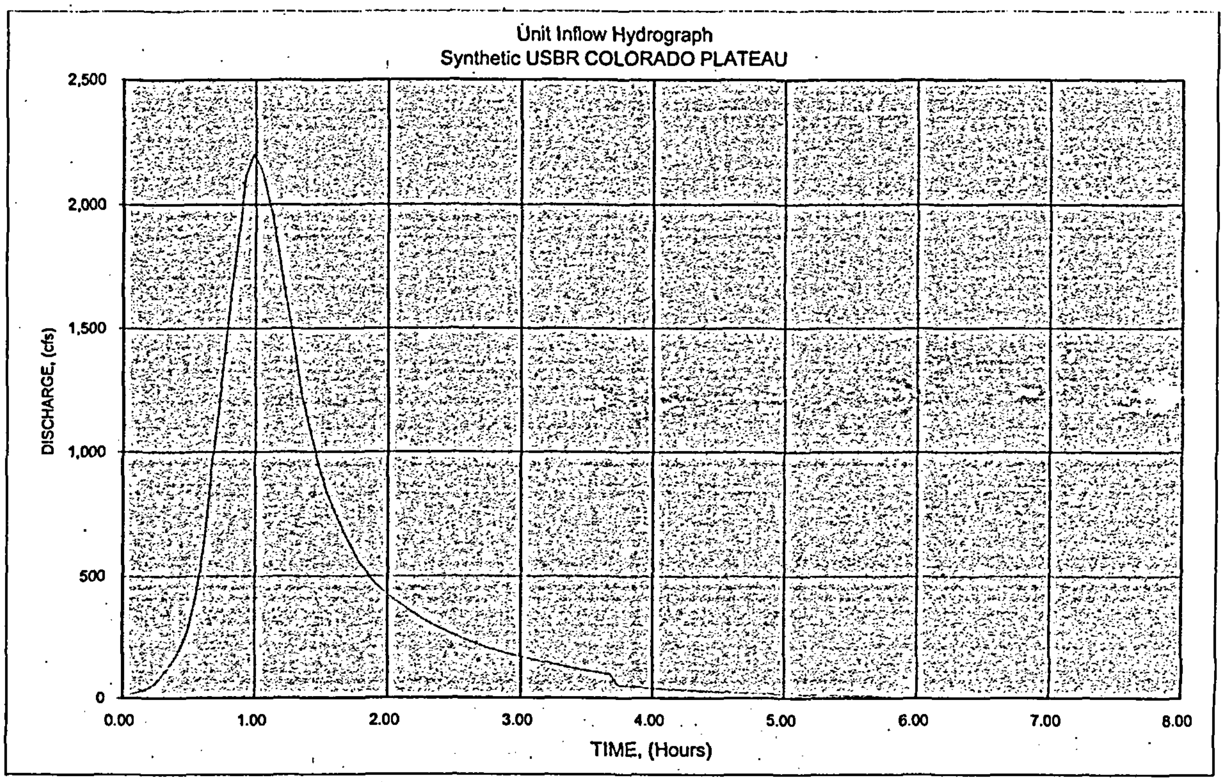
PARAMETERS:

Calculated: Lag Time, Lg = 1.14 Hours Unit Duration, D = 12.46 minutes

Calculated Timestep = 3.68 minutes

Data to be used in Analysis Unit Duration, D = 10 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	18	33	59	112	188	302	533	922	1330	1720
UI	2102	2181	2050	1833	1561	1276	1066	903	773	675
UI	588	520	464	426	392	361	334	311	288	267
UI	248	229	211	197	182	169	157	146	135	125
UI	116	108	101	93	86	80	74	68	64	59
UI	55	51	48	44	41	38	35	32	30	28
UI	26	24	22	21	19	18	17	16	15	14
UI	13	11	11	9	9	5				
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USBR calculated unitgraph peak = 2201 Interpolated Peak = 2181

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.06	3.7	0.19	14	305.0	3.74	224.2	0.66	50
10.0	0.12	7.4	0.32	24	310.0	3.80	227.9	0.63	48
15.0	0.18	11.0	0.48	37	315.0	3.86	231.6	0.59	45
20.0	0.25	14.7	0.74	56	320.0	3.92	235.3	0.56	43
25.0	0.31	18.4	1.21	92	325.0	3.98	239.0	0.53	40
30.0	0.37	22.1	1.81	138	330.0	4.04	242.6	0.50	38
35.0	0.43	25.7	2.63	200	335.0	4.11	246.3	0.47	36
40.0	0.49	29.4	3.68	280	340.0	4.17	250.0	0.45	34
45.0	0.55	33.1	5.47	417	345.0	4.23	253.7	0.42	32
50.0	0.61	36.8	8.41	640	350.0	4.29	257.3	0.40	30
55.0	0.67	40.4	12.61	960	355.0	4.35	261.0	0.38	29
60.0	0.74	44.1	16.50	1,256	360.0	4.41	264.7	0.36	27
65.0	0.80	47.8	20.50	1,561	365.0	4.47	268.4	0.34	26
70.0	0.86	51.5	23.97	1,825	370.0	4.53	272.0	0.33	25
75.0	0.92	55.1	27.75	2,113	375.0	4.60	275.7	0.30	23
80.0	0.98	58.8	28.91	2,201	380.0	4.66	279.4	0.28	21
85.0	1.04	62.5	28.07	2,137	385.0	4.72	283.1	0.27	21
90.0	1.10	66.2	26.38	2,009	390.0	4.78	286.7	0.26	20
95.0	1.16	69.8	24.18	1,841	395.0	4.84	290.4	0.24	18
100.0	1.23	73.5	21.55	1,641	400.0	4.90	294.1	0.23	18
105.0	1.29	77.2	18.92	1,441	405.0	4.96	297.8	0.22	17
110.0	1.35	80.9	16.08	1,224	410.0	5.02	301.4	0.21	16
115.0	1.41	84.6	14.19	1,081	415.0	5.09	305.1	0.20	15
120.0	1.47	88.2	12.61	960	420.0	5.15	308.8	0.19	14
125.0	1.53	91.9	11.04	841	425.0	5.21	312.5	0.18	14
130.0	1.59	95.6	9.99	761	430.0	5.27	316.2	0.17	13
135.0	1.65	99.3	9.04	688	435.0	5.33	319.8	0.16	12
140.0	1.72	102.9	8.20	624	440.0	5.39	323.5	0.15	11
145.0	1.78	106.6	7.36	560	445.0	5.45	327.2	0.15	11
150.0	1.84	110.3	6.78	516	450.0	5.51	330.9	0.13	10
155.0	1.90	114.0	6.20	472	455.0	5.58	334.5	0.12	9
160.0	1.96	117.6	5.83	444	460.0	5.64	338.2	0.12	9
165.0	2.02	121.3	5.47	417	465.0	5.70	341.9	0.11	8
170.0	2.08	125.0	5.15	392	470.0	5.76	345.6		
175.0	2.14	128.7	4.84	369	475.0	5.82	349.2		
180.0	2.21	132.3	4.57	348	480.0	5.88	352.9		
185.0	2.27	136.0	4.31	328	485.0	5.94	356.6		
190.0	2.33	139.7	4.10	312	490.0	6.00	360.3		
195.0	2.39	143.4	3.87	295	495.0	6.07	363.9		
200.0	2.45	147.0	3.68	280	500.0	6.13	367.6		
205.0	2.51	150.7	3.47	264	505.0	6.19	371.3		
210.0	2.57	154.4	3.28	250	510.0	6.25	375.0		
215.0	2.63	158.1	3.10	236	515.0	6.31	378.6		
220.0	2.70	161.8	2.93	223	520.0	6.37	382.3		
225.0	2.76	165.4	2.75	209	525.0	6.43	386.0		
230.0	2.82	169.1	2.63	200	530.0	6.49	389.7		
235.0	2.88	172.8	2.47	188	535.0	6.56	393.4		
240.0	2.94	176.5	2.33	177	540.0	6.62	397.0		
245.0	3.00	180.1	2.22	169	545.0	6.68	400.7		
250.0	3.06	183.8	2.10	160	550.0	6.74	404.4		
255.0	3.12	187.5	1.99	152	555.0	6.80	408.1		
260.0	3.19	191.2	1.88	143	560.0	6.86	411.7		
265.0	3.25	194.8	1.78	136	565.0	6.92	415.4		
270.0	3.31	198.5	1.68	128	570.0	6.98	419.1		
275.0	3.37	202.2	1.59	121	575.0	7.05	422.8		
280.0	3.43	205.9	1.50	114	580.0	7.11	426.4		
285.0	3.49	209.5	1.43	109	585.0	7.17	430.1		
290.0	3.55	213.2	1.36	104	590.0	7.23	433.8		
295.0	3.61	216.9	1.28	97	595.0	7.29	437.5		
300.0	3.68	220.6	1.21	92	600.0	7.35	441.1		

NOTES : Use for models including Basin 3 for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin A-10, 25, 100, 200 Proposed Conditions

Drainage Area =	0.3456 sq. miles	Lg+D/2 =	0.55 Hours
Basin Slope =	501 ft./mile	Basin Factor =	0.05
L =	1.55 mi., Length of Watercourse	V' =	9.29 cfs/Day
Lca =	0.68 mi., Distance to Centroid	Qs =	16.8 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

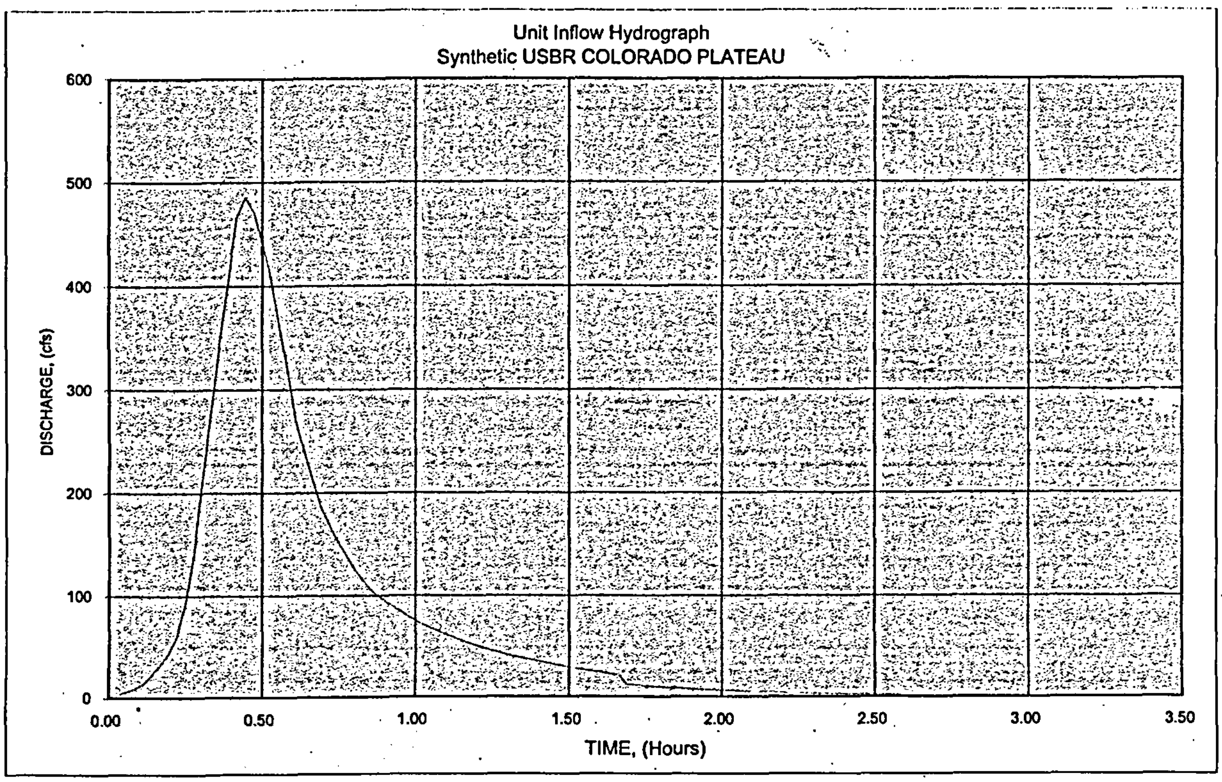
PARAMETERS:

Calculated: Lag Time, Lg = 0.51 Hours Unit Duration, D = 5.59 minutes

Calculated Timestep = 1.66 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute Interval**

UI	8	31	93	279	467	441	314	210	151	113
UI	91	76	65	55	46	39	33	28	24	20
UI	17	14	12	10	9	7	6	5	4	4
UI	3	3	2	2						
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USBR calculated unitgraph peak = 485 Interpolated Peak = 467

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.7	0.19	3	305.0	1.69	101.4	0.66	11
10.0	0.06	3.3	0.32	5	310.0	1.72	103.0	0.63	11
15.0	0.08	5.0	0.48	8	315.0	1.74	104.7	0.59	10
20.0	0.11	6.6	0.74	12	320.0	1.77	106.3	0.56	9
25.0	0.14	8.3	1.21	20	325.0	1.80	108.0	0.53	9
30.0	0.17	10.0	1.81	30	330.0	1.83	109.7	0.50	8
35.0	0.19	11.6	2.63	44	335.0	1.86	111.3	0.47	8
40.0	0.22	13.3	3.68	62	340.0	1.88	113.0	0.45	8
45.0	0.25	15.0	5.47	92	345.0	1.91	114.6	0.42	7
50.0	0.28	16.6	8.41	141	350.0	1.94	116.3	0.40	7
55.0	0.30	18.3	12.61	212	355.0	1.97	118.0	0.38	6
60.0	0.33	19.9	16.50	277	360.0	1.99	119.6	0.36	6
65.0	0.36	21.6	20.50	344	365.0	2.02	121.3	0.34	6
70.0	0.39	23.3	23.97	402	370.0	2.05	123.0	0.33	6
75.0	0.42	24.9	27.75	466	375.0	2.08	124.6	0.30	5
80.0	0.44	26.6	28.91	485	380.0	2.10	126.3	0.28	5
85.0	0.47	28.2	28.07	471	385.0	2.13	127.9	0.27	5
90.0	0.50	29.9	26.38	443	390.0	2.16	129.6	0.26	4
95.0	0.53	31.6	24.18	406	395.0	2.19	131.3	0.24	4
100.0	0.55	33.2	21.55	362	400.0	2.22	132.9	0.23	4
105.0	0.58	34.9	18.92	317	405.0	2.24	134.6	0.22	4
110.0	0.61	36.6	16.08	270	410.0	2.27	136.2	0.21	4
115.0	0.64	38.2	14.19	238	415.0	2.30	137.9	0.20	3
120.0	0.66	39.9	12.61	212	420.0	2.33	139.6	0.19	3
125.0	0.69	41.5	11.04	185	425.0	2.35	141.2	0.18	3
130.0	0.72	43.2	9.99	168	430.0	2.38	142.9	0.17	3
135.0	0.75	44.9	9.04	152	435.0	2.41	144.6	0.16	3
140.0	0.78	46.5	8.20	138	440.0	2.44	146.2	0.15	3
145.0	0.80	48.2	7.36	123	445.0	2.46	147.9	0.15	3
150.0	0.83	49.8	6.78	114	450.0	2.49	149.5	0.13	2
155.0	0.86	51.5	6.20	104	455.0	2.52	151.2	0.12	2
160.0	0.89	53.2	5.83	98	460.0	2.55	152.9	0.12	2
165.0	0.91	54.8	5.47	92	465.0	2.58	154.5	0.11	2
170.0	0.94	56.5	5.15	86	470.0	2.60	156.2		
175.0	0.97	58.2	4.84	81	475.0	2.63	157.8		
180.0	1.00	59.8	4.57	77	480.0	2.66	159.5		
185.0	1.02	61.5	4.31	72	485.0	2.69	161.2		
190.0	1.05	63.1	4.10	69	490.0	2.71	162.8		
195.0	1.08	64.8	3.87	65	495.0	2.74	164.5		
200.0	1.11	66.5	3.68	62	500.0	2.77	166.2		
205.0	1.14	68.1	3.47	58	505.0	2.80	167.8		
210.0	1.16	69.8	3.28	55	510.0	2.82	169.5		
215.0	1.19	71.4	3.10	52	515.0	2.85	171.1		
220.0	1.22	73.1	2.93	49	520.0	2.88	172.8		
225.0	1.25	74.8	2.75	46	525.0	2.91	174.5		
230.0	1.27	76.4	2.63	44	530.0	2.94	176.1		
235.0	1.30	78.1	2.47	41	535.0	2.96	177.8		
240.0	1.33	79.8	2.33	39	540.0	2.99	179.4		
245.0	1.36	81.4	2.22	37	545.0	3.02	181.1		
250.0	1.38	83.1	2.10	35	550.0	3.05	182.8		
255.0	1.41	84.7	1.99	33	555.0	3.07	184.4		
260.0	1.44	86.4	1.88	32	560.0	3.10	186.1		
265.0	1.47	88.1	1.78	30	565.0	3.13	187.8		
270.0	1.50	89.7	1.68	28	570.0	3.16	189.4		
275.0	1.52	91.4	1.59	27	575.0	3.18	191.1		
280.0	1.55	93.0	1.50	25	580.0	3.21	192.7		
285.0	1.58	94.7	1.43	24	585.0	3.24	194.4		
290.0	1.61	96.4	1.36	23	590.0	3.27	196.1		
295.0	1.63	98.0	1.28	21	595.0	3.30	197.7		
300.0	1.66	99.7	1.21	20	600.0	3.32	199.4		

NOTES : Use for models including Basin A for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

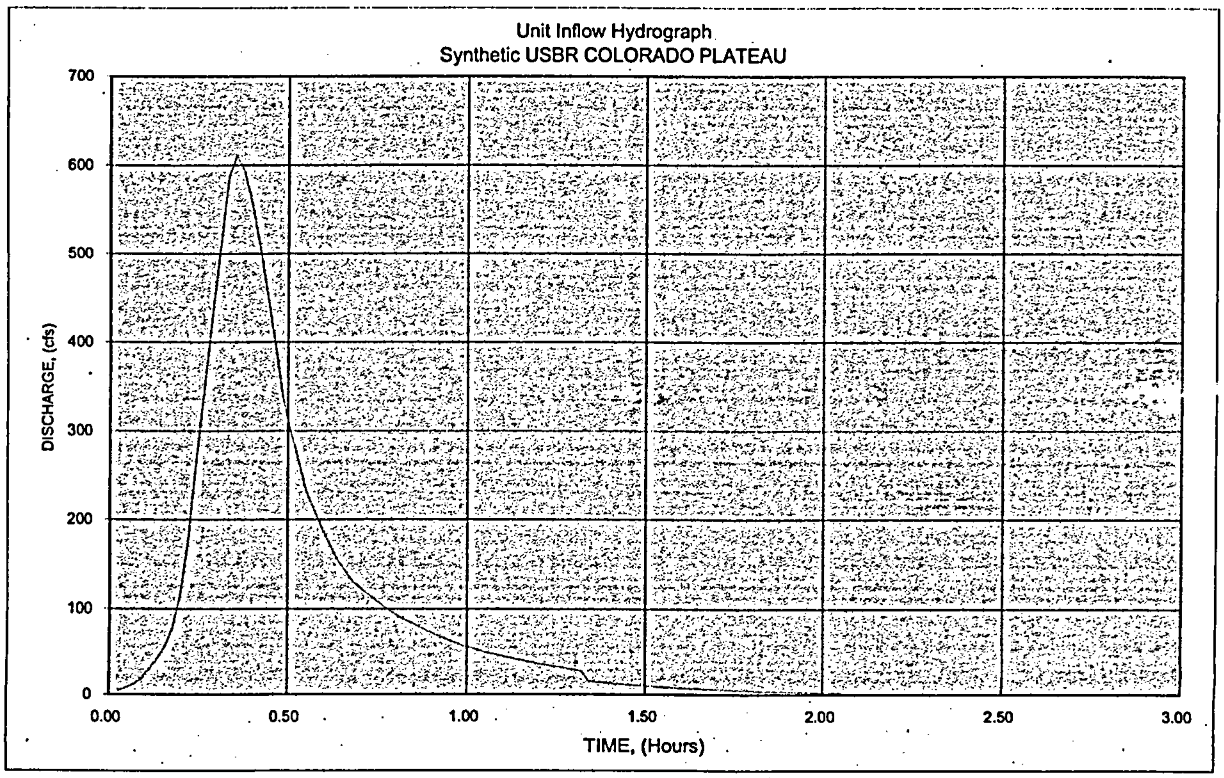
Basin A-PMP Proposed Conditions

Drainage Area =	0.3456 sq. miles		Lg+D/2 =	0.44 Hours
Basin Slope =	501 ft./mile		Basin Factor =	0.05
L =	1.55 mi., Length of Watercourse		V' =	9.29 cfs/Day
Lca =	0.68 mi., Distance to Centroid		Qs =	21.1 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

PARAMETERS:

Calculated:	Lag Time, Lg =	0.40 Hours	Unit Duration, D =	4.35 minutes
			Calculated Timestep =	1.32 minutes

Data to be used	Unit Duration, D =	5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
In Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	14	68	296	590	514	311	201	140	108	87
UI	71	57	46	38	30	25	20	16	13	11
UI	9	7	6	5	4	3	2			
UI										
UI										
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USBR calculated unitgraph peak = 611 Interpolated Peak = 590

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.02	1.3	0.19	4
10.0	0.04	2.6	0.32	7
15.0	0.07	4.0	0.48	10
20.0	0.09	5.3	0.74	16
25.0	0.11	6.6	1.21	26
30.0	0.13	7.9	1.81	38
35.0	0.15	9.2	2.63	56
40.0	0.18	10.6	3.68	78
45.0	0.20	11.9	5.47	116
50.0	0.22	13.2	8.41	178
55.0	0.24	14.5	12.61	266
60.0	0.26	15.8	16.50	348
65.0	0.29	17.2	20.50	433
70.0	0.31	18.5	23.97	506
75.0	0.33	19.8	27.75	586
80.0	0.35	21.1	28.91	611
85.0	0.37	22.4	28.07	593
90.0	0.40	23.8	26.38	557
95.0	0.42	25.1	24.18	511
100.0	0.44	26.4	21.55	455
105.0	0.46	27.7	18.92	400
110.0	0.48	29.0	16.08	340
115.0	0.51	30.4	14.19	300
120.0	0.53	31.7	12.61	266
125.0	0.55	33.0	11.04	233
130.0	0.57	34.3	9.99	211
135.0	0.59	35.6	9.04	191
140.0	0.62	37.0	8.20	173
145.0	0.64	38.3	7.36	155
150.0	0.66	39.6	6.78	143
155.0	0.68	40.9	6.20	131
160.0	0.70	42.2	5.83	123
165.0	0.73	43.6	5.47	116
170.0	0.75	44.9	5.15	109
175.0	0.77	46.2	4.84	102
180.0	0.79	47.5	4.57	97
185.0	0.81	48.8	4.31	91
190.0	0.84	50.2	4.10	87
195.0	0.86	51.5	3.87	82
200.0	0.88	52.8	3.68	78
205.0	0.90	54.1	3.47	73
210.0	0.92	55.4	3.28	69
215.0	0.95	56.8	3.10	65
220.0	0.97	58.1	2.93	62
225.0	0.99	59.4	2.75	58
230.0	1.01	60.7	2.63	56
235.0	1.03	62.0	2.47	52
240.0	1.06	63.4	2.33	49
245.0	1.08	64.7	2.22	47
250.0	1.10	66.0	2.10	44
255.0	1.12	67.3	1.99	42
260.0	1.14	68.6	1.88	40
265.0	1.17	70.0	1.78	38
270.0	1.19	71.3	1.68	35
275.0	1.21	72.6	1.59	34
280.0	1.23	73.9	1.50	32
285.0	1.25	75.2	1.43	30
290.0	1.28	76.6	1.36	29
295.0	1.30	77.9	1.28	27
300.0	1.32	79.2	1.21	26
305.0	1.34	80.5	0.66	14
310.0	1.36	81.8	0.63	13
315.0	1.39	83.2	0.59	12
320.0	1.41	84.5	0.56	12
325.0	1.43	85.8	0.53	11
330.0	1.45	87.1	0.50	11
335.0	1.47	88.4	0.47	10
340.0	1.50	89.8	0.45	10
345.0	1.52	91.1	0.42	9
350.0	1.54	92.4	0.40	8
355.0	1.56	93.7	0.38	8
360.0	1.58	95.0	0.36	8
365.0	1.61	96.4	0.34	7
370.0	1.63	97.7	0.33	7
375.0	1.65	99.0	0.30	6
380.0	1.67	100.3	0.28	6
385.0	1.69	101.6	0.27	6
390.0	1.72	103.0	0.26	5
395.0	1.74	104.3	0.24	5
400.0	1.76	105.6	0.23	5
405.0	1.78	106.9	0.22	5
410.0	1.80	108.2	0.21	4
415.0	1.83	109.6	0.20	4
420.0	1.85	110.9	0.19	4
425.0	1.87	112.2	0.18	4
430.0	1.89	113.5	0.17	4
435.0	1.91	114.8	0.16	3
440.0	1.94	116.2	0.15	3
445.0	1.96	117.5	0.15	3
450.0	1.98	118.8	0.13	3
455.0	2.00	120.1	0.12	3
460.0	2.02	121.5	0.12	3
465.0	2.05	122.8	0.11	2
470.0	2.07	124.1		
475.0	2.09	125.4		
480.0	2.11	126.7		
485.0	2.13	128.1		
490.0	2.16	129.4		
495.0	2.18	130.7		
500.0	2.20	132.0		
505.0	2.22	133.3		
510.0	2.24	134.7		
515.0	2.27	136.0		
520.0	2.29	137.3		
525.0	2.31	138.6		
530.0	2.33	139.9		
535.0	2.35	141.3		
540.0	2.38	142.6		
545.0	2.40	143.9		
550.0	2.42	145.2		
555.0	2.44	146.5		
560.0	2.46	147.9		
565.0	2.49	149.2		
570.0	2.51	150.5		
575.0	2.53	151.8		
580.0	2.55	153.1		
585.0	2.57	154.5		
590.0	2.60	155.8		
595.0	2.62	157.1		
600.0	2.64	158.4		

NOTES : Use for models including Basin A for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

Basin B-10, 25, 100, 200 Proposed Conditions

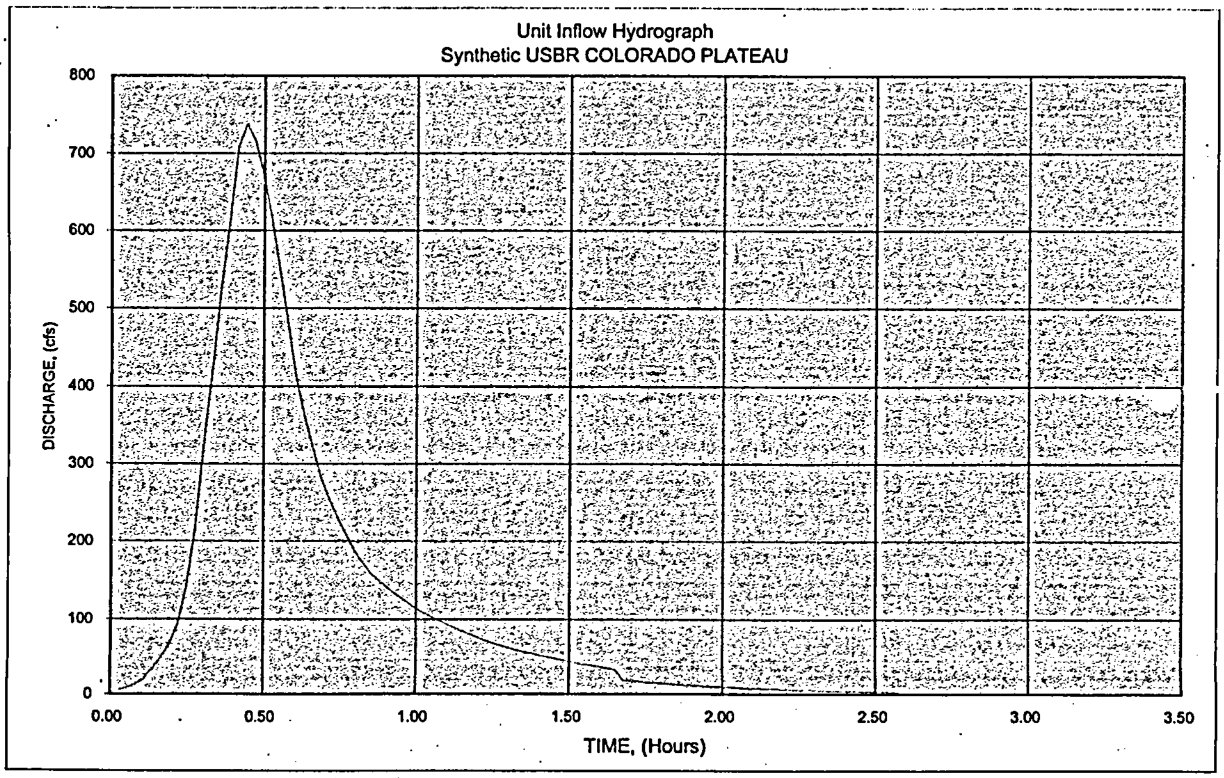
Drainage Area =	0.5218 sq. miles		Lg+D/2 =	0.55	Hours
Basin Slope =	666 ft./mile		Basin Factor =	0.05	
L =	1.38 mi., Length of Watercourse		V' =	14.03	cfs/Day
Lca =	0.86 mi., Distance to Centroid		Qs =	25.5	* q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n				

PARAMETERS:

Calculated: Lag Time, Lg = 0.51 Hours — Unit Duration, D = 5.54 minutes; Calculated Timestep = 1.65 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	12	47	147	434	713	663	467	312	225	168
UI	137	114	97	82	69	58	49	42	35	30
UI	25	21	18	15	13	11	9	8	7	6
UI	5	4	3	3						
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USBR calculated unitgraph peak = 738 Interpolated Peak = 713

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.6	0.19	5	305.0	1.68	100.6	0.66	17
10.0	0.05	3.3	0.32	8	310.0	1.70	102.3	0.63	16
15.0	0.08	4.9	0.48	12	315.0	1.73	103.9	0.59	15
20.0	0.11	6.6	0.74	19	320.0	1.76	105.6	0.56	14
25.0	0.14	8.2	1.21	31	325.0	1.79	107.2	0.53	14
30.0	0.16	9.9	1.81	46	330.0	1.81	108.9	0.50	13
35.0	0.19	11.5	2.63	67	335.0	1.84	110.5	0.47	12
40.0	0.22	13.2	3.68	94	340.0	1.87	112.2	0.45	11
45.0	0.25	14.8	5.47	140	345.0	1.90	113.8	0.42	11
50.0	0.27	16.5	8.41	215	350.0	1.92	115.5	0.40	10
55.0	0.30	18.1	12.61	322	355.0	1.95	117.1	0.38	10
60.0	0.33	19.8	16.50	421	360.0	1.98	118.8	0.36	9
65.0	0.36	21.4	20.50	523	365.0	2.01	120.4	0.34	9
70.0	0.38	23.1	23.97	612	370.0	2.03	122.1	0.33	8
75.0	0.41	24.7	27.75	708	375.0	2.06	123.7	0.30	8
80.0	0.44	26.4	28.91	738	380.0	2.09	125.4	0.28	7
85.0	0.47	28.0	28.07	716	385.0	2.12	127.0	0.27	7
90.0	0.49	29.7	26.38	673	390.0	2.14	128.7	0.26	7
95.0	0.52	31.3	24.18	617	395.0	2.17	130.3	0.24	6
100.0	0.55	33.0	21.55	550	400.0	2.20	132.0	0.23	6
105.0	0.58	34.6	18.92	483	405.0	2.23	133.6	0.22	6
110.0	0.60	36.3	16.08	410	410.0	2.25	135.3	0.21	5
115.0	0.63	37.9	14.19	362	415.0	2.28	136.9	0.20	5
120.0	0.66	39.6	12.61	322	420.0	2.31	138.6	0.19	5
125.0	0.69	41.2	11.04	282	425.0	2.34	140.2	0.18	5
130.0	0.71	42.9	9.99	255	430.0	2.36	141.9	0.17	4
135.0	0.74	44.5	9.04	231	435.0	2.39	143.5	0.16	4
140.0	0.77	46.2	8.20	209	440.0	2.42	145.2	0.15	4
145.0	0.80	47.8	7.36	188	445.0	2.45	146.8	0.15	4
150.0	0.82	49.5	6.78	173	450.0	2.47	148.5	0.13	3
155.0	0.85	51.1	6.20	158	455.0	2.50	150.1	0.12	3
160.0	0.88	52.8	5.83	149	460.0	2.53	151.8	0.12	3
165.0	0.91	54.4	5.47	140	465.0	2.56	153.4	0.11	3
170.0	0.93	56.1	5.15	131	470.0	2.58	155.1		
175.0	0.96	57.7	4.84	124	475.0	2.61	156.7		
180.0	0.99	59.4	4.57	117	480.0	2.64	158.4		
185.0	1.02	61.0	4.31	110	485.0	2.67	160.0		
190.0	1.04	62.7	4.10	105	490.0	2.69	161.7		
195.0	1.07	64.3	3.87	99	495.0	2.72	163.3		
200.0	1.10	66.0	3.68	94	500.0	2.75	165.0		
205.0	1.13	67.6	3.47	89	505.0	2.78	166.6		
210.0	1.15	69.3	3.28	84	510.0	2.80	168.3		
215.0	1.18	70.9	3.10	79	515.0	2.83	169.9		
220.0	1.21	72.6	2.93	75	520.0	2.86	171.6		
225.0	1.24	74.2	2.75	70	525.0	2.89	173.2		
230.0	1.26	75.9	2.63	67	530.0	2.91	174.9		
235.0	1.29	77.5	2.47	63	535.0	2.94	176.5		
240.0	1.32	79.2	2.33	59	540.0	2.97	178.2		
245.0	1.35	80.8	2.22	57	545.0	3.00	179.8		
250.0	1.37	82.5	2.10	54	550.0	3.02	181.5		
255.0	1.40	84.1	1.99	51	555.0	3.05	183.1		
260.0	1.43	85.8	1.88	48	560.0	3.08	184.8		
265.0	1.46	87.4	1.78	45	565.0	3.11	186.4		
270.0	1.48	89.1	1.68	43	570.0	3.13	188.1		
275.0	1.51	90.7	1.59	41	575.0	3.16	189.7		
280.0	1.54	92.4	1.50	38	580.0	3.19	191.4		
285.0	1.57	94.0	1.43	36	585.0	3.22	193.0		
290.0	1.59	95.7	1.36	35	590.0	3.24	194.7		
295.0	1.62	97.3	1.28	33	595.0	3.27	196.3		
300.0	1.65	99.0	1.21	31	600.0	3.30	198.0		

NOTES : Use for models including Basin B for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

Basin B-PMP Proposed Conditions

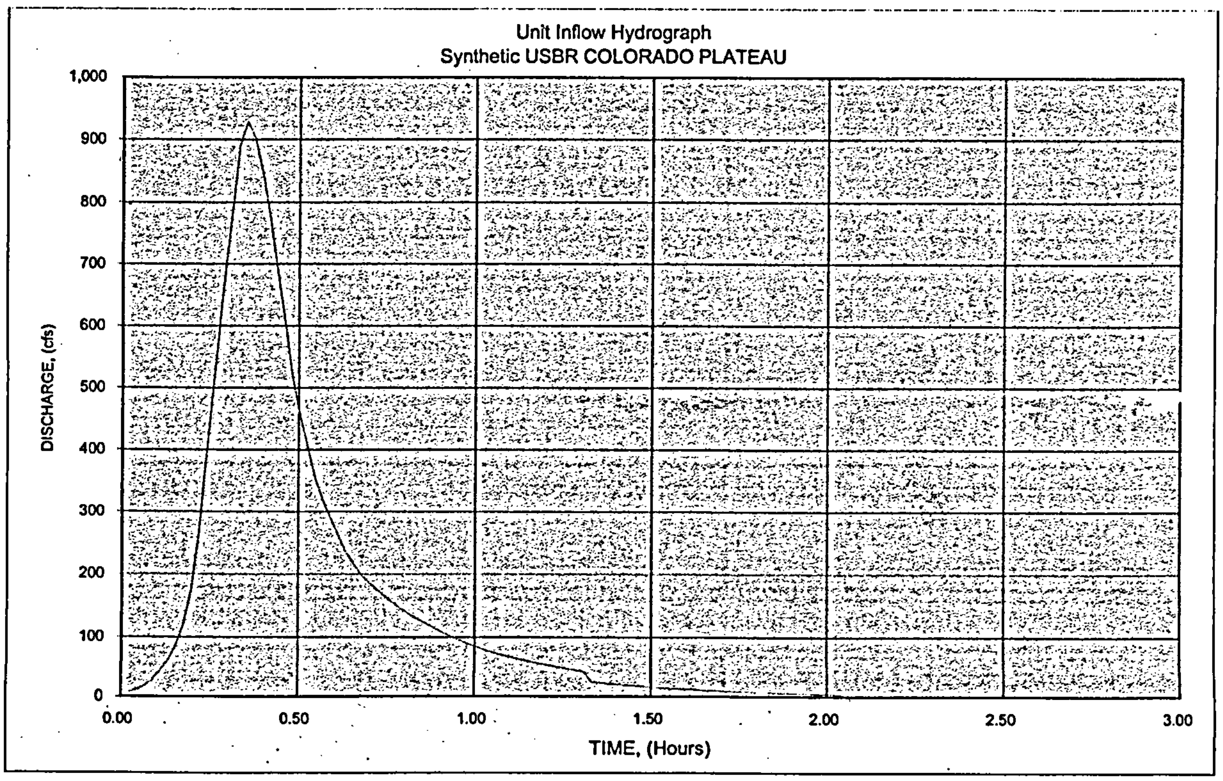
Drainage Area =	0.5218 sq. miles	Lg+D/2 =	0.44 Hours
Basin Slope =	666 ft./mile	Basin Factor =	0.05
L =	1.38 mi., Length of Watercourse	V' =	14.03 cfs/Day
Lca =	0.86 mi., Distance to Centroid	Qs =	32.1 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.40 Hours	Unit Duration, D =	4.31 minutes
			Calculated Timestep =	1.31 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	22	106	460	901	770	463	299	208	162	131
UI	106	85	69	56	45	37	30	24	20	16
UI	13	11	8	7	6	5	4			
UI										
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USBR calculated unitgraph peak = 928 Interpolated Peak = 901

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.02	1.3	0.19	6	305.0	1.33	80.0	0.66	21
10.0	0.04	2.6	0.32	10	310.0	1.35	81.3	0.63	20
15.0	0.07	3.9	0.48	15	315.0	1.38	82.6	0.59	19
20.0	0.09	5.2	0.74	24	320.0	1.40	83.9	0.56	18
25.0	0.11	6.6	1.21	39	325.0	1.42	85.2	0.53	17
30.0	0.13	7.9	1.81	58	330.0	1.44	86.5	0.50	16
35.0	0.15	9.2	2.63	84	335.0	1.46	87.8	0.47	15
40.0	0.17	10.5	3.68	118	340.0	1.49	89.1	0.45	14
45.0	0.20	11.8	5.47	176	345.0	1.51	90.4	0.42	13
50.0	0.22	13.1	8.41	270	350.0	1.53	91.8	0.40	13
55.0	0.24	14.4	12.61	405	355.0	1.55	93.1	0.38	12
60.0	0.26	15.7	16.50	530	360.0	1.57	94.4	0.36	12
65.0	0.28	17.0	20.50	658	365.0	1.59	95.7	0.34	11
70.0	0.31	18.4	23.97	770	370.0	1.62	97.0	0.33	11
75.0	0.33	19.7	27.75	891	375.0	1.64	98.3	0.30	10
80.0	0.35	21.0	28.91	928	380.0	1.66	99.6	0.28	9
85.0	0.37	22.3	28.07	901	385.0	1.68	100.9	0.27	9
90.0	0.39	23.6	26.38	847	390.0	1.70	102.2	0.26	8
95.0	0.42	24.9	24.18	776	395.0	1.73	103.6	0.24	8
100.0	0.44	26.2	21.55	692	400.0	1.75	104.9	0.23	7
105.0	0.46	27.5	18.92	608	405.0	1.77	106.2	0.22	7
110.0	0.48	28.8	16.08	516	410.0	1.79	107.5	0.21	7
115.0	0.50	30.1	14.19	456	415.0	1.81	108.8	0.20	6
120.0	0.52	31.5	12.61	405	420.0	1.84	110.1	0.19	6
125.0	0.55	32.8	11.04	355	425.0	1.86	111.4	0.18	6
130.0	0.57	34.1	9.99	321	430.0	1.88	112.7	0.17	5
135.0	0.59	35.4	9.04	290	435.0	1.90	114.0	0.16	5
140.0	0.61	36.7	8.20	263	440.0	1.92	115.4	0.15	5
145.0	0.63	38.0	7.36	236	445.0	1.94	116.7	0.15	5
150.0	0.66	39.3	6.78	218	450.0	1.97	118.0	0.13	4
155.0	0.68	40.6	6.20	199	455.0	1.99	119.3	0.12	4
160.0	0.70	41.9	5.83	187	460.0	2.01	120.6	0.12	4
165.0	0.72	43.3	5.47	176	465.0	2.03	121.9	0.11	4
170.0	0.74	44.6	5.15	165	470.0	2.05	123.2		
175.0	0.76	45.9	4.84	155	475.0	2.08	124.5		
180.0	0.79	47.2	4.57	147	480.0	2.10	125.8		
185.0	0.81	48.5	4.31	138	485.0	2.12	127.1		
190.0	0.83	49.8	4.10	132	490.0	2.14	128.5		
195.0	0.85	51.1	3.87	124	495.0	2.16	129.8		
200.0	0.87	52.4	3.68	118	500.0	2.18	131.1		
205.0	0.90	53.7	3.47	111	505.0	2.21	132.4		
210.0	0.92	55.1	3.28	105	510.0	2.23	133.7		
215.0	0.94	56.4	3.10	100	515.0	2.25	135.0		
220.0	0.96	57.7	2.93	94	520.0	2.27	136.3		
225.0	0.98	59.0	2.75	88	525.0	2.29	137.6		
230.0	1.00	60.3	2.63	84	530.0	2.32	138.9		
235.0	1.03	61.6	2.47	79	535.0	2.34	140.3		
240.0	1.05	62.9	2.33	75	540.0	2.36	141.6		
245.0	1.07	64.2	2.22	71	545.0	2.38	142.9		
250.0	1.09	65.5	2.10	67	550.0	2.40	144.2		
255.0	1.11	66.9	1.99	64	555.0	2.42	145.5		
260.0	1.14	68.2	1.88	60	560.0	2.45	146.8		
265.0	1.16	69.5	1.78	57	565.0	2.47	148.1		
270.0	1.18	70.8	1.68	54	570.0	2.49	149.4		
275.0	1.20	72.1	1.59	51	575.0	2.51	150.7		
280.0	1.22	73.4	1.50	48	580.0	2.53	152.1		
285.0	1.25	74.7	1.43	46	585.0	2.56	153.4		
290.0	1.27	76.0	1.36	44	590.0	2.58	154.7		
295.0	1.29	77.3	1.28	41	595.0	2.60	156.0		
300.0	1.31	78.6	1.21	39	600.0	2.62	157.3		

