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Mapping 100-Year Floodplain Boundaries Following the Cerro Grande Wildfire

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Abstract

A combined ArcView GIS-HEC modeling application for floodplain analysis of pre- and post-burned watersheds is described. The burned study area is located on Pajarito Plateau near Los Alamos National Laboratory (the Laboratory), where the Cerro Grande Wildfire burned 42,878 acres (17,352 ha) in May 2000. This area is dominated by rugged mountains that are dissected by numerous steep canyons having both ephemeral and perennial channel reaches. Vegetation consists of pinon-juniper woodlands located between 6,000-7,000 feet (1,829-2,134 m) above mean sea level (ft MSL), and Ponderosa pine stands between 7,000-10,000 ft MSL (2,134-3,048 m). Approximately seventeen percent of the burned area is located within the Laboratory, and the remainder is located in upstream or adjacent watersheds. Pre-burn floodplains were previously mapped in 1990-91 using early HEC models as part of the hazardous waste site permitting process. Precipitation and stream gage data provide essential information characterizing rainfall-runoff relationships before and after the fire. They also provide a means of monitoring spatial and temporal changes as forest recovery progresses. The 2000 summer monsoon began in late June and provided several significant runoff events for model calibration. HEC-HMS modeled responses were sequentially refined so that observed and predicted hydrograph peaks were matched at numerous channel locations. The 100-year, 6-hour design storm was eventually used to predict peak hydrographs at critical sites. These results were compared to pre-fire simulations so that new flood-prone areas could be systematically identified. Stream channel cross-sectional geometries were extracted from a gridded 1-foot (0.3 m) DEM using ArcView GIS. Then floodpool topwidths, depths, and flow velocities were remapped using the HEC-RAS model. Finally, numerous surveyed channel sections were selectively made at crucial sites for DEM verification. These evaluations provided timely guidance that influenced the decision to construct several flood detention structures that were completed in September 2000.

INTRODUCTION

The Los Alamos National Laboratory (the Laboratory) was established in 1943 as part of the Manhattan Project. It is located (35° 52′ N, 106° 19′ W) in north-central New Mexico (USA) about 60 miles (97 km) north-northeast of Albuquerque, and 25 miles (40 km) northwest of Santa Fe (Figure 1). Los Alamos has a semiarid, temperate mountain climate. This 43-square mile (111-square km) facility is situated on Pajarito Plateau between the Jemez Mountains on the west and the Rio Grande Valley to the east. The Plateau slopes east-southeast for more than 15 channel miles (24 km), where it terminates along the Rio Grande in White Rock Canyon. Topography ranges from 7,800 feet (2,377 m) above mean sea level (ft MSL) along the western Laboratory margin to about 6,400 ft MSL (1,951 m) at the canyon rim. The Plateau is dissected by a system of gaged and ungaged watersheds that are dominated by ephemeral stream drainage. Here we define a gaged watershed as one having at least one rain gage (input) and one stream gage (output) so that the system response can be estimated (Dooge, 1959, 1973). Some perennial channel reaches are also locally defined. All of these watersheds are elongated in the west-to-

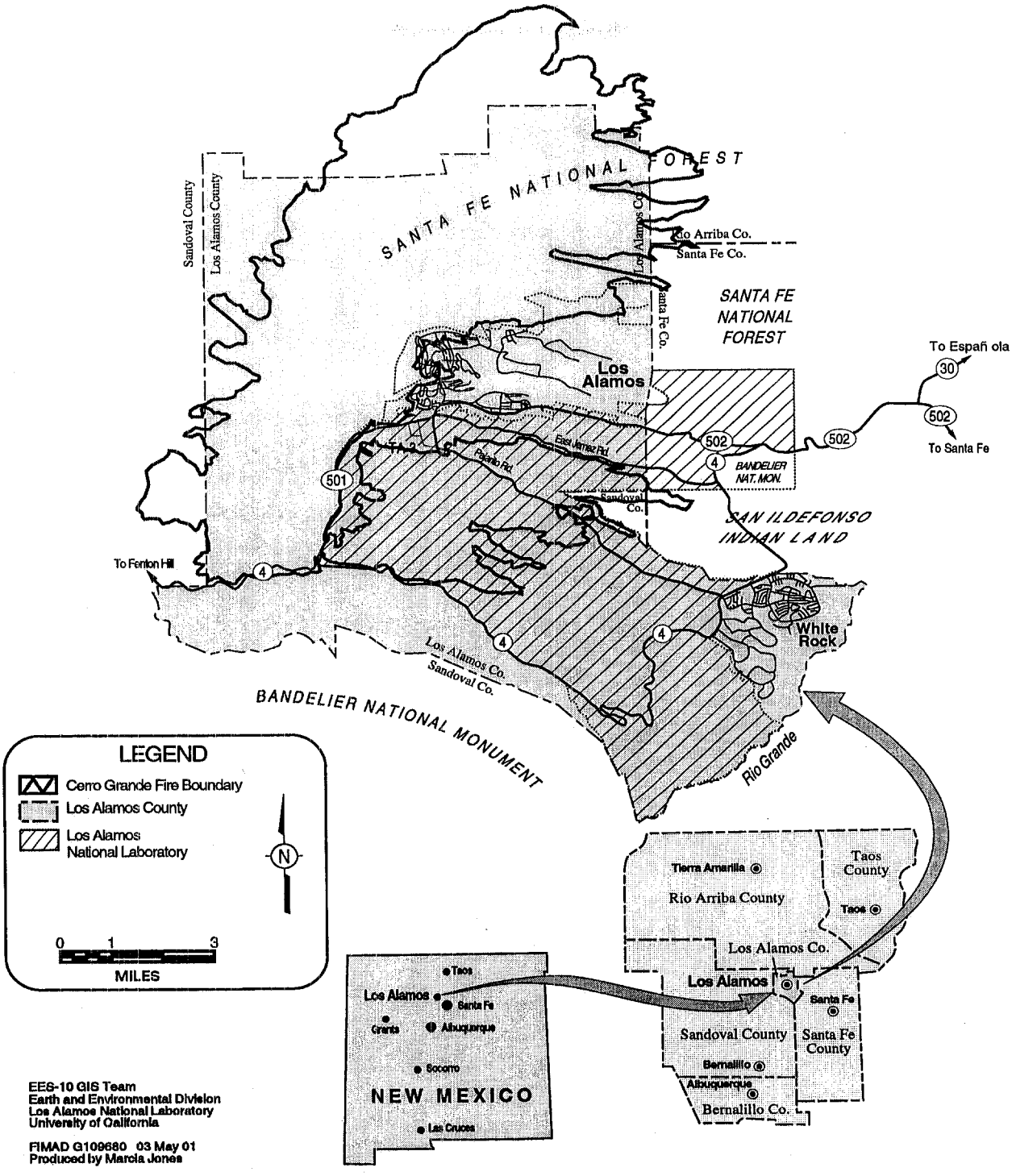


Figure 1. Location map showing Cerro Grande wildfire near Los Alamos, New Mexico.

east flow direction along Pajarito Plateau, and are extremely narrow in the north-south direction. All total, there are 13 separate watersheds draining Laboratory lands that contain over 100 channel miles (161 km) requiring floodplain identification. These floodplains are defined at

approximately 200-foot (61 m) intervals using topographic data obtained from a 1-foot (0.3 m) gridded digital elevation model (DEM). These data were obtained from a 1992 aerial photogrammetric survey of the Laboratory and surrounding areas.