NOTES : Use for models including Basin B for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin for Culvert C7-10, 25, 100, 200 Proposed Conditions

Drainage Area =	0.4087	sq. miles	Lg+D/2 =	0.51	Hours
Basin Slope =	501	ft./mile	Basin Factor =	0.04	
L =	1.27	mi., Length of Watercourse	V' =	10.99	cfs/Day
Lca =	0.62	mi., Distance to Centroid	Qs =	21.7	* q, cfs
Kn =	0.054	-, Ave. Weighted Manning's n			

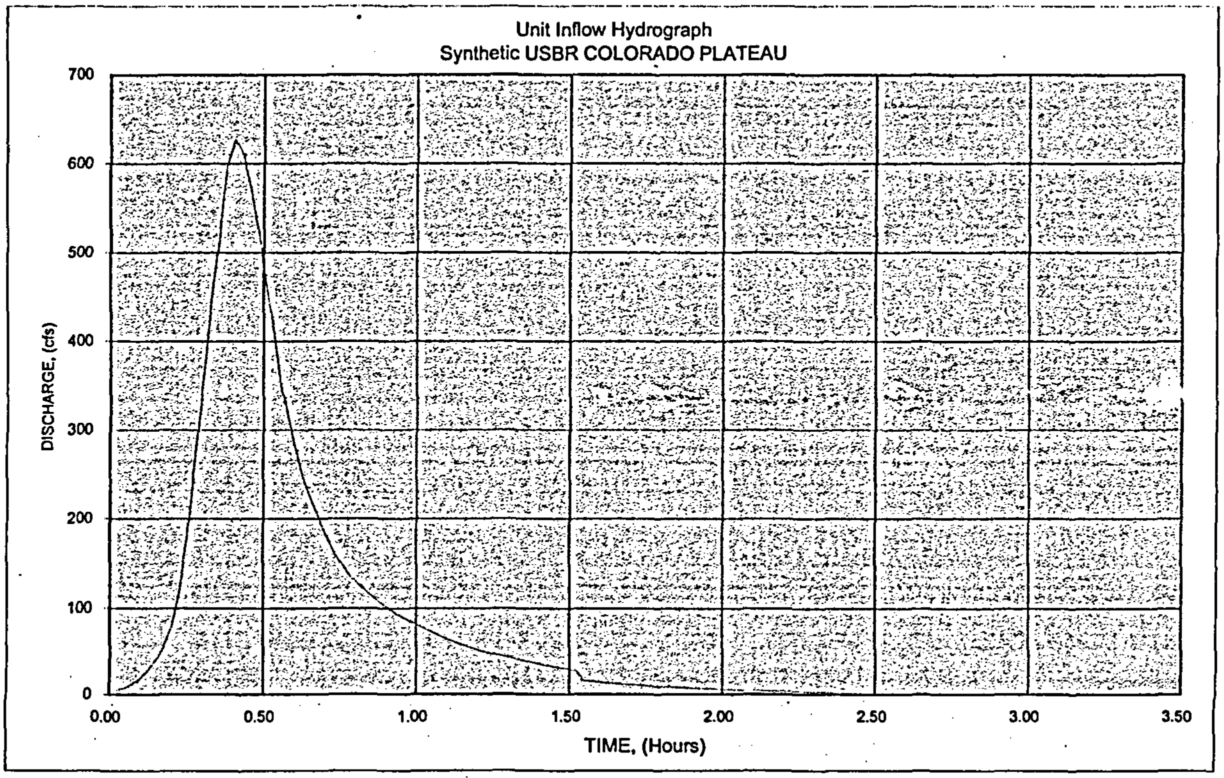
PARAMETERS:

Calculated: Lag Time, Lg = 0.47 Hours — Unit Duration, D = 5.07 minutes

Calculated Timestep = 1.52 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	12	49	174	456	619	483	307	210	152	120
UI	98	82	68	57	47	39	33	27	23	19
UI	16	13	11	9	8	6	5	5	4	3
UI	3									
UI										
UI										
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USBR calculated unitgraph peak = 627   Interpolated Peak = 619

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.5	0.19	4	305.0	1.55	92.8	0.66	14
10.0	0.05	3.0	0.32	7	310.0	1.57	94.3	0.63	14
15.0	0.08	4.6	0.48	10	315.0	1.60	95.8	0.59	13
20.0	0.10	6.1	0.74	16	320.0	1.62	97.3	0.56	12
25.0	0.13	7.6	1.21	26	325.0	1.65	98.8	0.53	11
30.0	0.15	9.1	1.81	39	330.0	1.67	100.4	0.50	11
35.0	0.18	10.6	2.63	57	335.0	1.70	101.9	0.47	10
40.0	0.20	12.2	3.68	80	340.0	1.72	103.4	0.45	10
45.0	0.23	13.7	5.47	119	345.0	1.75	104.9	0.42	9
50.0	0.25	15.2	8.41	182	350.0	1.77	106.4	0.40	9
55.0	0.28	16.7	12.61	273	355.0	1.80	108.0	0.38	8
60.0	0.30	18.2	16.50	358	360.0	1.82	109.5	0.36	8
65.0	0.33	19.8	20.50	444	365.0	1.85	111.0	0.34	7
70.0	0.35	21.3	23.97	520	370.0	1.88	112.5	0.33	7
75.0	0.38	22.8	27.75	602	375.0	1.90	114.0	0.30	7
80.0	0.41	24.3	28.91	627	380.0	1.93	115.6	0.28	6
85.0	0.43	25.9	28.07	609	385.0	1.95	117.1	0.27	6
90.0	0.46	27.4	26.38	572	390.0	1.98	118.6	0.26	6
95.0	0.48	28.9	24.18	524	395.0	2.00	120.1	0.24	5
100.0	0.51	30.4	21.55	467	400.0	2.03	121.6	0.23	5
105.0	0.53	31.9	18.92	410	405.0	2.05	123.2	0.22	5
110.0	0.56	33.5	16.08	349	410.0	2.08	124.7	0.21	5
115.0	0.58	35.0	14.19	308	415.0	2.10	126.2	0.20	4
120.0	0.61	36.5	12.61	273	420.0	2.13	127.7	0.19	4
125.0	0.63	38.0	11.04	239	425.0	2.15	129.3	0.18	4
130.0	0.66	39.5	9.99	217	430.0	2.18	130.8	0.17	4
135.0	0.68	41.1	9.04	196	435.0	2.20	132.3	0.16	3
140.0	0.71	42.6	8.20	178	440.0	2.23	133.8	0.15	3
145.0	0.73	44.1	7.36	160	445.0	2.26	135.3	0.15	3
150.0	0.76	45.6	6.78	147	450.0	2.28	136.9	0.13	3
155.0	0.79	47.1	6.20	134	455.0	2.31	138.4	0.12	3
160.0	0.81	48.7	5.83	126	460.0	2.33	139.9	0.12	3
165.0	0.84	50.2	5.47	119	465.0	2.36	141.4	0.11	2
170.0	0.86	51.7	5.15	112	470.0	2.38	142.9		
175.0	0.89	53.2	4.84	105	475.0	2.41	144.5		
180.0	0.91	54.7	4.57	99	480.0	2.43	146.0		
185.0	0.94	56.3	4.31	93	485.0	2.46	147.5		
190.0	0.96	57.8	4.10	89	490.0	2.48	149.0		
195.0	0.99	59.3	3.87	84	495.0	2.51	150.5		
200.0	1.01	60.8	3.68	80	500.0	2.53	152.1		
205.0	1.04	62.3	3.47	75	505.0	2.56	153.6		
210.0	1.06	63.9	3.28	71	510.0	2.59	155.1		
215.0	1.09	65.4	3.10	67	515.0	2.61	156.6		
220.0	1.12	66.9	2.93	64	520.0	2.64	158.1		
225.0	1.14	68.4	2.75	60	525.0	2.66	159.7		
230.0	1.17	69.9	2.63	57	530.0	2.69	161.2		
235.0	1.19	71.5	2.47	54	535.0	2.71	162.7		
240.0	1.22	73.0	2.33	51	540.0	2.74	164.2		
245.0	1.24	74.5	2.22	48	545.0	2.76	165.7		
250.0	1.27	76.0	2.10	46	550.0	2.79	167.3		
255.0	1.29	77.6	1.99	43	555.0	2.81	168.8		
260.0	1.32	79.1	1.88	41	560.0	2.84	170.3		
265.0	1.34	80.6	1.78	39	565.0	2.86	171.8		
270.0	1.37	82.1	1.68	36	570.0	2.89	173.3		
275.0	1.39	83.6	1.59	34	575.0	2.91	174.9		
280.0	1.42	85.2	1.50	33	580.0	2.94	176.4		
285.0	1.44	86.7	1.43	31	585.0	2.97	177.9		
290.0	1.47	88.2	1.36	29	590.0	2.99	179.4		
295.0	1.50	89.7	1.28	28	595.0	3.02	181.0		
300.0	1.52	91.2	1.21	26	600.0	3.04	182.5		

NOTES : Use for models including the Culvert C7 Basin for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin D-10, 25, 100, 200 Proposed Conditions

Drainage Area =	0.3827 sq. miles		Lg+D/2 =	0.71 Hours
Basin Slope =	62.23 ft./mile		Basin Factor =	0.11
L =	1.25 mi., Length of Watercourse		V' =	10.29 cfs/Day
Lca =	0.68 mi., Distance to Centroid		Qs =	14.4 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n			

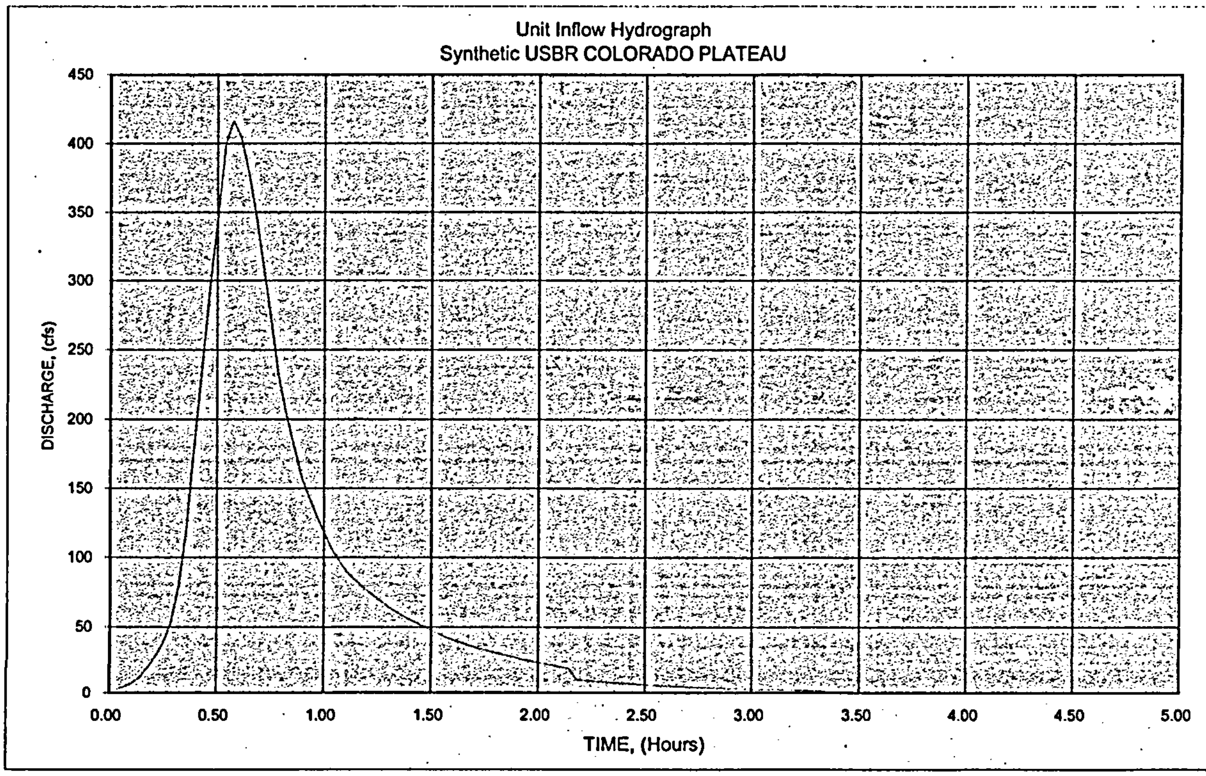
PARAMETERS:

Calculated: Lag Time, Lg = 0.67 Hours Unit Duration, D = 7.34 minutes

Calculated Timestep = 2.14 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	5	15	38	93	218	345	412	359	273	197
UI	149	118	95	81	70	61	54	47	41	36
UI	32	28	25	22	19	17	15	13	11	10
UI	9	8	7	6	5	5	4	4	3	3
UI	3	2	2	2						
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USBR calculated unitgraph peak = 416 Interpolated Peak = 412

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.04	2.1	0.19	3	305.0	2.18	130.8	0.66	10
10.0	0.07	4.3	0.32	5	310.0	2.22	132.9	0.63	9
15.0	0.11	6.4	0.48	7	315.0	2.25	135.1	0.59	8
20.0	0.14	8.6	0.74	11	320.0	2.29	137.2	0.56	8
25.0	0.18	10.7	1.21	17	325.0	2.32	139.4	0.53	8
30.0	0.21	12.9	1.81	26	330.0	2.36	141.5	0.50	7
35.0	0.25	15.0	2.63	38	335.0	2.39	143.7	0.47	7
40.0	0.29	17.2	3.68	53	340.0	2.43	145.8	0.45	6
45.0	0.32	19.3	5.47	79	345.0	2.47	148.0	0.42	6
50.0	0.36	21.4	8.41	121	350.0	2.50	150.1	0.40	6
55.0	0.39	23.6	12.61	182	355.0	2.54	152.2	0.38	5
60.0	0.43	25.7	16.50	238	360.0	2.57	154.4	0.36	5
65.0	0.46	27.9	20.50	295	365.0	2.61	156.5	0.34	5
70.0	0.50	30.0	23.97	345	370.0	2.64	158.7	0.33	5
75.0	0.54	32.2	27.75	400	375.0	2.68	160.8	0.30	4
80.0	0.57	34.3	28.91	416	380.0	2.72	163.0	0.28	4
85.0	0.61	36.5	28.07	404	385.0	2.75	165.1	0.27	4
90.0	0.64	38.6	26.38	380	390.0	2.79	167.3	0.26	4
95.0	0.68	40.7	24.18	348	395.0	2.82	169.4	0.24	3
100.0	0.71	42.9	21.55	310	400.0	2.86	171.5	0.23	3
105.0	0.75	45.0	18.92	272	405.0	2.89	173.7	0.22	3
110.0	0.79	47.2	16.08	232	410.0	2.93	175.8	0.21	3
115.0	0.82	49.3	14.19	204	415.0	2.97	178.0	0.20	3
120.0	0.86	51.5	12.61	182	420.0	3.00	180.1	0.19	3
125.0	0.89	53.6	11.04	159	425.0	3.04	182.3	0.18	3
130.0	0.93	55.8	9.99	144	430.0	3.07	184.4	0.17	2
135.0	0.96	57.9	9.04	130	435.0	3.11	186.5	0.16	2
140.0	1.00	60.0	8.20	118	440.0	3.14	188.7	0.15	2
145.0	1.04	62.2	7.36	106	445.0	3.18	190.8	0.15	2
150.0	1.07	64.3	6.78	98	450.0	3.22	193.0	0.13	2
155.0	1.11	66.5	6.20	89	455.0	3.25	195.1	0.12	2
160.0	1.14	68.6	5.83	84	460.0	3.29	197.3	0.12	2
165.0	1.18	70.8	5.47	79	465.0	3.32	199.4	0.11	2
170.0	1.22	72.9	5.15	74	470.0	3.36	201.6		
175.0	1.25	75.0	4.84	70	475.0	3.40	203.7		
180.0	1.29	77.2	4.57	66	480.0	3.43	205.8		
185.0	1.32	79.3	4.31	62	485.0	3.47	208.0		
190.0	1.36	81.5	4.10	59	490.0	3.50	210.1		
195.0	1.39	83.6	3.87	56	495.0	3.54	212.3		
200.0	1.43	85.8	3.68	53	500.0	3.57	214.4		
205.0	1.47	87.9	3.47	50	505.0	3.61	216.6		
210.0	1.50	90.1	3.28	47	510.0	3.65	218.7		
215.0	1.54	92.2	3.10	45	515.0	3.68	220.9		
220.0	1.57	94.3	2.93	42	520.0	3.72	223.0		
225.0	1.61	96.5	2.75	40	525.0	3.75	225.1		
230.0	1.64	98.6	2.63	38	530.0	3.79	227.3		
235.0	1.68	100.8	2.47	36	535.0	3.82	229.4		
240.0	1.72	102.9	2.33	34	540.0	3.86	231.6		
245.0	1.75	105.1	2.22	32	545.0	3.90	233.7		
250.0	1.79	107.2	2.10	30	550.0	3.93	235.9		
255.0	1.82	109.4	1.99	29	555.0	3.97	238.0		
260.0	1.86	111.5	1.88	27	560.0	4.00	240.2		
265.0	1.89	113.6	1.78	26	565.0	4.04	242.3		
270.0	1.93	115.8	1.68	24	570.0	4.07	244.4		
275.0	1.97	117.9	1.59	23	575.0	4.11	246.6		
280.0	2.00	120.1	1.50	22	580.0	4.15	248.7		
285.0	2.04	122.2	1.43	21	585.0	4.18	250.9		
290.0	2.07	124.4	1.36	20	590.0	4.22	253.0		
295.0	2.11	126.5	1.28	18	595.0	4.25	255.2		
300.0	2.14	128.7	1.21	17	600.0	4.29	257.3		

NOTES : Use for models including Basin D for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

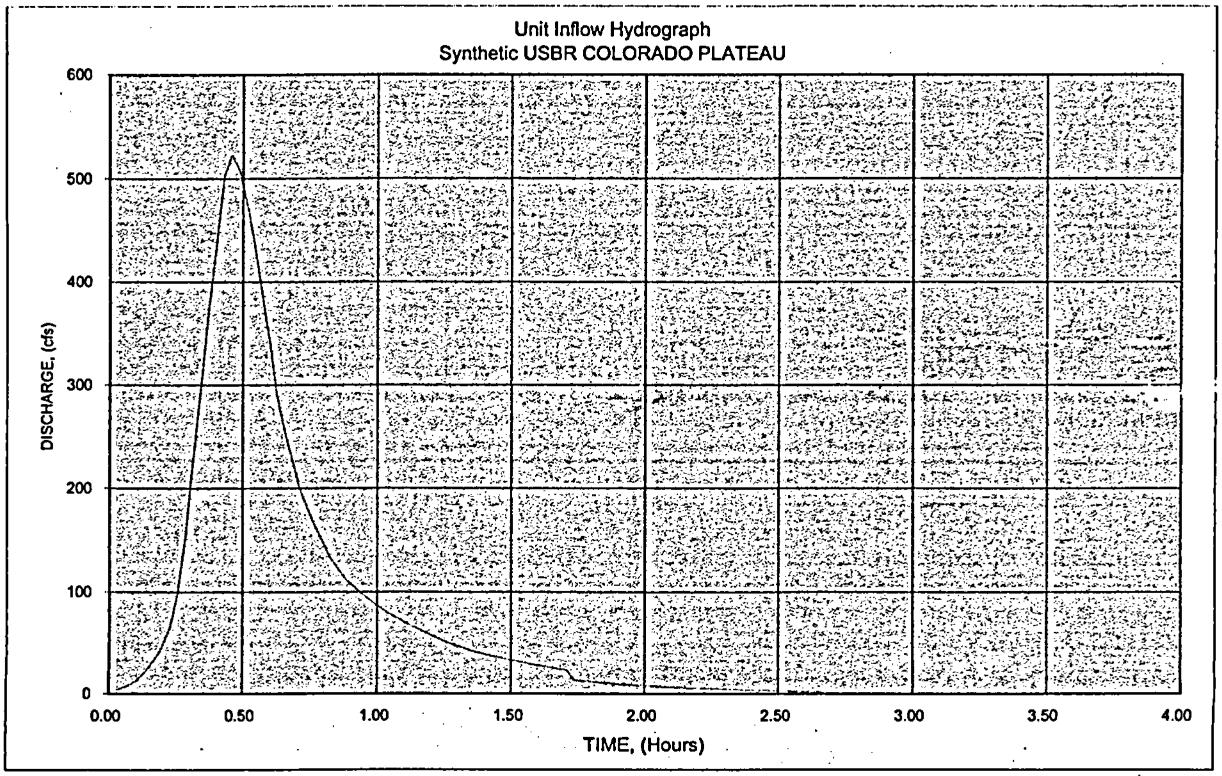
Basin D-PMP Proposed Conditions

Drainage Area =	0.3827 sq. miles		Lg+D/2 =	0.57 Hours
Basin Slope =	62.37 ft./mile		Basin Factor =	0.11
L =	1.28 mi., Length of Watercourse		V' =	10.29 cfs/Day
Lca =	0.68 mi., Distance to Centroid		Qs =	18.1 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

PARAMETERS:

Calculated: Lag Time, Lg = 0.53 Hours Unit Duration, D = 5.75 minutes
Calculated Timestep = 1.71 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph 5 minute interval

UI	8	31	92	278	477	490	366	244	175	130
UI	104	87	74	63	53	45	38	33	28	24
UI	20	17	15	12	11	9	8	7	5	5
UI	4	3	3	3	2					
UI										
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USBR calculated unitgraph peak = 523 Interpolated Peak = 490

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.7	0.19	3	305.0	1.74	104.1	0.66	12
10.0	0.06	3.4	0.32	6	310.0	1.76	105.9	0.63	11
15.0	0.09	5.1	0.48	9	315.0	1.79	107.6	0.59	11
20.0	0.11	6.8	0.74	13	320.0	1.82	109.3	0.56	10
25.0	0.14	8.5	1.21	22	325.0	1.85	111.0	0.53	10
30.0	0.17	10.2	1.81	33	330.0	1.88	112.7	0.50	9
35.0	0.20	12.0	2.63	48	335.0	1.91	114.4	0.47	8
40.0	0.23	13.7	3.68	67	340.0	1.93	116.1	0.45	8
45.0	0.26	15.4	5.47	99	345.0	1.96	117.8	0.42	8
50.0	0.28	17.1	8.41	152	350.0	1.99	119.5	0.40	7
55.0	0.31	18.8	12.61	228	355.0	2.02	121.2	0.38	7
60.0	0.34	20.5	16.50	298	360.0	2.05	122.9	0.36	7
65.0	0.37	22.2	20.50	371	365.0	2.08	124.6	0.34	6
70.0	0.40	23.9	23.97	433	370.0	2.11	126.3	0.33	6
75.0	0.43	25.6	27.75	502	375.0	2.13	128.0	0.30	5
80.0	0.46	27.3	28.91	523	380.0	2.16	129.8	0.28	5
85.0	0.48	29.0	28.07	508	385.0	2.19	131.5	0.27	5
90.0	0.51	30.7	26.38	477	390.0	2.22	133.2	0.26	5
95.0	0.54	32.4	24.18	437	395.0	2.25	134.9	0.24	4
100.0	0.57	34.1	21.55	390	400.0	2.28	136.6	0.23	4
105.0	0.60	35.9	18.92	342	405.0	2.30	138.3	0.22	4
110.0	0.63	37.6	16.08	291	410.0	2.33	140.0	0.21	4
115.0	0.65	39.3	14.19	257	415.0	2.36	141.7	0.20	4
120.0	0.68	41.0	12.61	228	420.0	2.39	143.4	0.19	3
125.0	0.71	42.7	11.04	200	425.0	2.42	145.1	0.18	3
130.0	0.74	44.4	9.99	181	430.0	2.45	146.8	0.17	3
135.0	0.77	46.1	9.04	163	435.0	2.48	148.5	0.16	3
140.0	0.80	47.8	8.20	148	440.0	2.50	150.2	0.15	3
145.0	0.83	49.5	7.36	133	445.0	2.53	151.9	0.15	3
150.0	0.85	51.2	6.78	123	450.0	2.56	153.7	0.13	2
155.0	0.88	52.9	6.20	112	455.0	2.59	155.4	0.12	2
160.0	0.91	54.6	5.83	105	460.0	2.62	157.1	0.12	2
165.0	0.94	56.3	5.47	99	465.0	2.65	158.8	0.11	2
170.0	0.97	58.0	5,15	93	470.0	2.67	160.5		
175.0	1.00	59.8	4.84	88	475.0	2.70	162.2		
180.0	1.02	61.5	4.57	83	480.0	2.73	163.9		
185.0	1.05	63.2	4.31	78	485.0	2.76	165.6		
190.0	1.08	64.9	4.10	74	490.0	2.79	167.3		
195.0	1.11	66.6	3.87	70	495.0	2.82	169.0		
200.0	1.14	68.3	3.68	67	500.0	2.85	170.7		
205.0	1.17	70.0	3.47	63	505.0	2.87	172.4		
210.0	1.20	71.7	3.28	59	510.0	2.90	174.1		
215.0	1.22	73.4	3.10	56	515.0	2.93	175.8		
220.0	1.25	75.1	2.93	53	520.0	2.96	177.6		
225.0	1.28	76.8	2.75	50	525.0	2.99	179.3		
230.0	1.31	78.5	2.63	48	530.0	3.02	181.0		
235.0	1.34	80.2	2.47	45	535.0	3.04	182.7		
240.0	1.37	81.9	2.33	42	540.0	3.07	184.4		
245.0	1.39	83.7	2.22	40	545.0	3.10	186.1		
250.0	1.42	85.4	2.10	38	550.0	3.13	187.8		
255.0	1.45	87.1	1.99	36	555.0	3.16	189.5		
260.0	1.48	88.8	1.88	34	560.0	3.19	191.2		
265.0	1.51	90.5	1.78	32	565.0	3.22	192.9		
270.0	1.54	92.2	1.68	30	570.0	3.24	194.6		
275.0	1.56	93.9	1.59	29	575.0	3.27	196.3		
280.0	1.59	95.6	1.50	27	580.0	3.30	198.0		
285.0	1.62	97.3	1.43	26	585.0	3.33	199.8		
290.0	1.65	99.0	1.36	25	590.0	3.36	201.5		
295.0	1.68	100.7	1.28	23	595.0	3.39	203.2		
300.0	1.71	102.4	1.21	22	600.0	3.41	204.9		

NOTES : Use for models including Basin D for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin G-10, 25, 100, 200 Proposed Conditions

Drainage Area =	1.3775 sq. miles	Lg+D/2 =	0.93 Hours
Basin Slope =	353 ft./mile	Basin Factor =	0.25
L =	2.96 mi., Length of Watercourse	V' =	37.04 cfs/Day
Lca =	1.58 mi., Distance to Centroid	Qs =	39.9 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

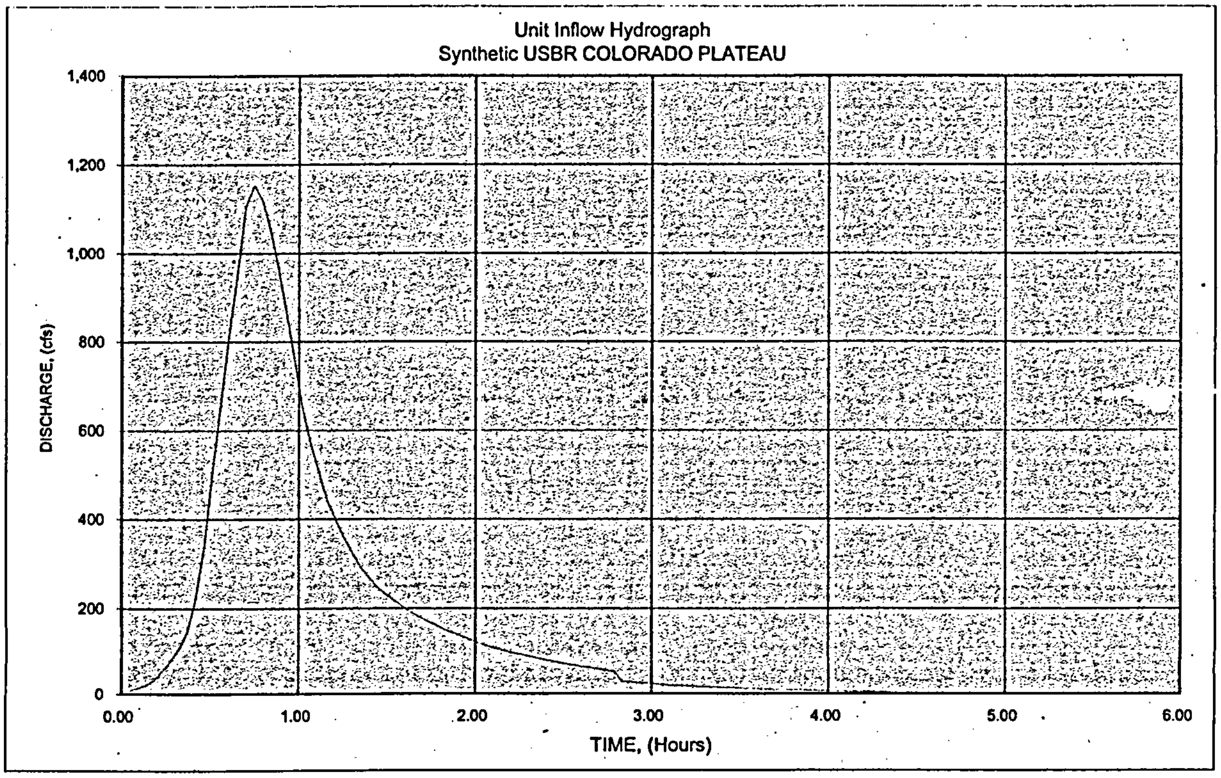
PARAMETERS:

Calculated: Lag Time, Lg = 0.89 Hours Unit Duration, D = 9.68 minutes

Calculated Timestep = 2.79 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	12	25	57	112	216	463	747	1009	1148	1056
UI	887	694	545	435	364	303	259	228	204	183
UI	166	151	136	123	111	101	91	83	75	68
UI	61	56	50	46	41	37	34	31	28	25
UI	23	21	19	17	15	14	13	11	10	9
UI	9	8	7	6	6	5	5			
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USBR calculated unitgraph peak = 1153 Interpolated Peak = 1148

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.05	2.8	0.19	8	305.0	2.83	170.0	0.66	26
10.0	0.09	5.6	0.32	13	310.0	2.88	172.8	0.63	25
15.0	0.14	8.4	0.48	19	315.0	2.93	175.6	0.59	24
20.0	0.19	11.1	0.74	30	320.0	2.97	178.4	0.56	22
25.0	0.23	13.9	1.21	48	325.0	3.02	181.1	0.53	21
30.0	0.28	16.7	1.81	72	330.0	3.07	183.9	0.50	20
35.0	0.33	19.5	2.63	105	335.0	3.11	186.7	0.47	19
40.0	0.37	22.3	3.68	147	340.0	3.16	189.5	0.45	18
45.0	0.42	25.1	5.47	218	345.0	3.20	192.3	0.42	17
50.0	0.46	27.9	8.41	335	350.0	3.25	195.1	0.40	16
55.0	0.51	30.7	12.61	503	355.0	3.30	197.9	0.38	15
60.0	0.56	33.4	16.50	658	360.0	3.34	200.7	0.36	14
65.0	0.60	36.2	20.50	817	365.0	3.39	203.4	0.34	14
70.0	0.65	39.0	23.97	956	370.0	3.44	206.2	0.33	13
75.0	0.70	41.8	27.75	1,106	375.0	3.48	209.0	0.30	12
80.0	0.74	44.6	28.91	1,153	380.0	3.53	211.8	0.28	11
85.0	0.79	47.4	28.07	1,119	385.0	3.58	214.6	0.27	11
90.0	0.84	50.2	26.38	1,052	390.0	3.62	217.4	0.26	10
95.0	0.88	53.0	24.18	964	395.0	3.67	220.2	0.24	10
100.0	0.93	55.7	21.55	859	400.0	3.72	223.0	0.23	9
105.0	0.98	58.5	18.92	754	405.0	3.76	225.7	0.22	9
110.0	1.02	61.3	16.08	641	410.0	3.81	228.5	0.21	8
115.0	1.07	64.1	14.19	566	415.0	3.86	231.3	0.20	8
120.0	1.11	66.9	12.61	503	420.0	3.90	234.1	0.19	8
125.0	1.16	69.7	11.04	440	425.0	3.95	236.9	0.18	7
130.0	1.21	72.5	9.99	398	430.0	3.99	239.7	0.17	7
135.0	1.25	75.2	9.04	360	435.0	4.04	242.5	0.16	6
140.0	1.30	78.0	8.20	327	440.0	4.09	245.2	0.15	6
145.0	1.35	80.8	7.36	293	445.0	4.13	248.0	0.15	6
150.0	1.39	83.6	6.78	270	450.0	4.18	250.8	0.13	5
155.0	1.44	86.4	6.20	247	455.0	4.23	253.6	0.12	5
160.0	1.49	89.2	5.83	232	460.0	4.27	256.4	0.12	5
165.0	1.53	92.0	5.47	218	465.0	4.32	259.2	0.11	4
170.0	1.58	94.8	5.15	205	470.0	4.37	262.0		
175.0	1.63	97.5	4.84	193	475.0	4.41	264.8		
180.0	1.67	100.3	4.57	182	480.0	4.46	267.5		
185.0	1.72	103.1	4.31	172	485.0	4.51	270.3		
190.0	1.77	105.9	4.10	163	490.0	4.55	273.1		
195.0	1.81	108.7	3.87	154	495.0	4.60	275.9		
200.0	1.86	111.5	3.68	147	500.0	4.64	278.7		
205.0	1.90	114.3	3.47	138	505.0	4.69	281.5		
210.0	1.95	117.0	3.28	131	510.0	4.74	284.3		
215.0	2.00	119.8	3.10	124	515.0	4.78	287.0		
220.0	2.04	122.6	2.93	117	520.0	4.83	289.8		
225.0	2.09	125.4	2.75	110	525.0	4.88	292.6		
230.0	2.14	128.2	2.63	105	530.0	4.92	295.4		
235.0	2.18	131.0	2.47	98	535.0	4.97	298.2		
240.0	2.23	133.8	2.33	93	540.0	5.02	301.0		
245.0	2.28	136.6	2.22	89	545.0	5.06	303.8		
250.0	2.32	139.3	2.10	84	550.0	5.11	306.6		
255.0	2.37	142.1	1.99	79	555.0	5.16	309.3		
260.0	2.42	144.9	1.88	75	560.0	5.20	312.1		
265.0	2.46	147.7	1.78	71	565.0	5.25	314.9		
270.0	2.51	150.5	1.68	67	570.0	5.30	317.7		
275.0	2.55	153.3	1.59	63	575.0	5.34	320.5		
280.0	2.60	156.1	1.50	60	580.0	5.39	323.3		
285.0	2.65	158.9	1.43	57	585.0	5.43	326.1		
290.0	2.69	161.6	1.36	54	590.0	5.48	328.9		
295.0	2.74	164.4	1.28	51	595.0	5.53	331.6		
300.0	2.79	167.2	1.21	48	600.0	5.57	334.4		

NOTES : Use for models including Basin G for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Basin G-PMP Proposed Conditions

Drainage Area =	1.3775 sq. miles		Lg+D/2 =	0.73 Hours
Basin Slope =	353 ft./mile		Basin Factor =	0.25
L =	2.96 mi., Length of Watercourse		V' =	37.04 cfs/Day
Lca =	1.58 mi., Distance to Centroid		Qs =	50.6 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n			

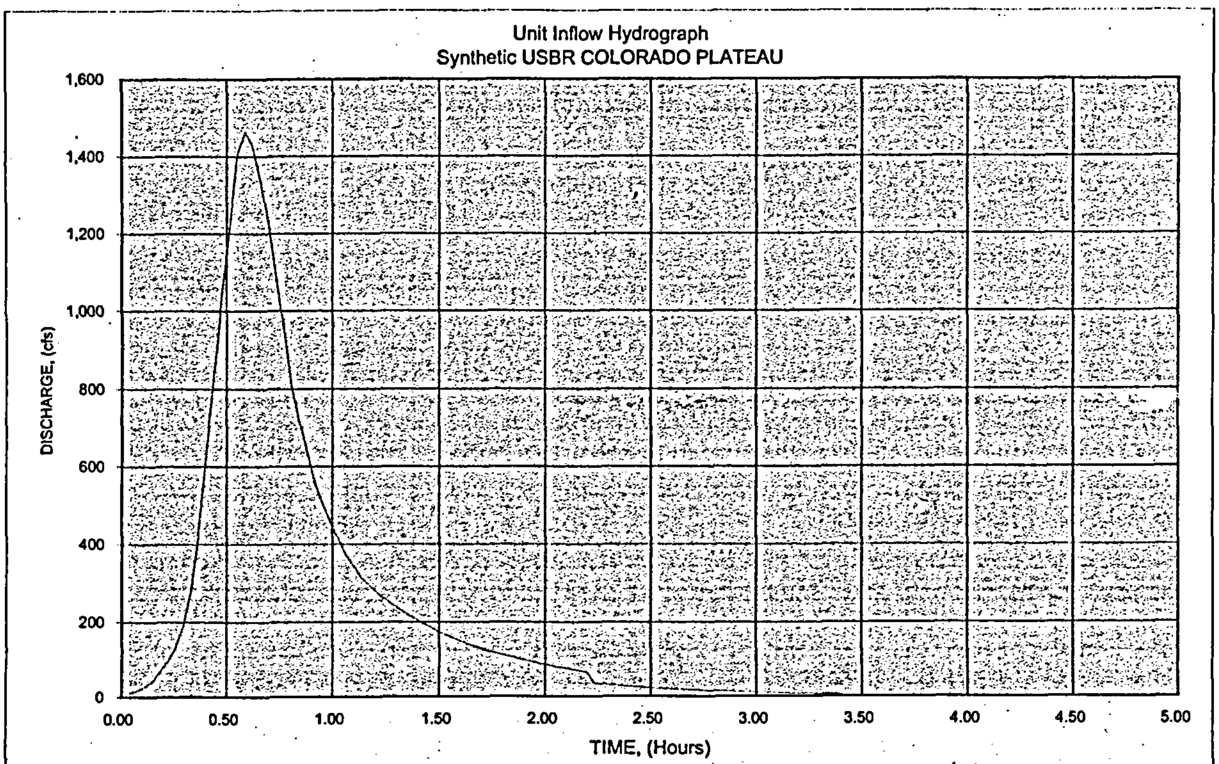
PARAMETERS:

Calculated: Lag Time, Lg = 0.69 Hours Unit Duration, D = 7.53 minutes

Calculated Timestep = 2.20 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph 5 minute interval

UI	18	51	126	293	715	1154	1460	1311	1025	740
UI	556	444	355	297	258	226	199	176	155	136
UI	119	106	93	82	73	64	56	50	43	39
UI	34	30	27	23	21	18	16	14	12	11
UI	10	9	8	6	6					
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USBR calculated unitgraph peak = 1463 Interpolated Peak = 1460

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.04	2.2	0.19	10	305.0	2.23	133.9	0.66	33
10.0	0.07	4.4	0.32	16	310.0	2.27	136.1	0.63	32
15.0	0.11	6.6	0.48	24	315.0	2.31	138.3	0.59	30
20.0	0.15	8.8	0.74	37	320.0	2.34	140.5	0.56	28
25.0	0.18	11.0	1.21	61	325.0	2.38	142.7	0.53	27
30.0	0.22	13.2	1.81	92	330.0	2.41	144.9	0.50	25
35.0	0.26	15.4	2.63	133	335.0	2.45	147.1	0.47	24
40.0	0.29	17.6	3.68	186	340.0	2.49	149.3	0.45	23
45.0	0.33	19.8	5.47	277	345.0	2.52	151.5	0.42	21
50.0	0.37	22.0	8.41	426	350.0	2.56	153.7	0.40	20
55.0	0.40	24.1	12.61	638	355.0	2.60	155.9	0.38	19
60.0	0.44	26.3	16.50	835	360.0	2.63	158.1	0.36	18
65.0	0.48	28.5	20.50	1,038	365.0	2.67	160.3	0.34	17
70.0	0.51	30.7	23.97	1,213	370.0	2.71	162.5	0.33	17
75.0	0.55	32.9	27.75	1,405	375.0	2.74	164.7	0.30	15
80.0	0.59	35.1	28.91	1,463	380.0	2.78	166.8	0.28	14
85.0	0.62	37.3	28.07	1,421	385.0	2.82	169.0	0.27	14
90.0	0.66	39.5	26.38	1,335	390.0	2.85	171.2	0.26	13
95.0	0.70	41.7	24.18	1,224	395.0	2.89	173.4	0.24	12
100.0	0.73	43.9	21.55	1,091	400.0	2.93	175.6	0.23	12
105.0	0.77	46.1	18.92	958	405.0	2.96	177.8	0.22	11
110.0	0.80	48.3	16.08	814	410.0	3.00	180.0	0.21	11
115.0	0.84	50.5	14.19	718	415.0	3.04	182.2	0.20	10
120.0	0.88	52.7	12.61	638	420.0	3.07	184.4	0.19	10
125.0	0.91	54.9	11.04	559	425.0	3.11	186.6	0.18	9
130.0	0.95	57.1	9.99	506	430.0	3.15	188.8	0.17	9
135.0	0.99	59.3	9.04	458	435.0	3.18	191.0	0.16	8
140.0	1.02	61.5	8.20	415	440.0	3.22	193.2	0.15	8
145.0	1.06	63.7	7.36	373	445.0	3.26	195.4	0.15	8
150.0	1.10	65.9	6.78	343	450.0	3.29	197.6	0.13	7
155.0	1.13	68.1	6.20	314	455.0	3.33	199.8	0.12	6
160.0	1.17	70.3	5.83	295	460.0	3.37	202.0	0.12	6
165.0	1.21	72.4	5.47	277	465.0	3.40	204.2	0.11	6
170.0	1.24	74.6	5.15	261	470.0	3.44	206.4		
175.0	1.28	76.8	4.84	245	475.0	3.48	208.6		
180.0	1.32	79.0	4.57	231	480.0	3.51	210.8		
185.0	1.35	81.2	4.31	218	485.0	3.55	212.9		
190.0	1.39	83.4	4.10	208	490.0	3.59	215.1		
195.0	1.43	85.6	3.87	196	495.0	3.62	217.3		
200.0	1.46	87.8	3.68	186	500.0	3.66	219.5		
205.0	1.50	90.0	3.47	176	505.0	3.70	221.7		
210.0	1.54	92.2	3.28	166	510.0	3.73	223.9		
215.0	1.57	94.4	3.10	157	515.0	3.77	226.1		
220.0	1.61	96.6	2.93	148	520.0	3.81	228.3		
225.0	1.65	98.8	2.75	139	525.0	3.84	230.5		
230.0	1.68	101.0	2.63	133	530.0	3.88	232.7		
235.0	1.72	103.2	2.47	125	535.0	3.92	234.9		
240.0	1.76	105.4	2.33	118	540.0	3.95	237.1		
245.0	1.79	107.6	2.22	112	545.0	3.99	239.3		
250.0	1.83	109.8	2.10	106	550.0	4.02	241.5		
255.0	1.87	112.0	1.99	101	555.0	4.06	243.7		
260.0	1.90	114.2	1.88	95	560.0	4.10	245.9		
265.0	1.94	116.4	1.78	90	565.0	4.13	248.1		
270.0	1.98	118.5	1.68	85	570.0	4.17	250.3		
275.0	2.01	120.7	1.59	80	575.0	4.21	252.5		
280.0	2.05	122.9	1.50	76	580.0	4.24	254.7		
285.0	2.09	125.1	1.43	72	585.0	4.28	256.9		
290.0	2.12	127.3	1.36	69	590.0	4.32	259.1		
295.0	2.16	129.5	1.28	65	595.0	4.35	261.2		
300.0	2.20	131.7	1.21	61	600.0	4.39	263.4		

NOTES : Use for models including Basin G for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

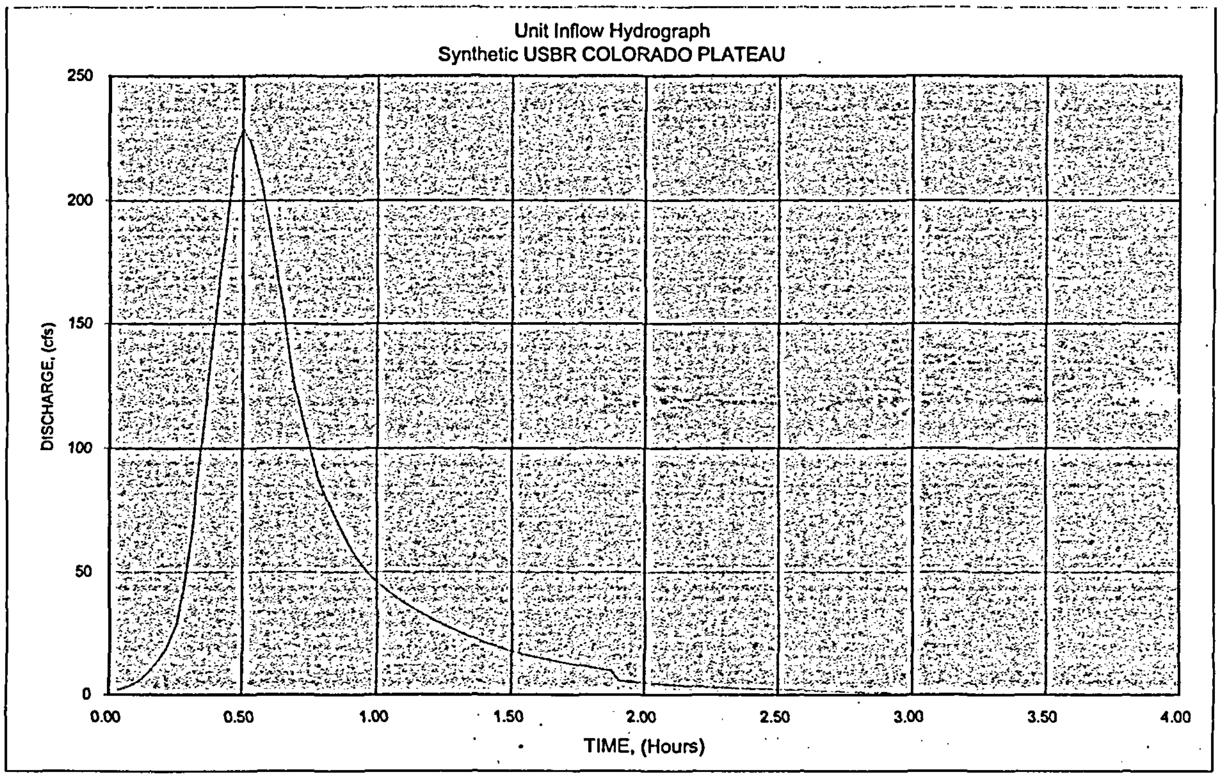
Design Point 1-10, 25, 100, 200 Proposed Conditions

Drainage Area =	0.1839 sq. miles	Lg+D/2 =	0.63 Hours
Basin Slope =	70.74 ft./mile	Basin Factor =	0.07
L =	1.13 mi., Length of Watercourse	V' =	4.95 cfs/Day
Lca =	0.52 mi., Distance to Centroid	Qs =	7.9 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.58 Hours	Unit Duration, D =	6.36 minutes
			Calculated Timestep =	1.88 minutes

Data to be used	Unit Duration, D =	5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute Interval**

UI	6	24	88	220	282	210	133	91	66	53
UI	43	36	30	25	20	17	14	12	10	8
UI	7	6	5	4	3	3	2	2	2	1
UI										
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USBR calculated unitgraph peak = 229 Interpolated Peak = 282

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.9	0.19	2	305.0	1.91	114.4	0.66	5
10.0	0.06	3.8	0.32	3	310.0	1.94	116.3	0.63	5
15.0	0.09	5.6	0.48	4	315.0	1.97	118.1	0.59	5
20.0	0.13	7.5	0.74	6	320.0	2.00	120.0	0.56	4
25.0	0.16	9.4	1.21	10	325.0	2.03	121.9	0.53	4
30.0	0.19	11.3	1.81	14	330.0	2.06	123.8	0.50	4
35.0	0.22	13.1	2.63	21	335.0	2.09	125.6	0.47	4
40.0	0.25	15.0	3.68	29	340.0	2.13	127.5	0.45	4
45.0	0.28	16.9	5.47	43	345.0	2.16	129.4	0.42	3
50.0	0.31	18.8	8.41	67	350.0	2.19	131.3	0.40	3
55.0	0.34	20.6	12.61	100	355.0	2.22	133.1	0.38	3
60.0	0.38	22.5	16.50	131	360.0	2.25	135.0	0.36	3
65.0	0.41	24.4	20.50	162	365.0	2.28	136.9	0.34	3
70.0	0.44	26.3	23.97	190	370.0	2.31	138.8	0.33	3
75.0	0.47	28.1	27.75	220	375.0	2.34	140.6	0.30	2
80.0	0.50	30.0	28.91	229	380.0	2.38	142.5	0.28	2
85.0	0.53	31.9	28.07	222	385.0	2.41	144.4	0.27	2
90.0	0.56	33.8	26.38	209	390.0	2.44	146.3	0.26	2
95.0	0.59	35.6	24.18	191	395.0	2.47	148.1	0.24	2
100.0	0.63	37.5	21.55	170	400.0	2.50	150.0	0.23	2
105.0	0.66	39.4	18.92	150	405.0	2.53	151.9	0.22	2
110.0	0.69	41.3	16.08	127	410.0	2.56	153.8	0.21	2
115.0	0.72	43.1	14.19	112	415.0	2.59	155.6	0.20	2
120.0	0.75	45.0	12.61	100	420.0	2.63	157.5	0.19	2
125.0	0.78	46.9	11.04	87	425.0	2.66	159.4	0.18	1
130.0	0.81	48.8	9.99	79	430.0	2.69	161.3	0.17	1
135.0	0.84	50.6	9.04	72	435.0	2.72	163.1	0.16	1
140.0	0.88	52.5	8.20	65	440.0	2.75	165.0	0.15	1
145.0	0.91	54.4	7.36	58	445.0	2.78	166.9	0.15	1
150.0	0.94	56.3	6.78	54	450.0	2.81	168.8	0.13	1
155.0	0.97	58.1	6.20	49	455.0	2.84	170.6	0.12	1
160.0	1.00	60.0	5.83	46	460.0	2.88	172.5	0.12	1
165.0	1.03	61.9	5.47	43	465.0	2.91	174.4	0.11	1
170.0	1.06	63.8	5.15	41	470.0	2.94	176.3		
175.0	1.09	65.6	4.84	38	475.0	2.97	178.1		
180.0	1.13	67.5	4.57	36	480.0	3.00	180.0		
185.0	1.16	69.4	4.31	34	485.0	3.03	181.9		
190.0	1.19	71.3	4.10	32	490.0	3.06	183.8		
195.0	1.22	73.1	3.87	31	495.0	3.09	185.6		
200.0	1.25	75.0	3.68	29	500.0	3.13	187.5		
205.0	1.28	76.9	3.47	27	505.0	3.16	189.4		
210.0	1.31	78.8	3.28	26	510.0	3.19	191.3		
215.0	1.34	80.6	3.10	25	515.0	3.22	193.1		
220.0	1.38	82.5	2.93	23	520.0	3.25	195.0		
225.0	1.41	84.4	2.75	22	525.0	3.28	196.9		
230.0	1.44	86.3	2.63	21	530.0	3.31	198.8		
235.0	1.47	88.1	2.47	20	535.0	3.34	200.6		
240.0	1.50	90.0	2.33	18	540.0	3.38	202.5		
245.0	1.53	91.9	2.22	18	545.0	3.41	204.4		
250.0	1.56	93.8	2.10	17	550.0	3.44	206.3		
255.0	1.59	95.6	1.99	16	555.0	3.47	208.1		
260.0	1.63	97.5	1.88	15	560.0	3.50	210.0		
265.0	1.66	99.4	1.78	14	565.0	3.53	211.9		
270.0	1.69	101.3	1.68	13	570.0	3.56	213.8		
275.0	1.72	103.1	1.59	13	575.0	3.59	215.6		
280.0	1.75	105.0	1.50	12	580.0	3.63	217.5		
285.0	1.78	106.9	1.43	11	585.0	3.66	219.4		
290.0	1.81	108.8	1.36	11	590.0	3.69	221.3		
295.0	1.84	110.6	1.28	10	595.0	3.72	223.2		
300.0	1.88	112.5	1.21	10	600.0	3.75	225.0		

NOTES : Use for models including Design Point 1 (Basin E) for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

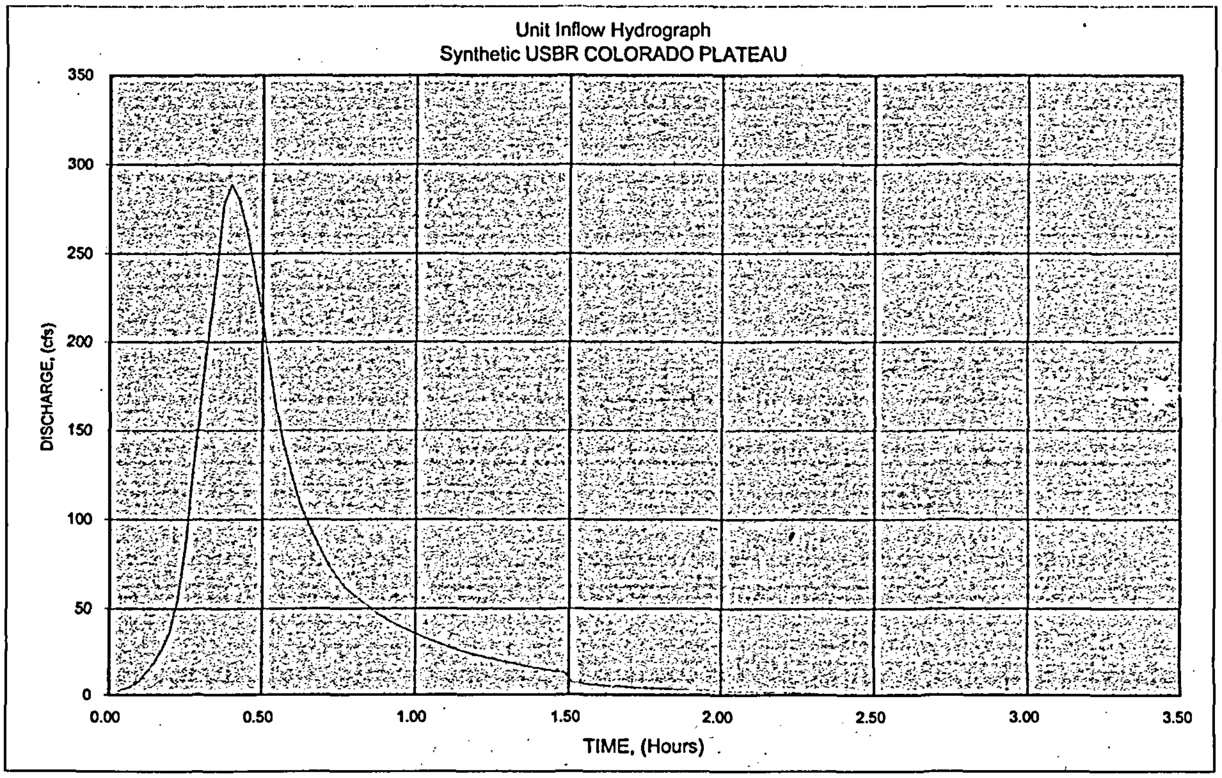
Design Point 1-PMP Proposed Conditions

Drainage Area =	0.1839 sq. miles	Lg+D/2 =	0.50 Hours
Basin Slope =	70.74 ft./mile	Basin Factor =	0.07
L =	1.13 mi., Length of Watercourse	V' =	4.95 cfs/Day
Lca =	0.52 mi., Distance to Centroid	Qs =	10.0 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.45 Hours	Unit Duration, D =	4.95 minutes
			Calculated Timestep =	1.49 minutes

Data to be used	Unit Duration, D =	5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	6	24	88	220	282	210	133	91	66	53
UI	43	36	30	25	20	17	14	12	10	8
UI	7	6	5	4	3	3	2	2	2	1
UI										
UI										
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USBR calculated unitgraph peak = 289 Interpolated Peak = 282

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.02	1.5	0.19	2	305.0	1.51	90.7	0.66	7
10.0	0.05	3.0	0.32	3	310.0	1.54	92.1	0.63	6
15.0	0.07	4.5	0.48	5	315.0	1.56	93.6	0.59	6
20.0	0.10	5.9	0.74	7	320.0	1.59	95.1	0.56	6
25.0	0.12	7.4	1.21	12	325.0	1.61	96.6	0.53	5
30.0	0.15	8.9	1.81	18	330.0	1.63	98.1	0.50	5
35.0	0.17	10.4	2.63	26	335.0	1.66	99.6	0.47	5
40.0	0.20	11.9	3.68	37	340.0	1.68	101.1	0.45	4
45.0	0.22	13.4	5.47	55	345.0	1.71	102.6	0.42	4
50.0	0.25	14.9	8.41	84	350.0	1.73	104.0	0.40	4
55.0	0.27	16.3	12.61	126	355.0	1.76	105.5	0.38	4
60.0	0.30	17.8	16.50	165	360.0	1.78	107.0	0.36	4
65.0	0.32	19.3	20.50	205	365.0	1.81	108.5	0.34	3
70.0	0.35	20.8	23.97	239	370.0	1.83	110.0	0.33	3
75.0	0.37	22.3	27.75	277	375.0	1.86	111.5	0.30	3
80.0	0.40	23.8	28.91	289	380.0	1.88	113.0	0.28	3
85.0	0.42	25.3	28.07	280	385.0	1.91	114.4	0.27	3
90.0	0.45	26.8	26.38	263	390.0	1.93	115.9	0.26	3
95.0	0.47	28.2	24.18	241	395.0	1.96	117.4	0.24	2
100.0	0.50	29.7	21.55	215	400.0	1.98	118.9	0.23	2
105.0	0.52	31.2	18.92	189	405.0	2.01	120.4	0.22	2
110.0	0.54	32.7	16.08	161	410.0	2.03	121.9	0.21	2
115.0	0.57	34.2	14.19	142	415.0	2.06	123.4	0.20	2
120.0	0.59	35.7	12.61	126	420.0	2.08	124.8	0.19	2
125.0	0.62	37.2	11.04	110	425.0	2.11	126.3	0.18	2
130.0	0.64	38.6	9.99	100	430.0	2.13	127.8	0.17	2
135.0	0.67	40.1	9.04	90	435.0	2.16	129.3	0.16	2
140.0	0.69	41.6	8.20	82	440.0	2.18	130.8	0.15	1
145.0	0.72	43.1	7.36	73	445.0	2.20	132.3	0.15	1
150.0	0.74	44.6	6.78	68	450.0	2.23	133.8	0.13	1
155.0	0.77	46.1	6.20	62	455.0	2.25	135.3	0.12	1
160.0	0.79	47.6	5.83	58	460.0	2.28	136.7	0.12	1
165.0	0.82	49.0	5.47	55	465.0	2.30	138.2	0.11	1
170.0	0.84	50.5	5.15	51	470.0	2.33	139.7		
175.0	0.87	52.0	4.84	48	475.0	2.35	141.2		
180.0	0.89	53.5	4.57	46	480.0	2.38	142.7		
185.0	0.92	55.0	4.31	43	485.0	2.40	144.2		
190.0	0.94	56.5	4.10	41	490.0	2.43	145.7		
195.0	0.97	58.0	3.87	39	495.0	2.45	147.1		
200.0	0.99	59.5	3.68	37	500.0	2.48	148.6		
205.0	1.02	60.9	3.47	35	505.0	2.50	150.1		
210.0	1.04	62.4	3.28	33	510.0	2.53	151.6		
215.0	1.07	63.9	3.10	31	515.0	2.55	153.1		
220.0	1.09	65.4	2.93	29	520.0	2.58	154.6		
225.0	1.11	66.9	2.75	27	525.0	2.60	156.1		
230.0	1.14	68.4	2.63	26	530.0	2.63	157.5		
235.0	1.16	69.9	2.47	25	535.0	2.65	159.0		
240.0	1.19	71.3	2.33	23	540.0	2.68	160.5		
245.0	1.21	72.8	2.22	22	545.0	2.70	162.0		
250.0	1.24	74.3	2.10	21	550.0	2.72	163.5		
255.0	1.26	75.8	1.99	20	555.0	2.75	165.0		
260.0	1.29	77.3	1.88	19	560.0	2.77	166.5		
265.0	1.31	78.8	1.78	18	565.0	2.80	167.9		
270.0	1.34	80.3	1.68	17	570.0	2.82	169.4		
275.0	1.36	81.7	1.59	16	575.0	2.85	170.9		
280.0	1.39	83.2	1.50	15	580.0	2.87	172.4		
285.0	1.41	84.7	1.43	14	585.0	2.90	173.9		
290.0	1.44	86.2	1.36	14	590.0	2.92	175.4		
295.0	1.46	87.7	1.28	13	595.0	2.95	176.9		
300.0	1.49	89.2	1.21	12	600.0	2.97	178.4		

NOTES : Use for models including Design Point 1 (Basin E) for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

Design Point 2-10, 25, 100, 200 Proposed Conditions

Drainage Area =	0.0863 sq. miles		Lg+D/2 =	0.66 Hours
Basin Slope =	52.14 ft./mile		Basin Factor =	0.08
L =	1.04 mi., Length of Watercourse		V' =	2.32 cfs/Day
Lca =	0.59 mi., Distance to Centroid		Qs =	3.5 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n			

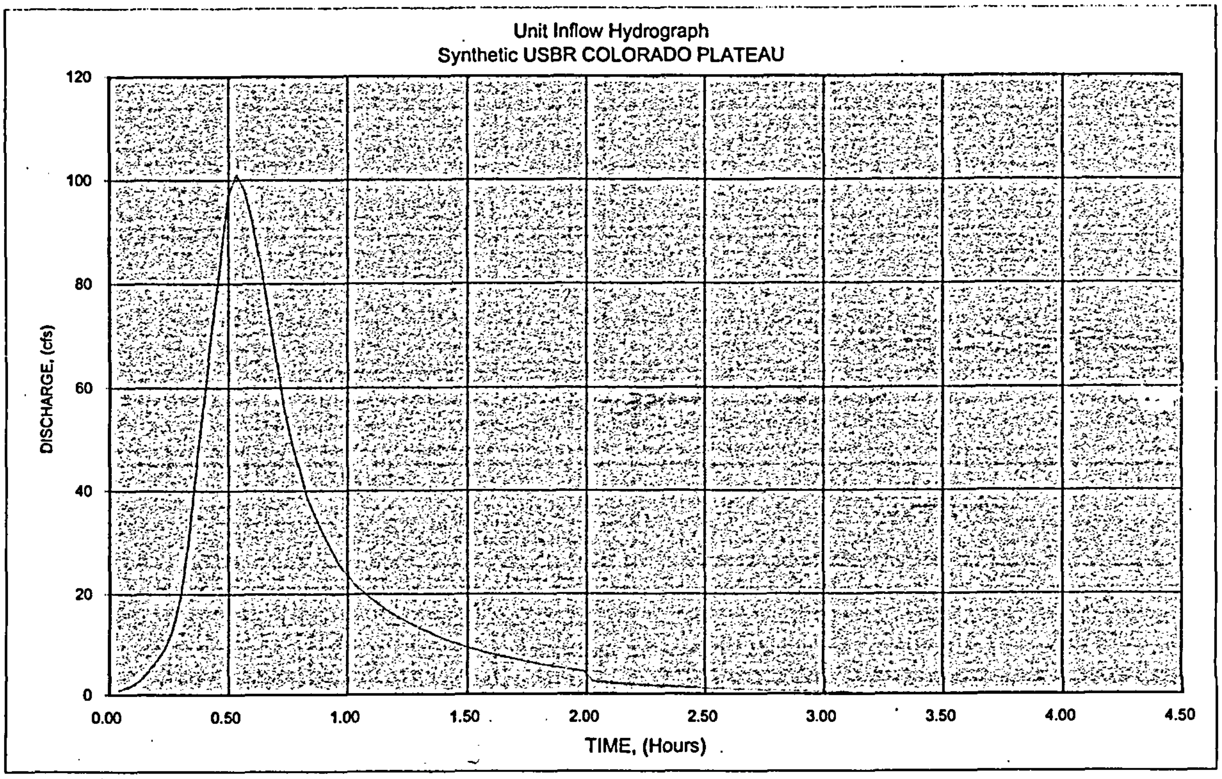
PARAMETERS:

Calculated: Lag Time, Lg = 0.62 Hours Unit Duration, D = 6.79 minutes

Calculated Timestep = 1.99 minutes

Data to be used in Analysis Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360

Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	1	4	11	30	65	97	95	75	52	38
UI	30	23	20	17	15	13	11	10	8	7
UI	6	5	5	4	4	3	3	2	2	2
UI	2	1	1	1	1	1	1	1	1	0
UI	0									
UI										
UI										
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USBR calculated unitgraph peak = 101 Interpolated Peak = 97

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	2.0	0.19	1	305.0	2.03	121.5	0.66	2
10.0	0.07	4.0	0.32	1	310.0	2.06	123.5	0.63	2
15.0	0.10	6.0	0.48	2	315.0	2.09	125.5	0.59	2
20.0	0.13	8.0	0.74	3	320.0	2.12	127.5	0.56	2
25.0	0.17	10.0	1.21	4	325.0	2.16	129.5	0.53	2
30.0	0.20	12.0	1.81	6	330.0	2.19	131.5	0.50	2
35.0	0.23	13.9	2.63	9	335.0	2.22	133.5	0.47	2
40.0	0.27	15.9	3.68	13	340.0	2.26	135.5	0.45	2
45.0	0.30	17.9	5.47	19	345.0	2.29	137.5	0.42	1
50.0	0.33	19.9	8.41	29	350.0	2.32	139.4	0.40	1
55.0	0.37	21.9	12.61	44	355.0	2.36	141.4	0.38	1
60.0	0.40	23.9	16.50	58	360.0	2.39	143.4	0.36	1
65.0	0.43	25.9	20.50	72	365.0	2.42	145.4	0.34	1
70.0	0.46	27.9	23.97	84	370.0	2.46	147.4	0.33	1
75.0	0.50	29.9	27.75	97	375.0	2.49	149.4	0.30	1
80.0	0.53	31.9	28.91	101	380.0	2.52	151.4	0.28	1
85.0	0.56	33.9	28.07	98	385.0	2.56	153.4	0.27	1
90.0	0.60	35.9	26.38	92	390.0	2.59	155.4	0.26	1
95.0	0.63	37.8	24.18	85	395.0	2.62	157.4	0.24	1
100.0	0.66	39.8	21.55	75	400.0	2.66	159.4	0.23	1
105.0	0.70	41.8	18.92	66	405.0	2.69	161.4	0.22	1
110.0	0.73	43.8	16.08	56	410.0	2.72	163.3	0.21	1
115.0	0.76	45.8	14.19	50	415.0	2.76	165.3	0.20	1
120.0	0.80	47.8	12.61	44	420.0	2.79	167.3	0.19	1
125.0	0.83	49.8	11.04	39	425.0	2.82	169.3	0.18	1
130.0	0.86	51.8	9.99	35	430.0	2.86	171.3	0.17	1
135.0	0.90	53.8	9.04	32	435.0	2.89	173.3	0.16	1
140.0	0.93	55.8	8.20	29	440.0	2.92	175.3	0.15	1
145.0	0.96	57.8	7.36	26	445.0	2.95	177.3	0.15	1
150.0	1.00	59.8	6.78	24	450.0	2.99	179.3	0.13	0
155.0	1.03	61.8	6.20	22	455.0	3.02	181.3	0.12	0
160.0	1.06	63.7	5.83	20	460.0	3.05	183.3	0.12	0
165.0	1.10	65.7	5.47	19	465.0	3.09	185.3	0.11	0
170.0	1.13	67.7	5.15	18	470.0	3.12	187.3		
175.0	1.16	69.7	4.84	17	475.0	3.15	189.2		
180.0	1.20	71.7	4.57	16	480.0	3.19	191.2		
185.0	1.23	73.7	4.31	15	485.0	3.22	193.2		
190.0	1.26	75.7	4.10	14	490.0	3.25	195.2		
195.0	1.29	77.7	3.87	14	495.0	3.29	197.2		
200.0	1.33	79.7	3.68	13	500.0	3.32	199.2		
205.0	1.36	81.7	3.47	12	505.0	3.35	201.2		
210.0	1.39	83.7	3.28	11	510.0	3.39	203.2		
215.0	1.43	85.7	3.10	11	515.0	3.42	205.2		
220.0	1.46	87.7	2.93	10	520.0	3.45	207.2		
225.0	1.49	89.6	2.75	10	525.0	3.49	209.2		
230.0	1.53	91.6	2.63	9	530.0	3.52	211.2		
235.0	1.56	93.6	2.47	9	535.0	3.55	213.1		
240.0	1.59	95.6	2.33	8	540.0	3.59	215.1		
245.0	1.63	97.6	2.22	8	545.0	3.62	217.1		
250.0	1.66	99.6	2.10	7	550.0	3.65	219.1		
255.0	1.69	101.6	1.99	7	555.0	3.69	221.1		
260.0	1.73	103.6	1.88	7	560.0	3.72	223.1		
265.0	1.76	105.6	1.78	6	565.0	3.75	225.1		
270.0	1.79	107.6	1.68	6	570.0	3.78	227.1		
275.0	1.83	109.6	1.59	6	575.0	3.82	229.1		
280.0	1.86	111.6	1.50	5	580.0	3.85	231.1		
285.0	1.89	113.5	1.43	5	585.0	3.88	233.1		
290.0	1.93	115.5	1.36	5	590.0	3.92	235.1		
295.0	1.96	117.5	1.28	4	595.0	3.95	237.1		
300.0	1.99	119.5	1.21	4	600.0	3.98	239.0		

NOTES : Use for models including Design Point 2 (Basin F) for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH

18-May-06

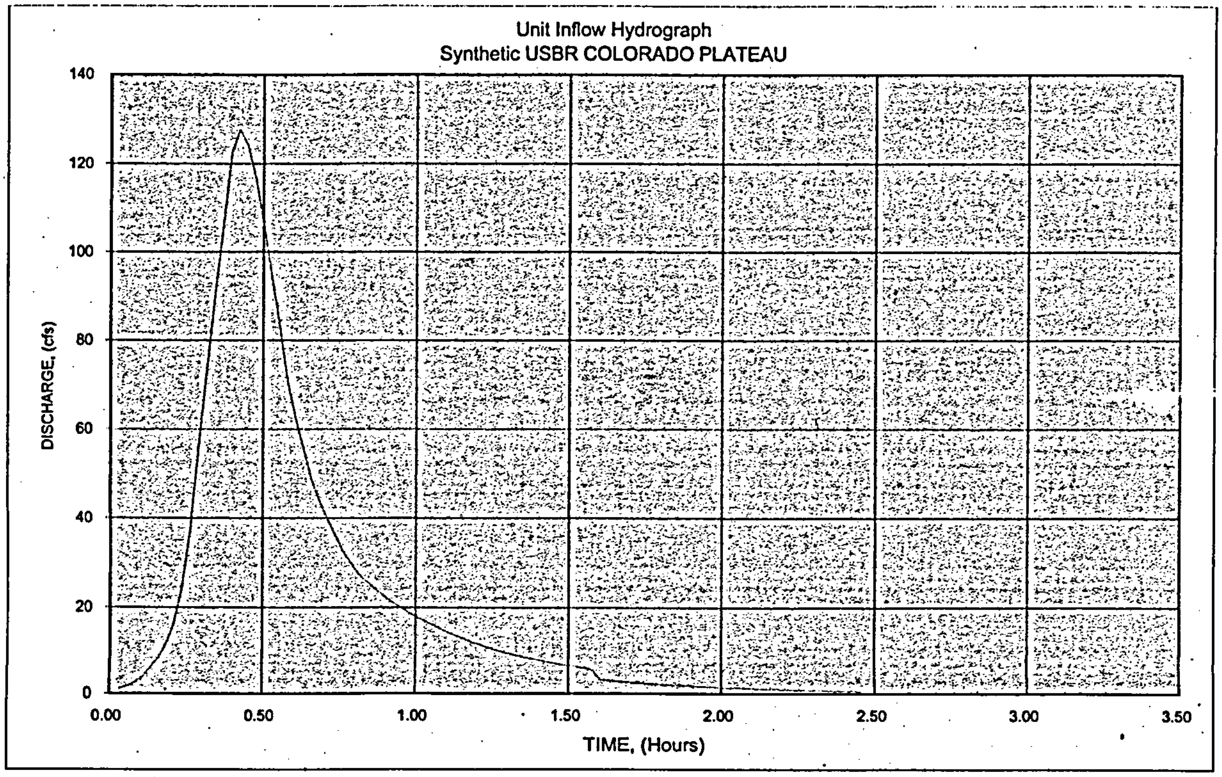
Design Point 2-PMP Proposed Conditions

Drainage Area =	0.0863 sq. miles	Lg+D/2 =	0.53 Hours
Basin Slope =	52.14 ft./mile	Basin Factor =	0.08
L =	1.04 mi., Length of Watercourse	V' =	2.32 cfs/Day
Lca =	0.59 mi., Distance to Centroid	Qs =	4.4 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.48 Hours	Unit Duration, D =	5.28 minutes
			Calculated Timestep =	1.58 minutes

Data to be used	Unit Duration, D =	5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	2	9	31	85	127	106	69	47	34	26
UI	22	18	15	13	11	9	7	6	5	4
UI	4	3	3	2	2	2	1	1	1	1
UI	1	1								
UI										
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USBR calculated unitgraph peak = 128 Interpolated Peak = 127

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.6	0.19	1	305.0	1.60	96.2	0.66	3
10.0	0.05	3.2	0.32	1	310.0	1.63	97.8	0.63	3
15.0	0.08	4.7	0.48	2	315.0	1.66	99.4	0.59	3
20.0	0.11	6.3	0.74	3	320.0	1.68	100.9	0.56	2
25.0	0.13	7.9	1.21	5	325.0	1.71	102.5	0.53	2
30.0	0.16	9.5	1.81	8	330.0	1.73	104.1	0.50	2
35.0	0.18	11.0	2.63	12	335.0	1.76	105.7	0.47	2
40.0	0.21	12.6	3.68	16	340.0	1.79	107.2	0.45	2
45.0	0.24	14.2	5.47	24	345.0	1.81	108.8	0.42	2
50.0	0.26	15.8	8.41	37	350.0	1.84	110.4	0.40	2
55.0	0.29	17.3	12.61	56	355.0	1.87	112.0	0.38	2
60.0	0.32	18.9	16.50	73	360.0	1.89	113.6	0.36	2
65.0	0.34	20.5	20.50	90	365.0	1.92	115.1	0.34	2
70.0	0.37	22.1	23.97	106	370.0	1.95	116.7	0.33	1
75.0	0.39	23.7	27.75	122	375.0	1.97	118.3	0.30	1
80.0	0.42	25.2	28.91	128	380.0	2.00	119.9	0.28	1
85.0	0.45	26.8	28.07	124	385.0	2.02	121.4	0.27	1
90.0	0.47	28.4	26.38	116	390.0	2.05	123.0	0.26	1
95.0	0.50	30.0	24.18	107	395.0	2.08	124.6	0.24	1
100.0	0.53	31.5	21.55	95	400.0	2.10	126.2	0.23	1
105.0	0.55	33.1	18.92	84	405.0	2.13	127.7	0.22	1
110.0	0.58	34.7	16.08	71	410.0	2.16	129.3	0.21	1
115.0	0.60	36.3	14.19	63	415.0	2.18	130.9	0.20	1
120.0	0.63	37.9	12.61	56	420.0	2.21	132.5	0.19	1
125.0	0.66	39.4	11.04	49	425.0	2.23	134.1	0.18	1
130.0	0.68	41.0	9.99	44	430.0	2.26	135.6	0.17	1
135.0	0.71	42.6	9.04	40	435.0	2.29	137.2	0.16	1
140.0	0.74	44.2	8.20	36	440.0	2.31	138.8	0.15	1
145.0	0.76	45.7	7.36	32	445.0	2.34	140.4	0.15	1
150.0	0.79	47.3	6.78	30	450.0	2.37	141.9	0.13	1
155.0	0.81	48.9	6.20	27	455.0	2.39	143.5	0.12	1
160.0	0.84	50.5	5.83	26	460.0	2.42	145.1	0.12	1
165.0	0.87	52.0	5.47	24	465.0	2.44	146.7	0.11	0
170.0	0.89	53.6	5.15	23	470.0	2.47	148.3		
175.0	0.92	55.2	4.84	21	475.0	2.50	149.8		
180.0	0.95	56.8	4.57	20	480.0	2.52	151.4		
185.0	0.97	58.4	4.31	19	485.0	2.55	153.0		
190.0	1.00	59.9	4.10	18	490.0	2.58	154.6		
195.0	1.03	61.5	3.87	17	495.0	2.60	156.1		
200.0	1.05	63.1	3.68	16	500.0	2.63	157.7		
205.0	1.08	64.7	3.47	15	505.0	2.65	159.3		
210.0	1.10	66.2	3.28	14	510.0	2.68	160.9		
215.0	1.13	67.8	3.10	14	515.0	2.71	162.4		
220.0	1.16	69.4	2.93	13	520.0	2.73	164.0		
225.0	1.18	71.0	2.75	12	525.0	2.76	165.6		
230.0	1.21	72.5	2.63	12	530.0	2.79	167.2		
235.0	1.24	74.1	2.47	11	535.0	2.81	168.8		
240.0	1.26	75.7	2.33	10	540.0	2.84	170.3		
245.0	1.29	77.3	2.22	10	545.0	2.87	171.9		
250.0	1.31	78.9	2.10	9	550.0	2.89	173.5		
255.0	1.34	80.4	1.99	9	555.0	2.92	175.1		
260.0	1.37	82.0	1.88	8	560.0	2.94	176.6		
265.0	1.39	83.6	1.78	8	565.0	2.97	178.2		
270.0	1.42	85.2	1.68	7	570.0	3.00	179.8		
275.0	1.45	86.7	1.59	7	575.0	3.02	181.4		
280.0	1.47	88.3	1.50	7	580.0	3.05	182.9		
285.0	1.50	89.9	1.43	6	585.0	3.08	184.5		
290.0	1.52	91.5	1.36	6	590.0	3.10	186.1		
295.0	1.55	93.1	1.28	6	595.0	3.13	187.7		
300.0	1.58	94.6	1.21	5	600.0	3.15	189.3		

NOTES : Use for models including Design Point 2 (Basin F) for the PMP Local event

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

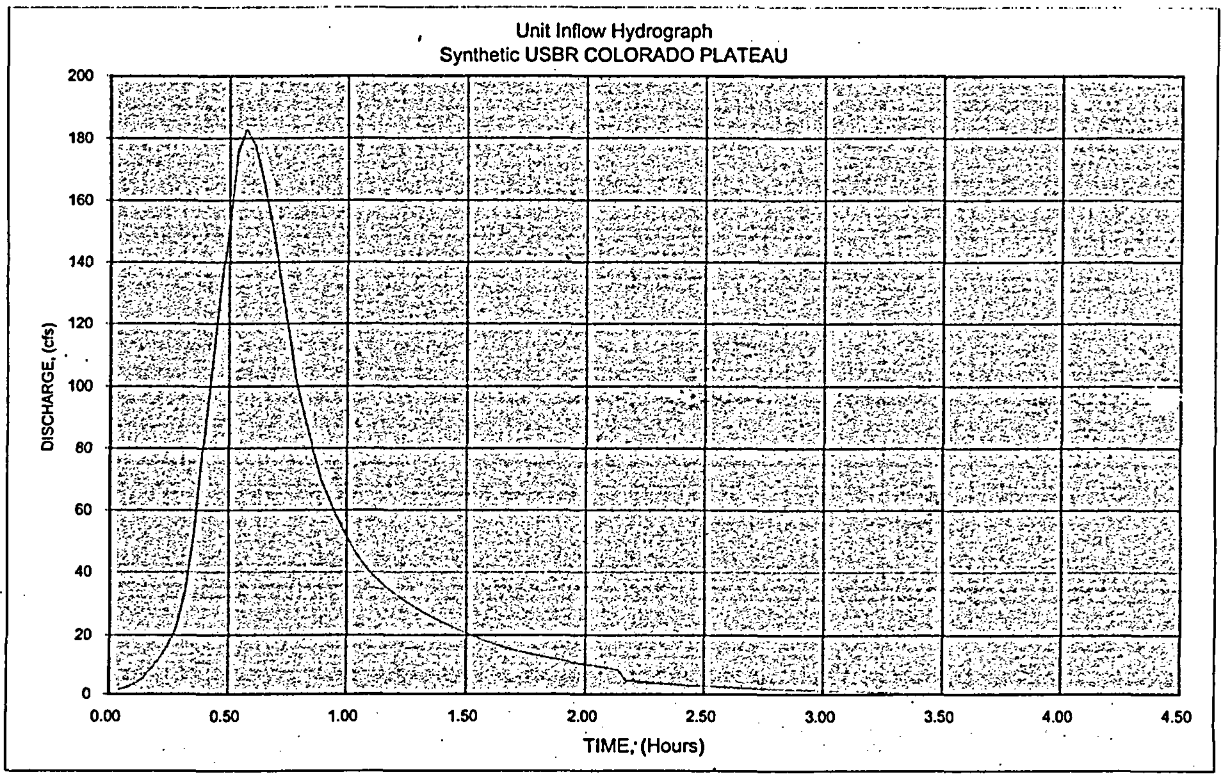
Design Point 3-10, 25, 100, 200 Proposed Conditions