The Cerro Grande wildfire began as a US National Park Service prescribed burn on May 4, 2000. It quickly spread out of control because of high winds and extremely dry conditions. The fire was contained on June 6, 2000, after consuming approximately 42,878 acres (17,352 ha), including 7,439 acres (3,010 ha) within the Laboratory. The fire continued to burn inside the containment line throughout July as seen in Figure 1. A complete summary of fire-related events is available (BAER, 2000).

Although the Laboratory has maintained a comprehensive environmental monitoring program since 1949, it became a permitted hazardous waste treatment, storage, and disposal facility in 1990. Permit conditions stipulate that these Resource Conservation and Recovery Act (RCRA) facilities must delineate all 100-year floodplain elevations within their boundaries [40 CFR 270.14(b)(11)(iii)]. These floodplains were originally mapped (McLin, 1992) using the US Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) computer-based Flood Hydrograph Package (HEC-1) and the Water Surface Profiles Package (HEC-2). These techniques are well-documented and routinely used for floodplain analyses (USACE, 1985, 1982; Hoggan, 1996). Updated models (USACE, 2001a, 2001b) now include HEC-HMS (Hydrologic Modeling System) and HEC-RAS (River Analysis System). The Laboratory's RCRA operating permit is subject to renewal in 2001. All floodplain boundaries have been remapped for this renewal because they have expanded following the fire. These changes are in direct response to fire-related modifications in the rainfall-runoff process due to reductions in watershed vegetation cover and development of hydrophobic soil conditions. As the forest around the Laboratory recovers over the next several decades, these floodplain boundaries are expected to recede slowly back toward their pre-fire boundaries at some undetermined rate.

The US Geological Survey (USGS) has produced probabilistic techniques to estimate peak discharges in New Mexico streams (Waltemeyer, 1986; Thomas and Gold, 1982). These studies define the regional magnitude and flood frequency within stream channels using multiple regression techniques for the 2, 5, 10, 25, 50, and 100-year storm events. However, as seen in Figures 2 and 3, these empirical equations produce significantly larger pre-fire hydrograph peaks for ungaged watersheds compared to observed peaks or HEC-HMS simulations (McLin, 1992). The observed peaks in Figure 2 were obtained from backwater calculations (Veenhuis, 2000), while the observed peaks in Figure 3 were recorded at stream gages (Shaull et al., 2000). The USGS procedure yields peaks that are typically one to two orders of magnitude larger than physical observations or HEC-HMS simulated peaks using equivalent subbasin parameters. More importantly, there is no known methodology to extrapolate the USGS technique to post-fire watershed conditions. Hence, these probabilistic techniques are not used in this evaluation.

HEC-HMS is a single event, rainfall-runoff model that can be used to simulate real or hypothetical storm hydrographs in gaged or ungaged watersheds in response to user specified rainfall hyetographs (USACE, 2001a). As used here, HEC-HMS employs traditional 50, 100, or 500-year, 6-hour design storm events for Los Alamos. These representative design storms are

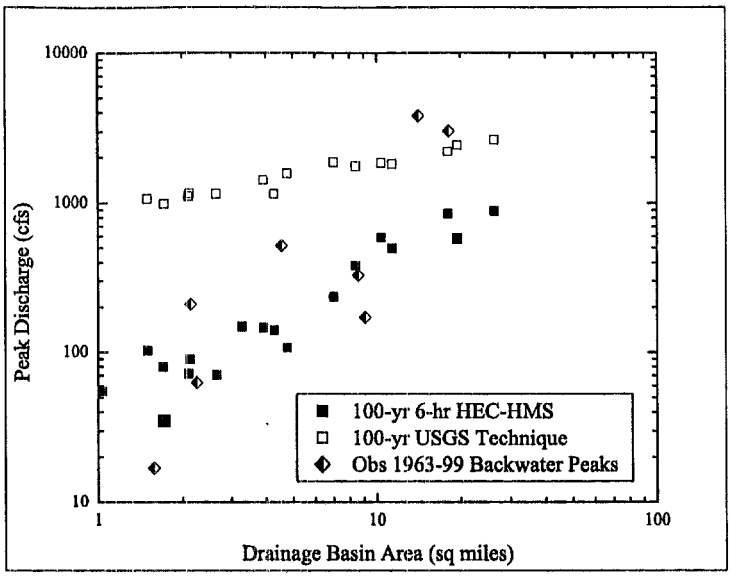


Figure 2. Comparison of simulated HEC-HMS and USGS 100-yearpre-fire pea discharges at eastern Laboratory boundary. Observed peaks are from backwater calculations.

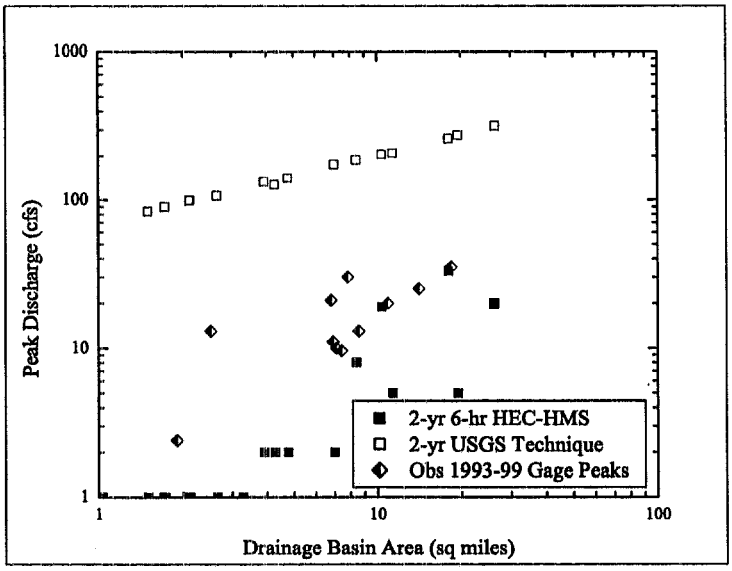


Figure 3. Comparison of simulated HEC-HMS and USGS 2-year pre-fire peak discharges at eastern Laboratory boundary. Observed peaks are from stream gage records.

hypothetical events that were constructed using historical precipitation patterns from six Pajarito Plateau recording rain gages (McLin, 1992). Predicted HEC-HMS hydrograph peaks, along with stream channel geometry and watershed drainage characteristics, are then utilized by the HEC-

RAS model to compute either 50, 100, or 500-year floodplain boundaries. This procedure is well established in modern engineering practice.

For the modeling efforts described here, stream channel cross-sections at varying locations were obtained from the Laboratory's computer-based graphical information system (ArcView GIS) and is similar to an earlier GIS-HEC topographic data extraction procedure (McLin, 1993). For this study, cross-sections are located approximately every 200 feet (61 m) along each reach. Topographic data are automatically extracted from the DEM database in order to minimize channel-surveying tasks. This procedure is performed for each cross-section following the pre-selected channel reach pathway. Each DEM point along the cross-section forms an (x, y, z) topographic point that is geo-referenced to the New Mexico State Plane coordinate system. A typical 100-foot (30 m) long cross section contains between 15 and 50 data points. These cross-sectional features are exported to the HEC-RAS model using HEC-geoRAS, an ArcView extension capability developed by the USACE-HEC.

The independently executed HEC-RAS model employs a HEC-HMS hydrograph peak to simulate a water surface elevation at each channel section using a steady, gradually varied flow approximation. Here the water surface elevation is computed as a function of channel distance using an iterative standard-step method (USACE, 2001b). The model computes a pair of left and right overbank floodpool coordinates for each section that identifies where the DEM land surface and computed floodpool intersect. Coordinate pairs from adjacent channel sections are imported back into ArcView GIS and linked together using the geo-referenced New Mexico State Plane coordinate system. These linked coordinates define the floodplain over the entire channel reach. Parameter estimation procedures and construction of input data files for pre- and post-fire conditions are described in the sections below. Finally, scale maps depicting the Laboratory boundary and all floodplains have been generated.

DESIGN STORM FOR LOS ALAMOS

An observed storm hydrograph for a given watershed is closely related to the spatial and temporal storm distribution that generated it. However, observed large recurrence interval storms are generally unavailable so hypothetical design storms must be used in most engineering applications. In this paper, we describe the 100-year, 6-hour design storm event for Los Alamos that is assumed to produce the 100-year floodplain. The reader should note that other 100-year storm events (e.g., the 100-year, 24-hour event) will produce different 100-year floodplain definitions. Other design storm construction methodologies also exist (e.g., Chow et al., 1988; USBR, 1977; Miller et al., 1973) and depend on availability of precipitation records.

In constructing a design storm event, several important steps are required, including (1) storm frequency or return period; (2) storm duration, total rainfall depth, and watershed area adjustment; and (3) storm time distribution and duration of rainfall excess. In our case, the US Environmental Protection Agency (EPA) stipulates that RCRA permitted facilities must use the 100-year storm to define all floodplains. The USACE recommends (M. Magnuson, USACE Albuquerque District Office, personal communication, 1989) that a 6-hour storm event should be

used for northern New Mexico in most 100-year flood simulations. Bowen (1990, 1996) has tabulated statistically based rainfall depths for various storms. No areal adjustment was made for rainfall depths because individual subbasins are less than about 3 mi^2 (8 km^2). Hence, factors (1) and (2) above are fixed via institutional constraints and rainfall observations. The selection rationale for factor (3) is described below.

A representative rainfall hyetograph must be selected that is based either on the worst possible storm pattern or from recorded storm distribution patterns. This hyetograph will significantly affect the shape and peak value of the resulting runoff hydrograph for a given watershed. Daily precipitation depths have been measured in Los Alamos since 1911 (Bowen, 1990, 1996). Individual storm patterns have been recorded at 15-minute intervals beginning in 1964. These data were used to develop intensity-duration-frequency (IDF) relationships (McLin, 1992, 2001). These IDF curves (Figure 4) were used to establish individual 6-hour design storm distributions for the 2, 5, 10, 25, 50, 100, and 500-year events.

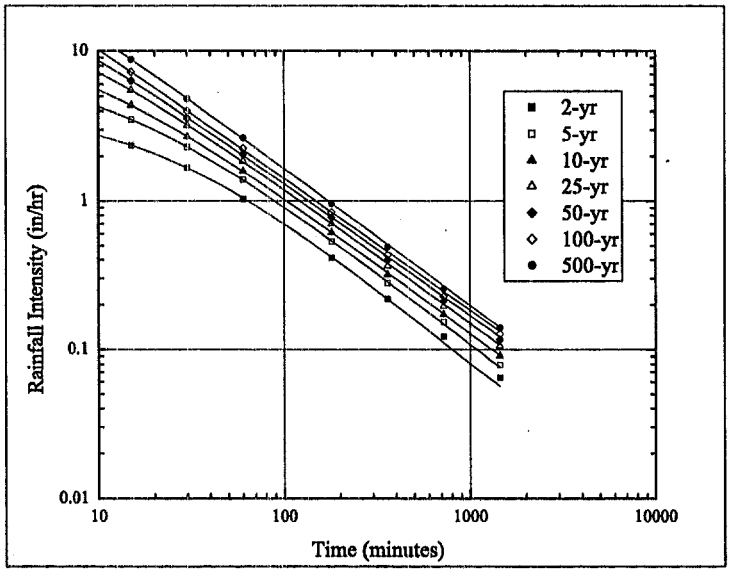


Figure 4. Intensity-duration-frequency curves for Los Alamos, New Mexico.

Once IDF curves are constructed, then a 6-hour design storm hyetograph can be developed for each return period event using the alternating block method (Chow et al., 1988, p. 454-466). Results for the dimensionless 2 and 100-year instantaneous storm events are shown in Figure 5. All of the cumulative 6-hour storm distributions developed and used in this report are summarized in Appendix A; these include the 2, 5, 10, 25, 50, 100, and 500-year events. The SCS (Soil Conservation Service, now the Natural Resources Conservation Service) 100-year, 6-hour design storm distribution (SCS, 1993) is also shown for comparison. Note that the SCS curve will produce a more uniform rainfall distribution, and lower corresponding hydrograph peak. As seen in Figure 5, the 6-hour instantaneous design storm distributions used here are bell-shaped with a midpoint peak intensity at 3 hours. These distributions imply gradually increasing

and decreasing intensities preceding and following peak values. This design storm pattern essentially satisfies soil infiltration and other abstraction loss requirements with low rainfall intensity, and generates higher hydrographs in response to higher rainfall intensities later. Observed New Mexico summer thunderstorms typically result from intense prefrontal squall lines moving south to north. These thunderstorms are exceptionally localized events that rarely cover more than about 0.5 mi^2 (1.3 km^2). Hence, our design is conservative since it is simultaneously applied to all subbasins within the west-east oriented watersheds.

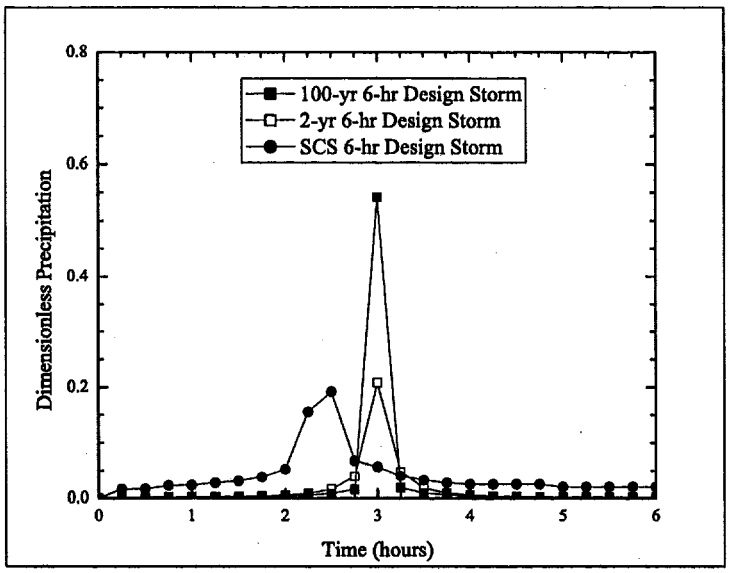


Figure 5. Six-hour design storms for Los Alamos; the SCS 6-hour storm is shown for comparison.

Each of the 6-hour design storm distributions described above contains all of the shorter duration events with the same recurrence interval. For example, the 100-year, 6-hour design storm contains the 100-year, 15-minute storm in its central 15-minute interval. Likewise, the 100-year, 1-hour storm is contained within the central 60-minute interval of the 100-year, 6-hour design distribution. In other words, the 100-year, 6-hour design storm incorporates all 100-year events with storm durations of 6 hours or less. This observation is directly related to the alternating block method used to construct the design storm. Hence, the 6-hour design storm will produce larger hydrographs than shorter duration design storms with the same recurrence interval because it has a longer period of low intensity rainfall before its central peak. For example, the 6-hour design storm will yield larger hydrograph peaks than its 1-hour counterpart. This is a significant point that is often overlooked.