Drainage Area =	0.1675 sq. miles	Lg+D/2 =	0.71 Hours
Basin Slope =	77.56 ft./mile	Basin Factor =	0.11
L =	1.34 mi., Length of Watercourse	V' =	4.50 cfs/Day
Lca =	0.7 mi., Distance to Centroid	Qs =	6.3 * q, cfs
Kn =	0.054 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated:	Lag Time, Lg =	0.67 Hours	Unit Duration, D =	7.31 minutes
			Calculated Timestep =	2.14 minutes

Data to be used	Unit Duration, D =	5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
in Analysis	Selected Timestep =	5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	2	7	17	41	97	153	181	157	119	86
UI	65	51	41	35	30	27	24	21	18	16
UI	14	12	11	9	8	7	6	6	5	4
UI	4	3	3	3	2	2	2	2	1	1
UI	1	1	1	1						
UI										
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USBR calculated unitgraph peak = 183 Interpolated Peak = 181

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.04	2.1	0.19	1	305.0	2.17	130.3	0.66	4
10.0	0.07	4.3	0.32	2	310.0	2.21	132.5	0.63	4
15.0	0.11	6.4	0.48	3	315.0	2.24	134.6	0.59	4
20.0	0.14	8.5	0.74	5	320.0	2.28	136.7	0.56	4
25.0	0.18	10.7	1.21	8	325.0	2.31	138.9	0.53	3
30.0	0.21	12.8	1.81	11	330.0	2.35	141.0	0.50	3
35.0	0.25	15.0	2.63	17	335.0	2.39	143.1	0.47	3
40.0	0.28	17.1	3.68	23	340.0	2.42	145.3	0.45	3
45.0	0.32	19.2	5.47	35	345.0	2.46	147.4	0.42	3
50.0	0.36	21.4	8.41	53	350.0	2.49	149.6	0.40	3
55.0	0.39	23.5	12.61	80	355.0	2.53	151.7	0.38	2
60.0	0.43	25.6	16.50	104	360.0	2.56	153.8	0.36	2
65.0	0.46	27.8	20.50	130	365.0	2.60	156.0	0.34	2
70.0	0.50	29.9	23.97	152	370.0	2.64	158.1	0.33	2
75.0	0.53	32.0	27.75	176	375.0	2.67	160.2	0.30	2
80.0	0.57	34.2	28.91	183	380.0	2.71	162.4	0.28	2
85.0	0.61	36.3	28.07	178	385.0	2.74	164.5	0.27	2
90.0	0.64	38.5	26.38	167	390.0	2.78	166.6	0.26	2
95.0	0.68	40.6	24.18	153	395.0	2.81	168.8	0.24	2
100.0	0.71	42.7	21.55	136	400.0	2.85	170.9	0.23	1
105.0	0.75	44.9	18.92	120	405.0	2.88	173.1	0.22	1
110.0	0.78	47.0	16.08	102	410.0	2.92	175.2	0.21	1
115.0	0.82	49.1	14.19	90	415.0	2.96	177.3	0.20	1
120.0	0.85	51.3	12.61	80	420.0	2.99	179.5	0.19	1
125.0	0.89	53.4	11.04	70	425.0	3.03	181.6	0.18	1
130.0	0.93	55.5	9.99	63	430.0	3.06	183.7	0.17	1
135.0	0.96	57.7	9.04	57	435.0	3.10	185.9	0.16	1
140.0	1.00	59.8	8.20	52	440.0	3.13	188.0	0.15	1
145.0	1.03	62.0	7.36	47	445.0	3.17	190.2	0.15	1
150.0	1.07	64.1	6.78	43	450.0	3.20	192.3	0.13	1
155.0	1.10	66.2	6.20	39	455.0	3.24	194.4	0.12	1
160.0	1.14	68.4	5.83	37	460.0	3.28	196.6	0.12	1
165.0	1.18	70.5	5.47	35	465.0	3.31	198.7	0.11	1
170.0	1.21	72.6	5.15	33	470.0	3.35	200.8		
175.0	1.25	74.8	4.84	31	475.0	3.38	203.0		
180.0	1.28	76.9	4.57	29	480.0	3.42	205.1		
185.0	1.32	79.1	4.31	27	485.0	3.45	207.2		
190.0	1.35	81.2	4.10	26	490.0	3.49	209.4		
195.0	1.39	83.3	3.87	24	495.0	3.53	211.5		
200.0	1.42	85.5	3.68	23	500.0	3.56	213.7		
205.0	1.46	87.6	3.47	22	505.0	3.60	215.8		
210.0	1.50	89.7	3.28	21	510.0	3.63	217.9		
215.0	1.53	91.9	3.10	20	515.0	3.67	220.1		
220.0	1.57	94.0	2.93	19	520.0	3.70	222.2		
225.0	1.60	96.1	2.75	17	525.0	3.74	224.3		
230.0	1.64	98.3	2.63	17	530.0	3.77	226.5		
235.0	1.67	100.4	2.47	16	535.0	3.81	228.6		
240.0	1.71	102.6	2.33	15	540.0	3.85	230.7		
245.0	1.74	104.7	2.22	14	545.0	3.88	232.9		
250.0	1.78	106.8	2.10	13	550.0	3.92	235.0		
255.0	1.82	109.0	1.99	13	555.0	3.95	237.2		
260.0	1.85	111.1	1.88	12	560.0	3.99	239.3		
265.0	1.89	113.2	1.78	11	565.0	4.02	241.4		
270.0	1.92	115.4	1.68	11	570.0	4.06	243.6		
275.0	1.96	117.5	1.59	10	575.0	4.10	245.7		
280.0	1.99	119.6	1.50	9	580.0	4.13	247.8		
285.0	2.03	121.8	1.43	9	585.0	4.17	250.0		
290.0	2.07	123.9	1.36	9	590.0	4.20	252.1		
295.0	2.10	126.1	1.28	8	595.0	4.24	254.2		
300.0	2.14	128.2	1.21	8	600.0	4.27	256.4		

NOTES : Use for models including Design Point 3 (Basin C) for the 10, 25, 100 and 200 year events

COLORADO PLATEAU UNIT HYDROGRAPH 18-May-06

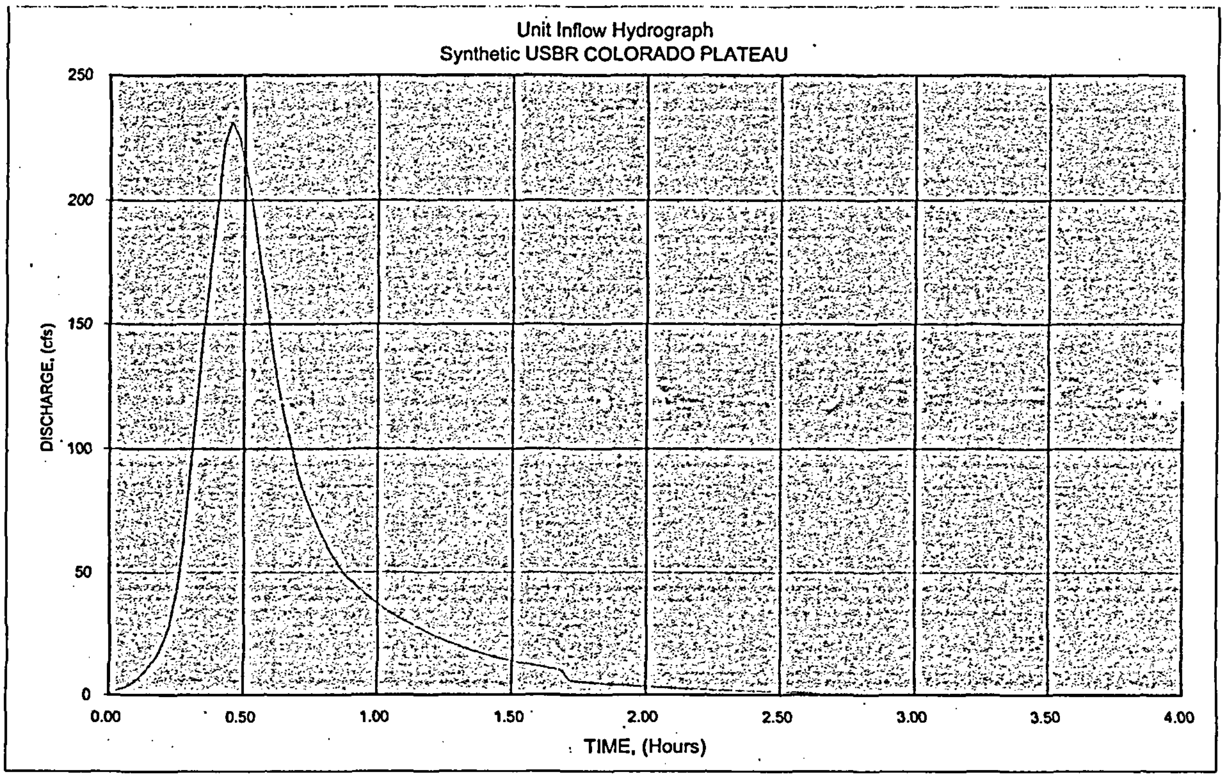
Design Point 3-PMP Proposed Conditions

Drainage Area =	0.1675 sq. miles	Lg+D/2 =	0.56 Hours
Basin Slope =	77.56 ft./mile	Basin Factor =	0.11
L =	1.34 mi., Length of Watercourse	V' =	4.50 cfs/Day
Lca =	0.7 mi., Distance to Centroid	Qs =	8.0 * q, cfs
Kn =	0.042 -, Ave. Weighted Manning's n		

PARAMETERS:

Calculated: Lag Time, Lg = 0.52 Hours — Unit Duration, D = 5.69 minutes; Calculated Timestep = 1.69 minutes

Data to be used in Analysis
Unit Duration, D = 5 minutes, round down to nearest of 5, 10, 15, 30, 60, 120, 180, or 360
Selected Timestep = 5 minutes, integer value evenly divisible into 60



UI Record - Unit Graph **5 minute interval**

UI	4	14	42	127	216	214	157	105	75	56
UI	45	38	32	27	23	19	17	14	12	10
UI	9	7	6	5	4	4	3	3	2	2
UI	2	1	1	1	0					
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USBR calculated unitgraph peak = 231   Interpolated Peak = 216

Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs	Time t, % of Lg+D/2	Hours	Min.	q	Qs cfs
5.0	0.03	1.7	0.19	2	305.0	1.72	103.1	0.66	5
10.0	0.06	3.4	0.32	3	310.0	1.75	104.8	0.63	5
15.0	0.08	5.1	0.48	4	315.0	1.77	106.4	0.59	5
20.0	0.11	6.8	0.74	6	320.0	1.80	108.1	0.56	4
25.0	0.14	8.4	1.21	10	325.0	1.83	109.8	0.53	4
30.0	0.17	10.1	1.81	14	330.0	1.86	111.5	0.50	4
35.0	0.20	11.8	2.63	21	335.0	1.89	113.2	0.47	4
40.0	0.23	13.5	3.68	29	340.0	1.91	114.9	0.45	4
45.0	0.25	15.2	5.47	44	345.0	1.94	116.6	0.42	3
50.0	0.28	16.9	8.41	67	350.0	1.97	118.3	0.40	3
55.0	0.31	18.6	12.61	101	355.0	2.00	120.0	0.38	3
60.0	0.34	20.3	16.50	132	360.0	2.03	121.6	0.36	3
65.0	0.37	22.0	20.50	164	365.0	2.06	123.3	0.34	3
70.0	0.39	23.7	23.97	192	370.0	2.08	125.0	0.33	3
75.0	0.42	25.3	27.75	222	375.0	2.11	126.7	0.30	2
80.0	0.45	27.0	28.91	231	380.0	2.14	128.4	0.28	2
85.0	0.48	28.7	28.07	224	385.0	2.17	130.1	0.27	2
90.0	0.51	30.4	26.38	211	390.0	2.20	131.8	0.26	2
95.0	0.54	32.1	24.18	193	395.0	2.22	133.5	0.24	2
100.0	0.56	33.8	21.55	172	400.0	2.25	135.2	0.23	2
105.0	0.59	35.5	18.92	151	405.0	2.28	136.9	0.22	2
110.0	0.62	37.2	16.08	129	410.0	2.31	138.5	0.21	2
115.0	0.65	38.9	14.19	113	415.0	2.34	140.2	0.20	2
120.0	0.68	40.5	12.61	101	420.0	2.37	141.9	0.19	2
125.0	0.70	42.2	11.04	88	425.0	2.39	143.6	0.18	1
130.0	0.73	43.9	9.99	80	430.0	2.42	145.3	0.17	1
135.0	0.76	45.6	9.04	72	435.0	2.45	147.0	0.16	1
140.0	0.79	47.3	8.20	66	440.0	2.48	148.7	0.15	1
145.0	0.82	49.0	7.36	59	445.0	2.51	150.4	0.15	1
150.0	0.84	50.7	6.78	54	450.0	2.53	152.1	0.13	1
155.0	0.87	52.4	6.20	50	455.0	2.56	153.7	0.12	1
160.0	0.90	54.1	5.83	47	460.0	2.59	155.4	0.12	1
165.0	0.93	55.8	5.47	44	465.0	2.62	157.1	0.11	1
170.0	0.96	57.4	5.15	41	470.0	2.65	158.8		
175.0	0.99	59.1	4.84	39	475.0	2.68	160.5		
180.0	1.01	60.8	4.57	37	480.0	2.70	162.2		
185.0	1.04	62.5	4.31	34	485.0	2.73	163.9		
190.0	1.07	64.2	4.10	33	490.0	2.76	165.6		
195.0	1.10	65.9	3.87	31	495.0	2.79	167.3		
200.0	1.13	67.6	3.68	29	500.0	2.82	169.0		
205.0	1.15	69.3	3.47	28	505.0	2.84	170.6		
210.0	1.18	71.0	3.28	26	510.0	2.87	172.3		
215.0	1.21	72.6	3.10	25	515.0	2.90	174.0		
220.0	1.24	74.3	2.93	23	520.0	2.93	175.7		
225.0	1.27	76.0	2.75	22	525.0	2.96	177.4		
230.0	1.30	77.7	2.63	21	530.0	2.98	179.1		
235.0	1.32	79.4	2.47	20	535.0	3.01	180.8		
240.0	1.35	81.1	2.33	19	540.0	3.04	182.5		
245.0	1.38	82.8	2.22	18	545.0	3.07	184.2		
250.0	1.41	84.5	2.10	17	550.0	3.10	185.8		
255.0	1.44	86.2	1.99	16	555.0	3.13	187.5		
260.0	1.46	87.9	1.88	15	560.0	3.15	189.2		
265.0	1.49	89.5	1.78	14	565.0	3.18	190.9		
270.0	1.52	91.2	1.68	13	570.0	3.21	192.6		
275.0	1.55	92.9	1.59	13	575.0	3.24	194.3		
280.0	1.58	94.6	1.50	12	580.0	3.27	196.0		
285.0	1.61	96.3	1.43	11	585.0	3.29	197.7		
290.0	1.63	98.0	1.36	11	590.0	3.32	199.4		
295.0	1.66	99.7	1.28	10	595.0	3.35	201.1		
300.0	1.69	101.4	1.21	10	600.0	3.38	202.7		

NOTES : Use for models including Design Point 3 (Basin C) for the PMP Local event

Appendix B

Local Storm PMP Depth-Duration

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area less than 1 mi^2 ~~(km²)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00"W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

Step	5 min	1/4	1/2	3/4	1	2	3	4	5	6	
		Duration (hr)									
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~ <1 mi^2
6. Areal reduction [fig. 4.9].	61	61	67	71	73	76	78	80	81	82	% 22 mi^2
7. Areal reduced PMP [steps 5 X 6].	2.7	4.3	5.1	5.7	6.0	6.7	6.9	7.2	7.3	7.4	in. ~~(mm)~~
8. Incremental PMP [successive subtraction in step 7].					6.0	0.7	0.2	0.3	0.1	0.1	in. ~~(mm)~~
		4.3	0.8	0.6	0.3 } 15-min. increments						

9. Time sequence of incremental PMP according to: HMR No. 5

   Hourly increments [table 4.7]. 0.1 0.3 6.0 0.7 0.2 0.1 in. ~~(mm)~~

   Four largest 15-min. increments [table 4.8]. 4.3 0.8 0.6 0.3 in. ~~(mm)~~

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area ~~less than 1~~ 1.4 mi^2 ~~(km^2)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00" W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

	Duration (hr)										
	5 min	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~
6. Areal reduction [fig. 4.9].	96	96	97	97	98	98	98	99	99	99	
	~~6x~~	~~61~~	~~65~~	~~71~~	~~73~~	~~76~~	~~78~~	~~80~~	~~81~~	~~82~~	%
7. Areal reduced PMP [steps 5 X 6].	4.3	6.8	7.4	7.8	8.0	8.6	8.7	8.9	8.9	8.9	
	~~3.7~~	~~4.3~~	~~5.1~~	~~5.7~~	~~6.0~~	~~6.7~~	~~6.9~~	~~7.2~~	~~7.3~~	~~7.4~~	in. ~~(mm)~~

<1 mi^2

~~22~~ 1.4 mi^2

8. Incremental PMP [successive subtraction in step 7].
   8.0 0.6 0.1 0.2 0.0 0.0
   ~~6.0~~ ~~0.7~~ ~~0.2~~ ~~0.3~~ ~~0.1~~ ~~0.1~~ in. ~~(mm)~~

   ~~4.3~~ ~~0.8~~ ~~0.6~~ ~~0.3~~ } 15-min. increments
   6.8 0.6 0.4 0.2

9. Time sequence of incremental PMP according to:
   HMR No. 5

   Hourly increments [table 4.7].
   0.0 0.2 8.0 0.6 .2 0.0
   ~~0.1~~ ~~0.5~~ ~~6.0~~ ~~0.7~~ ~~0.2~~ ~~0.1~~ in. ~~(mm)~~

   Four largest 15-min. increments [table 4.8].
   ~~4.3~~ ~~0.8~~ ~~0.6~~ ~~0.3~~ in. ~~(mm)~~
   6.8 0.6 0.4 0.2

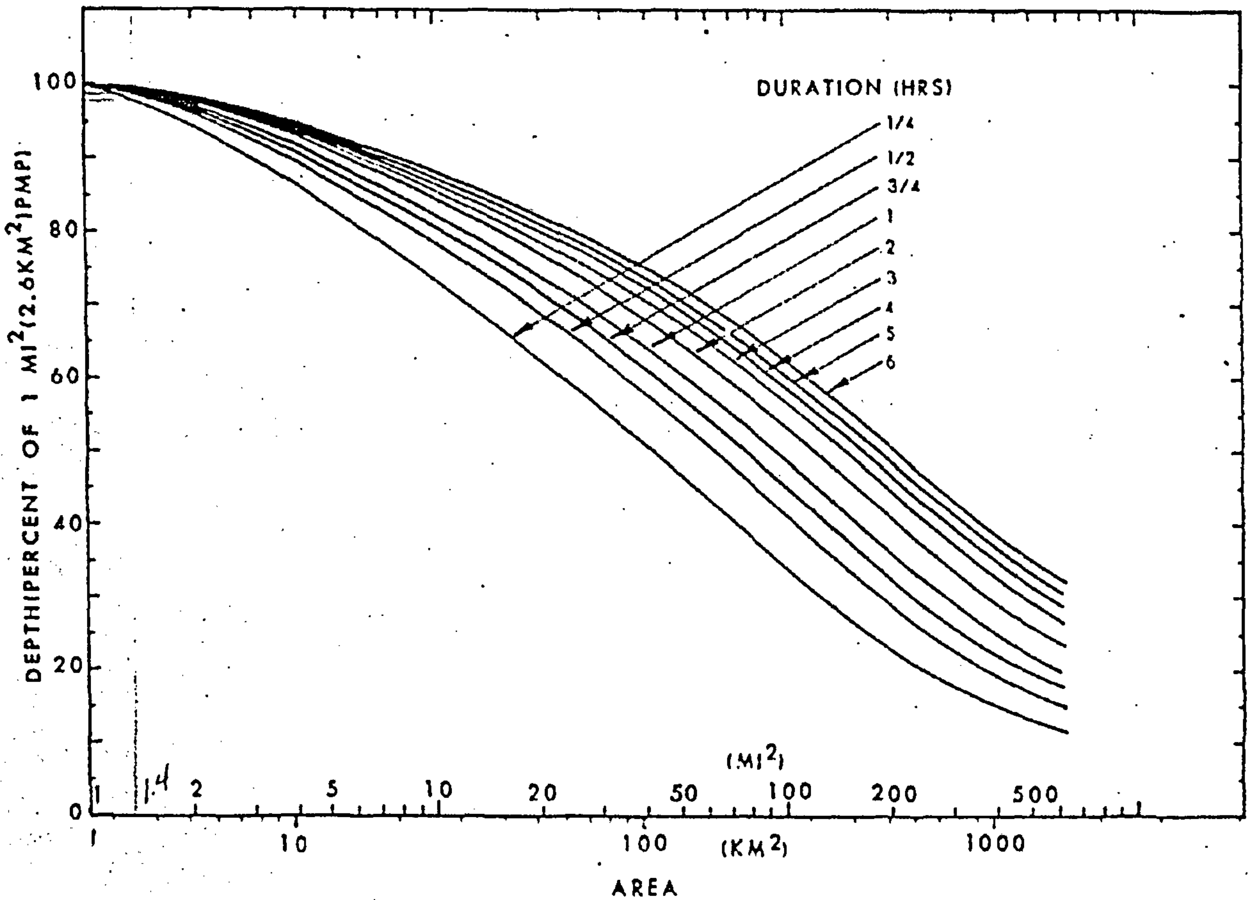

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area ~~less than 1~~ 2.6 mi^2 ~~(km^2)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00" W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

	Duration (hr)										
	5 min	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~
6. Areal reduction [fig. 4.9].	92 ~~61~~	92 ~~61~~	94 ~~67~~	95 ~~71~~	96 ~~73~~	96 ~~76~~	97 ~~78~~	97 ~~80~~	97 ~~81~~	98 ~~82~~	%
7. Areal reduced PMP [steps 5 X 6].	4.1 ~~2.7~~	6.5 ~~4.3~~	7.1 ~~5.1~~	7.6 ~~5.7~~	7.9 ~~6.0~~	8.4 ~~6.7~~	8.6 ~~6.9~~	8.7 ~~7.2~~	8.7 ~~7.3~~	8.8 ~~7.4~~	in. ~~(mm)~~
8. Incremental PMP [successive subtraction in step 7].					7.9 ~~6.0~~	0.5 ~~0.7~~	0.2 ~~0.2~~	0.1 ~~0.3~~	0.0 0.1	0.1 0.1	in. ~~(mm)~~
15-min. increments		6.5 ~~4.8~~	0.6 0.8	0.5 0.6	0.3						

<1 mi^2

22 mi^2

9. Time sequence of incremental PMP according to:

HMR No. 5

Hourly increments [table 4.7]. 0.1 ~~0.1~~ 0.2 ~~0.3~~ 7.9 ~~6.0~~ 0.5 ~~0.7~~ 0.1 ~~0.2~~ 0.0 0.1 in. ~~(mm)~~

Four largest 15-min. increments [table 4.8]. 6.5 ~~4.8~~ 0.6 0.8 0.5 0.6 0.3 in. ~~(mm)~~

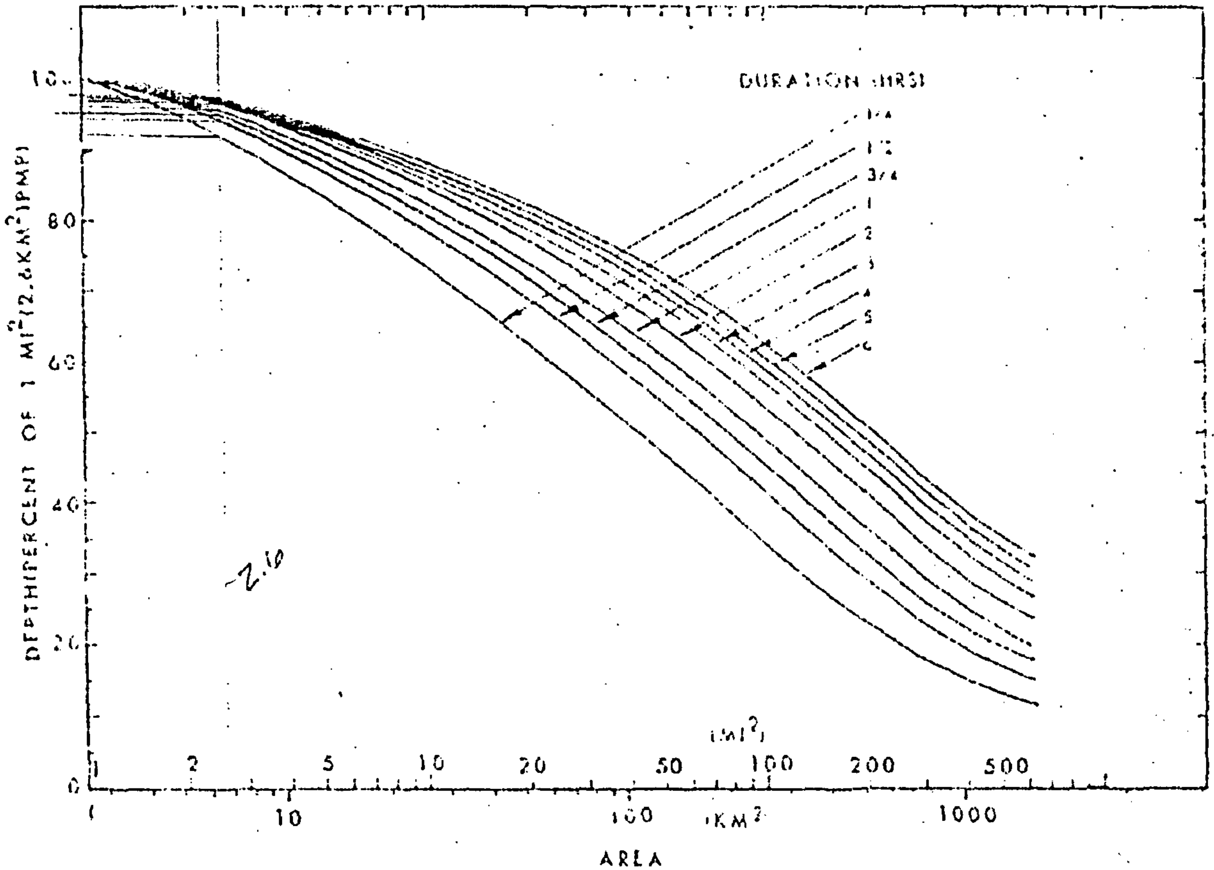

Figure 2.10.--Adopted depth-area relations for local-storm PMP.

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area 2.7 ~~less than 1~~ mi^2 ~~(km^2)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00" W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

	Duration (hr)										
	5 min.	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~
6. Areal reduction [fig. 4.9].	92	92 ~~61~~	94 ~~67~~	95 ~~71~~	96 ~~73~~	96 ~~76~~	96 ~~78~~	97 ~~80~~	97 ~~81~~	97 ~~82~~	%
7. Areal reduced PMP [steps 5 X 6].	4.1	6.5 ~~4.3~~	7.1 ~~5.1~~	7.6 ~~5.7~~	7.9 ~~6.0~~	8.4 ~~6.7~~	8.5 ~~6.9~~	8.7 ~~7.2~~	8.7 ~~7.3~~	8.7 ~~7.4~~	in. ~~(mm)~~
8. Incremental PMP [successive subtraction in step 7].					7.9 ~~6.0~~	0.5 ~~0.7~~	0.1 ~~0.2~~	0.2 ~~0.3~~	0.0 ~~0.1~~	0.0 ~~0.1~~	in. ~~(mm)~~
		6.5 ~~4.3~~	0.6 ~~0.8~~	0.5 ~~0.6~~	0.3	} 15-min. increments					

9. Time sequence of incremental PMP according to:

   HMR No. 5

   Hourly increments [table 4.7]. 0.0 ~~0.1~~ 0.2 ~~0.5~~ 7.9 ~~6.0~~ 0.5 ~~0.7~~ 0.1 ~~0.2~~ 0.0 ~~0.1~~ in. ~~(mm)~~

   Four largest 15-min. increments [table 4.8]. 6.5 ~~4.3~~ 0.6 ~~0.8~~ 0.5 ~~0.6~~ 0.3 in. ~~(mm)~~

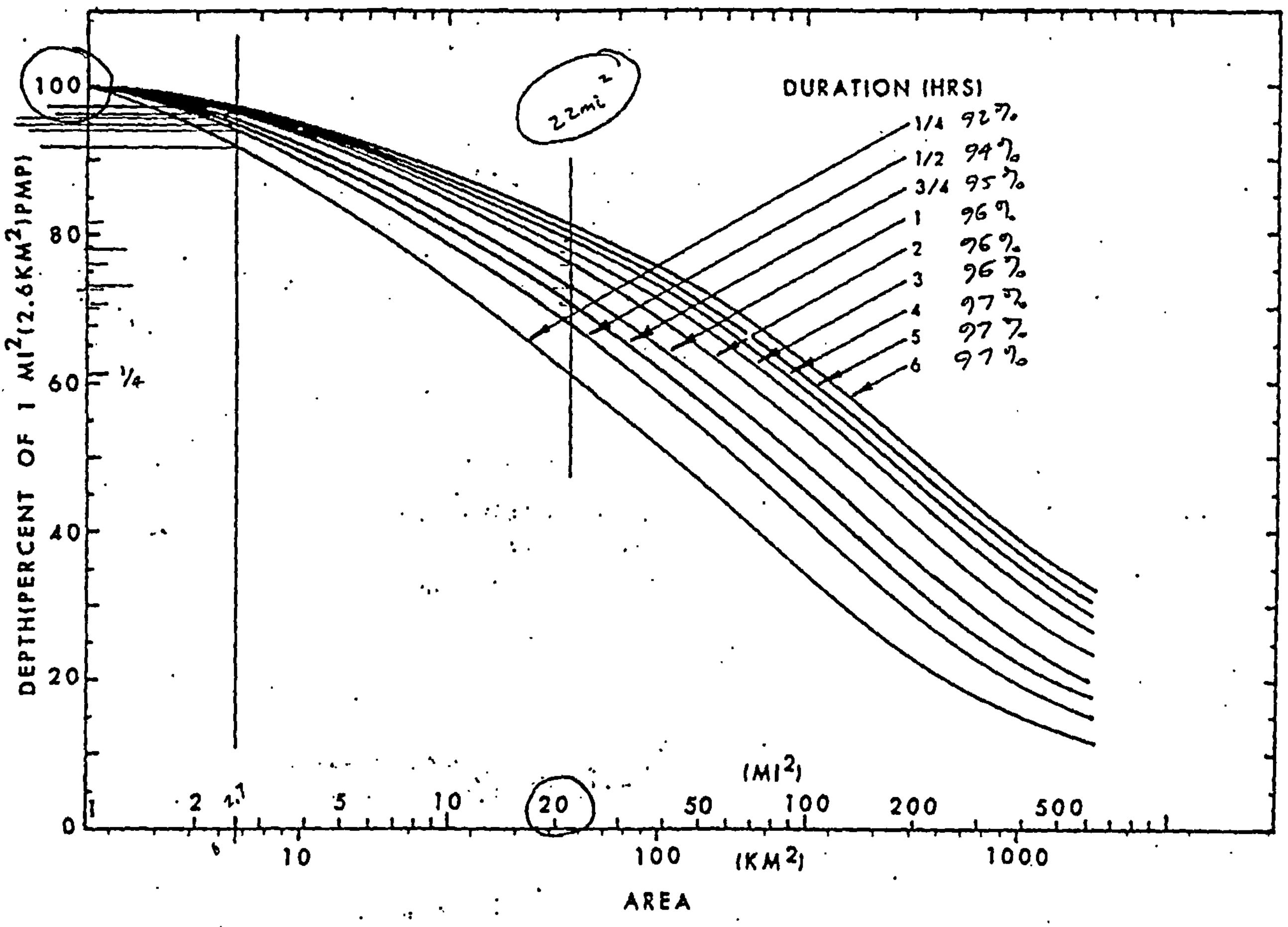

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area 3.5 ~~[illegible]~~ mi^2 ~~(km^2)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00"W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

	5 min	1/4	1/2	3/4	1	2	3	4	5	6	
		Duration (hr)									
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~
6. Areal reduction [fig. 4.9].	88 ~~64~~	88 ~~61~~	91 ~~67~~	92 ~~71~~	93 ~~73~~	94 ~~76~~	95 ~~78~~	95 80	96 81	96 ~~82~~	%
7. Areal reduced PMP [steps 5 X 6].	4.0 ~~2.7~~	6.2 ~~4.3~~	6.9 ~~5.1~~	7.4 ~~5.7~~	7.6 ~~6.6~~	8.3 ~~6.7~~	8.5 ~~6.9~~	8.6 ~~7.2~~	8.6 7.3	8.6 7.4	in. ~~(mm)~~
8. Incremental PMP [successive subtraction in step 7].					6.0	0.7	0.2	0.3	0.1	0.1	in. ~~(mm)~~
		4.3	0.8	0.6	0.3	} 15-min. increments					

<1 mi²

22 mi²

9. Time sequence of incremental PMP according to:

HMR No. 5

Hourly increments [table 4.7].	0.1	0.3	6.0	0.7	0.2	0.1	in. ~~(mm)~~
Four largest 15-min. increments [table 4.8].	4.3	0.8	0.6	0.3	in. ~~(mm)~~		

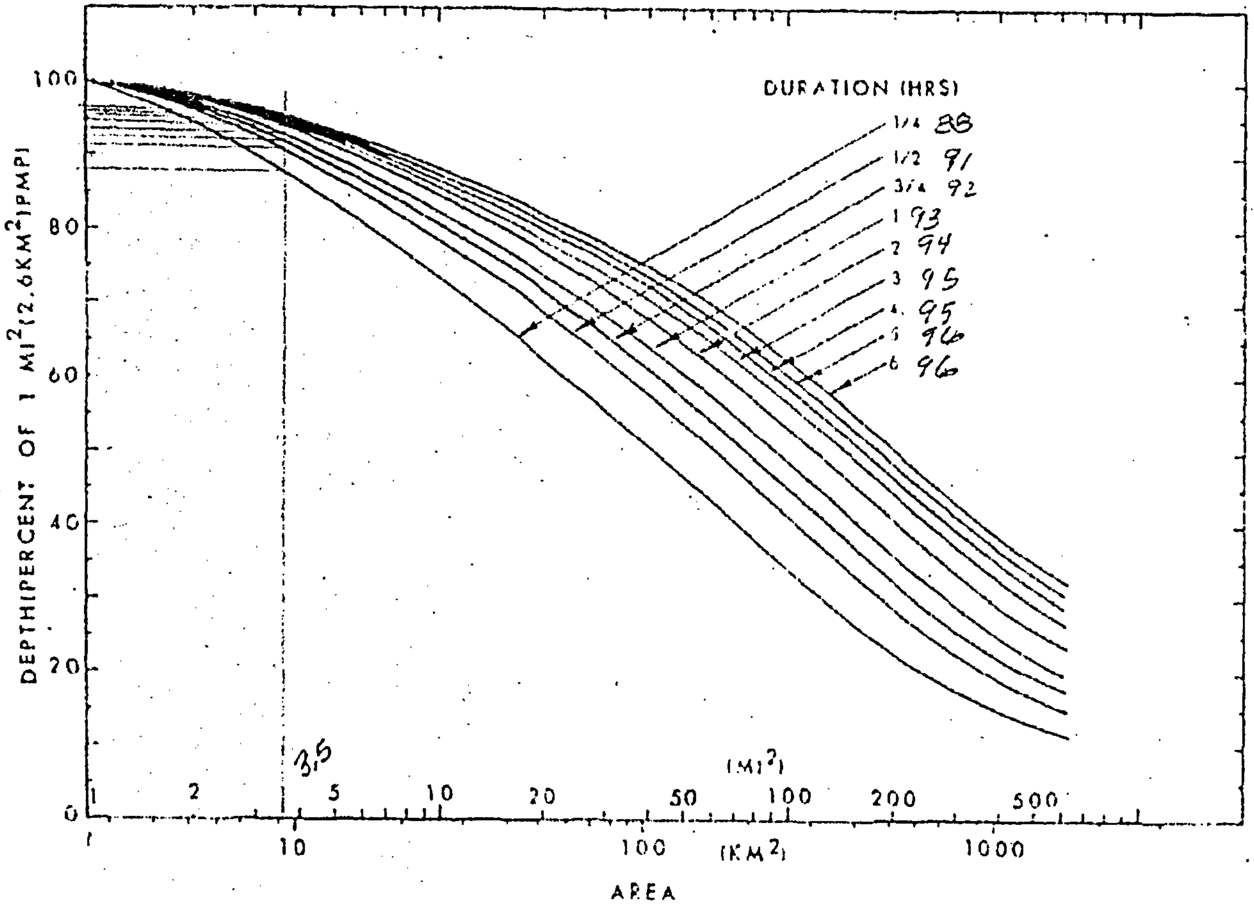

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

9

Drainage Crescent Junction Disposal Site Area ~~less than~~ 1 mi² (~~km²~~)
Latitude 38°57'50" (38.96°) Longitude 109°48'00"W (109.80°) Minimum Elevation 4940 ft (~~m~~)

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi² (2.6-km²) PMP for drainage [fig. 4.5]. 8.2 in. (~~mm~~)

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. (~~mm~~)

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

Step	5 min	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi² (2.6-km²) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. (~~mm~~)
6. Areal reduction [fig. 4.9].	76	76 ~~61~~	80 ~~67~~	82 ~~71~~	84 ~~73~~	86 ~~76~~	87 ~~78~~	88 ~~80~~	88 ~~81~~	89 ~~82~~	%
7. Areal reduced PMP [steps 5 X 6].	3.4	5.4 ~~4.3~~	6.1 ~~5.1~~	6.6 ~~5.7~~	6.9 ~~6.0~~	7.6 ~~6.7~~	7.7 ~~6.9~~	7.9 ~~7.2~~	7.9 ~~7.3~~	8.0 ~~7.4~~	in. (~~mm~~)
8. Incremental PMP [successive subtraction in step 7].					6.9 ~~6.0~~	0.7	0.1 ~~0.2~~	0.2 ~~0.3~~	0.0 ~~0.1~~	0.1	in. (~~mm~~)

Step 8, 15-min. increments: 5.4 ~~4.3~~ 0.7 ~~0.8~~ 0.5 ~~0.6~~ 0.3 } 15-min. increments

9. Time sequence of incremental PMP according to: HMR No. 5

   Hourly increments [table 4.7]. 0.1 0.2 ~~0.3~~ 6.9 ~~6.0~~ 0.7 0.1 ~~0.2~~ 0.0 ~~0.1~~ in. (~~mm~~)

   Four largest 15-min. increments [table 4.8]. 5.4 ~~4.3~~ 0.7 ~~0.8~~ 0.5 ~~0.6~~ 0.3 in. (~~mm~~)

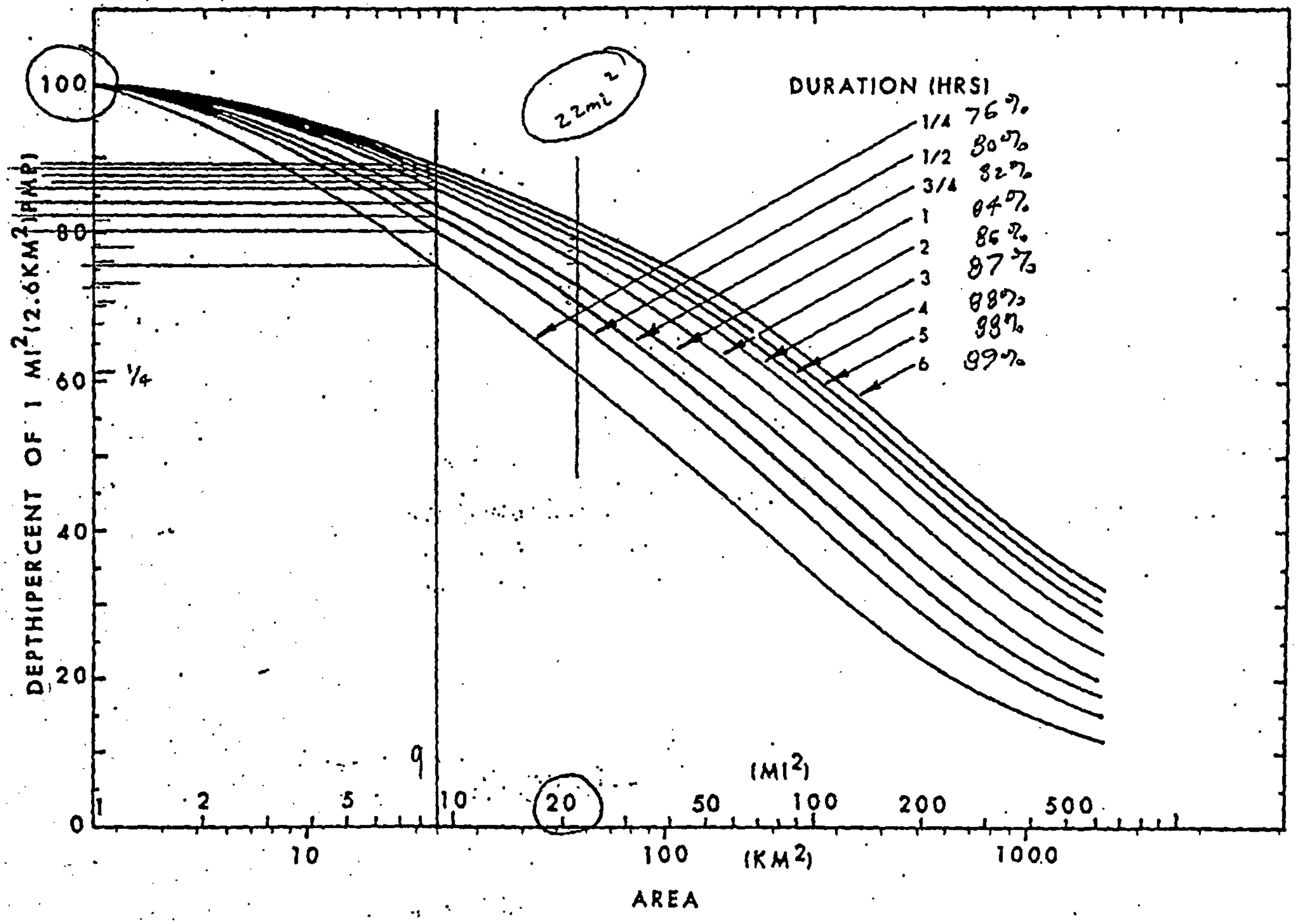

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

HMR No. 49

Drainage Crescent Junction Disposal Site Area 15 ~~less than 1~~ mi² ~~(km²)~~
Latitude 38°57'50" (38.96°) Longitude 109°48'00"W (109.80°) Minimum Elevation 4940 ft ~~(m)~~