As employed here, the HEC-HMS simulations used total rainfall depths reported by Bowen (1990, 1996) and the cumulative design storm distributions computed from the instantaneous distributions described above. Rainfall depths from Bowen (1990) were also adjusted for elevation differences between subbasin centroids using a least squares linear

regression of rain gage elevations and recorded precipitation depths (McLin, 1992). This was done to account for orthographic effects across Pajarito Plateau. These elevation-corrected rainfall depths are listed in Appendix B according to subbasins within individual watersheds.

HEC-HMS MODEL

HEC-HMS is a general-purpose model that can predict the optimal unit hydrograph, channel loss rate, stream flow routing parameters, snowmelt computations, unit hydrograph computations, hydrograph routing and combinations, and hydrograph balancing operations. HEC-HMS can be used to forecast both pre- and post-burn flooding impacts associated with these changing land-use patterns. Output from the model includes the design storm hydrograph for each subbasin. Hydrograph peaks are then utilized in the HEC-RAS model as input data.

HEC-HMS can utilize five different unit hydrographs (UH) to simulate runoff, including a user specified UH, kinematic wave, Clark, Snyder, or SCS UH. The SCS UH was selected in this study to characterize the relationship between rainfall-runoff and peak discharge. The SCS rainfall abstraction loss rate was also utilized as explained later. Finally, HEC-HMS can route computed flood flows through downstream subbasins using a variety of techniques, including modified Puls, Muskingum, Muskingum-Cunge, kinematic wave, and level-pool reservoir routing. The Muskingum method was selected for this option because channel losses and flood-wave attenuation in individual watersheds have not been fully characterized. Hence these losses were assumed to be zero even though they are known to be relatively high in certain pre-fire stream channel reaches (e.g., those channel reaches with relatively thick alluvial deposits). Muskingum routing parameters were computed from average channel flow velocities using Manning's equation. In addition, level-pool reservoir routing was selected to move water through road culverts with high embankments and for flood detention structures.

Obviously, not all rainfall from a storm contributes to direct runoff since some is lost during the overland flow process. These abstractions include vegetation interception, depression storage, soil infiltration, evaporation, and other minor losses. Five theoretical rainfall loss calculation techniques are incorporated in HEC-HMS, including the initial and uniform, HEC exponential, Green-Ampt, Holton, and SCS curve number (CN). However, the SCS CN loss method provides a systematic method for computing composite CN values that can account for changing impervious areas or dramatic land use alterations. The SCS synthetic UH expresses the ratio of discharge to peak discharge against the ratio of time to basin lag time. Here lag time is given by (Viessman et al., 1977):

$$t_p = D/2 + t_l \quad \text{and} \quad t_l = [l^{0.8}\,(S+1)^{0.7}]/[1900\,Y^{0.5}] \qquad (1)$$

where t_p is the time (hours) from rainfall beginning to peak discharge, D is rainfall duration (hours), t_l is subbasin lag time (hours), l is the longest water course length (feet) from the subbasin outflow toward the upstream watershed divide, S is potential maximum retention after rainfall begins (inches), and Y is the average watershed slope (%) along the flowpath. Note that

in (1) the lag time is directly related to CN since S=1000/CN-10. Once rainfall excess has been determined, a unit hydrograph can be computed for each subbasin.

In Figure 6, pre-fire Los Alamos watershed data are used to show SCS basin lag times from (1) as a function of Snyder lag times (Viessman et al., 1977). Empirical coefficients used in the Snyder technique were obtained from USACE studies (M. Magnuson, USACE Albuquerque District Office, personal communication, 1989) from the Rio Puerco in New Mexico and Rio Grande near El Paso, Texas (lower curve). Synder lag times for the upper curve were obtained using a modified form of the Snyder relationship and coefficients for mountainous watersheds near Los Angeles, California (Linsley et al., 1982, pp. 223-225). Figure 6 clearly shows that SCS basin lag times used in this study are bracketed by extremes produced with the Snyder technique. Computation of post-fire changes in Snyder lag times was not possible because changes in empirical coefficients associated with the fire could not be evaluated. Appendix C summarizes pre-fire HEC-HMS model parameters; these data were originally reported in McLin (1992). Appendix D summarizes post-fire HEC-HMS model parameters that were used in the present study. Appendix E shows a HEC-HMS model input data file for Pajarito Canyon, including the flood retention structure located above Technical Area 18 (TA-18).

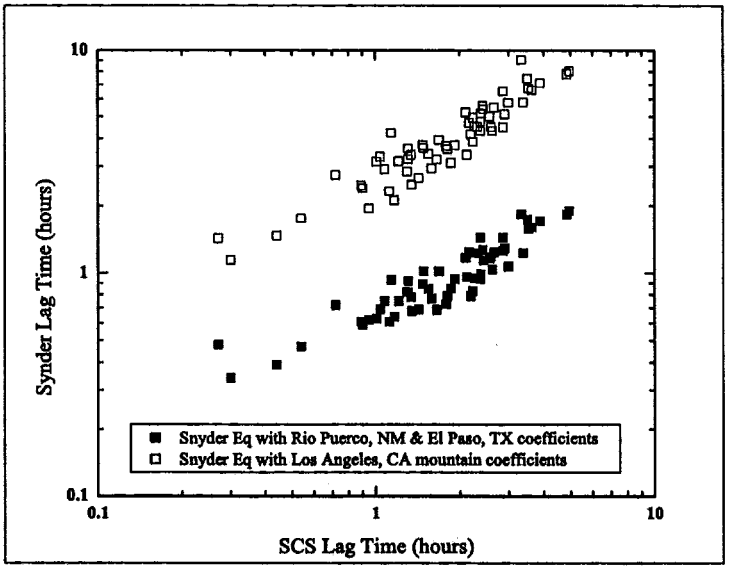


Figure 6. Comparison of SCS and Snyder pre-fire basin lag times for Los Alamos using equivalent basin parameters.

Figure 7 shows a plot of changes in pre- and post-fire SCS CN values and lag times for impacted watersheds. Note that t_l values from (1) have been dramatically reduced in upland subbasins where CN values have increased the most. Fire impacts are also the most pronounced in these same locations (see Wilson et al., this issue). In some headwater subbasins, lag time has been reduced from 90 minutes to under 33 minutes. This implies that both recording rain and stream gages need to be collecting data every 15 minutes or less in order to capture the dynamic

nature of the rainfall-runoff process. In other words, data acquisition rates for systems inputs and outputs need to be less than one-half the system response time (approximated here by t_l) in order to avoid data aliasing (Jenkins and Watts, 1968, p. 285).

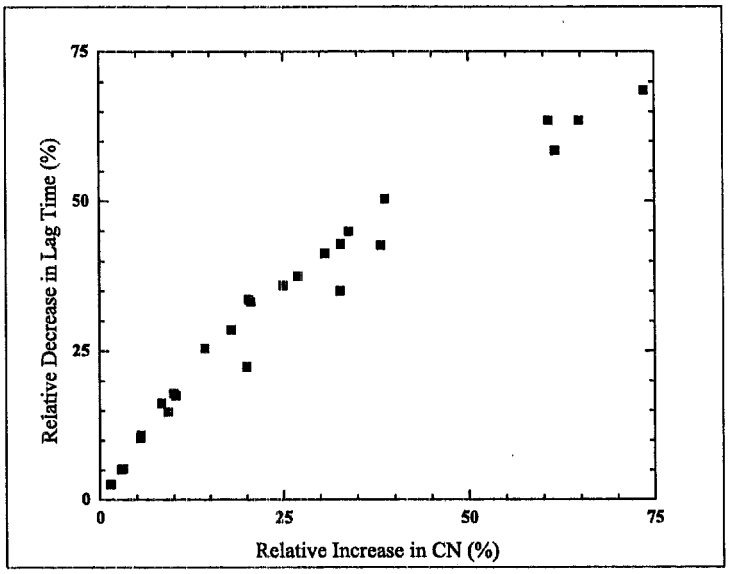


Figure 7. Cerro Grande wildfire changes in curve number (CN) and basin lag times. Here a relative change is defined as (pre-fire value - post-fire value)/(pre-fire value).

In addition to ease of use, (1) has the advantage that impacts of development within a given watershed can be evaluated since changes in CN over time are easily estimated. These same impacts can not be systematically evaluated with the kinematic wave, Snyder, or Clark UH methods.

Pre-fire CN values were determined for all watersheds (McLin, 1992) and formed a starting point for post-fire simulations. These pre-fire values typically ranged from the mid-50s and 60s for wooded alpine forests, to 70s and 80s for mountain brush and pinon-juniper woodlands. These values were originally obtained using a quasi-model calibration procedure for ungaged watersheds as discussed below.

Once all pre-fire basin characteristic parameters had been estimated, then individual watershed hydrographs could be generated. Before this was done, however, a parameter sensitivity analysis was made. All model parameters were constrained to a vary narrow range of observed values except for composite subbasin CN numbers. These CN values were estimated from county soil maps (Nyhan et al., 1978) and standard tables (Hoggan, 1996), although alternative methodologies are available (Hawkins 1993; Hjelmfelt, 1980). To evaluate the uncertainty in estimated pre-fire CN values, hydrograph peaks produced by the 2-year, 6-hour design storm event for Los Alamos were examined for all subbasins. The logic for this design procedure is straightforward: one can quickly develop a general appreciation for flood

magnitudes associated with individual pre-fire 2-year storm events from physical observation. These qualitative observations suggest that pre-fire 2-year flood peaks in Los Alamos County are only slightly larger than zero. This same appreciation can not be easily developed for pre-fire 100-year magnitude events because these events are rarely observed. Following this logic, all HEC-HMS simulations should accurately reflect observed pre-fire 2-year events if one is to have confidence in large recurrence-interval flood predictions. One should recognize that once all pre-fire subbasin characteristic parameters have been determined, then one only needs to change subbasin rainfall totals and design storm distribution patterns in order to generate larger recurrence interval hydrographs.

Each pre-fire watershed simulation was made for the 2-year, 6-hour Los Alamos design storm event. If a given subbasin yielded a hydrograph peak that was unreasonably high or low, then the composite CN was adjusted either downward or upward, respectively, and a new simulation was made. Recall that a change in CN implies a corresponding change in basin lag time, as suggested by (1). This iterative process was repeated several times for each watershed. Individual composite CN values were typically adjusted less than 3% until the predicted 2-year hydrograph peak was greater than zero but less than about 3 cfs (85 l/s) for an average sized subbasin. Approximately half of all subbasins required a composite CN adjustment; these adjustments were nearly equally divided between increases and decreases in CN values. Once these CN values were fixed, then the larger recurrence interval hydrographs were computed using the 6-hour rainfall totals and the design storm distribution patterns developed earlier.

The post-fire CN values were initially modified from original values using weighting factors based on the percent of subbasin areas that were burned. These burned areas were subdivided into low (57% of total burn area), medium (8% of total), and high (34% of total) severity burned areas as defined by the Burned Area Emergency Rehabilitation team (BAER, 2000). This classification is qualitatively linked to changes in soil texture and infiltration capacity. High burn severity areas are located in those areas where the surficial soil structure has been altered. These soils typically have a hydrophobic layer that was formed during the fire. This layer is located approximately 0.25 inch (6.4 mm) below the surface and is between 0.25 to 3.0 inches thick (6.4 to 76 mm). These hydrophobic soils develop when high temperature fires produce heavy volatile organics that migrate into soils and condense (Imeson et al., 1992; Dekker and Ritsema, 1994). For the Cerro Grande wildfire, these hydrophobic soils are preferentially located on north-facing canyon slopes with heavy ponderosa pine forests. They occur on approximately 22% of the total burn area. Medium severity burn areas show little or no hydrophobicity and are concentrated on south-facing canyon slopes with sparser vegetation, on mesa tops, and in canyon bottoms. Low severity burn areas are generally located along the perimeter of more severely burned areas. This hydrophobic soil distribution is related to the distribution of fuels, temperature, and heavy winds during the fire. Quantitative evaluation of infiltration capacity changes in these hydrophobic soils is currently underway.

The BAER team originally assigned CN values of 65, 85, and 90 to the low, medium, and high severity burn areas, respectively. We modified these CN values to include a range of values for each severity classification. Thus for low severity burns, we estimated CN values range from a low of 65 to a high of 85, with an expected value of 75. For moderate severity burned areas,

we estimated than CN values range from a low of 80 to a high of 90, with an expected value of 85. Finally, for high severity burned areas, we estimated that CN values range from a low of 85 to a high of 95, with an expected value of 90. Unburned areas retained their original pre-fire CN values; however, we assumed these values could range four CN points above and below this original value. A composite CN value was computed for each subbasin using these four burn severity weight factors and four expected CN values. These weight factors were computed according to the fraction of burned area within each subbasin area (i.e., unburned, low, medium, or high severity). Each respective weight factor was multiplied by each respective CN value and the results were summed to obtain the composite CN value. This process was then repeated for the low and high CN estimates to establish lower and upper limits on these CN composites. These calibration efforts will also be repeated as forest recovery progresses to document the time rate of change in calibrated CN values. The procedure described here was necessary, however, because public safety and environmental questions needed addressing before the summer (2000) monsoon season created flooding hazards in the Laboratory.

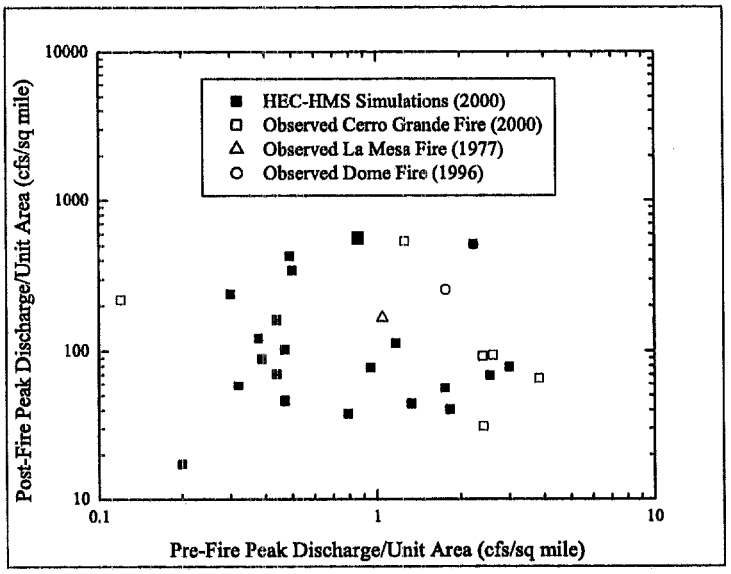


Figure 8. Comparison of observed and simulated peak discharges per unit drainage basin area. The La Mesa and Dome wildfires occured south of the Cerro Grande wildfire in the years indicated.