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi² (2.6-km²) PMP for drainage [fig. 4.5]. 8.2 in. ~~(mm)~~

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. (None req'd) 100 %

   b. Multiply step 1 by step 2a. 8.2 in. ~~(mm)~~

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.1

	5 min	1/4	1/2	3/4	1	2	3	4	5	6	
		Duration (hr)									
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	55	86	93	97	100	107	109	110	110	110	%
5. 1-mi² (2.6-km²) PMP for indicated durations [step 2b X step 4].	4.5	7.1	7.6	8.0	8.2	8.8	8.9	9.0	9.0	9.0	in. ~~(mm)~~
6. Areal reduction [fig. 4.9].	67	67 ~~61~~	73 ~~65~~	76 ~~71~~	78 ~~73~~	81 ~~76~~	81 ~~78~~	83 ~~80~~	84 ~~81~~	85 ~~82~~	%
7. Areal reduced PMP [steps 5 X 6].	3.0	4.8 ~~4.3~~	5.5 ~~5.1~~	6.1 ~~5.7~~	6.4 ~~6.0~~	7.0 ~~6.1~~	7.2 ~~6.9~~	7.5 ~~7.2~~	7.6 ~~7.3~~	7.7 ~~7.4~~	in. ~~(mm)~~

8. Incremental PMP [successive subtraction in step 7]. 6.4 ~~6.0~~ 0.6 ~~0.1~~ 0.2 0.3 0.1 0.1 in. ~~(mm)~~
   4.8 ~~4.3~~ 0.7 ~~0.8~~ 0.6 0.3 } 15-min. increments

9. Time sequence of incremental PMP according to: HMR No. 5

   Hourly increments [table 4.7]. 0.1 0.3 6.4 ~~6.0~~ 0.6 ~~0.1~~ 0.2 0.1 in. ~~(mm)~~

   Four largest 15-min. increments [table 4.8]. 4.8 ~~4.3~~ 0.7 ~~0.8~~ 0.6 0.3 in. ~~(mm)~~

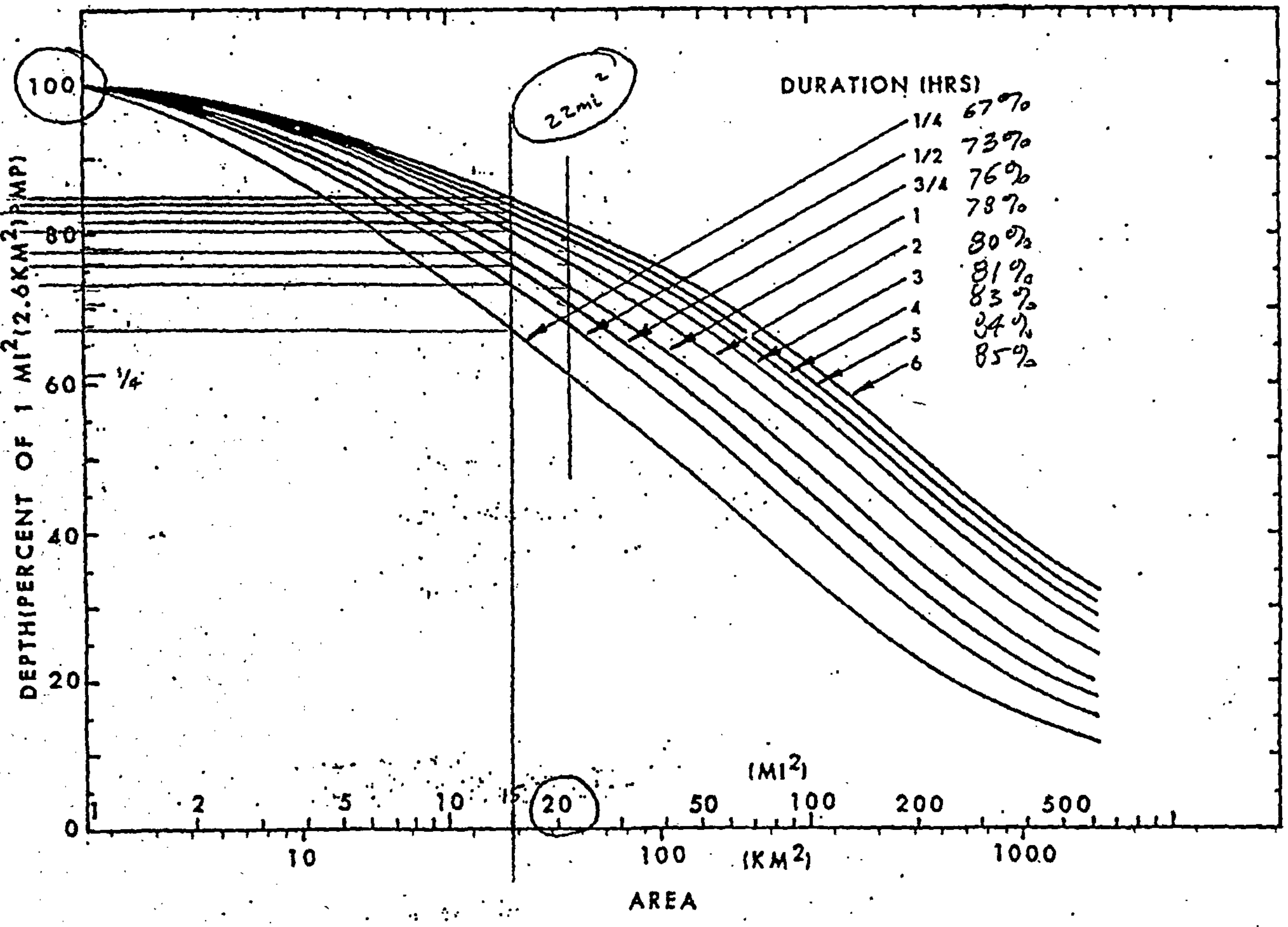

Figure 4.9.--Adopted depth-area relations for local-storm PMP.

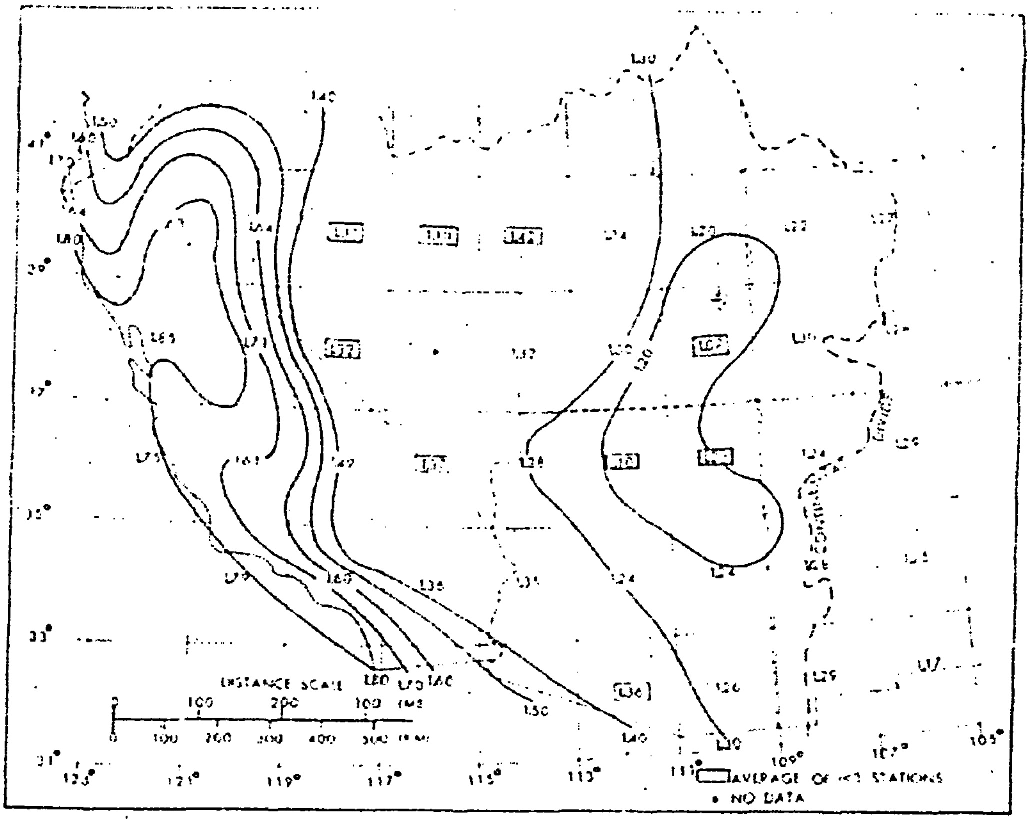

Figure 4.[illegible]--Analysis of 6/1-hr ratios of averaged maximum station data (plotted at midpoints of a 2° latitude-longitude grid).

establish the basic depth-duration curve, then structure a variable set of depth-duration curves to cover the range of 6/1-hr ratios that are needed.

Three sets of data were considered for obtaining a base relation (see table 4.3 for depth-duration data).

a. An average of depth-duration relations from each of 17 greatest 3-hr rains from summer storms (1940-49) in Utah (U. S. Weather Bureau 1951b) and in unpublished tabulations for Nevada and Arizona (1940-63). The 3-hr amounts ranged from 1 to 3 inches (25 to 76 mm) in these events.

b. An average depth-duration relation from 14 of the most extreme short-duration storms listed in Storm Rainfall (U. S. Army, Corps of Engineers 1945-). These storms come from Eastern and Central States and have 3-hr amounts of 5 to 22 inches (127 to 559 mm).

ratios than storms with high 3/1-hr ratios. The geographical distribution of 15-min to 1-hr ratios also were inversely correlated with magnitudes of the 6/1-hr ratios of figure 4.7. For example, Los Angeles and San Diego (high 6/1-hr ratios) have low 15-min to 1-hr ratios (approximately 0.60) whereas the 15-min to 1-hr ratios in Arizona and Utah (low 6/1-hr ratios) were generally higher (approximately 0.75).

Depth-duration relations for durations less than 1 hour were then smoothed to provide a family of curves consistent with the relations determined for 1 to 6 hours, as shown in figure 4.3. Adjustment was necessary to some of the curves to provide smoother relations through the common point at 1 hour.

We believe we were justified in reducing the number of the curves shown in figure 4.3 for durations less than 1 hour, letting one curve apply to a range of 6/1-hr ratios. The corresponding curves have been indicated by letter designators, A-D, on figure 4.3. As an example, for any 6-hr amount between 115% and 135% of 1-hr, 1-mi^2 (2.6-km^2) PMP, the associated values for durations less than 1 hour are obtained from the curve designated as "B".

Table 4.4 lists durational variations in percent of 1-hr PMP for selected 6/1-hr rain ratios. These values were interpolated from figure 4.3.

To determine 6-hr PMP for a basin, use figure 4.3 (or table 4.4) and the geographical distribution of 6/1-hr ratios given in figure 4.7.

Table 4.4.--Durational variation of 1-mi^2 (2.6-km^2) local-storm PMP in percent of 1-hr PMP (see figure 4.3)

6/1-hr ratio	Duration (hr) 1/4	1/2	3/4	1	2	3	4	5	6
1.1	86	93	97	100	107	109	110	110	110
1.2	74	89	95	100	110	115	118	119	120
1.3	74	89	95	100	114	121	125	128	130
1.4	63	83	93	100	118	126	132	137	140
1.5	63	83	93	100	121	132	140	145	150
1.6	43	70	87	100	124	136	147	154	160
1.8	43	70	87	100	130	149	161	171	180
2.0	43	70	87	100	137	161	175	188	200

4.5 Depth-Area Relation

We have thus far developed local-storm PMP for an area of 1 mi^2 (2.6 km^2). To apply PMP to a basin, we need to determine how 1-mi^2 (2.6-km^2) PMP should decrease with increasing area. We have adopted depth-area relations based on rainfalls in the Southwest and from consideration of a model thunderstorm.

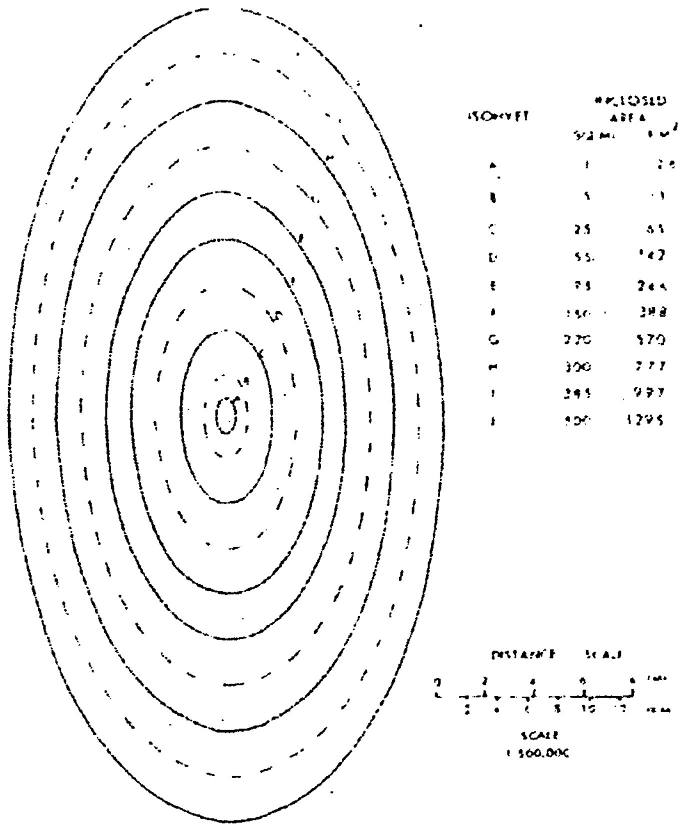

Figure 4.10.--Idealized local-storm isohyetal pattern.

storm period. The sequence of hourly incremental PMP for the Southwest 6-hr thunderstorm in accord with this study is presented in column 2 of table 4.7. A small variation from this sequence is given in Engineering Manual 1110-2-1411 (U. S. Army, Corps of Engineers 1965). The latter, listed in column 3 of table 4.7, places greater incremental amounts somewhat more toward the end of the 6-hr storm period. In application, the choice of either of these distributions is left to the user since one may prove to be more critical in a specific case than the other.

Table 4.7.--Time sequence for hourly incremental PMP in 6-hr storm

Increment	HMR No. 5[1]	EM1110-2-1411[2]
	Sequence Position	
Largest hourly amount	Third	Fourth
2nd largest	Fourth	Third
3rd largest	Second	Fifth
4th largest	Fifth	Second
5th largest	First	Last
least	Last	First

[1] U. S. Weather Bureau 1947.
[2] U. S. Corps of Engineers 1952.

Also of importance is the sequence of the four 15-min incremental PMP values. We recommend a time distribution, table 4.8, giving the greatest intensity in the first 15-min interval (U.S. Weather Bureau 1947). This is based on data from a broad geographical region. Additional support for this time distribution is found in the reports of specific storms by Keppell (1963) and Osborn and Renard (1969).

Table 4.8.--Time sequence for 15-min incremental PMP within 1 hr.

Increment	Sequence Position
Largest 15-min amount	First
2nd largest	Second
3rd largest	Third
least	Last

4.8 Seasonal Distribution

The time of the year when local-storm PMP is most likely is of interest. Guidance was obtained from analysis of the distribution of maximum 1-hr thunderstorm events through the warm season at the recording stations in Utah, Arizona, and in southern California (south of 37°N and east of the Sierra Nevada ridgeline). The period of record used was for 1940-72 with an average record length for the stations considered of 27 years. The month with the one greatest thunderstorm rainfall for the period of record at each station was noted. The totals of these events for each month, by States, are shown in table 4.9.

Table 4.9.--Seasonal distribution of thunderstorm rainfalls.

(The maximum event at each of 108 stations, period of record 1940-72.)

	Month						
	M	J	J	A	S	O	No. of Cases
Utah	1	5	9	14	5		34
Arizona		4	16	19	4		43
S. Calif.*		14	10	7			31
No. of cases/mo.	1	23	35	40	9	0	

*South of 37°N and east of Sierra Nevada ridgeline.

Appendix C

HEC-HMS Output

Project: Crescent Junction Ex Simulation Run: CW 25			
Start of Run:	01Jan2006, 00:00	Basin Model:	Crescent Wash-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	25-yr 24-hr
Compute Time:	18May2006, 13:20:23	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Crescent Wash	22.5600	2975.47	01Jan2006, 14:15	0.49
I-70	22.5600	2975.47	01Jan2006, 14:15	0.49

Project: Crescent Junction Ex Simulation Run: CW 100

Start of Run:	01Jan2006, 00:00	Basin Model:	Crescent Wash-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:20:55	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Crescent Wash	22.5600	5982.86	01Jan2006, 14:10	0.98
I-70	22.5600	5982.86	01Jan2006, 14:10	0.98

Project: Crescent Junction Ex	Simulation Run: CW PMP Local

Start of Run:	01Jan2006, 00:00	Basin Model:	Crescent Wash-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local 22 sq mi
Compute Time:	18May2006, 13:06:09	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Crescent Wash	22.5600	45196.66	01Jan2006, 04:40	6.11
Sink-1	22.5600	45196.66	01Jan2006, 04:40	6.11

Project: Crescent Junction Ex	Simulation Run: BASIN 1-100

Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:22:10	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1	2.6300	2135.13	01Jan2006, 12:35	0.99
DP 6	2.6300	2135.13	01Jan2006, 12:35	0.99

Project: Crescent Junction Ex Simulation Run: BASIN 1-PMP LOCAL

Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local 2.7 sq mi
Compute Time:	18May2006, 13:22:40	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1	2.6300	21287.52	01Jan2006, 03:25	7.77
DP 6	2.6300	21287.52	01Jan2006, 03:25	7.77

Project: Crescent_Junction_Pr	Simulation Run: Basin 1-100

Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:41:52	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1 Routed	2.6300	2210.10	01Jan2006, 12:35	1.00
DP 6	2.6300	2210.10	01Jan2006, 12:35	1.00

Project: Crescent_Junction_Pr	Simulation Run: Basin 1-PMP		
Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 1-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local 2.7 sq mi
Compute Time:	18May2006, 13:42:53	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1 Routed	2.6300	21321.77	01Jan2006, 03:25	10.80
DP 6	2.6300	21321.77	01Jan2006, 03:25	10.80

Project: Crescent Junction Ex	Simulation Run: BASIN 2-25			

Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 2-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	25-yr 24-hr
Compute Time:	18May2006, 13:24:57	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 2	8.9600	1726.31	01Jan2006, 13:30	0.49
RR Bridge	8.9600	1726.31	01Jan2006, 13:30	0.49

Project: Crescent Junction Ex	Simulation Run: BASIN 2-100		
Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 2-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:26:09	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 2	8.9600	3453.04	01Jan2006, 13:30	0.99
RR Bridge	8.9600	3453.04	01Jan2006, 13:30	0.99

Project: Crescent Junction Ex	Simulation Run: BASIN 2-PMP		
Start of Run:	01Jan2006, 00:00	Basin Model:	Basin 2-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local 9 sq mi
Compute Time:	18May2006, 13:26:56	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 2	8.9600	29868.86	01Jan2006, 04:05	7.01
RR Bridge	8.9600	29868.86	01Jan2006, 04:05	7.01

Project: Crescent Junction Ex	Simulation Run: 123 100

Start of Run:	01Jan2006, 00:00	Basin Model:	Basins 123-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:32:06	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1	2.6300	2135.13	01Jan2006, 12:35	0.99
Basin 2	8.9600	3453.04	01Jan2006, 13:30	0.99
Basin 3	3.4700	1553.39	01Jan2006, 13:15	0.99
I-70	15.0600	5108.83	01Jan2006, 13:30	0.99
I-70 CULVERT	15.0600	5108.83	01Jan2006, 13:30	0.99
Kendall Wash E	8.9600	3441.54	01Jan2006, 13:35	0.99
Kendall Wash W	2.6300	2066.77	01Jan2006, 12:40	0.99

Project: Crescent Junction Ex Simulation Run: 123 PMP Local

Start of Run:	01Jan2006, 00:00	Basin Model:	Basins 123-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local 15 sq mi
Compute Time:	18May2006, 13:33:12	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1	2.6300	16218.18	01Jan2006, 03:25	6.38
Basin 2	8.9600	27260.23	01Jan2006, 04:05	6.41
Basin 3	3.4700	12147.64	01Jan2006, 03:55	6.41
I-70	15.0600	40835.44	01Jan2006, 04:05	6.41
I-70 CULVERT	15.0600	40835.44	01Jan2006, 04:05	6.41
Kendall Wash E	8.9600	26892.86	01Jan2006, 04:10	6.41
Kendall Wash W	2.6300	15865.63	01Jan2006, 03:25	6.39

HEC-HMS

Project : Crescent Junction Ex

Basin Model : Basins 123-PMP

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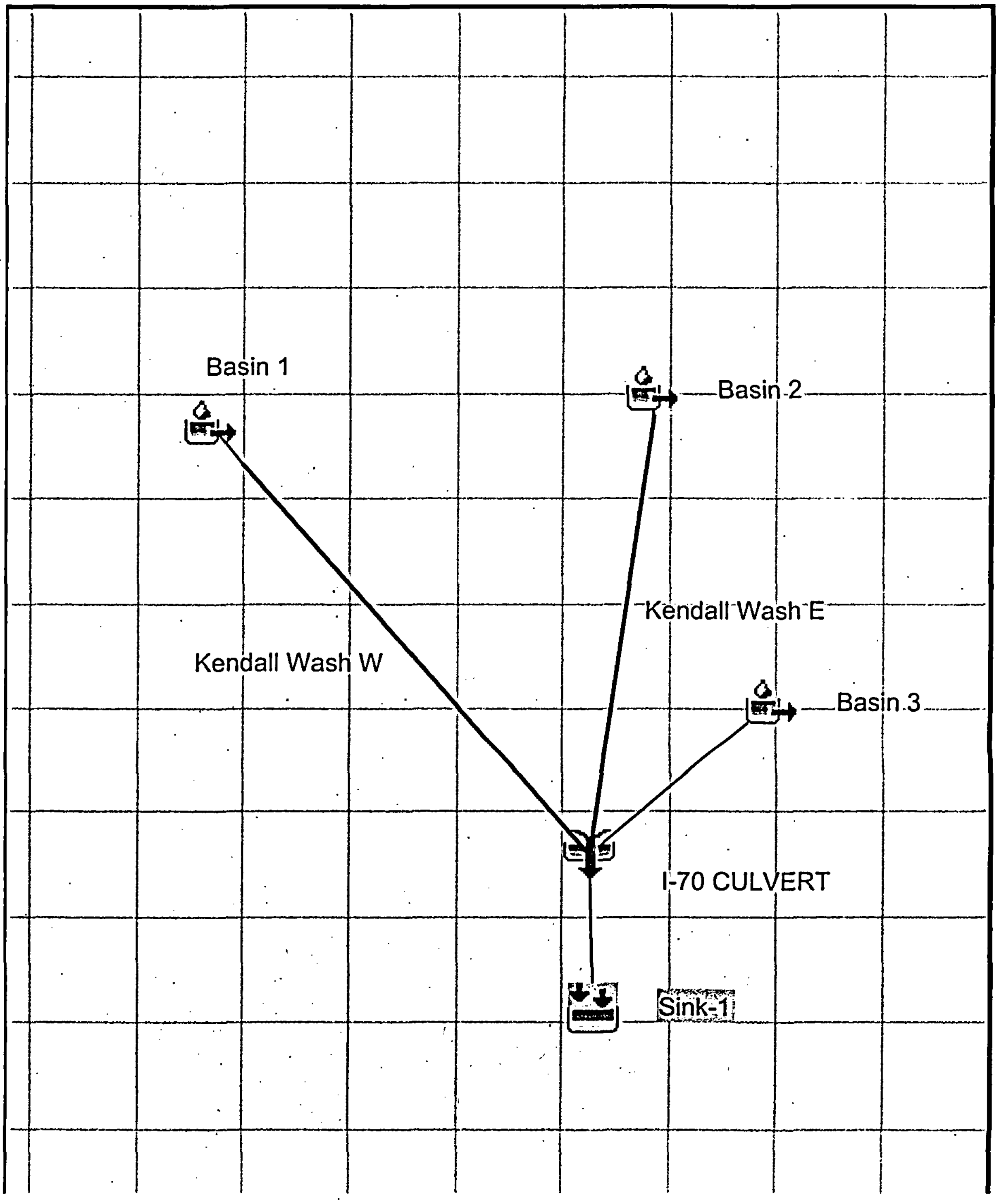

Project: Crescent_Junction_Pr Simulation Run: Basins 123-100

Start of Run:	01Jan2006, 00:00	Basin Model:	Basins 123-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:46:23	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1 Routed	2.6300	2210.10	01Jan2006, 12:35	1.00
Basin 2	8.9600	3453.04	01Jan2006, 13:30	0.99
Basin 3	3.4700	1553.39	01Jan2006, 13:15	0.99
I-70	15.0600	5098.41	01Jan2006, 13:30	0.99
I-70 CULVERT	15.0600	5098.41	01Jan2006, 13:30	0.99
Kendall Wash E	8.9600	3441.54	01Jan2006, 13:35	0.99
Kendall Wash W	2.6300	2166.34	01Jan2006, 12:35	1.00

Project: Crescent_Junction_Pr Simulation Run: BASINS 123 PMP

Start of Run:	01Jan2006, 00:00	Basin Model:	Basins 123-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local 15 sq mi
Compute Time:	18May2006, 13:48:35	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin 1 Routed	2.6300	16252.58	01Jan2006, 03:25	8.88
Basin 2	8.9600	27260.23	01Jan2006, 04:05	6.41
Basin 3	3.4700	12147.64	01Jan2006, 03:55	6.41
I-70	15.0600	40871.36	01Jan2006, 04:05	6.84
I-70 CULVERT	15.0600	40871.36	01Jan2006, 04:05	6.84
Kendall Wash E	8.9600	26892.86	01Jan2006, 04:10	6.41
Kendall Wash W	2.6300	15899.38	01Jan2006, 03:25	8.89

Project : Crescent_Junction_Pr

Basin Model : Basins 123-PMP

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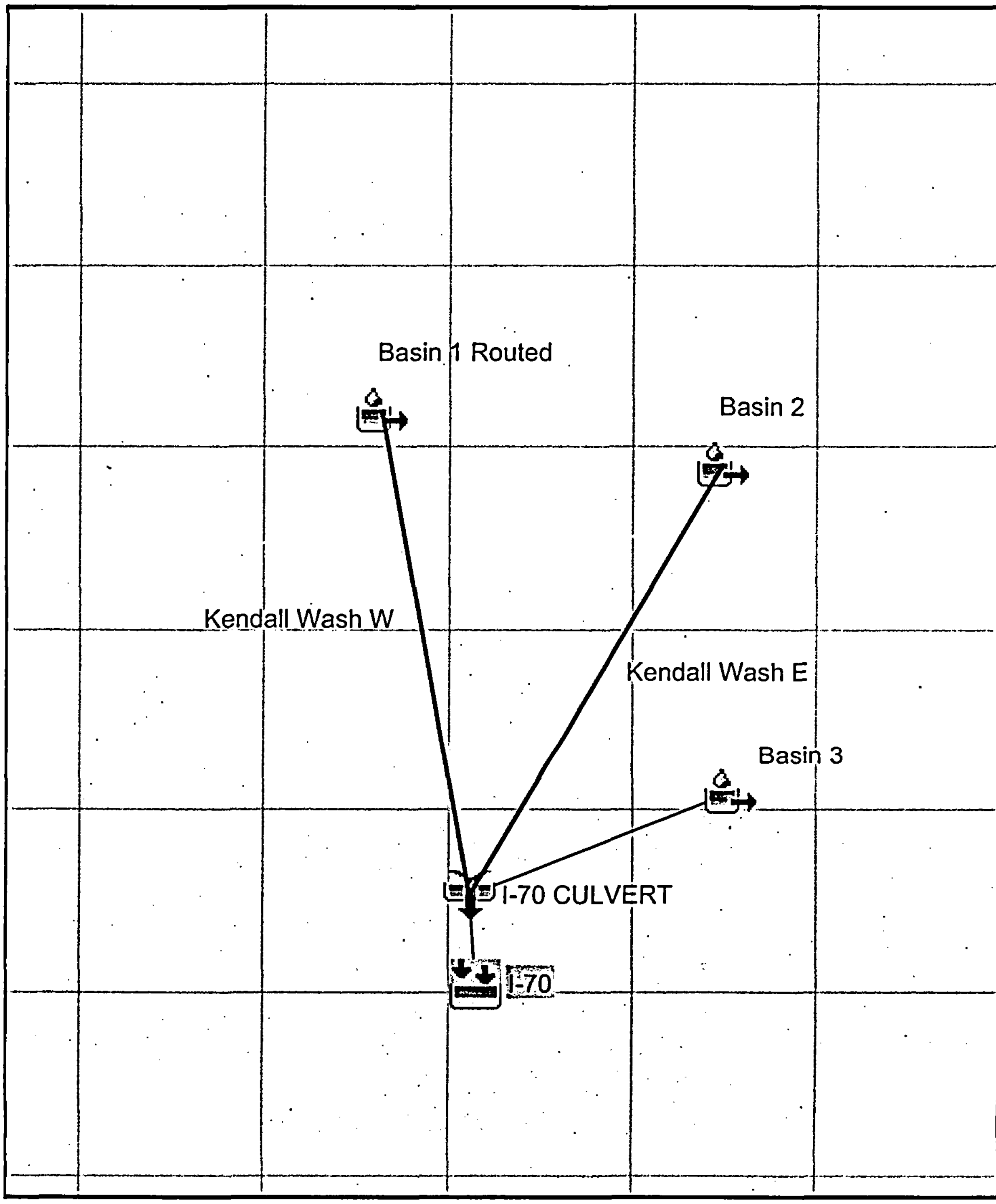
HEC-HMS



Project: Crescent_Junction_Pr Simulation Run: DP 4&5-25

Start of Run:	01Jan2006, 00:00	Basin Model:	P-DP 4&5-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	25-yr 24-hr
Compute Time:	18May2006, 13:49:54	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin B	0.5218	291.31	01Jan2006, 12:25	0.49
Basin D	0.3827	187.06	01Jan2006, 12:35	0.57
DP 4	0.5218	291.31	01Jan2006, 12:25	0.49
DP 5	0.9045	447.59	01Jan2006, 12:30	0.52
West Ditch	0.5218	281.01	01Jan2006, 12:25	0.49

Project: Crescent_Junction_Pr Simulation Run: DP 4&5-PMP			
Start of Run:	01Jan2006, 00:00	Basin Model:	P-DP 4&5-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local <1 sq mi
Compute Time:	18May2006, 13:51:38	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin B	0.5218	5858.79	01Jan2006, 03:15	8.21
Basin D	0.3827	3426.58	01Jan2006, 03:25	8.48
DP 4	0.5218	5858.79	01Jan2006, 03:15	8.21
DP 5	0.9045	8722.28	01Jan2006, 03:20	8.34
West Ditch	0.5218	5539.08	01Jan2006, 03:15	8.24

HEC-HMS

Project : Crescent Junction Pr

Basin Model : P-DP 4&5-event

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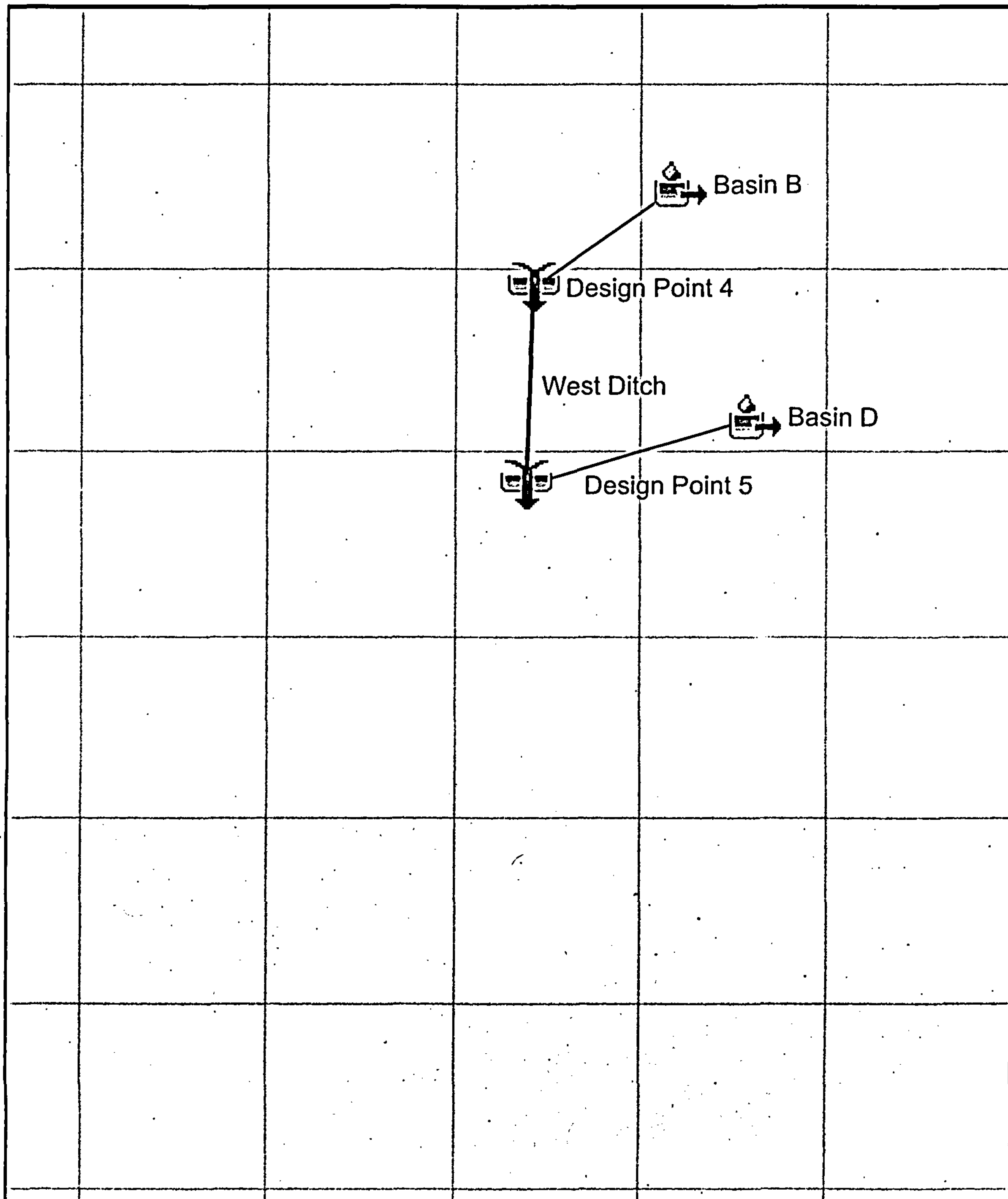

Project: Crescent_Junction_Pr Simulation Run: BASIN C-25

Start of Run:	01Jan2006, 00:00	Basin Model:	P-BASIN C-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	25-yr 24-hr
Compute Time:	18May2006, 13:56:17	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin C	0.1675	74.72	01Jan2006, 12:30	0.49
DP 3-ExCulv @ RR	0.1675	74.72	01Jan2006, 12:30	0.49

Project: Crescent_Junction_Pr	Simulation Run: BASIN C-100		
Start of Run:	01Jan2006, 00:00	Basin Model:	P-BASIN C-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	18May2006, 13:57:43	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin C	0.1675	146.99	01Jan2006, 12:30	0.99
DP 3-ExCulv @RR	0.1675	146.99	01Jan2006, 12:30	0.99

Project: Crescent_Junction_Pr Simulation Run: BASIN C-PMP

Start of Run:	01Jan2006, 00:00	Basin Model:	P-BASIN C-PMP
End of Run:	02Jan2006, 00:00	Meteorologic Model:	PMP Local <1 sq mi
Compute Time:	18May2006, 13:58:25	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin C	0.1675	1488.43	01Jan2006, 03:20	8.18
DP3-Ex Culv @CRF	0.1675	1488.43	01Jan2006, 03:20	8.18

Project: Crescent_Junction_Pr	Simulation Run: P-DRAINAGE 25

Start of Run:	01Jan2006, 00:00	Basin Model:	P-DRAINAGE-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	25-yr 24-hr
Compute Time:	18May2006, 14:02:40	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Basin A	0.3456	192.54	01Jan2006, 12:25	0.49
Basin B	0.5218	291.31	01Jan2006, 12:25	0.49
Basin C	0.1675	74.72	01Jan2006, 12:30	0.49
Basin D	0.3827	187.06	01Jan2006, 12:35	0.57
Basin E	0.1839	91.30	01Jan2006, 12:30	0.49
Basin F	0.0863	41.65	01Jan2006, 12:30	0.49
Basin for Culv C7	0.4087	238.92	01Jan2006, 12:20	0.49
Culv C1-DP 2	0.0863	41.65	01Jan2006, 12:30	0.49
Culv C5	1.2501	610.57	01Jan2006, 12:30	0.52
Culv C7	0.4087	238.92	01Jan2006, 12:20	0.49
DP 4	0.5218	291.31	01Jan2006, 12:25	0.49
DP 5	0.9045	447.59	01Jan2006, 12:30	0.52
DP 6	1.2501	608.41	01Jan2006, 12:30	0.52
Ex-Culv @ RR	0.1675	74.72	01Jan2006, 12:30	0.49
Reach-1	0.9045	445.60	01Jan2006, 12:30	0.53
Reach-2	1.2501	608.41	01Jan2006, 12:30	0.52
Texas Dip	0.1839	91.30	01Jan2006, 12:30	0.49
West Ditch	0.5218	281.01	01Jan2006, 12:25	0.49

HEC-HMS

Project : Crescent Junction Pr

Basin Model : P-DRAINAGE-event

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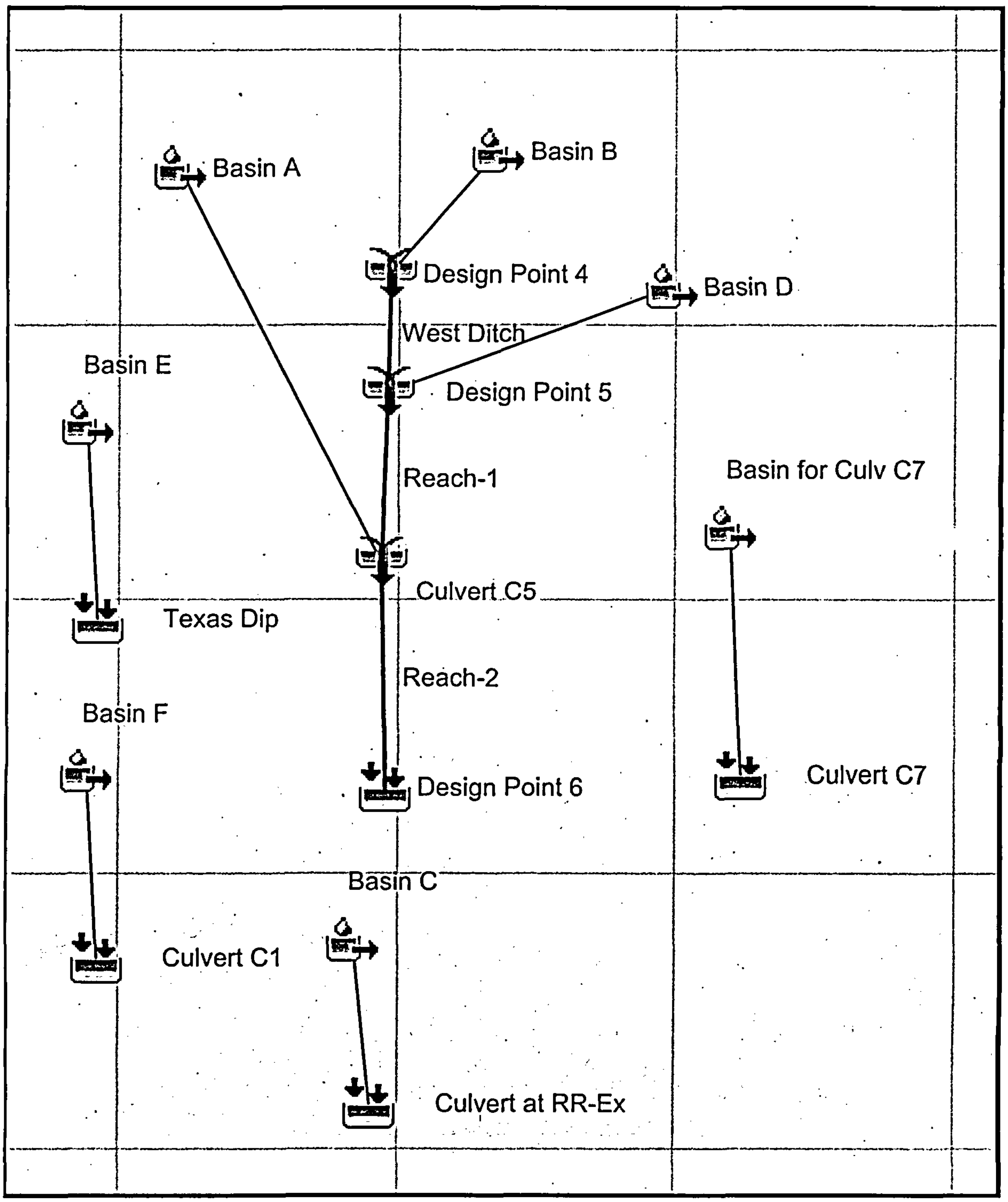