Figure 8 shows a dramatic increase between pre- and post-fire hydrograph peaks per unit area for both observed and simulated storm events. The observed data in Figure 8 were obtained from stream gages (Cerro Grande fire) and backwater calculations (La Mesa and Domes fires) for several regional wildfires (McLin,2001; Veenhuis, 2000; Cannon and Reneau, 2000). Simulated values were obtained with the HEC-HMS model using the pre- and post-burn CN values described earlier. In addition, the 2-year, 1-hour design storm distribution was used for these simulations because this pattern best represented the observed rainfall pattern following each of the fires. Figure 8 suggests that the final CN values for the post–burn areas yield simulated hydrograph peaks that compare favorably with observed values.

Figure 9 shows a comparison between observed and HEC-HMS predicted hydrographs for Starmer Canyon, a small tributary watershed located in the Santa Fe National Forest along the western Laboratory perimeter. This watershed was severely burned during the Cerro Grande wildfire. The observed hydrograph was in response to approximately 0.69 inches (17.5 mm) of rain that fell in less than 45 minutes on 28 June 2000. The observed and predicted hydrograph peaks match well. However, total observed runoff volume is considerably less than the predicted volume. Five additional observed and predicted hydrographs for other small watersheds follow a similar pattern. These comparisons suggest that the shape of the SCS unit hydrograph may not completely represent Pajarito Plateau watersheds or that channel infiltration losses are significant. These preliminary results are encouraging however.

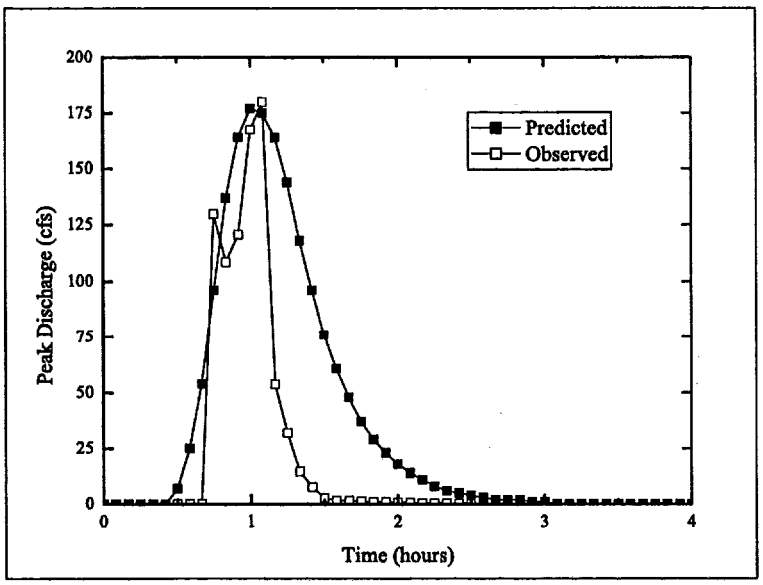


Figure 9. Observed and simulated hydrographs for the Starmer Canyon watershed following a small thunderstorm on 28 June 2000.

HEC-RAS FLOODPLAIN MAPPING

The HEC-RAS model calculates and plots water surface profiles for subcritical, critical, and supercritical gradually varied, steady flows in channels of any cross-sectional configuration. Surface water profile analyses are commonly used to map floodplains at RCRA sites, determine flood protection levee heights, and establish flood hazard zones for insurance purposes. The HEC-HMS and HEC-RAS models are typically used in conjunction with one another for these floodplain assessment studies.

Flow regime boundary geometry is defined in the HEC-RAS model with cross-sections and reach distances between adjacent cross-sections. These cross-sections are located at user

specified intervals along the stream channel so that the flow capacity in the channel and overbank areas can be characterized. Reducing the distance between adjacent sections will increase the model's accuracy because erratic fluctuations in energy losses between sections can be minimized. Manning's equation is initially used to determine how much of the cross-sectional flow is in the channel and how much is in the overbank areas. Values for subarea conveyance (i.e., all terms in Manning's equation except the friction slope term) are known if the friction slope is assumed constant throughout a given cross-section. A starting water surface elevation at either the downstream (subcritical) or upstream (supercritical) end of the watercourse, expansion or contraction coefficients, Manning's roughness factor n, and stream discharge are specified as input data.

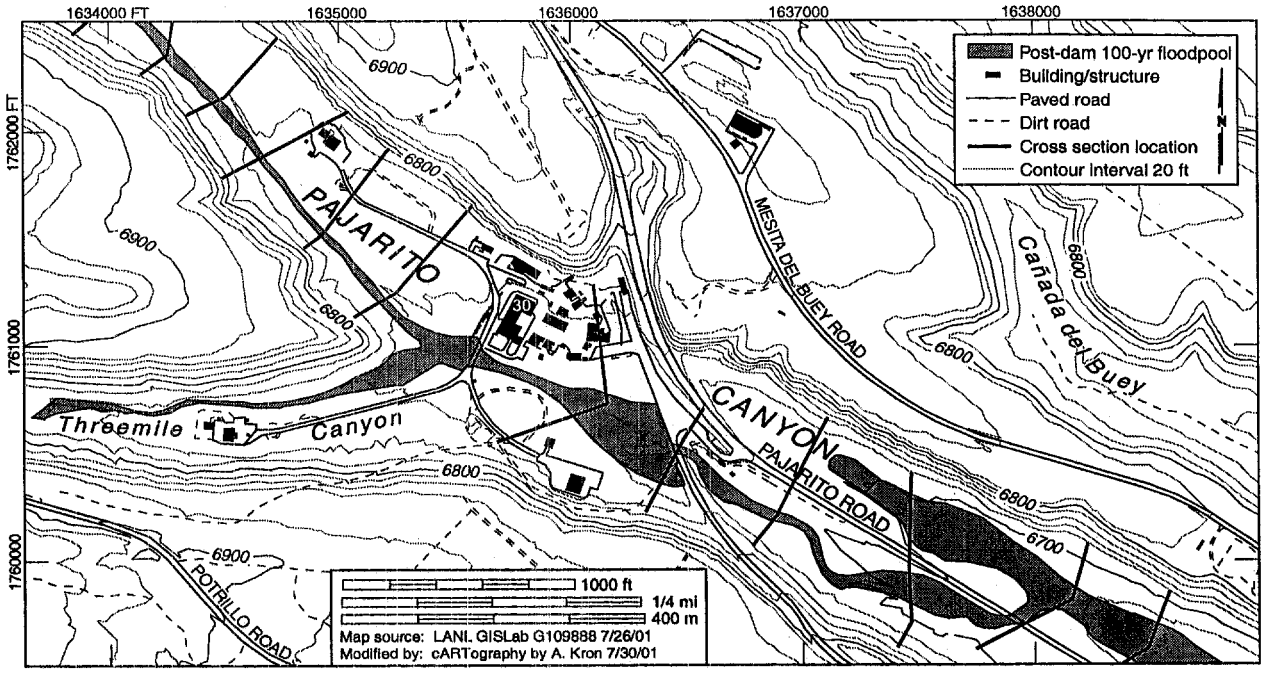


Figure 10. Predicted post-fire 100-year floodplain map for TA-18 following construction of the upstream flood control structure.

This floodplain mapping procedure implies that natural channels meet uniform flow conditions, that the energy grade is approximately equal to the average channel bed slope, and that water surface elevations can be obtained from a normal-depth calculation. These assumptions are conservative in most natural channels. Figure 10 depicts an example of the predicted post-fire 100-year floodpools in Pajarito Canyon near TA-18 after construction of the flood control structure. Other floodplain maps are attached to this report for all canyons crossing Laboratory lands.