Appendix D

Rational Method Output

TIME OF CONCENTRATION

$t_c = t_i + t_t$

Initial or Overland Flow = ti
$ti = [0.395(1.1\text{-}C_5)SQRT(L)]/S^{0.33}$

Overland Travel Time = t_t
$V = C_v S_w^{0.5}$
Where: C_v = conveyance coefficient from UD Table RO-2
S_w = watercourse slope (ft/ft)
$t_t = L/60V$

CHECK:
$t_c = (L/180) + 10$ forUrbanized areas only
Minimum t_c = 10 minutes

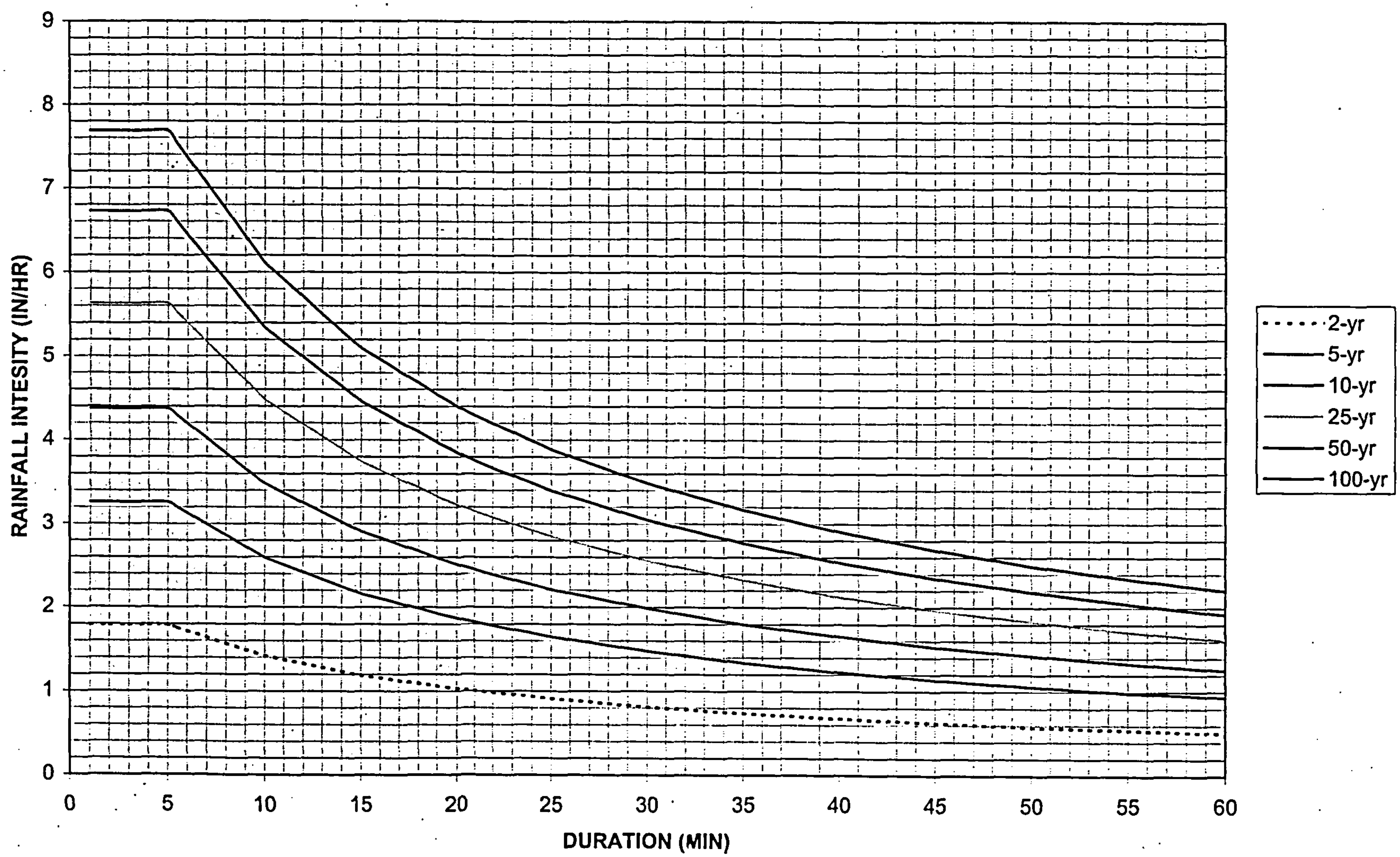
ONSITE CULVERTS

Initial/Overland Flow (t_i)					Gutter or Channelized Flow (t_t)					Total Travel Time	check max	check min	Use
Basin	L (ft)	Slope (ft/ft)	C_5	Ti (min)	L (ft)	Slope (%)	C_v[1]	V (ft/sec)	Tt (min)	Tc=Ti+Tt Tc (min)	Tc (min)	Tc (min)	Tc (min)
Culvert C2	500	0.014	0.09	36.56	1700	1.400	10.00	1.18	23.95	60.51	na	10.0	60.5
Culvert C3	500	0.014	0.09	36.56	900	1.400	10.00	1.18	12.68	49.24	na	10.0	49.2
Culvert C4	500	0.014	0.09	36.56	3500	1.400	10.00	1.18	49.30	85.86	na	10.0	85.9
Culvert C6	800	0.014	0.09	46.16	400	1.400	10.00	1.18	5.63	51.79	na	10.0	51.8

TABLE RO-2
Conveyance Coefficiant, C_v

Type of Land Surface\	Conveyance Coefficient, C_v
Heavy Meadow	2.5
Tillage/Field	5
Short pasture & lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas	20

I-D-F CURVE FOR CRESCENT JUNCTION, UTAH



25 YEAR PEAK FLOWS

USE RATIONAL METHOD TO CALCULATE PEAK FLOWS"
Q = CIA

Basin	Area (ac)	Runoff Coeff. (C_{25})	T_C (min)	C*A (ac)	I (in/hr)	Q25 (cfs)
Culvert C2	32.0	0.17	60.51	5.44	1.62	8.81
Culvert C3	11.0	0.17	49.24	1.87	1.87	3.50
Culvert C4	64.0	0.17	85.86	10.88	1.62	17.63
Culvert C6	30.0	0.17	51.70	5.10	1.80	9.18

Appendix E

Calibration and Check of Flows in Crescent Wash

The purpose of this appendix is to document the calibration and provide a check of calculated flows in Crescent Wash. The USGS had a gaging station in Crescent Wash at a point slightly downstream of the analysis point for this project. The drainage area at the old gage is 23.3 square miles, as opposed to 22.5 sq miles at the I-70 crossing. There are 10 years of record taken between 1959 and 1969. It should be noted that the basin is relatively undeveloped so flows taken 37 to 47 years ago should be relatively typical of the basin today. However, there are only 10 years of record. Thus information derived from the gaging station is considered only as a relative check for order of magnitude compared to the computations.

Using the 10 years of data the USGS developed a flood frequency curve using Log-Pearson Type III probability distribution (Vaill). The results of this analysis are shown in Table E1, below. These flows are compared to the 25-year and 100-year floods calculated in HEC-HMS using the specified unit hydrograph, a CN value of 70 for determining initial losses and a constant infiltration rate of 0.3 in/hour. Precipitation values are derived from NOAA Atlas 14. The results of the analysis are within 3% of the USGS results, when adjusted for drainage area. Thus the calculated values are utilized for this project and the parameters (CN, infiltration, and precipitation) are applied to the ungaged basins within the study area for determining the 25-year and 100-year floods.

Table E1. Flow comparison for Crescent Wash, 25-year storm

Storm event	*USGS (23.3 mi²)*		*HEC-HMS (22.5mi²)*	
	cfs	*cfs/mi²*	*cfs*	*cfs/mi²*
25-year storm	3,260	140	3,021	134
100-year storm	6,460	277	6,073	270

Several additional gaged sites where also checked for peak flows per square mile. Sites selected for comparison are similar in elevation and size and are in similar environmental conditions as the project site. Peak flows were calculated by the USGS using Log-Pearson Type III probability distribution (Vaill). Table E2 indicates that the flows per square mile are conservative as compared to the other basins. However, given the gaged information available on Crescent Wash, the calculated values will be utilized.

Table E2. Comparison of Peak Flows per Square Miles

Station no.	Station Name	DA, mi^2	elev	Q_{25}, cfs	Q_{25}/DA, cfs/mi^2	Q_{100}, cfs	Q_{100}/DA, cfs/mi^2
9181000	Onion Creek nr Moab, Ut	18.8	5,702	2,470	131.4	3,380	179.8
9185200	Kane Springs Canyon nr La Sal, Ut	17.8	6,620	1,340	75.3	1,770	99.4
9306235	Corral Gulch below Water Gulch nr Rangley, CO	8.6	7,740	382	44.4	1,120	130.2
9606242	Corral Gulch nr Rangely, Co	31.6	7,490	883	27.9	2,450	77.5
9328900	Crescent Wash nr Crescent Junction, Ut	23.3	6,180	3,260	139.9	6,460	277.3

Water Resources

Data Category: Surface Water
Geographic Area: Utah
go

News: Available soon in NWISWeb

Peak Streamflow for Utah

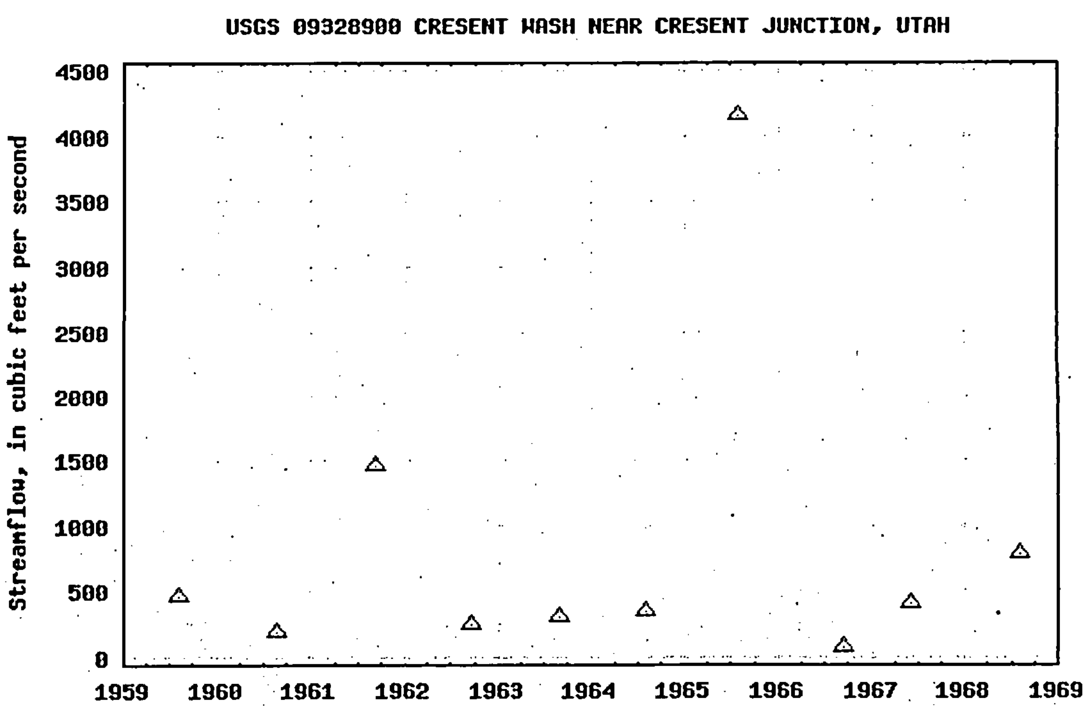
USGS 09328900 CRESENT WASH NEAR CRESENT JUNCTION, UTAH

Available data for this site: Site home page GO

Grand County, Utah
Hydrologic Unit Code 14060008
Latitude 38°56'32", Longitude 109°49'14" NAD27
Drainage area 23.30 square miles
Gage datum 4,880.00 feet above sea level NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- WATSTORE formatted file
- Reselect output format



Download a presentation-quality graph

Analysis of the Magnitude and Frequency of Floods in Colorado

By J.E. Vaill

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 99–4190

Prepared in cooperation with the
COLORADO DEPARTMENT OF TRANSPORTATION
and the BUREAU OF LAND MANAGEMENT

Denver, Colorado
2000

Table 3. Drainage-basin characteristics and flood-frequency data at streamflow-gaging stations—Continued

[LATDEG, latitude in decimal degrees; LNGDEG, longitude in decimal degree; DAREA, drainage area in square miles; YRSPK, years P2, P5, P10, P25, P100, P200, and P500 are the indicated recurrence intervals for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year,

Map number (fig. 1)	Station number	Station name	LATDEG	LNGDEG	DAREA	YRSPK	ELEV	PRECIP
271	09302500	Marvine Creek near Buford, Colo.	40.0383	107.4875	59.7	12	9,780	32.2
272	09303000	North Fork White River at Buford, Colo.	39.9875	107.6139	259.0	24	9,529	30.9
273	09303300	South Fork White River at Budges Resort, Colo.	39.8433	107.3342	52.3	19	10,569	40.0
274	09303320	Wagonwheel Creek at Budges Resort, Colo.	39.8428	107.3361	7.4	14	10,640	40.0
275	09303400	South Fork White River near Budges Resort, Colo.	39.8642	107.5333	128.0	19	10,250	40.0
276	09304000	South Fork White River at Buford, Colo.	39.9744	107.6247	177.0	25	9,800	36.3
277	09304300	Coal Creek near Meeker, Colo.	40.0914	107.7694	25.1	11	7,956	28.5
278	09304500	White River near Meeker, Colo.	40.0336	107.8617	755.0	66	8,940	29.6
279	09306007	Piceance Creek below Rio Blanco, Colo.	39.8261	108.1825	177.0	21	7,628	24.5
280	09306058	Willow Creek near Rio Blanco, Colo.	39.8372	108.2436	48.4	12	7,500	21.8
281	09306061	Piceance Creek above Hunter Creek, near Rio Blanco, Colo.	39.8506	108.2583	309.0	14	7,552	21.2
282	09306200	Piceance Creek below Ryan Gulch, near Rio Blanco, Colo.	39.9211	108.2969	506.0	11	7,415	20.8
283	09306235	Corral Gulch below Water Gulch, near Rangely, Colo.	39.9061	108.5322	8.6	14	7,740	20.0
284	09306242	Corral Gulch near Rangely, Colo.	39.9203	108.4722	31.6	21	7,490	20.0
285	09306255	Yellow Creek near White River, Colo.	40.1686	108.4006	262.0	17	6,877	17.3
286	09306800	Bitter Creek near Bonanza, Utah	39.7533	109.3542	324.0	10	7,146	16.1
287	09307500	Willow Creek above diversions near Ouray, Utah	39.5664	109.5867	297.0	24	7,650	16.8
288	09308000	Willow Creek near Ouray, Utah	39.9389	109.6478	897.0	23	7,080	13.7
289	09328900	Crescent Wash near Crescent Junction, Utah	38.9422	109.8206	23.3	10	6,180	12.7
290	09340000	East Fork San Juan River near Pagosa Springs, Colo.	37.3694	106.8917	86.9	41	10,200	39.0
291	09341500	West Fork San Juan River near Pagosa Springs, Colo.	37.3786	106.8989	87.9	26	10,000	42.0
292	09342500	San Juan River at Pagosa Springs, Colo.	37.2661	107.0103	298.0	46	9,700	36.0
293	09343000	Rio Blanco near Pagosa Springs, Colo.	37.2128	106.7939	58.0	37	10,000	39.0
294	09343500	Rito Blanco near Pagosa Springs, Colo.	37.1936	106.9047	23.3	18	9,400	34.0
295	09344000	Navajo River at Banded Peak Ranch, near Chromo, Colo.	37.0853	106.6889	69.8	41	10,500	37.0
296	09345500	Little Navajo River at Chromo, Colo.	37.0456	106.8425	21.9	17	8,900	26.0
297	09346000	Navajo River at Edith, Colo.	37.0028	106.9069	172.0	36	9,200	33.0
298	09346200	Rio Amargo at Dulce, N. Mex.	36.9333	107.0000	168.0	26	7,930	17.7
299	09349500	Piedra River near Piedra, Colo.	37.2222	107.3422	371.0	34	9,400	33.0
300	09349800	Piedra River near Arboles, Colo.	37.0883	107.3972	629.0	20	8,300	27.0
301	09350800	Vaqueros Canyon near Gobernador, N. Mex.	36.7333	107.2833	60.5	31	7,500	15.0
302	09352500	Los Pinos River below Snowslide Canyon, near Weminuche Pass, Colo.	37.6389	107.3333	25.3	13	11,200	45.0

of record; ELEV, mean basin elevation in feet; PRECIP, mean annual precipitation in inches; BSLOPE, mean basin slope in foot per foot; 200-year, and 500-year peak discharge; --, not available]

Station number	BSLOPE	P2	P5	P10	P25	P50	P100	P200	P500
09302500	0.245	318	400	447	498	532	563	591	626
09303000	0.237	1,380	1,890	2,230	2,640	2,940	3,240	3,540	3,930
09303300	0.198	924	1,380	1,700	2,120	2,440	2,760	3,090	3,540
09303320	0.159	188	260	307	365	406	447	488	540
09303400	0.256	1,700	2,480	3,030	3,770	4,350	4,940	5,570	6,440
09304000	0.259	1,800	2,310	2,600	2,920	3,140	3,340	3,530	3,760
09304300	0.285	50	80	100	126	144	162	180	203
09304500	0.222	3,170	4,210	4,840	5,600	6,140	6,650	7,150	7,780
09306007	0.283	148	294	411	576	710	851	1,000	1,210
09306058	0.272	14	36	58	99	140	191	254	360
09306061	0.263	193	381	534	758	943	1,140	1,360	1,660
09306200	0.243	145	255	345	479	594	723	867	1,080
09306235	0.253	14	69	158	382	673	1,120	1,780	3,110
09306242	0.236	39	175	383	883	1,510	2,450	3,810	6,490
09306255	0.197	154	508	982	2,040	3,310	5,170	7,850	13,200
09306800	0.287	115	451	894	1,820	2,840	4,210	6,000	9,150
09307500	--	241	476	692	1,050	1,380	1,780	2,260	3,030
09308000	--	636	1,860	3,170	5,510	7,810	10,600	14,000	19,300
09328900	--	439	1,140	1,890	3,260	4,670	6,460	8,720	12,600
09340000	0.387	924	1,350	1,640	2,020	2,300	2,600	2,900	3,310
09341500	0.400	1,320	1,830	2,170	2,590	2,910	3,230	3,550	3,970
09342500	0.342	2,610	4,160	5,480	7,570	9,460	11,700	14,300	18,400
09343000	0.428	853	1,200	1,450	1,780	2,030	2,290	2,570	2,950
09343500	0.239	190	313	401	519	610	704	800	932
09344000	0.368	650	897	1,070	1,280	1,450	1,620	1,790	2,020
09345500	0.225	146	253	334	447	538	633	733	874
09346000	0.277	852	1,310	1,660	2,160	2,570	3,020	3,510	4,230
09346200	--	1,030	1,490	1,830	2,280	2,650	3,040	3,440	4,030
09349500	0.344	2,090	3,480	4,640	6,400	7,950	9,710	11,700	14,800
09349800	0.290	2,420	3,960	5,130	6,790	8,150	9,610	11,200	13,500
09350800	--	196	490	822	1,470	2,180	3,130	4,410	6,760
09352500	--	324	518	656	839	981	1,130	1,280	1,480

Project: Crescent Junction Ex Simulation Run: CW 25			
Start of Run:	01Jan2006, 00:00	Basin Model:	Crescent Wash-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	25-yr 24-hr
Compute Time:	16May2006, 17:21:41	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Crescent Wash	22.5600	3020.71	01Jan2006, 14:10	0.49
Sink-1	22.5600	3020.71	01Jan2006, 14:10	0.49

Project: Crescent Junction Ex	Simulation Run: CW 100

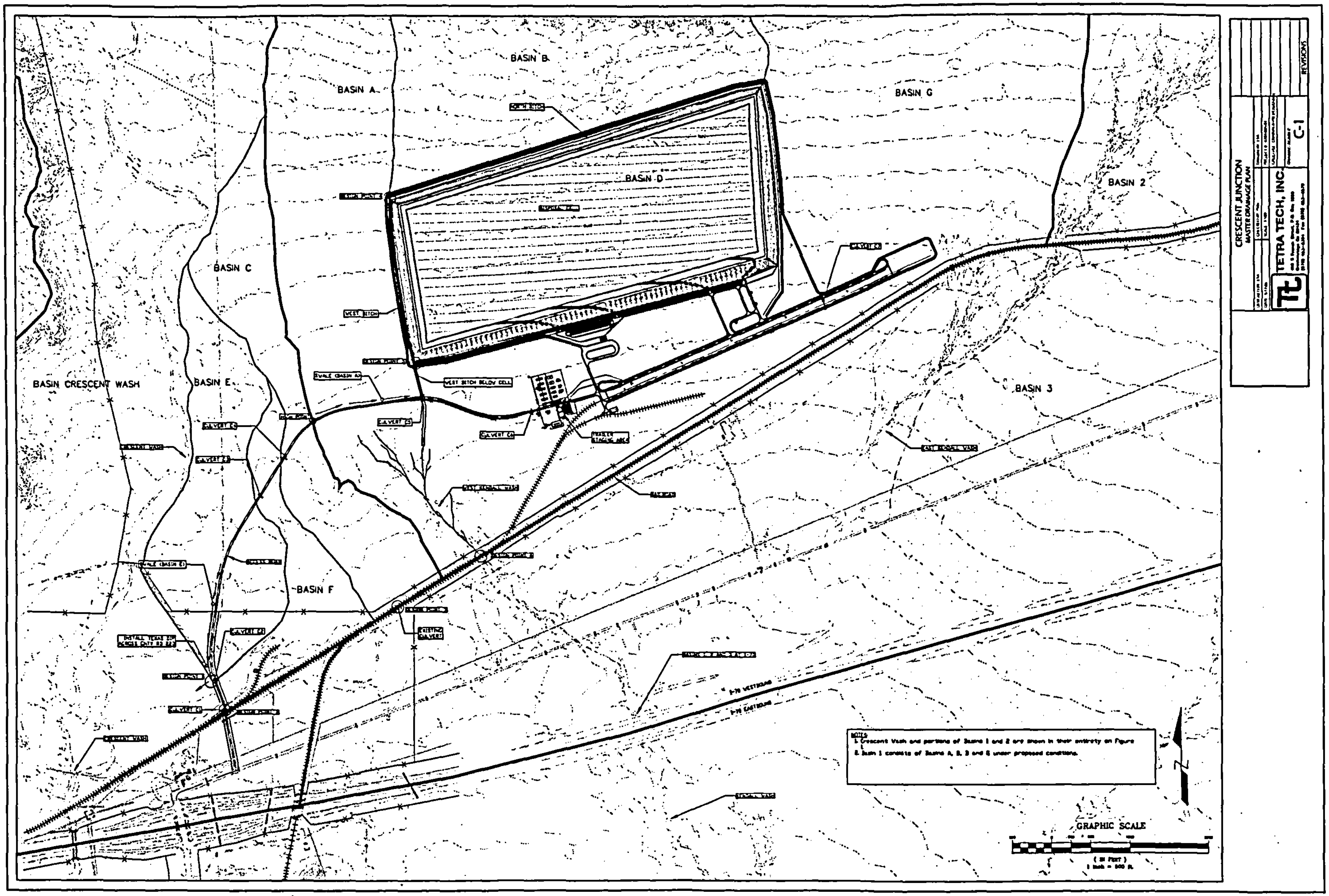
Start of Run:	01Jan2006, 00:00	Basin Model:	Crescent Wash-event
End of Run:	02Jan2006, 00:00	Meteorologic Model:	100-yr 24-hr
Compute Time:	15May2006, 15:48:31	Control Specifications:	1 day at 5 min step

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Crescent Wash	22.5400	6072.68	01Jan2006, 14:10	0.98
Sink-1	22.5400	6072.68	01Jan2006, 14:10	0.98

Appendix F

Master Drainage Plan


BASIN A
BASIN B
BASIN G
BASIN D
BASIN 2
BASIN C
BASIN CRESCENT WASH
BASIN E
BASIN 3
BASIN F
NORTH DITCH
WEST DITCH
WEST DITCH BELOW CELL
CULVERT C5
CULVERT C4
CULVERT C3
CULVERT C2
CULVERT C1
CULVERT C6
EXISTING CULVERT
TRAILER STAGING AREA
WEST REGRADE WASH
EAST REGRADE WASH
CRESCENT WASH
I-70 WESTBOUND
I-70 EASTBOUND
NOTES
1. Crescent Wash and portions of Basins 1 and 2 are shown in their entirety on Figure
2. Basin 1 consists of Basins A, B, D and G under proposed conditions.
GRAPHIC SCALE
(IN FEET)
1 inch = 500 ft.
CRESCENT JUNCTION
MASTER DRAINAGE PLAN
TETRA TECH, INC.
C-1
REVISIONS

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-5-25-00 **Discipline:** Engineering **No. of Sheets:** 7

Project: Moab UMTRA Project

Site: Crescent Junction Disposal Site

Feature:
Diversion Channel Design, North Side Disposal Cell

Sources of Data:

Bonnin, G.M., D. Todd, T. Lin, T. Parzbok, T. A. Yekta, and D. Riley, 2003. "Precipitation-Frequency Atlas of the United States," *U. S. National Oceanic and Atmospheric Administration* (NOAA) *Atlas 14*, Volume I, Version 3, NOAA, National Weather Service, Silver Spring, Maryland, for Thompson, Utah.

U.S. Department of Energy (DOE), 2006. Moab UMTRA Project, Crescent Junction Disposal Site, *Calculation No. MOA-02-05-2006-5-08-00, Site Hydrology Calculation.*

Sources of Formulae and References:

Abt, S.R., and T.L. Johnson, 1991. "Riprap Design for Overtopping Flows," *Journal of Hydrologic Engineering,* ASCE, 117(8):959–972.

Abt, S.R., M.S. Khattak, J.D. Nelson, J.F. Ruff, A. Shaikh, R.J. Wittler, D.W. Lee, and N.E. Hikle, 1987. "Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase I," NUREG/CR-4651.

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NUREG-1623, by T.L. Johnson, 2002. "Design of Erosion Protection for Long-Term Stabilization Final Report," Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C.

Schuum, S.A., M.D. Harvey, and C.C. Watson, 1988. *Incised Channels Morphology, Dynamics and Control,* Water Resource Publications, Littleton, Colorado.

U.S. Army Corps of Engineers (ACE), 1994. "Hydraulic Design of Flood Control Channels," EM 1110-2-1601, Office of the Chief of Engineers, Washington D.C.

Preliminary Calc. ☐ **Final Calc.** ☐ **Supersedes Calc. No.**

Author: [signature] Name 6/13/06 Date **Checked by:** [signature] Name 6-9-06 Date

Approved by: [signature] Name 6-9-06 Date Name Date

Name Date

[signature] Name 6/12/06 Date

Problem Statement:

- Determine the configuration (size and shape) of a diversion channel system to intercept both everyday operational and extreme flood surface-water flows from reaching the proposed disposal cell and causing detrimental erosion.
- Determine the size of erosion-control riprap for the channel.
- Discuss expected performance and operation of the diversion channel system.

Method of Solution:

Evaluate the size and dimensions of a diversion channel to route extreme flood flows arising from the probable maximum precipitation (PMP) event away from the proposed disposal cell following methods outlined in Chapter 3 of Appendix D of NUREG 1623. Obtain magnitude of the probable maximum flood (PMF) flow value from the PMP for drainage basins hydrology contained in the Site Hydrology Calculation (DOE 2006).

Design the channel to be erosionally resistant under the PMF flow and provide a method to route operational flows from lower intensity, frequent storm events. The 24-hour, 200-year precipitation event is selected as the upper-limit storm-representing design for the lower intensity, frequent storm events. Determine the total flow rate for a 24-hour, 200-year precipitation event with the Rational Method (Q=CiA) routed to the proposed disposal cell. Transmit this flow in a pilot channel located in the main diversion channel to divert everyday "operational" flows.

Assumptions:

- Topographic maps provided in the Site Hydrology Calculation (DOE 2006) are accurate.
- Riprap stone is angular, possesses a specific gravity of 2.64, and has a minimum Nuclear Regulatory Commission durability criteria score of 80 (Appendix D, NUREG 1623); thus it will not require oversizing for use in frequently saturated areas.

Calculation:

- The upland drainage basin for the proposed disposal cell was determined in the Site Hydrology Calculation and is shown in Figure 1. A PMF flow rate of 5,859 cubic feet (ft^3) s-1 is the reported flow rate at the cell.
- A 30-foot (ft)-wide trapezoidal channel with 5H to 1V (20 percent) side slopes located adjacent to the northern side of the proposed disposal cell will be evaluated. Overall slope of the channel will follow the existing land slope from the upper northeastern end to the southwest end (see Figure 1).
- Invert slope of the channel is computed from the difference in elevation between the northeastern end to the southwest end divided by the length between them:

$$(4{,}990\text{ ft} - 5{,}014\text{ ft})/4{,}955\text{ ft} = 0.005,\ [-0.5\%]$$

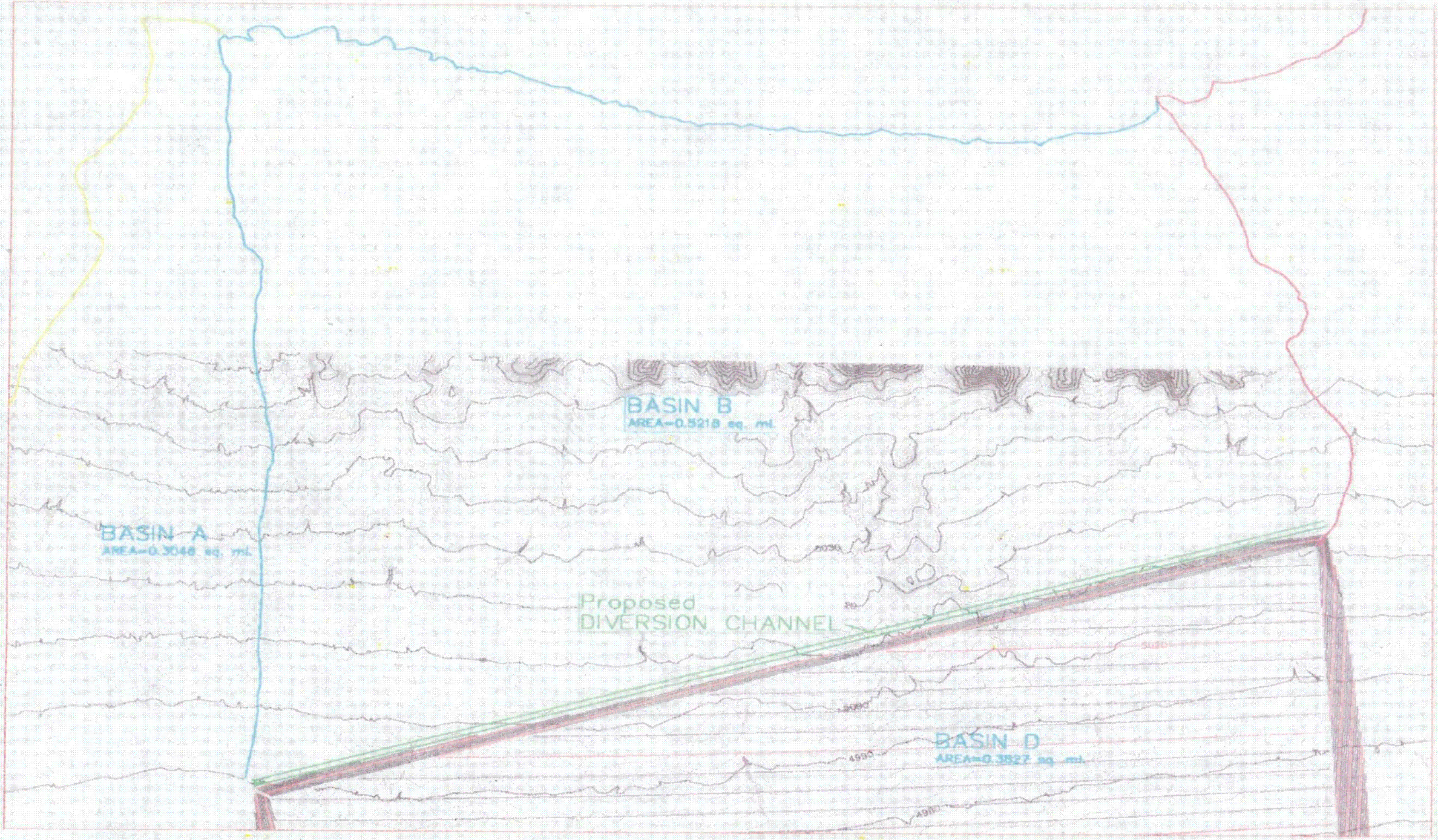


Figure No. 1

Figure 1. Upland Drainage Basin for the Proposed Diversion Channel

C28

- An initial value for Manning's n is computed using procedures discussed by Abt et al., (1987) and Abt et al. (1991) by assuming a mean riprap diameter of 24 inches as follows:

$$n = 0.0456*(D_{50} * S)^{0.159} \tag{1}$$
$$n = 0.0456*(24 * 0.005)^{0.159}$$
$$n = 0.033$$

where: n is Manning's n,
D_{50} is the mean riprap diameter in inches, and
S is the channel slope (ft/ft).

Chow (1959) reports a value for n of 0.033 for the normal value of a gravel-lined channel with sides of dry rubble or riprap (Table 5-6 B-2.*d*.5 page 111), confirming the initial estimate.

The depth of flow in the channel during PMF flow is computed with Manning's equation for open-channel flow:

$$Q = 1.486/n * A * R_h^{2/3} * S^{½} \tag{2}$$

where: Q is the PMF flow rate,
A is the cross-sectional flow area,
R_h is the hydraulic radius equal to the cross-sectional flow area divided by the wetted perimeter, and all other variables are previously defined.

Cross-sectional flow area and hydraulic radius are expressed as a function of the flow depth (y), base width of the channel (B) and side slope (ŝ H:1V) by:

$$A = B*y + ŝ*y^2 \tag{3}$$

Hydraulic radius is evaluated by:

$$R_h = A / B + 2*y*(ŝ^2 + 1^2)^{1/2} \tag{4}$$

Substituting a 30-ft-wide base and 5H:1V side slopes into equations (2), (3) and (4) and solving for y through iterations produces y = 6.1 ft.

A check on the assumed mean riprap size is performed by computing the tractive shear stress (τ, pounds per square foot [psf]) at the base of the channel as:

$$\tau = \gamma_w * S * y \tag{5}$$
$$= 1.90 \text{ psf}$$

where: γ_w is the unit weight of water (62.4 pounds per ft^{-3}),
y is the depth of flow (ft),
S is the channel slope (ft/ft) as previously defined.

Tractive shear stress is related to the mean rock size through equation (6) of the ACE (ACE 1994) as:

$$\tau = \alpha^* (\gamma_s - \gamma_w) * D_{50} \tag{6}$$

where: γ_s is the unit weight of riprap (62.4 pounds ft^{-3} times specific gravity of 2.64), and
α is a coefficient of 0.04.

Equating equation (5) and (6) results in a D_{50} of 0.46 ft. Since this D_{50} is smaller than the assumed value, Manning's *n* is re-evaluated producing a value of 0.035. The process is repeated until a depth of flow, computed rock size and Manning's *n* converge.

A resulting depth of flow of 5.8 ft, a tractive shear stress of 1.8 psf and D_{50} of 0.44 ft (5.3 inches) are determined.

The 24-hour, 200-year precipitation event for Thompson, Utah, is 2.54 inches (see attached sheet, NOAA Atlas 14, Thompson, Utah), which relates to 0.106 inches/hour.

Using the Rational formula, Q = CiA to compute total runoff from the upland drainage basin,

where: Q = total runoff ($ft^3\ s^{-1}$),
C = runoff coefficient,
i = rainfall intensity (inches $hour^{-1}$),
A = drainage basin area (acres).

A total runoff of 8.83 $ft^3\ s^{-1}$ using a realistic value of 0.30 for the runoff coefficient, C. Total runoff increases to 29.4 $ft^3\ s^{-1}$ using a value of C = 1 (totally impervious due to saturated conditions, 100 percent runoff).

Manning's equation presented in equation (2) is again used to compute the depth of flow in a "V" ditch pilot channel. The cross-sectional flow area and hydraulic radius change; the remaining variables do not. A Manning's *n* of 0.030 is assumed to produce a flow depth of 5 ft, with a slope of 0.5 percent flowing 8.9 $ft^3\ s^{-1}$. This flow rate approximates the total flow from the 200-year event and will be used for preliminary design. A value of 0.030 for Manning's *n* relates a channel roughness corresponding to a gravel/cobble surface.

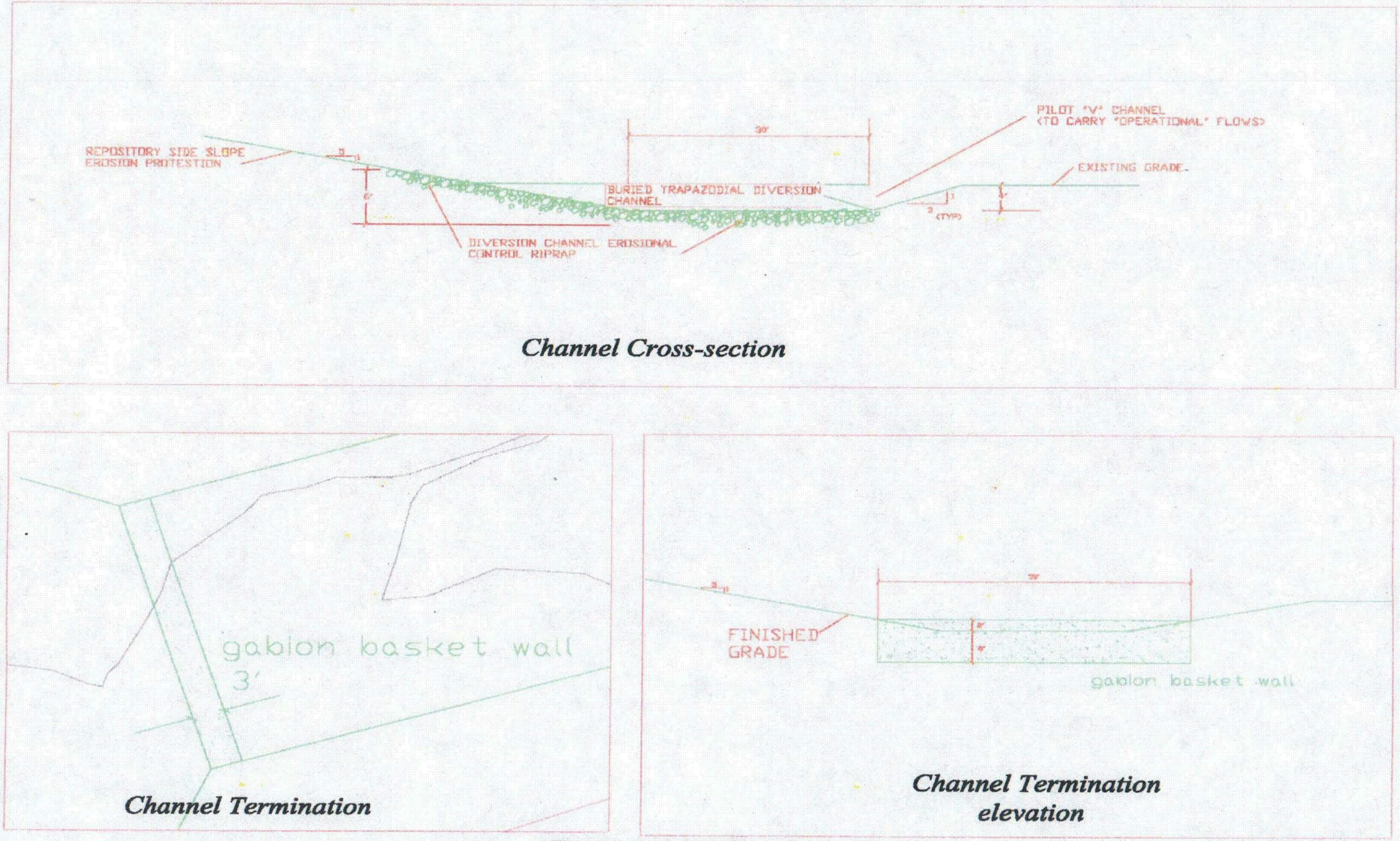
Discussion:

Based on the analysis above, a 30-ft-wide trapezoidal channel with 5H to 1V side slopes 6 ft deep, lined with a 12-inch-thick (2 D_{50}) layer of 6-inch D_{50} riprap will protect the proposed disposal cell from the PMF.