DISCUSSION AND CONCLUSIONS

The successful integration of modern GIS databases and hydrologic models is an emerging technology (Maidment and Djokic, 2000). Most federal, and many State, facilities already have significant GIS topographic coverage. This paper describes an application of HEC-HMS and HEC-RAS floodplain models to complex terrain using ArcView GIS extracted topographic data. These models are recognized by the EPA, USACE, and others as the best available technology for floodplain definition in ungaged watersheds. Combining these models with a GIS capability represents a refinement in their continued use.

The SCS curve number method was used in this study to predict runoff. The relative merits of this empirical approach versus physically based representations have been openly debated in the literature for years. However, Loague and Freeze (1985) have shown that physically based models generally do not predict runoff any better than the relatively simple approach used here. In addition, extension of physical models to ungaged watersheds retains many limitations of simple approaches. Furthermore, the SCS method has the advantage that future changes in land use patterns (e.g., pre- and post-fire watershed alterations or urbanization) are easily addressed.

Most event simulation models represent the rainfall-runoff process as a linear input-output system. This implies that model calibration studies can utilize data from low recurrence-interval storm and runoff events to characterize the watershed response. Typically, these calibration results are then extended to large recurrence-interval events. This well-established practice is far from perfect because the system response may not be linear over this entire range. For example, the calibration efforts described here utilize convective summer thunderstorm data that rarely exceed three hours in duration. However, large recurrence-interval storms in the southwest are often associated with long-duration hurricanes that move inland from the Gulf of Mexico or the Baja Peninsula. One practical solution to this problem is to use a 6- or 24-hour design storm with peak rainfall intensities near the middle of the storm distribution to mimic these rare events.

Finally, observed increases in hydrograph peaks and total runoff volume following wildfires are well documented in the literature. For northern New Mexico, these increases in peak flow appear to be in the range of one to two orders of magnitude per unit drainage basin area. Furthermore, recording rain and stream gages should collect data at less than one-half the post-fire system response time, or basin lag time, to capture the dynamic nature of the rainfall-runoff process.

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Appendix A

Table A-1. Individual 6-hour design storm distributions for Los Alamos County.

Time	Time	Cumulative 6-Hour Design Storm Distributions (dimensionless)						
(min)	(hrs)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
0	0.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	0.0833	0.000651	0.000988	0.001274	0.001410	0.001599	0.001612	0.001120
10	0.1667	0.001342	0.002017	0.002591	0.002863	0.003243	0.003267	0.002272
15	0.2500	0.002078	0.003090	0.003954	0.004361	0.004933	0.004968	0.003458
20	0.3333	0.002862	0.004211	0.005366	0.005907	0.006673	0.006716	0.004681
25	0.4167	0.003699	0.005382	0.006831	0.007504	0.008466	0.008515	0.005941
30	0.5000	0.004595	0.006609	0.008353	0.009156	0.010316	0.010369	0.007243
35	0.5833	0.005554	0.007897	0.009936	0.010868	0.012225	0.012280	0.008589
40	0.6667	0.006584	0.009251	0.011585	0.012642	0.014199	0.014253	0.009982
45	0.7500	0.007693	0.010676	0.013306	0.014486	0.016243	0.016292	0.011426
50	0.8333	0.008888	0.012181	0.015106	0.016403	0.018361	0.018403	0.012925
55	0.9167	0.010180	0.013773	0.016990	0.018400	0.020559	0.020589	0.014482
60	1.0000	0.011581	0.015462	0.018969	0.020486	0.022845	0.022859	0.016104
65	1.0833	0.013104	0.017258	0.021050	0.022666	0.025226	0.025218	0.017796
70	1.1667	0.014766	0.019174	0.023246	0.024952	0.027710	0.027674	0.019564
75	1.2500	0.016584	0.021224	0.025568	0.027354	0.030308	0.030236	0.021416
80	1.3333	0.018580	0.023425	0.028031	0.029884	0.033030	0.032915	0.023361
85	1.4167	0.020782	0.025798	0.030652	0.032557	0.035890	0.035722	0.025407
90	1.5000	0.023222	0.028367	0.033453	0.035390	0.038904	0.038671	0.027568
95	1.5833	0.025936	0.031161	0.036457	0.038404	0.042089	0.041779	0.029857
100	1.6667	0.028975	0.034217	0.039695	0.041623	0.045468	0.045063	0.032291
105	1.7500	0.032395	0.037578	0.043203	0.045077	0.049066	0.048548	0.034890
110	1.8333	0.036271	0.041301	0.047027	0.048803	0.052916	0.052260	0.037677
115	1.9167	0.040698	0.045455	0.051224	0.052848	0.057057	0.056233	0.040685
120	2.0000	0.045797	0.050132	0.055867	0.057270	0.061538	0.060510	0.043950
125	2.0833	0.051728	0.055452	0.061053	0.062146	0.066423	0.065145	0.047523
130	2.1667	0.058706	0.061574	0.066909	0.067575	0.071795	0.070206	0.051469
135	2.2500	0.067024	0.068721	0.073612	0.073697	0.077767	0.075786	0.055876
140	2.3333	0.077099	0.077209	0.081411	0.080704	0.084493	0.082010	0.060868
145	2.4167	0.089534	0.087502	0.090675	0.088881	0.092198	0.089059	0.066624
150	2.5000	0.105244	0.100318	0.101973	0.098668	0.101223	0.097201	0.073419
155	2.5833	0.125677	0.116833	0.116246	0.110789	0.112122	0.106863	0.081710
160	2.6667	0.153276	0.139117	0.135177	0.126551	0.125880	0.118788	0.092316
165	2.7500	0.192491	0.171211	0.162161	0.148639	0.144500	0.134449	0.106947
170	2.8333	0.252349	0.222289	0.205381	0.183807	0.173032	0.157470	0.130064
175	2.9167	0.354224	0.318917	0.291784	0.256815	0.230839	0.201581	0.179897
180	3.0000	0.562600	0.588462	0.614820	0.654523	0.695267	0.742916	0.750146
185	3.0833	0.703960	0.737874	0.759785	0.787259	0.803799	0.824356	0.850593
190	3.1667	0.780733	0.806111	0.818537	0.835488	0.842266	0.854579	0.882527
195	3.2500	0.828665	0.845971	0.852050	0.862773	0.864833	0.873203	0.900495

Table A-1. Individual 6-hour design storm distributions for Los Alamos County.