To confirm and illustrate that the 6-inch D_{50} size riprap will provide erosion protection under a 6.1-ft flow depth, the flow depth that is required to compute a 12-inch mean diameter piece of riprap is back calculated at 14.7 ft using equations (5) and (6).

As a best-management practice, a gabion weir that extends 6 ft below finish grade will act to dissipate flow energy and prevent headward channel migration into the diversion channel (Figure 2). Any small flows that exit the channel will slowly permeate through the gabion weir. During flood stage, the weir will act as a sediment trap for large particles entrained at the base of the flow. A majority of the flow will pass over the weir and out to native ground on the west side of the proposed disposal cell, eventually arriving at West Kendall wash. Over the long-tern, mesh forming the gabions will disintegrate leaving a triangular mound of rock. This is expected to be similar to a typical "check dam" now frequently employed by the National Resource Conservation Service.

A pilot "V" channel will be placed on the northern right side of the channel will divert operation flows up to the 24-hour, 200-year precipitation event. Extending the pilot channel 100 ft beyond termination of the main channel will help to prevent erosion from initiating in the main channel. The gabion wall is not extended to the pilot channel, increasing the likelihood for erosion to begin, and stay, in the pilot channel (the disposal cell will still be protected by the erosion control riprap discussed below).



Channel Cross-section

Channel Termination

Channel Termination elevation

Figure No. 2

Figure 2. Proposed Diversion Channel Design

C29

Expected operational performance:

Run-on from frequent storm events will be intercepted and diverted by the pilot channel. Erosion and deposition are expected to occur in the channel over the lifetime of the facility. Development of the channel is expected to follow the genesis of typical desert arroyo (see Graf 2002 and Schuum et al. 1988). Erosion and deposition will occur continuously as the channel system conforms to the local climate and ecology approaching a dynamic stability.

During large magnitude storm events, such as the design PMF, runoff will be extreme and rapid. Flow will inundate the pilot channel and divert along the northern side of the disposal cell. Estimated rise of water on the disposal is computed by applying Manning's equation to a large "V" channel with one side slope at 5H: 1V (20 percent) and the other at 50H:1V (2 percent). A weighted mean value for *n* is used based on the length of erosion riprap ($n = 0.035$) or native ground ($n = 0.020$) submerged. Using a flow rate of 5,859 $ft^3\ s^{-1}$, *a 5.9-ft depth is computed.*

Additional conservatism is attainable by burying erosion control riprap in the channel after placement, as shown on Figure 2. Doing this in conjunction with construction of the pilot channel will cause all flow to operate in the pilot channel, up to the extreme event. During the PMF, the erosive power of flood flows will be lessened because the flow will be transporting sacrificial material used to bury riprap that forms the protection against the PMF. Erosion control riprap will have to extend up the slope a minimum of 2 ft.

Conclusion and Recommendations:

The relatively small riprap size results from the relatively large width and low-bed slope of the channel.

Figure 2 shows the recommended channel cross-section and gabion wall.

Computer Source:

- Not applicable.

ATTACHMENT

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

THOMPSON, UTAH (42-8705) 38.9667 N 109.7167 W 5219 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M. Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003

Extracted: Wed May 17 2006

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Help | D

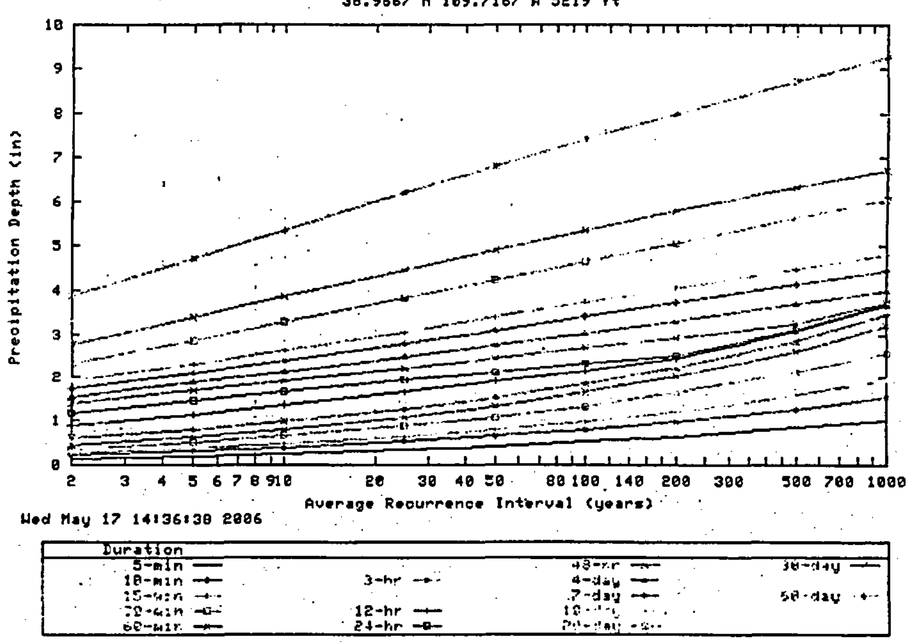
Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.14	0.21	0.27	0.36	0.44	0.54	0.59	0.74	0.90	1.19	1.38	1.54	1.73	1.91	2.35	2.81	3.32	3.87
5	0.20	0.31	0.38	0.51	0.63	0.74	0.79	0.95	1.15	1.45	1.68	1.87	2.10	2.32	2.88	3.41	4.04	4.73
10	0.26	0.39	0.48	0.65	0.81	0.92	0.98	1.14	1.36	1.65	1.91	2.14	2.40	2.65	3.29	3.88	4.59	5.38
25	0.34	0.52	0.65	0.87	1.08	1.22	1.27	1.43	1.66	1.92	2.24	2.50	2.82	3.09	3.84	4.48	5.30	6.21
50	0.43	0.65	0.81	1.09	1.35	1.49	1.53	1.67	1.90	2.12	2.48	2.78	3.12	3.42	4.26	4.93	5.83	6.82
100	0.53	0.80	0.99	1.34	1.66	1.82	1.85	1.97	2.17	2.33	2.72	3.06	3.44	3.75	4.68	5.37	6.34	7.42
200	0.65	0.98	1.22	1.65	2.04	2.22	2.25	2.36	2.49	$\boxed{2.54}$	2.97	3.35	3.75	4.07	5.09	5.80	6.84	8.00
500	0.84	1.28	1.59	2.14	2.65	2.87	2.89	3.01	3.12	3.15	3.29	3.72	4.17	4.50	5.64	6.35	7.48	8.73
1000	1.02	1.56	1.93	2.60	3.22	3.46	3.48	3.60	[illegible]	3.72	3.76	4.00	4.49	4.82	6.05	6.74	7.95	9.27

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

Partial duration based Point Precipitation Frequency Estimates Version: 3
38.9667 N 109.7167 W 5219 ft



U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-06-00	**Discipline:** Geotechnical	**No. of Sheets:** 18

Project: Moab UMTRA Project

Site: Crescent Junction Disposal Site

Feature: Erosional Protection of Disposal Cell Cover

Sources of Data:

Geotechnical Engineering Group, Inc. (GEG), 2005. Technical Testing, Crescent Junction, GEG Job No. 2165, December 22.

U.S. Department of Energy (DOE), 2005. Crescent Junction Site Characterization. *Site Drainage-Hydrology Parameters*, Calc. No. MOA-02-08-2005-2-08-01, November.

U.S. Department of Energy (DOE), 2006. Crescent Junction Site Characterization, *Diversion Channel Design, North Side Disposal Cell*, Calc. No. MOA-02-02-2006-5-25-00.

Sources of Formulae and References:

Abt, S.R., and T.L. Johnson, 1991. "Riprap Design for Overtopping Flow", *Journal of Hydraulic Engineering*, v. 117, No. 8, August.

Abt, S.R., T.L. Johnson, C.I. Thornton, and S.C. Trabant, 1998. "Riprap Sizing at Toe of Embankment Slopes", *Journal of Hydraulic Engineering*, V. 124, No. 7, July.

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Nelson, J.D., S.R. Abt, R.L. Volpe, D. van Zyl, N.E. Hinkle, W.P. Staub, 1986. *Methodologies for Evaluating Long-Term Stabilization Design of Uranium Mill Tailings Impoundments*, NUREG/CR-4620, U.S. Nuclear Regulatory Commission (NRC), June.

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U.S. Department of Transportation (DOT), 1983. "Hydraulic Design of Energy Dissipaters for Culverts and Channels", *Hydraulic Engineering Circular* No. 14, September.

Preliminary Calc. ☐ Final Calc. ☐ Supersedes Calc. No.

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Approved by:	John E. Elmer [signature] (Name)	6-9-06 (Date)		John Elmer [signature] (Name)	6-9-06 (Date)
				[signature] Smith (Name)	6-10-06 (Date)
				R. A. Bat [signature] (Name)	6-12-06 (Date)

Problem Statement:

Determine the rock protection required to protect the cover of the disposal cell from erosion due to action of surface water and wind to meet the specifications of the *Code of Federal Regulations* (CFR) (40 CFR part 192).

Method of Solution:

- Determine the peak unit discharge from both the Probable Maximum Precipitation (PMP) and the 100-year precipitation event on the drainage basins of the disposal cell using the Rational method (Chow 1964).
- Evaluate erosional stability of soil cover on top slope of disposal cell using Temple method (Temple et al. 1987).
- Evaluate erosional stability of rock mulch on top slope of disposal cell using Safety Factor method (Nelson et al. 1986).
- Evaluate erosional stability of rock mulch or riprap on side slopes of disposal cell using both Stevenson method (Johnson 2002) and Abt and Johnson method (Abt and Johnson 1991).
- Evaluate surface sheet erosion of top slope of disposal cell due to action of surface water and wind using Modified Universal Soil Loss Equation (MUSLE) method (Nelson et al. 1986).
- Evaluate required rock size for toe apron to accommodate flow transitioning from cell slope to native ground using method proposed by Abt et al. (Abt et al.1998).
- Evaluate the need for bedding layer between cover soils and erosion protection material by estimating interstitial pore velocities using method proposed by Abt et al. (Abt et al. 1991).

Assumptions:

- The 100-year precipitation event is applicable for evaluating drought, fire, and post-construction conditions when little or no vegetation is on the cover.
- The PMP precipitation event is applicable for long-term erosional stability analyses.
- The 1-hour PMP event is estimated to be 8.2 inches, and the 1-hour 100-year event is estimated to be 1.65 inches (DOE 2005).
- The layout of the disposal cell is shown in Figure 1. This layout shows a 2 percent top slope, 5:1 (horizontal:vertical) side slopes, and a total footprint area of 248 acres.
- Rock available for erosion protection will be angular, have a specific gravity of 2.65, and will meet Nuclear Regulatory Commission (NRC) durability requirements.

Calculation:

See "Discussion."

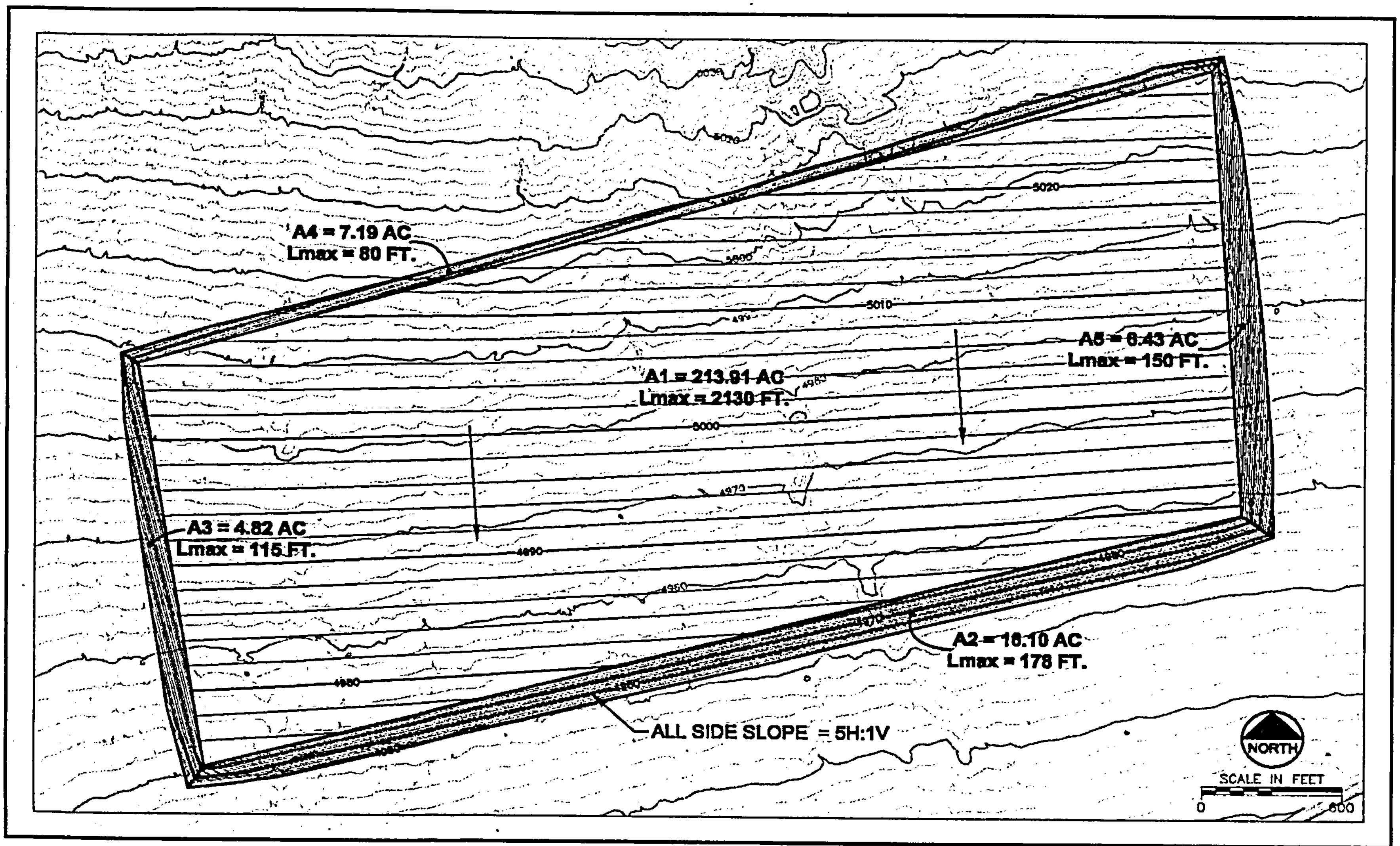

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FIGURE 1
DISPOSAL CELL LAYOUT

Date:	MAY 2006
Project:	181268
File:	CELL-DESIGN..07-2

Figure 1. Disposal Cell Layout

Discussion:

Drainage Area Characteristics

Five drainage areas were delineated on the cover of the disposal cell, as shown in Figure 1. The area and flow length of these drainage areas were calculated using computer-aided design (CAD) tools.

Peak flows occurring within each drainage area are calculated using a rainfall duration equivalent to the time of concentration for each drainage basin. The time of concentration is a characteristic of the geometry and slopes of the drainage areas, and is computed by three different methods, with the average of the three methods used to calculate peak discharges. The three methods used to calculate the time of concentration are described below.

1) The Kirpich equation as presented in NUREG/CR-4620 (Nelson et al. 1986):

$$T_c = 0.0078\frac{L^{0.77}}{S^{0.385}}$$

where:

T_c = time of concentration (minutes),
L = slope length (feet [ft]), and
S = slope (ft/ft).

2) The Soil Conservation Service (SCS) Triangular Hydrograph Theory, as presented in NUREG/CR-4620 (Nelson et al. 1986):

$$T_c = \left(\frac{11.9L^3}{H}\right)^{0.385}$$

where:

T_c = time of concentration (hours),
L = slope length (miles), and
H = slope height (ft).

3) The Brant and Oberman equation as presented in the Moab Uranium Mill Tailings Remedial Action Project (UMTRA) Technical Approach Document (TAD) (DOE 1989):

$$T_c = C\left(\frac{L}{Si^2}\right)^{\frac{1}{3}}$$

where:

T_c = time of concentration (minutes),
C = coefficient = 1.0 for bare earth,
S = slope (ft/ ft), and
i = one-hour rainfall intensity (inches/hour).

As specified in UMTRA TAD (DOE 1989), T_c is limited to a minimum of 2.5 minutes. Because precipitation falling on the top of the cover flows to the south slope, the time of concentration for the south-side slope is equivalent to the time of concentration of precipitation on the top slope plus the time of concentration of precipitation occurring on the south-side slope. The characteristics of the drainage areas on the disposal cell are summarized in Table 1.

Table 1. Drainage Area Characteristics

Drainage Area Description	Incremental Drainage Area (acres)	Slope (ft/ft)	Slope Length (ft)	Time of Concentration (min)			
				Kirpich	SCS	Brant and Oberman	Average
A1, top	213.91	0.02	2,130	12.9	12.9	11.7	12.5
A2, south slope	16.10	0.2	170	13.6	13.6	14.0	13.7
A3, west slope	4.82	0.2	115	0.6	0.6	2.0	2.5*
A4, north slope	7.19	0.2	80	0.4	0.4	1.8	2.5*
A5, east slope	6.43	0.2	150	0.7	0.7	2.2	2.5*

*Time of concentration is limited to a minimum of 2.5 minutes.

Peak Discharge

One of the technical criteria for the stability of the disposal cell is acceptable erosional stability from extreme storm events (10 CFR part 40, Appendix A). NRC has interpreted this criterion to be able to safely pass the peak runoff from storms up to the PMP event (Johnson 2002). The PMP event has a 1-hour depth of 8.2 inches, and a 15-minute depth of 7.1 inches (DOE 2005). For events with durations less than 15 minutes, precipitation depths as a percent of the 1-hour PMP are estimated using the following formula, as given in Table 4.1 of the UMTRA TAD (DOE 1989):

$$\%PMP_{1-hour} = \frac{RD}{0.0089RD + 0.0686}$$

where: RD = rainfall duration (minutes).

The precipitation depth of any given storm duration is then calculated as:

$$PD_{PMP} = \%PMP_{1-hour} \times PMP_{1-hour}$$

where: PD_{PMP} = precipitation depth of the PMP storm with duration equivalent to the time of concentration (inches).

The precipitation events for 100-year recurrence interval for several storm durations were taken from Appendix A of the *Crescent Junction Site Characterization, Site Drainage-Hydrology Parameters Calculation* (DOE 2005) and are summarized in Table 2. Precipitation depths for durations other than those listed in Table 2 are interpolated.

Table 2. 100-Year Storm Event Precipitation Depths

Rainfall Duration (min)	Precipitation Depth (inches)	Intensity (inches/hr)
5	0.53	6.36
10	0.8	4.80
15	0.99	3.96
30	1.33	2.66
60	1.65	1.65
120	1.82	0.91

The rainfall intensity is calculated for a rainfall duration equivalent to the time of concentration for the drainage basin. Rainfall intensity (inches per hour) is calculated as follows:

$$I = \frac{PD \times 60}{RD}$$

The Rational method (Chow 1964) was used to determine the peak discharge from the PMP and the 100-year event for evaluation of cover erosion protection. For each drainage area, the peak flow was calculated with the Rational Formula, as follows:

$$Q = CIA$$

where:

Q = peak flow (cfs),
C = runoff coefficient,
I = rainfall intensity (inches per hour) corresponding to the time of concentration, and
A = area (acres).

The runoff coefficient is approximately 1.0 for PMP conditions, as discussed in UMTRA TAD (section 4.1.3). A runoff coefficient of 0.9 is used for 100-year storm events based on a conservative estimate for a riprap/rock surface.

Peak flow may also be expressed as a unit discharge as follows:

$$q = \frac{Q}{w} = \frac{CIL}{43200}$$

where:

q = unit discharge (cubic feet per second per foot [cfs/ft]),
w = unit width (ft),
C = runoff coefficient = 1.0,
I = rainfall intensity (inches per hour), and
L = slope length (ft).

Table 3 shows the results of the PMP peak flow in cubic feet per second (cfs) and the unit discharge calculations in cubic feet per second per foot (cfs/ft) for the areas shown in Figure 1. Table 4 shows results for the 100-year storm. These peak unit flows will be applied to the entire drainage area when evaluating erosional stability. Additional supporting calculations can be found in Appendix A.

Table 3. Results of PMP Peak Flow and Unit Discharge

Drainage Area Description	Runoff Coef. C	Average T_c (min)	Percent $PMP_{1\text{-}hr}$	PD_{PMP} (inches)	Intensity (inches/hr)	Peak Flow, Q (cfs)	Unit Discharge, q (cfs/ft)
A1, top	1.0	12.5	69.4	5.7	27.4	5,863	1.35
A2, south slope	1.0	13.7	72.0	5.9	25.8	5,928	1.37
A3, west slope	1.0	2.5	27.5	2.3	54.2	261	0.14
A4, north slope	1.0	2.5	27.5	2.3	54.2	389	0.10
A5, east slope	1.0	2.5	27.5	2.3	54.2	348	0.19

Table 4. Results of 100-Year Peak Flow and Unit Discharge

Drainage Area Description	Runoff Coef. C	Average T_c (min)	$PD_{100\text{-yr}}$ (inches)	Intensity (inches/hr)	Peak Flow, Q (cfs)	Unit Flow q (cfs/ft)
A1, top	0.9	12.5	0.9	4.5	856.7	0.20
A2, south slope	0.9	13.7	0.9	4.3	888.5	0.21
A3, west slope	0.9	2.5	0.5	6.4	27.6	0.02
A4, north slope	0.9	2.5	0.5	6.4	41.2	0.01
A5, east slope	0.9	2.5	0.5	6.4	36.8	0.02

Top Surface: Erosional Stability of Soil Cover

The top surface of the disposal cell was evaluated for erosional stability without a rock layer using the method developed by Temple et al. (1987). This procedure, developed to analyze grassy channels, estimates stresses from runoff on channel vegetation as well as the channel surface soils. The erosional stability of the cover surface was evaluated by calculating a factor of safety against erosion due to the peak runoff. Factor-of-safety values were calculated as the ratio of the allowable stresses (the resisting strength of the cover vegetation or soils) to the effective stresses (the stresses impacted by the runoff flowing over the cover). As outlined in UMTRA TAD (1989), the 100-year peak unit flows (Table 4) were used to analyze the stability of a non-vegetated slope, such as would be representative of post-construction, drought, or burn conditions. PMP peak unit flows (Table 3) were used to analyze the stability of a vegetated slope, assuming a poor to fair cover of grass eventually will be established on the cover. In addition, peak flows are multiplied by a concentration factor of 3.0 to account for channelization of flow.

The stress calculations are summarized below. Potential materials evaluated for use as cover soils were (1) low-plasticity silt and clayey material from excavated on-site alluvial and eolian deposits, (2) excavated on-site weathered Mancos Formation shale, and (3) imported coarse-grained sands and gravels.

Allowable Stresses

Allowable stresses for the non-vegetated cover soils were calculated using the equations in Temple et al. (1987). For cohesive soils, the resistance is based on the plastic limit and void ratio of the material. The equation for allowable shear strength for cohesive soils is:

$$\tau_a = \tau_{ab} C_e^{\,2}$$

where:

τ_a = allowable shear strength (pounds per square feet [psf]),
τ_{ab} = basis allowable shear strength (for a CL) = $(1.07\,[PI]^2 + 14.3[PI] + 47.7) \times 10^{-4}$,
C_e = soil parameter = $1.48 - 0.57e$,
PI = plasticity index, and
e = void ratio.

For non-cohesive soils, the resistance is based on particle size, specifically the size where 75 percent of the material is finer, or D_{75}. The equation for allowable shear strength for non-cohesive soils is:

$$\tau_a = 0.4 D_{75}$$

where D_{75} is in inches.

Plasticity index and void ratio are estimated from preliminary geotechnical laboratory testing results for on-site material (GEG 2005), assuming compaction to approximately 85 percent of maximum dry density as determined from the Modified Proctor test.

For vegetated slopes, the allowable stresses are a function of the quality of vegetation established on the cover, as given by the following equation:

$$\tau_{va} = 0.75C_l$$

where:

τ_{va} = allowable vegetation shear strength (psf),
C_l = cover index = $2.5 \times \left(h \times \sqrt{M}\right)^{\frac{1}{3}}$,
h = stem length (ft), and
M = stem density factor (stems per square foot).

Because of the arid climate at the site, vegetative properties are modeled as poor, with average stem height of 0.3 ft, and a stem density factor of 17 as given in Temple et al. (1987), conservatively using poor conditions represented by a poor stand of Sudan grass (a bunch grass providing incomplete surface cover).

<u>Effective Stresses</u>

The effective shear stress on soil due to peak runoff from the 100-year event on the non-vegetated slope is calculated as:

$$\tau_e = \gamma dS$$

where:

τ_e = effective shear stress (psf),
γ = unit weight of water = 62.4 pcf,
d = depth of flow (ft), and
S = slope of cover surface (ft/ft).

For vegetated slopes, the effective shear stress on soil due to peak runoff from the PMP event is calculated as:

$$\tau_e = \gamma dS(1 - C_f)\left(\frac{n_s}{n_v}\right)^2$$

where:

C_F = cover factor = 0.25 for poor vegetation, and
n_s = soil grain roughness factor, calculated by the following equation:

$$n_s = 0.0156 \text{, for cohesive soil}$$

$$n_s = 0.0256(d_{75})^{\frac{1}{6}} \text{, for granular soil, where d is in inches.}$$

n_v = combination of resistance due to soil roughness, n_s and vegetation, n_r, calculated by:

$$n_v = \sqrt{n_r^2 - 0.0156^2 + n_s^2}$$

where: n_r = resistance due to vegetation, calculated by:

$$n_r = \exp\left(0.01329C_l(\ln q)^2 - 0.09543C_l \ln q + 0.2971C_l - 4.16\right)$$

where: q = unit flow (cfs/ft).

The cover factor, C_f, is assumed to be 0.5 for good vegetation conditions, and 0.25 for poor vegetation, as given in Temple et al. (1987) for Sudan grass. The effective shear stress on vegetation is calculated as:

$$\tau_{ve} = \gamma dS - \tau_e$$

where τ_v = effective vegetal stress (psf).

The depth of flow is calculated by iteration of Manning's equation:

$$q = \frac{1.486dR^{\frac{2}{3}}\sqrt{S}}{n}$$

where:

q = unit flow (cfs/ft),
d = depth of flow (ft),
R = hydraulic radius = d for wide channels,
S = slope (ft/ft), and
n = Manning's coefficient.

For bare-soil conditions, n is equivalent to n_s, soil grain roughness. For vegetated conditions, n is equivalent to n_v, a combination of resistance due to soil roughness (n_s) and vegetation (n_r).

Table 5 summarizes the stability of the 100-year precipitation on bare-soil conditions, and Table 6 summarizes long-term stability of the PMP event on poorly vegetated cover. More detailed calculation tables can be found in Appendix A.

As shown by the resulting shear stress ratios in Tables 5 and 6, both the eolian/sheet wash on-site soils and the weathered Mancos materials are too erosive to resist erosion (1) during the 100-year precipitation without vegetation or (2) during the PMP event with vegetation. Imported coarse sandy gravel with D_{75} of 1.1 inches would be adequate as a soil cover. The sandy gravel will adequately resist erosion to the 100-year precipitation without vegetation, and can also resist erosion from the PMP event, assuming at least a poor stand of grass or equivalent is established on the cover.

Table 5. Erosional Stability of 100-Year Precipitation on Bare Soil

Top Slope (ft/ft) 2.0 percent			
100-Year Flow (cfs/ft) 0.20			
Concentration Factor 3			
Cover Soil Eolian/Sheet Wash		Weathered Mancos	Sandy Gravel
Soil Characteristic	PI=5	PI=10	D_{75}=1.1 in
n_s	0.0156	0.0156	0.0260
Depth of flow, d (ft)	0.15	0.15	0.21
Allowable shear stress, τ_a (psf)	0.018	0.038	0.440
Effective shear stress, τ_e (psf)	0.193	0.193	0.262
Shear stress ratio[a]	0.10	0.20	1.68

[a]Design criteria is shear stress ratio of 1.0 or greater

Table 6. Erosional Stability of PMP on Poorly Vegetated Cover

Top Slope (ft/ft) 2.0 percent			
PMP Flow (cfs/ft) 1.35			
Concentration Factor 3			
Cover Soil Eolian/Sheet Wash		**Weathered Mancos**	**Coarse Sand**
Soil Characteristic	PI=5	PI=10	D_{75}=1.1 in
n_s	0.0156	0.0156	0.0260
n_r	0.0259	0.0259	0.0259
n_v	0.0259	0.0259	0.0332
Depth of flow, d (ft)	0.659	0.659	0.766
Allowable soil shear stress, τ (psf)	0.018	0.038	0.440
Allowable vegetated shear stress, τ_{va} (psf)	2.01	2.01	2.01
Effective soil shear stress, τ_e (psf)	0.2236	0.2236	0.4387
Effective vegetated shear stress, τ_{ve} (psf)	0.5993	0.5993	0.5166
Shear stress ratio (soil)[a]	3.35	3.35	3.88
Shear stress ratio (vegetation)[a]	0.08	0.17	1.00

[a]Design criteria is shear stress ratio of 1.0 or greater

Rock Mulch Sizing for the Top Slopes

In addition to analyzing the top slope as a soil cover, the erosional stability of a rock mulch is also analyzed, using the Safety Factor method, as recommended in NUREG/CR-4620 (Nelson et al. 1986) and NUREG-1623 (Johnson 2002) for slopes less than 10 percent. The safety factor against erosion for any given rock is calculated as:

$$SF = \frac{\cos\alpha \times \tan\phi}{\eta \times \tan\phi + \sin\alpha}$$

where:

α = angle of slope measured from horizontal,
ϕ = angle or repose of rock, and
η = stability number.

The stability number is calculated as:

$$\eta = \frac{21\tau_o}{(S_s - 1)\gamma D}$$

where:

τ_o = bed shear stress (psf),
S_s = specific weight of the rock,
γ = specific weight of water,
D = representative rock size (ft),

and:

$$\tau_o = \gamma d s$$

where:

d = depth of flow (ft), and
s = slope (ft/ft).

The key parameters used in the rock mulch sizing calculations are outlined below in Table 7. For a PMP event, a factor of safety slightly greater than 1.0 is recommended (NUREG/CR-4620). The method assumes uniform sheet flow across the entire drainage basin. The peak unit discharges due to the PMP (Table 3) were used to represent flow conditions on the top slope. A concentration factor of 3 was used to account for potential flow channelization. The angle of repose and specific gravity of rock were assumed and will need to be verified for final design. More details of the calculation can be found in Appendix A.

Table 7. Rock Mulch Sizing for Top Slope Using Safety Factor Method

Top Slope (ft/ft)	2.0 percent
Angle of repose of rock (degrees)	37
Specific Gravity of rock	2.65
PMP unit flow (cfs/ft)	1.35
Concentration factor	3
Design flow (cfs/ft)	4.05
D_{50} rock mulch (in)	2.2
Factor of Safety	1.02

Riprap Sizing for the Side Slopes

The erosional stability of the side slopes is analyzed using Stephenson's method (Johnson 2002) and Abt and Johnson's method (1991), as discussed in NUREG-1623. These methods are recommended for slopes greater than 10 percent. The median rock size (D_{50}) using Stephenson's method is calculated as:

$$D_{50} = \left[\frac{q \times (\tan\theta)^{\frac{7}{6}} \times n^{\frac{1}{6}}}{Cg^{\frac{1}{2}}\left[(1-n)(s-1)\cos\theta(\tan\phi - \tan\theta)\right]^{\frac{5}{3}}} \right]^{\frac{2}{3}}$$

where:

q = unit discharge (cfs/ft),
θ = angle of the slope measured from horizontal,
n = porosity of rock,
C = factor varying from 0.22 for gravel to 0.27 for crushed granite,
g = acceleration of gravity,
s = relative density of the rock, and
ϕ = angle or repose of rock.

The D_{50} rock sizes using the Abt and Johnson method is calculated as:

$$D_{50} = 5.23 S^{0.43} q^{0.56}$$

where:

q = unit discharge (cfs/ft), and
S = Slope (ft/ft).

The key parameters used in the rock mulch sizing calculations are outlined in Table 8. More details of the calculation can be found in Appendix A.

Table 8. Rock Mulch Sizing for Side Slopes

Method	Stephenson				Abt and Johnson				Average of Stephenson/ Abt and Johnson			
Side Slope (ft/ft)	20 Percent				20 Percent				20 Percent			
Area	A2 South	A3 West	A4 North	A5 East	A2 South	A3 West	A4 North	A5 East	A2 South	A3 West	A4 North	A5 East
PMP unit flow (cfs/ft)	1.37	0.14	0.10	0.19	1.37	0.14	0.10	0.19	1.37	0.14	0.10	0.19
Concentration factor	3	3	3	3	3	3	3	3	3	3	3	3
Coefficient of Movement	---	---	---	---	1.35	1.35	1.35	1.35	---	---	---	---
Design flow (cfs/ft)	4.12	0.43	0.30	0.56	5.56	0.58	0.41	0.76	---	---	---	---
D_{50} for angular rock (in)	9.5	2.1	1.7	2.5	6.8	1.9	1.6	2.2	8.2	2.0	1.6	2.4

The method assumes uniform sheet flow across the entire drainage basin. The peak unit discharges due to the PMP (Table 3) were used to represent flow conditions on the top slope. A concentration factor of 3 was used to account for flow channelization. The angle of repose and specific gravity of rock were assumed and will need to be adjusted (if necessary) with actual source characteristics.

Using an average of results from Stephenson's and Abt and Johnson's methods, the side slopes will have a median rock size ranging from 1.6 to 2.4 inches for the north, east, and west slopes, and a median rock size of 8.2 inches for the south slope. If rounded rock is used for erosion protection, the median rock size should be increased by approximately 40 percent (Abt and Johnson 1991). In addition, median rock size may be oversized for durability considerations once the rock source has been identified.

The rock protection layer thickness should be at least 1.5 to 2 times the median rock size.

Sensitivity of Required Rock Size of Rock Mulch and Riprap Protection to Cell Configuration

The rock mulch on the top of the disposal cell and the riprap on the side slopes has been designed for minimum D_{50} rock size based on the cell configuration given in Figure 1. Figure 2 and Figure 3 are presented to show how changes in the disposal cell configuration may affect the rock sizes required for erosion protection, or conversely, what changes in the disposal cell configuration would be required in order to be able to use an available rock size.

Wind Erosion

The potential for wind erosion of the top surface of disposal cell during drought conditions was evaluated using the MUSLE method, as presented in NUREG/CR-4620 (Nelson et al. 1986). Three potential cover materials were evaluated: (1) on-site sheet wash/eolian soils, (2) on-site excavated weathered Mancos shale, and (3) imported coarse gravel.

Figure 2
Required D50 for Top of Disposal Cell
(Safety Factor Method)

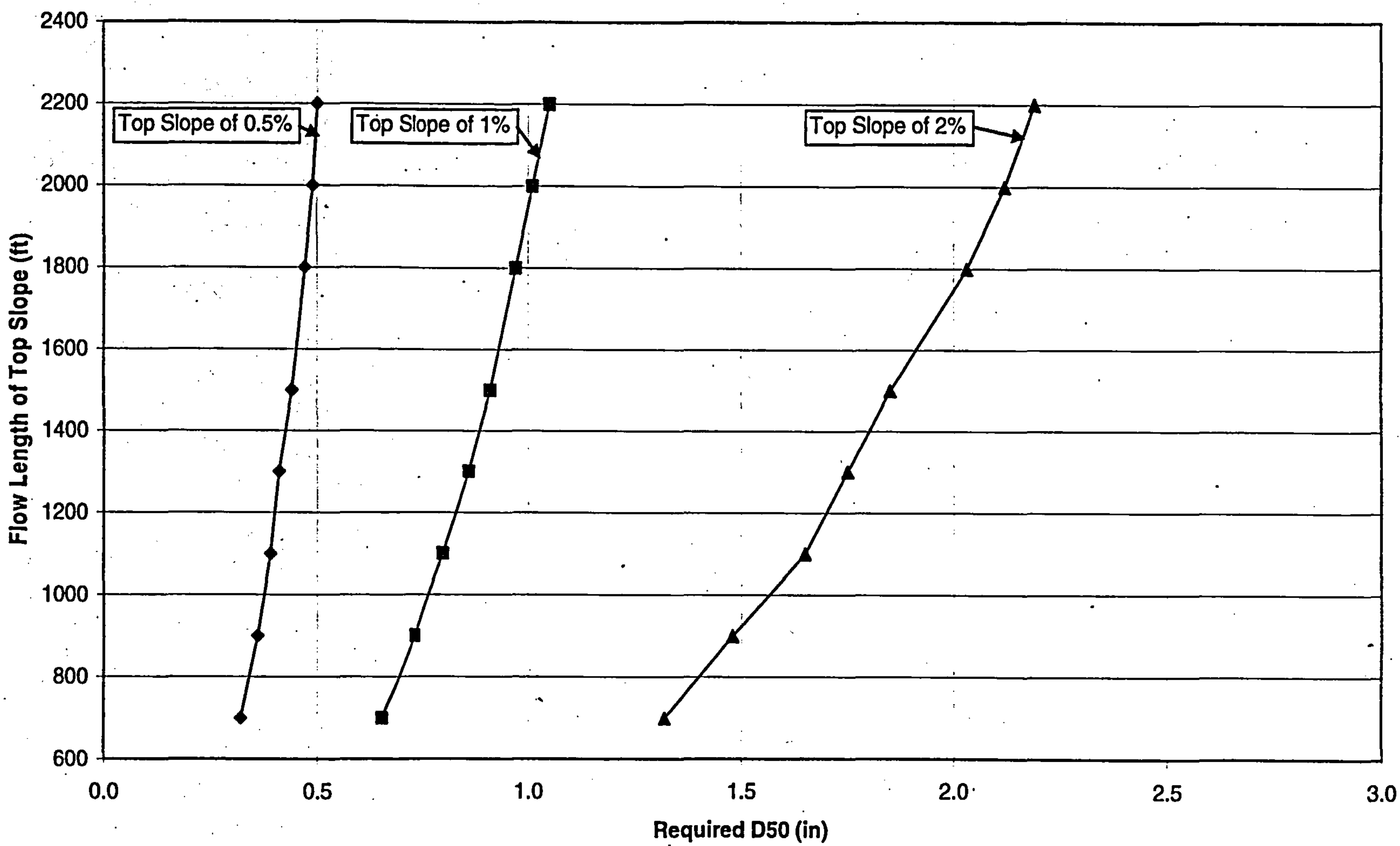


Figure 2. Required D_{50} for Top of Disposal Cell.

Figure 3
Required D50 for Side Slope with Contributed Flow from Top Slope
Assuming Variable Top Slope and Top Length, Side Slope of 20%, Side Slope Length of 150 ft
(Abt-Johnson Method)

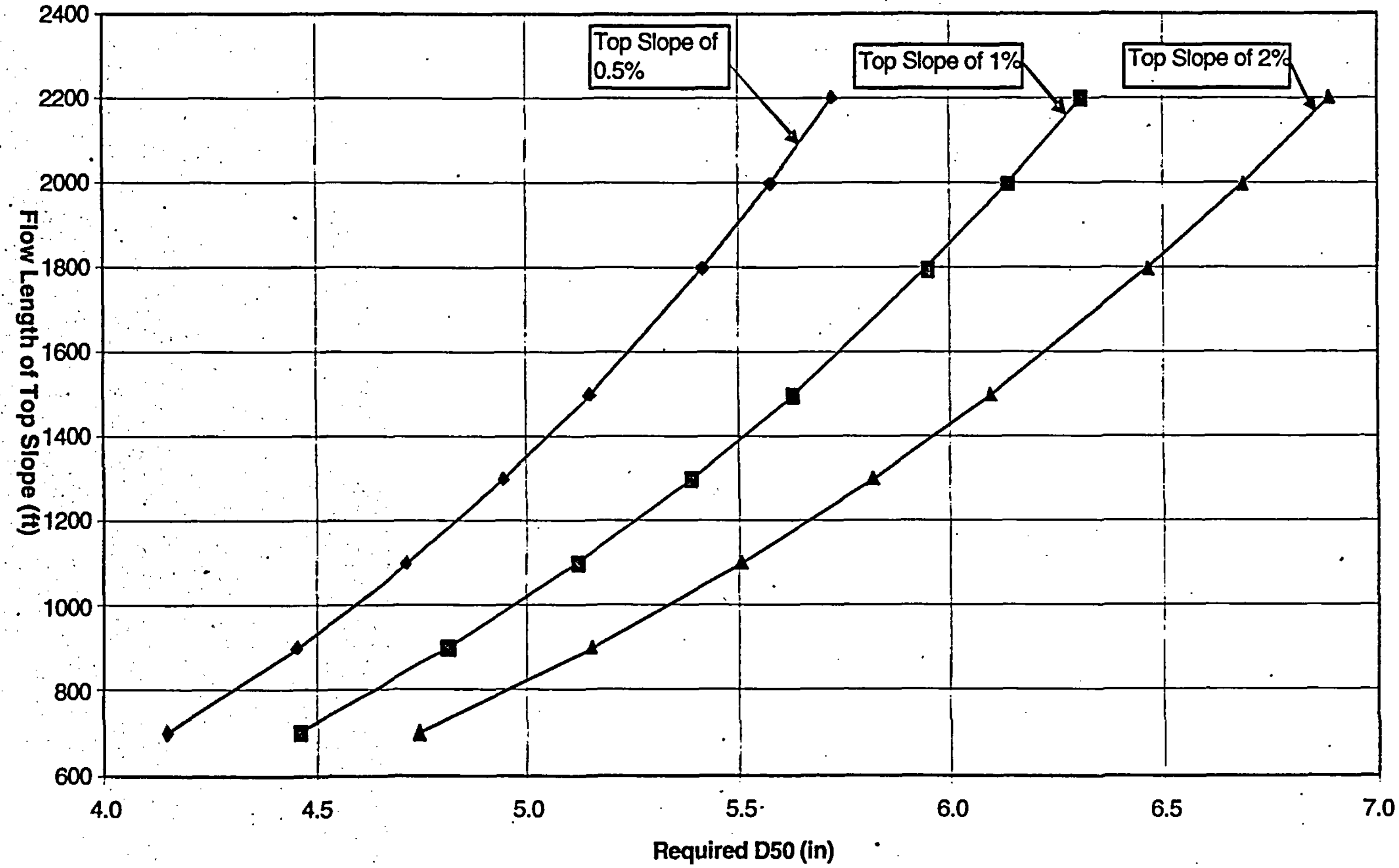


Figure 3. Required D_{50} for Side Slope With Contributed Flow From Top Slope

Figure 4
Required D50 for Side Slope with No Contributed Flow from Top Slope
Assuming Side Slope of 20%
(Abt-Johnson Method)

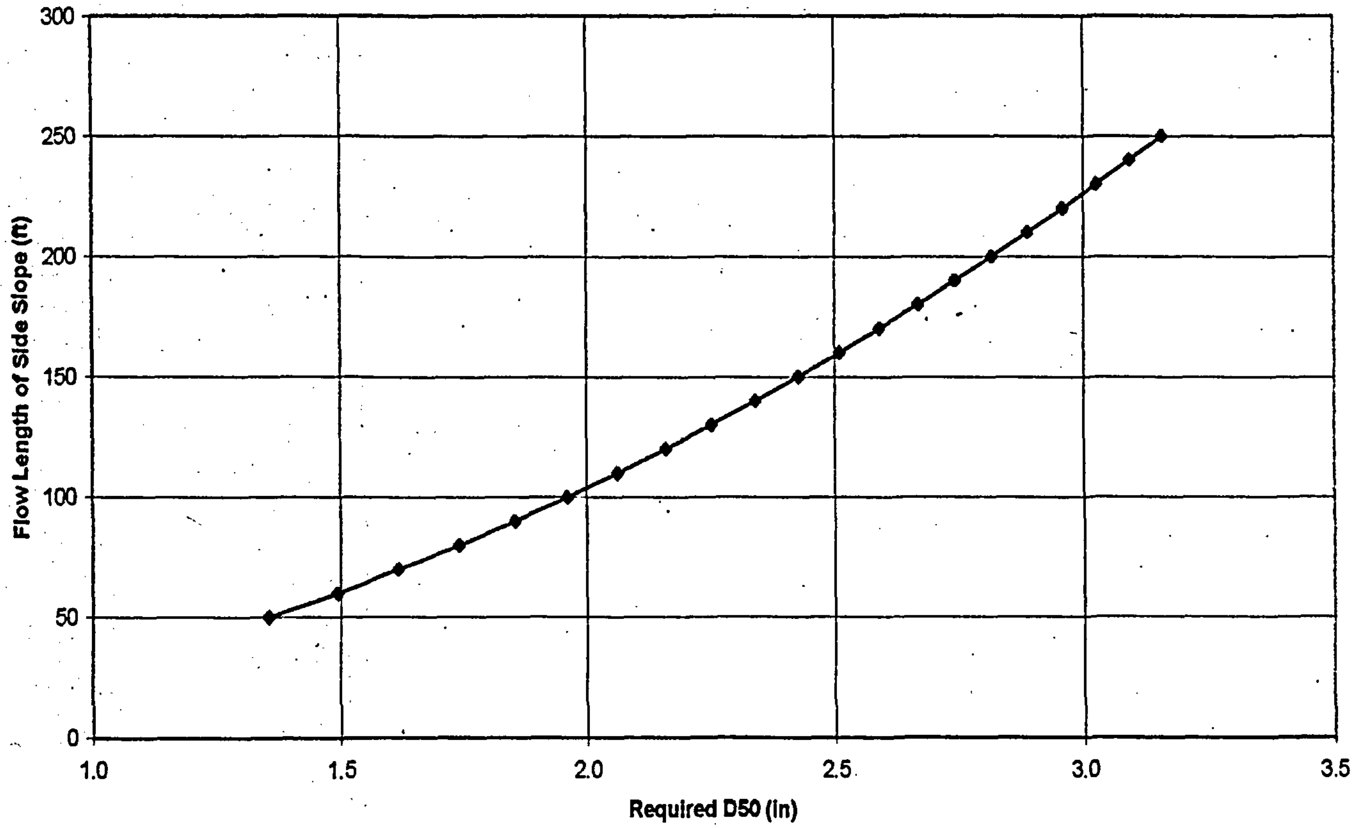


Figure 4. Required D50 for Side Slope with No Contributed Flow from Top Slope

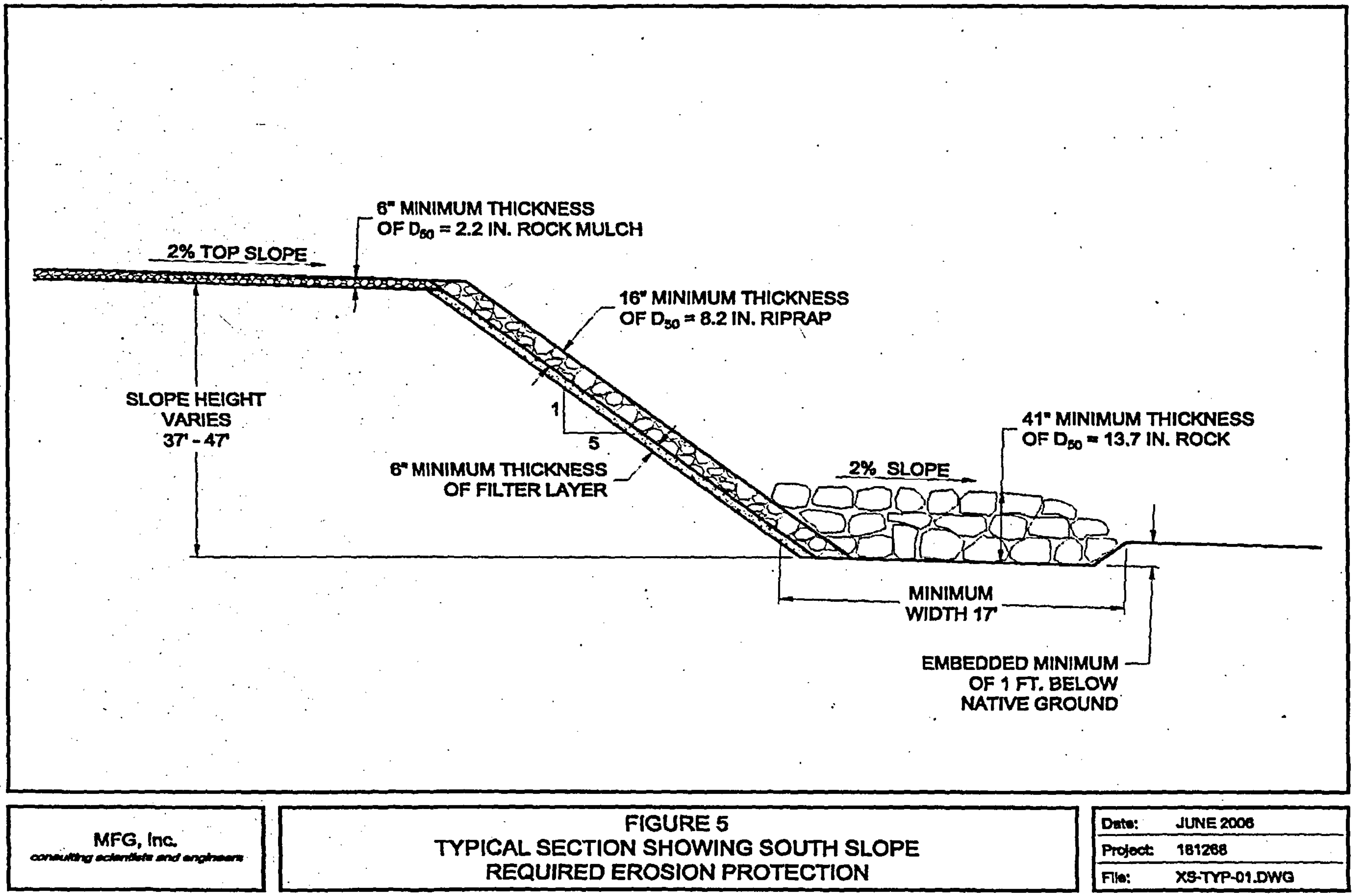


Figure 5. Typical Section Showing South Slope Required Erosion Protection

The soil loss equation was calculated as follows:

$$A = R \times K \times LS \times VM$$

where:

A = soil loss in tons per acre per year,
R = rainfall factor,
K = soil erodibility factor,
LS = topographic factor, and
VM = dimensionless erosion control factor relating to vegetative and mechanical factors.

The rainfall factor is 30, as given in NUREG/CR-4620 for the eastern third of Utah. The soil erodibility factor was estimated using the nomograph given in NUREG/CR-4620.

The topographic factor is calculated by the following equation:

$$LS = \frac{650 + 450 \times s + 65 \times s^2}{10{,}000 + s^2} \times \left(\frac{L}{72.6}\right)^m$$

where:

s = slope steepness in percent,
L = slope length in ft, and
m = exponent dependent upon slope steepness.

The dimensionless erosion control factor used was 0.4, from Table 5.3 of NUREG/CR-4620, representing seedings of 0 to 60 days to mimic light vegetation on the cover. Table 9 summarizes the results of the soil loss equation.

Table 9. Results of Soil Loss Equation

Soil Cover	Sheet Wash/Eolian	Weathered Shale	Coarse Gravel
Rainfall factor, R	30	30	30
Silt and very fine sand (%)	60	55	10
Sand (%)	25	5	20
Organic matter (%)	2	2	0
Soil structure	Very fine granular	Blocky, platy or massive	Med. or coarse granular
Relative permeability	Moderate	Moderate	Moderate to rapid
Erodibility factor	0.35	0.26	0.05
Topographic factor, LS	0.50	0.50	0.50
VM (low density seedings)	0.4	0.4	0.4
Soil loss (tons/acre/year)	2.09	1.56	0.30
Soil loss (inches/1,000 years)	11.5	8.6	1.6

The soil loss equation shows that the potential for sheet erosion is unacceptably high if either the native sheet wash/eolian soils or weathered shale is used as a soil cover. The soil loss of less than 2 inches over the life of the disposal cell for coarse gravel is acceptable; especially considering vegetation is not required for stability of this material (but is required for stability of native soil cover to protect against PMP event).

Riprap Sizing for Rock Aprons

Additional erosion protection will be provided for runoff from the east, west, and south-side slopes of the disposal cell with a rock apron. The north side of the disposal cell will receive runoff from the upland area north of the cell, and will require a diversion channel. The design of this diversion feature will be covered in a separate design calculation (Placeholder Reference, DOE 2006). The perimeter apron will: (1) serve as an impact basin and provide for energy dissipation of runoff, (2) provide erosion protection, and (3) transition flow from side slopes to natural ground. The median rock size required in the perimeter apron was calculated using the equations derived by Abt et al. (1998) as outlined in NUREG 1623 as follows:

$$D_{50energydissipation} = 10.46S^{0.43}(C_f q_d)^{0.56}$$

where S is the slope, C_f is the concentration factor, and q_d is the design unit discharge.

Based on Table 10, the rock apron should have a median rock size of 13.7 inches along the south toe and between 3.2 and 4.5 inches along the east and west toes. Oversizing will be required for rounded rock or for durability considerations. The width of the apron should be a minimum of 15 times the median rock size or construction width. Rock apron thickness should be a minimum of 3 times the median rock size.

Table 10. Riprap for Toe Apron

Method Abt et al. (1998)			
Side Slope (ft/ft) 20 Percent			
Area	A2 South	A3 West	A5 East
PMP unit flow (cfs/ft)	1.37	0.14	0.19
Concentration factor	3	3	3
Coefficient of Movement	1.35	1.35	1.35
Design flow (cfs/ft)	5.56	0.58	0.76
D_{50} for angular rock (in)	13.7	3.9	4.5
Minimum apron width (ft)	17	5	6
Minimum apron thickness (in)	41	12	14

The maximum unit flow off the south toe is 1.37 cfs/ft. Using this maximum flow, and an assumed slope of the rock apron of two percent, the maximum scour depth was calculated using procedures outlined in NUREG 1623 (Johnson 2002) and U.S. Department of Transportation (1983). The maximum scour depth from flow coming off the rock apron along the south side of the disposal cell is estimated to be 1 ft. Therefore, the bottom elevation of the rock apron should be placed a minimum of 1 ft below natural grade. Details of calculations can be found in Appendix A.

Bedding Requirements

NUREG-1623, Appendix D, recommends a filter or bedding layer be placed under erosion protection if interstitial velocities are greater than 1 ft/sec, in order to prevent erosion of the underlying soils. Bedding is not required if interstitial velocities are less than 0.5 ft/sec, and recommended depending on the characteristics of the underlying soil if velocities are between 0.5 and 1 ft/sec.

Interstitial velocities are calculated by procedures presented by Abt et al. (1991) as given in the following equation:

$$V_i = 0.23 * (g * D_{10} * S)^{\frac{1}{2}}$$

where:

V_i = interstitial velocities (ft/s),
g = acceleration of gravity (ft/s^2),
D_{10} = stone diameter at which 10 percent is finer (inches), and
S = gradient in decimal form.

The maximum D_{10} of the erosion protection is estimated based on D_{50} required for erosion protection, assuming the erosion protection will have a coefficient of uniformity (CU) of 6 and a band width of 5. Band width refers to the ratio of the minimum and maximum allowed particle sizes acceptable for any given percent finer designation. USDA (1994) recommends CU to be a maximum of 6 in order to prevent gap-grading of filters. Table 11 summarizes the results.

Table 11. Results of Bedding Requirements

Location	A1 Top	A2 South Side Slope	A3 West Side Slope	A4 North Side Slope	A5 East Side Slope	A2 South Apron	A3 West Apron	A5 East Apron
Minimum D_{50} (inches)	2.2	8.2	2.0	1.6	2.4	13.7	3.9	4.5
Maximum D_{10} (inches)	0.9	2.5	0.9	0.9	0.9	4.3	1.2	1.4
Slope (%)	0.02	0.2	0.2	0.2	0.2	0.02	0.02	0.02
Interstitial Velocity (ft/s)	0.18	0.93	0.57	0.57	0.57	0.38	0.20	0.22

The calculated interstitial velocities on the top slope and toe aprons are low enough that a bedding layer is not necessary. However, the interstitial velocities within the erosion protection on the side slopes are within the range of values where bedding is conditionally recommended. Because of the erosive nature of the native soils in the area that will likely be used underlying the erosion protection, a bedding layer is recommended beneath the rock protection on the side slopes.

Conclusion and Recommendations:

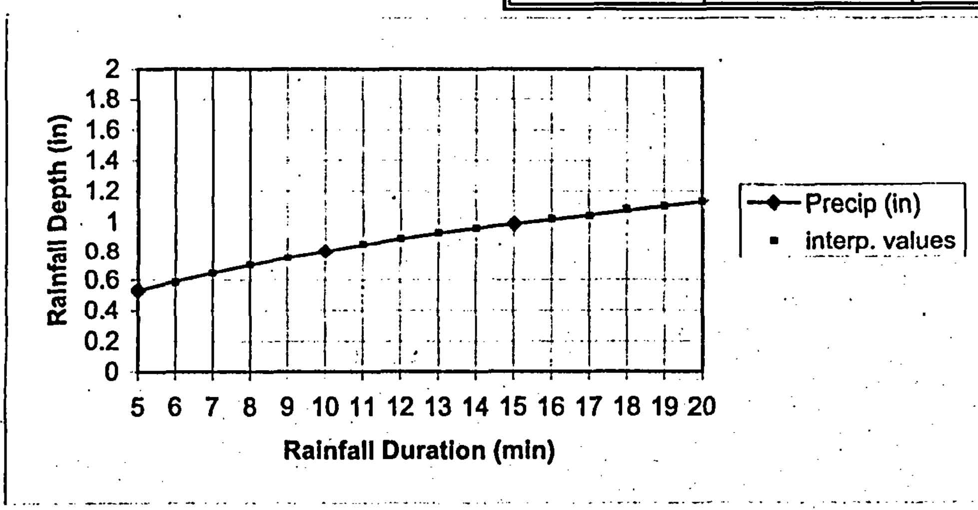
- Rock mulch with median rock size of 2.2 inches is recommended for the top slope of the disposal cell.
- Angular riprap protection with a median rock size of 8.2 inches is recommended for the south-side slope, and a median rock size of 1.6 to 2.4 inches is recommended for the east-, north-, and west-side slopes.
- Rock sizes should be adjusted if rock is not angular or does not meet NRC durability requirements (without oversizing).
- The riprap on the side slopes should be underlain with a bedding layer that meets filter criteria with the riprap and the underlying soils.
- A toe apron should be provided at the base of the east, south, and west-side slopes. Median rock sizes of 4.5, 13.7, and 3.9 inches, respectively, should be provided. The apron should be constructed such that the bottom elevation of the rock apron is a minimum of 1 ft below natural grade to protect against scour.
- Figure 4 summarizes the different components of the erosion protection for a typical section drawn through the south-side slope.

Appendix A
Supporting Calculations

Client:	Stoller	Job No.:	181268
Project:	Crescent Junction Disposal Cell	Date:	5/2/2006
Detail:	Erosion Protection	Computed By:	RTS

100-year precipitation event

Values from NOAA Table (DOE 2005)			Interpolated Values		
Storm Duration (min)	Precip (in)	Intensity (in/hr)	Storm Duration (min)	Interpolated Precip (in)	Interpolated Intensity (in/hr)
5	0.53	6.36	0	0.53	6.36
10	0.8	4.8	5	0.53	6.36
15	0.99	3.96	6	0.58	5.80
30	1.33	2.66	7	0.64	5.49
60	1.65	1.65	8	0.7	5.25
120	1.82	0.91	9	0.75	5.00
			10	0.8	4.80
			11	0.85	4.64
			12	0.89	4.45
			13	0.93	4.29
			14	0.96	4.11
			15	0.99	3.96
			16	1.02	3.83
			17	1.04	3.67
			18	1.08	3.60
			19	1.1	3.47
			20	1.13	3.39



P:\181268\RAP\erosional stability\ripraprev2:100yr precip

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**4/28/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

PMP Event

PMP calculation from Calc. No.: MOA-02-08-2005-2-08-00, Site Drainage--Hydrology Parameters
Use values for drainage area <1 square mile

Table 2. Estimated Precipitation Depths For Local-Storm PMP, Crescent Junction, Utah Site

Hourly Increments	First Hour	Second Hour	Third Hour				Fourth Hour	Fifth Hour	Sixth Hour
PMP Depths (inches)	0	0.1	8.2				0.6	0.1	0
Third-Hour Component Depths (inches)			7.1	0.5	0.4	0.2			

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**5/2/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Time of Concentration

1-hour PMP (in) 8.2

For top slopes of 2.0%, side slopes at 1V:5H

Description	Incremental Drainage Area (acres)	Slope (feet/feet)	Slope Length (feet)	Time of Concentration (minutes) Kirpich	SCS	Brant and Oberman	Average	% of 1-hour PMP	PD_{PMP} (in)	Intensity (in/hr)
A1, top	213.91	0.02	2130	12.9	12.9	11.7	12.5	69.4	5.7	27.4
A2, slope	16.10	0.2	170	13.6	13.6	14.0	13.7	72.0	5.9	25.8
A3, slope	4.82	0.2	115	0.6	0.6	2.0	2.5	27.5	2.3	54.2
A4, slope	7.19	0.2	80	0.4	0.4	1.8	2.5	27.5	2.3	54.2
A5, slope	6.43	0.2	150	0.7	0.7	2.2	2.5	27.5	2.3	54.2

Note: Flow over A2 includes flow from A1

Source: Brant and Oberman(1975) as presented in UMTRA TAD (1989)
Formula: tc=C(L/Si^2)^(1/3).
Source:Kirpich (1940) as presented in NUREG 4620
Formula: tc=0.00013*L^0.77/S^0.385 with L in feet, tc in hours
Source: SCS as presented in NUREG 4620
Formula: tc=(11.9L^3/H)^0.385 with L in miles, H in feet, t in hours
% of one-hour PMP=RD/(0.0089*RD+0.0686) for tc<15 min based on Table 4.1 of TAD

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**5/2/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Unit discharge of PMP

Top slope =2.0%

Description	Total Drainage Area (acres)	C	Tc (min)	Intensity (in/hr)	Q (cfs)	longest slope length (ft)	unit discharge (cfs/ft)
A1, top	213.91	1	12.5	27.4	5863.3	2130	1.35
A2, slope	230.01	1	13.7	25.8	5928.1	2300	1.37
A3, slope	4.82	1	2.5	54.2	261.0	115	0.14
A4, slope	7.19	1	2.5	54.2	389.4	80	0.10
A5, slope	6.43	1	2.5	54.2	348.2	150	0.19

Note: Flow over A2 includes flow from A1

Client:	Stoller	Job No.:	181268
Project:	Crescent Junction Disposal Cell	Date:	5/2/2006
Detail:	Erosion Protection	Computed By:	RTS

Unit discharge of 100-year precipitation

Top slope =2.0%

Description	Total Drainage Area (acres)	C	Tc (min)	Precip. Depth (in)	Intensity (in/hr)	Q (cfs)	longest slope length (ft)	unit discharge (cfs/ft)
A1, top	213.91	0.9	12.5	0.9	4.5	856.7	2130	0.20
A2, slope	230.01	0.9	13.7	0.9	4.3	888.5	2300	0.21
A3, slope	4.82	0.9	2.5	0.5	6.4	27.6	115	0.02
A4, slope	7.19	0.9	2.5	0.5	6.4	41.2	80	0.01
A5, slope	6.43	0.9	2.5	0.5	6.4	36.8	150	0.02

Note: Flow over A2 includes flow from A1

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**5/2/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Temple Method for 2% Top Slope

Reference: Temple, D.M., Robinson, K.M., Ahring, R.M., and Davis, A.G., 1987. Stability Design of Grass-Lined Open Channels, USDA Handbook 667. And as presented in UMTRA TAD Section 4.3.3 and NUREG 1623, Appendix A

native soil is classified as CL/ML with average values of LL=22, PI=4, %fines=70
This doesn't truly fit any of Temple's soil types, as PI is less than 10, but also not a sand

100-yr Design flow (cfs/ft)	0.20	
PMP Design flow (cfs/ft)	1.35	
Concentration Factor, F	3	
100-yr Design flow (cfs/ft), q	**0.6**	
PMP Design flow (cfs/ft), q	**4.05**	
Slope, S (ft/ft)	0.02	
average dry density (pcf)	103	(at 85% modified proctor)
average specific gravity	2.68	
void ratio, e	0.624	
unit weight water (pcf)	62.4	

	If SW or SP eolian/sheetwash	If CL eolian/sheetwash	if CL weathered mancos	If ML eolian/sheetwash	If imported coarse sand
d75 (inches)	<.05				1.1
Plasticity Index, PI		5	10	5	
End-of-construction, 100-yr precip					
Manning's n for non-veg slope	0.0156	0.0156	0.0156	0.0156	0.0260
assumed depth of flow, no veg (ft), d	0.15	0.15	0.15	0.15	0.21
calculated q (cfs/ft), no veg	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**
iterate with d until calc. q equals design q					
velocity, v, no veg (ft/s)	3.88	3.88	3.88	3.88	2.86
base allowable tractive shear stress (psf) τab=		0.014595	0.02977	0.00744	
void ratio correction factor, Ce=		1.124541359	1.124541359	1.124541359	
allowable tractive shear stress (psf), τa=	0.020	0.018	0.038	0.009	0.440
effective shear stress (psf), τe (no veg)	0.193	0.193	0.193	0.193	0.262
shear stress ratio, end of construction	0.10	0.10	0.20	0.05	1.68
Limit slope such that shear stress ratio is 1.0					
Stable slope	0.08%	0.07%	0.19%	0.03%	4.17%
Long-term, PMP precip					
Repr. stem length (in) h(ave)					
good veg	1	1	1	1	1
poor veg	0.3	0.3	0.3	0.3	0.3
Repr. stem density (stems/sq in), M(ave)					
good veg	50	50	50	50	50
poor veg	17	17	17	17	17
Retardance curve index, CI					
good veg	4.80	4.80	4.80	4.80	4.80
poor veg	2.67	2.67	2.67	2.67	2.67
Cover factor, Cf					
good veg	0.5	0.5	0.5	0.5	0.5
poor veg	0.25	0.25	0.25	0.25	0.25
allowable vegetated shear strength (psf), τva					
good veg	3.60	3.60	3.60	3.60	3.60
poor veg	2.01	2.01	2.01	2.01	2.01
Mannings n for soil roughness, ns=	0.0156	0.0156	0.0156	0.0156	0.0260
Mannings n for vegetal conditions, nr					
good veg	0.0388	0.0388	0.0388	0.0388	0.0388
poor veg	0.0259	0.0259	0.0259	0.0259	0.0259
Mannings n for vegetated slopes, nv					
good veg	0.0388	0.0388	0.0388	0.0388	0.0440
poor veg	0.0259	0.0259	0.0259	0.0259	0.0332
assumed depth of flow, d (ft)					
good veg	0.840	0.840	0.840	0.840	0.906
poor veg	0.659	0.659	0.659	0.659	0.766
calculated q (cfs/ft), with veg					
good veg	**4.05**	**4.05**	**4.05**	**4.05**	**4.05**
poor veg	**4.05**	**4.05**	**4.05**	**4.05**	**4.05**
iterate with d until q calc equals q design					
velocity (ft/s), v					
good veg	4.82	4.82	4.82	4.82	4.47
poor veg	6.14	6.14	6.14	6.14	5.29
effective shear stress (psf), τe					
good veg	0.0848	0.0848	0.0848	0.0848	0.1975
poor veg	0.2236	0.2236	0.2236	0.2236	0.4387
effective veg shear stress (psf) τve					
good veg	0.9629	0.9629	0.9629	0.9629	0.9330
poor veg	0.5993	0.5993	0.5993	0.5993	0.5166
shear stress ratio, vegetated slope					
good veg	**3.74**	**3.74**	**3.74**	**3.74**	**3.86**
poor veg	**3.35**	**3.35**	**3.35**	**3.35**	**3.88**
shear stress ratio, soil on vegetated slope					
good veg	**0.24**	**0.22**	**0.44**	**0.11**	**2.23**
poor veg	**0.09**	**0.08**	**0.17**	**0.04**	**1.00**

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**5/2/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Safety Factor Method

Appropriate for evaluating rock stability from flow parallel to cover and adjacent to the cover.
Design for SF of 1.5 for non-PMF applications, and slightly greater than 1.0 for PMF
Use for slopes less than 10 percent

	Top Slope	
Slope (ft/ft)	0.02	
angle α (rad)	0.020	
Angle of repose of rock (degees)	37	See Fig 4.1 of TAD or Fig 4.8 of NUREG 4620, typically between 32 and 42 for angular, 29 and 41 for rounded
Angle of repose of rock (rad))	0.646	
Specific gravity of rock	2.65	
PMP unit flow (cfs/ft)	1.35	(max from "flow-PMP" worksheet)
Concentration Factor	3	Typically between 1.1 to 3.2
design flow (cfs/ft)	4.05	
design flow over rock (cfs/ft)	4.05	assumes negligible flow through rock
Assumed D50 (in) #1	2	
Assumed D50 (in) #2	2.1	
Assumed D50 (in) #3	2.2	
Assumed D50 (in) #4	2.3	
Assumed D50 (in) #5	2.4	
Manning's n for rock #1	0.0273	Abt et al. 1987 as presented in UMTRA TAD
Manning's n for rock #2	0.0275	
Manning's n for rock #3	0.0278	
Manning's n for rock #4	0.0279	
Manning's n for rock #5	0.0281	
Assumed depth of flow for rock #1 (ft)	0.681	
Assumed depth of flow for rock #2 (ft)	0.684	
Assumed depth of flow for rock #3 (ft)	0.687	
Assumed depth of flow for rock #4 (ft)	0.690	
Assumed depth of flow for rock #5 (ft)	0.693	
Calculated flow for rock #1 (cfs/ft)	4.05	
Calculated flow for rock #2	4.05	
Calculated flow for rock #3	4.05	
Calculated flow for rock #4	4.05	
Calculated flow for rock #5	4.05	
modify depth of flow until calculated q = design q		
calculated velocity for rock #1, (ft/s)	5.95	
calculated velocity for rock #2, (ft/s)	5.92	
calculated velocity for rock #3, (ft/s)	5.90	
calculated velocity for rock #4, (ft/s)	5.87	
calculated velocity for rock #5, (ft/s)	5.85	
ave shear stress, τ for rock #1	0.85	
ave shear stress, τ for rock #2	0.85	
ave shear stress, τ for rock #3	0.86	
ave shear stress, τ for rock #4	0.86	
ave shear stress, τ for rock #5	0.86	
Stability number for rock #1	1.040	
Stability number for rock #2	0.995	
Stability number for rock #3	0.954	
Stability number for rock #4	0.916	
Stability number for rock #5	0.882	
Factor of Safety for rock #1	0.94	
Factor of Safety for rock #2	0.98	
Factor of Safety for rock #3	1.02	
Factor of Safety for rock #4	1.06	
Factor of Safety for rock #5	1.10	

Adjust assumed D50 until design criteria for Factor of Safety is bracketed

Client:	Stoller	Job No.:	181268
Project:	Crescent Junction Disposal Cell	Date:	5/9/2006
Detail:	Erosion Protection	Computed By:	RTS

Abt METHOD (Abt and Johnson, 1991) applicable for slopes of 50% or less.

Equations assume specific gravity of rock is 2.65 or greater and angular rock.
For rounded rock, increase size by 40%.

ROCK SIZING EQUATION d50 = 5.23*S^0.43q*^0.56

Area	A2	A3	A4	A5	
Side Slope (ft/ft)	0.2	0.2	0.2	0.2	
angle α (rad)	0.197	0.197	0.197	0.197	
PMP unit flow (cfs/ft)	1.37	0.14	0.10	0.19	(max from "flow-PMP" worksheet)
Concentration Factor	3	3	3	3	Typically between 1.1 to 3.2
Coef. Of Movement	1.35	1.35	1.35	1.35	1.35 to prevent movement
design flow (cfs/ft)	5.56	0.58	0.41	0.76	
design flow over rock (cfs/ft)	5.56	0.58	0.41	0.76	assumes negligible flow through rock
D50 (inches) angular	6.8	1.9	1.6	2.2	
D50 (inches) rounded	9.6	2.7	2.2	3.1	

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**5/9/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

STEPHENSON'S METHOD FOR SIZING RIPRAP

Applicable for shallow flow on slopes greater than 10%

Area	A2	A3	A4	A5	
slope (ft/ft)	0.2	0.2	0.2	0.2	
slope angle α (rad)	0.197	0.197	0.197	0.197	
Angle of repose of rock (degees)	41	41	41	41	See Fig 4.1 of TAD or Fig 4.8 of NUREG 4620, typically between 32 and 42 for angular, 29 and 41 for rounded
Angle of repose of rock (rad))	0.716	0.716	0.716	0.716	
Specific gravity of rock	2.65	2.65	2.65	2.65	
Dry unit weight of rock (pcf)	125	125	125	125	
Porosity of rock	0.32288	0.32288	0.32288	0.32288	
C	0.22	0.22	0.22	0.22	varies from 0.22 for gravel and pebbles to 0.27 for crushed granite
PMP unit flow (cfs/ft)	1.37	0.14	0.10	0.19	(max from from "flow" worksheet)
flow concentration	3	3	3	3	
design flow (cfs/ft)	4.12	0.43	0.30	0.56	
design flow over rock (cfs/ft)	4.12	0.43	0.30	0.56	assumes negligible flow through rock
D50 (inches) for angular rock	9.47	2.11	1.65	2.52	
D50 (inches) for rounded rock	13.25	2.95	2.32	3.52	

Client:	Stoller	Job No.:	181268
Project:	Crescent Junction Disposal Cell	Date:	2/6/2006
Detail:	Erosion Protection	Computed By:	RTS

Preliminary Gradations

This spreadsheet calculates preliminary gradations of riprap based on D50
Source: NUREG 4620
Source: USDA, National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters, October 1994.

Area	A1	A2	A3	A4	A5	A2 Apron	A3 Apron	A5 Apron	Comment
Minimum D50 (in)	2.20	8.15	2.02	1.62	2.38	13.68	3.87	4.49	Assuming angular rock, average between Abt and Stephenson methods
Rock thickness (in)	6.00	16.31	6.00	6.00	6.00	27.36	7.75	8.99	Based on constructability: 2*D50. May consider 12" as minimum thickness for rock.
Maximum D50 (in)	4.00	10.87	4.00	4.00	4.00	18.24	5.16	5.99	Based on constructability: Thickness/1.5
Maximum D50 (in)	11.00	40.77	10.11	8.09	11.91	68.40	19.37	22.47	Prevent gap-grading: minimum D50*5
Maximum D50 (in)	4.00	10.87	4.00	4.00	4.00	18.24	5.16	5.99	Smaller of two above criteria
Maximum D100 (in)	6.00	16.31	6.00	6.00	6.00	27.36	7.75	8.99	Based on constructability: 1*Thickness
Maximum D100 (in)	20.00	54.35	20.00	20.00	20.00	91.20	25.82	29.97	Based on internal stability?: 5*maximum D50
Maximum D100 (in)	6.00	16.31	6.00	6.00	6.00	27.36	7.75	8.99	Smaller of two above criteria
Minimum D100 (in)	4.40	16.31	4.04	3.24	4.76	27.36	7.75	8.99	Based on internal stability: 2*minimum D50
Minimum D15 (in)	0.38	1.02	0.38	0.38	0.38	1.71	0.48	0.56	Based on internal stability: Maximum D100/16
Maximum D15 (in)	1.88	5.10	1.88	1.88	1.88	8.55	2.42	2.81	Prevent gap-grading: Minimum D15*5
Minimum D60 (in)	3.08	11.41	2.83	2.26	3.33	19.15	5.42	6.29	Prevent gap-grading: D60/D10<=6
Maximum D60 (in)	5.60	15.22	5.60	5.60	5.60	25.54	7.23	8.39	Prevent gap-grading: D60/D10<=6
Minimum D10 (in)	0.51	1.90	0.47	0.38	0.56	3.19	0.90	1.05	Prevent gap-grading: D60/D10<=6
Maximum D10 (in)	0.93	2.54	0.93	0.93	0.93	4.26	1.21	1.40	Prevent gap-grading: D60/D10<=6

Summary

Percent Passing	Diameter (mm)							
50	56	207	51	41	60	347	98	114
50	102	276	102	102	102	463	131	152
100	152	414	152	152	152	695	197	228
100	112	414	103	82	121	695	197	228
15	10	26	10	10	10	43	12	14
15	48	129	48	48	48	217	61	71
60	78	290	72	58	85	486	138	160
60	142	387	142	142	142	649	184	213
10	13	48	12	10	14	81	23	27
10	24	64	24	24	24	108	31	36

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**2/6/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Interstitial Velocities

Source: NUREG 1623, Section D
Abt, SR, JF Ruff, RJ Wittler (1991). Estimating Flow Through Riprap, Journal of Hydraulic Engineering, Vol. 117, No. 5, May.

Area	A1	A2	A3	A4	A5	A2 apron	A3 apron	A5 apron	
Minimum D50 (inches)	2.20	8.15	2.02	1.62	2.38	13.68	3.87	4.49	from Safety Factor Method, or ave of Abt, Stephenson etc. assuming angular rock
Maximum D10 (inches)	0.93	2.54	0.93	0.93	0.93	4.26	1.21	1.40	from preliminary gradation specs
Slope (ft/ft)	0.02	0.2	0.2	0.2	0.2	0.02	0.02	0.02	from preliminary disposal cell layout
Velocity (ft/s)	0.18	0.93	0.56	0.56	0.56	0.38	0.20	0.22	calculated from Abt et al. (1991)
Underlying filter required?	no	maybe	maybe	maybe	maybe	no	no	no	Per NUREG 1623, Appendix D, section 2.1.1

Client:	Stoller	Job No.:	181268
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Detail:	Erosion Protection	Computed By:	RTS

Modified Universal Soil Loss Equation (MUSLE)

Source : Clyde et al. (1978) as presented in NUREG 4620, section 5.1.2
A=R*K*LS*VM

	Sheet wash/eolian	weathered shale	coarse gravel/sand	
Inputs for K factor				
Percent silt and very fine sand	60	55	10	
Percent sand (0.10-2.0 mm)	25	5	20	
Percent oganic matter	2	2	0	
Soil structure	No. 1	No. 3	No. 3	
Permeability	No. 3	No. 3	No. 2	
Inputs for LS factor				
Slope length (ft)	2130	2130	2130	
slope steepness (%)	2	2	2	
m exponent	0.3	0.3	0.3	from table 5.2 of NUREG 4620

		Sheet Wash/Eolian	Weathered Shale	Coarse Sand	
R	Rainfall Factor	30	30	30	From Table 5.1 of NUREG 4620 for eastern third of Utah
K	Soil Erodibility factor	0.35	0.26	0.05	From nomograph Fig. 5.1 of NUREG 4620
LS	Topographic factor	0.50	0.50	0.50	
VM	Dimensionless erosion control factor	0.4	0.4	0.4	From Table 5.3 of NUREG 4620 for seedings, 0-60 days
A	Soil Loss (tons/acre/year)	2.09	1.56	0.30	
A	Soil density (pcf)	100	100	100	
A	Soil Loss (inches/1000 years	11.5	8.6	1.6	

Client:	**Stoller**	**Job No.:**	**181268**
Project:	**Crescent Junction Disposal Cell**	**Date:**	**5/12/2006**
Detail:	**Erosion Protection**	**Computed By:**	**RTS**

Apron Protection

Source: Abt, SR, Johnson, TL, Thornton, CI, and Trabant, SC, Riprap Sizing at Toe of Embankment Slopes, Journal of Hydraulic Engineering, Vol. 124, No. 7, July 1998.

Equation: D50=10.46*S^0.43*qd^0.56

	North	South	East	West
unit discharge (cfs/ft)	0.10	1.37	0.19	0.14
Cr	1	1	1	1
Cf	3	3	3	3
Cm	1.35	1.35	1.35	1.35
design discharge (cfs/ft)	0.406164	5.557379	0.761558	0.583861
Slope (ft/ft)	0.2	0.2	0.2	0.2
D50 (in)	3.2	13.7	4.5	3.9

Client:	Stoller	Job No.:	181268
Project:	Crescent Junction Disposal Cell	Date:	5/12/2006
Detail:	Erosion Protection	Computed By:	RTS

Scour depth is based on equations presented by FHA based on erosion a culvert outlets
Source: US Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 14, September, 1983

Flow over riprap	**A2, south**	**A3, west**	**A5, east**		
Flow, q	1.37	0.14	0.19	cfs/ft	
gravity, g	32.2	32.2	32.2	ft/s^2	
time, t	15	15	15	minutes	
base time, to	316	316	316	minutes	
D50	13.7	3.9	4.5	in	
D50	1.14	0.32	0.37	ft	
Slope of Apron	0.02	0.02	0.02	(ft/ft)	
Manning's n	0.040	0.033	0.034	COE (1970) for submerged riprap	
depth of flow	0.45	0.10	0.12	ft	
velocity	3.06	1.41	1.54	ft/s	
Native soils					
plasticity index of alluvial soil	5	5	5	%	from GEG, 2005 lab data
unconfined compressive strength	1.4	1.4	1.4	psi	assumed value for silty clays (200 psf)
critical tractive shear (lb/ft^2)	0.254143	0.254143	0.254143		
modified shear number	71.41606	15.15466	18.19436		
d84 bedding	0.12	0.12	0.12	mm	Average for Eolian/shweet wash materials from GEG, 2005 lab data
d16 bedding	0.002	0.002	0.002	mm	Average for Eolian/shweet wash materials from GEG, 2005 lab data
gradation standard deviation, σ	7.745967	7.745967	7.745967		
gradation classification	graded	graded	graded		
	Depth				
α	0.86				coefficients for clay with PI 5-16
β	0.18				
θ	0.1				
αe	1.37				
equivalent depth, ye	0.45	0.10	0.12	ft	
depth of scour (ft)	0.98	0.22	0.27		

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