Time	Time	Cumulative 6-Hour Design Storm Distributions (dimensionless)						
(min)	(hrs)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
200	3.3333	0.861321	0.872452	0.874403	0.881215	0.880662	0.886734	0.912804
205	3.4167	0.884940	0.891507	0.890721	0.894936	0.892825	0.897403	0.922113
210	3.5000	0.902783	0.905985	0.903356	0.905773	0.902698	0.906237	0.929583
215	3.5833	0.916715	0.917428	0.913548	0.914686	0.911011	0.913792	0.935816
220	3.6667	0.927879	0.926747	0.922023	0.922236	0.918192	0.920401	0.941162
225	3.7500	0.937014	0.934518	0.929237	0.928771	0.924518	0.926285	0.945843
230	3.8333	0.944619	0.941120	0.935491	0.934526	0.930174	0.931592	0.950007
235	3.9167	0.951042	0.946817	0.940993	0.939664	0.935291	0.936430	0.953757
240	4.0000	0.956534	0.951798	0.945894	0.944302	0.939965	0.940878	0.957169
245	4.0833	0.961280	0.956201	0.950303	0.948527	0.944269	0.944998	0.960300
250	4.1667	0.965418	0.960130	0.954306	0.952406	0.948259	0.948836	0.963194
255	4.2500	0.969056	0.963664	0.957965	0.955992	0.951978	0.952430	0.965883
260	4.3333	0.972277	0.966867	0.961333	0.959324	0.955463	0.955812	0.968396
265	4.4167	0.975147	0.969787	0.964450	0.962437	0.958742	0.959005	0.970756
270	4.5000	0.977719	0.972464	0.967350	0.965358	0.961839	0.962031	0.972979
275	4.5833	0.980035	0.974932	0.970058	0.968108	0.964774	0.964907	0.975081
280	4.6667	0.982131	0.977216	0.972598	0.970708	0.967564	0.967649	0.977075
285	4.7500	0.984035	0.979339	0.974988	0.973172	0.970222	0.970268	0.978972
290	4.8333	0.985772	0.981320	0.977245	0.975514	0.972762	0.972776	0.980781
295	4.9167	0.987362	0.983174	0.979382	0.977746	0.975193	0.975183	0.982510
300	5.0000	0.988822	0.984915	0.981411	0.979878	0.977525	0.977496	0.984166
305	5.0833	0.990168	0.986555	0.983341	0.981919	0.979766	0.979723	0.985756
310	5.1667	0.991410	0.988102	0.985182	0.983875	0.981924	0.981871	0.987283
315	5.2500	0.992561	0.989566	0.986942	0.985755	0.984004	0.983945	0.988754
320	5.3333	0.993629	0.990955	0.988626	0.987563	0.986012	0.985951	0.990172
325	5.4167	0.994623	0.992275	0.990242	0.989306	0.987954	0.987892	0.991541
330	5.5000	0.995549	0.993532	0.991794	0.990987	0.989833	0.989774	0.992864
335	5.5833	0.996415	0.994731	0.993286	0.992611	0.991653	0.991600	0.994146
340	5.6667	0.997225	0.995876	0.994724	0.994182	0.993419	0.993374	0.995387
345	5.7500	0.997984	0.996972	0.996112	0.995704	0.995134	0.995098	0.996591
350	5.8333	0.998698	0.998023	0.997451	0.997179	0.996801	0.996775	0.997760
355	5.9167	0.999368	0.999031	0.998746	0.998610	0.998422	0.998408	0.998895
360	6.0000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Appendix B

Table B-1. Elevation-adjusted 6-hour precipitation for Pajarito Plateau watershed basins.

Location	Elevation	500-yr Ppt	100-yr Ppt	50-yr Ppt	25-yr Ppt	10-yr Ppt	5-yr Ppt	2-yr Ppt
TA-59	7379	3.08	2.61	2.42	2.21	1.94	1.71	1.34
TA-54	6690	2.39	1.94	1.77	1.59	1.36	1.17	0.89
Regression Equation: y = ax + b where y = 6-hr prec (in) and x = watershed basin centroid elevation (ft).								
slope (a)		1.001E-03	9.724E-04	9.434E-04	8.999E-04	8.418E-04	7.837E-04	6.531E-04
intercept (b)		-4.310	-4.566	-4.541	-4.430	-4.272	-4.073	-3.479
Watershed Guaje	**Centroid Elevation**	**500-yr Ppt**	**100-yr Ppt**	**50-yr Ppt**	**25-yr Ppt**	**10-yr Ppt**	**5-yr Ppt**	**2-yr Ppt**
1	8100	3.80	3.31	3.10	2.86	2.55	2.28	1.81
2	6700	2.40	1.95	1.78	1.60	1.37	1.18	0.90
3	7105	2.81	2.34	2.16	1.96	1.71	1.50	1.16
4	6400	2.10	1.66	1.50	1.33	1.12	0.94	0.70
5	5920	1.62	1.19	1.04	0.90	0.71	0.57	0.39
Rendija								
1	8250	3.95	3.46	3.24	2.99	2.67	2.39	1.91
2	8250	3.95	3.46	3.24	2.99	2.67	2.39	1.91
3	7420	3.12	2.65	2.46	2.25	1.97	1.74	1.37
4	7720	3.42	2.94	2.74	2.52	2.23	1.98	1.56
5	7780	3.48	3.00	2.80	2.57	2.28	2.02	1.60
6	7000	2.70	2.24	2.06	1.87	1.62	1.41	1.09
7	7420	3.12	2.65	2.46	2.25	1.97	1.74	1.37
8	6910	2.61	2.15	1.98	1.79	1.55	1.34	1.03
9	6880	2.58	2.12	1.95	1.76	1.52	1.32	1.01
10	6400	2.10	1.66	1.50	1.33	1.12	0.94	0.70
Barrancas								
1	6580	2.28	1.83	1.67	1.49	1.27	1.08	0.82
2	6200	1.90	1.46	1.31	1.15	0.95	0.79	0.57
3	6600	2.30	1.85	1.69	1.51	1.28	1.10	0.83
4	6140	1.84	1.41	1.25	1.10	0.90	0.74	0.53
Bayo								
1	7220	2.92	2.46	2.27	2.07	1.81	1.59	1.24
2	6500	2.20	1.76	1.59	1.42	1.20	1.02	0.77
3	6100	1.80	1.37	1.21	1.06	0.86	0.71	0.50
Pueblo								
1	8400	4.10	3.60	3.38	3.13	2.80	2.51	2.01
2	7300	3.00	2.53	2.35	2.14	1.87	1.65	1.29
3	6480	2.18	1.74	1.57	1.40	1.18	1.01	0.75
Los Alamos								
1	9200	4.90	4.38	4.14	3.85	3.47	3.14	2.53
2	7700	3.40	2.92	2.72	2.50	2.21	1.96	1.55
3	7050	2.75	2.29	2.11	1.91	1.66	1.45	1.13
4	6000	1.70	1.27	1.12	0.97	0.78	0.63	0.44
5	5740	1.44	1.02	0.87	0.74	0.56	0.43	0.27
6	5600	1.30	0.88	0.74	0.61	0.44	0.32	0.18
Sandia								
1	6900	2.60	2.14	1.97	1.78	1.54	1.33	1.03
2	6400	2.10	1.66	1.50	1.33	1.12	0.94	0.70
3	6300	2.00	1.56	1.40	1.24	1.03	0.86	0.64
4	5800	1.50	1.07	0.93	0.79	0.61	0.47	0.31

Table B-1. Elevation-adjusted 6-hour precipitation for Pajarito Plateau watershed basins.

Watershed Mortandad	Centroid Elevation	500-yr Ppt	100-yr Ppt	50-yr Ppt	25-yr Ppt	10-yr Ppt	5-yr Ppt	2-yr Ppt
1	7200	2.90	2.44	2.25	2.05	1.79	1.57	1.22
2	7045	2.75	2.29	2.10	1.91	1.66	1.45	1.12
3	6730	2.43	1.98	1.81	1.63	1.39	1.20	0.92
4	6640	2.34	1.89	1.72	1.55	1.32	1.13	0.86
5	6650	2.35	1.90	1.73	1.55	1.33	1.14	0.86
6	6340	2.04	1.60	1.44	1.28	1.07	0.90	0.66
Canada del Buey								
1	6865	2.57	2.11	1.94	1.75	1.51	1.31	1.00
2	6500	2.20	1.76	1.59	1.42	1.20	1.02	0.77
Pajarito								
1	8720	4.42	3.91	3.69	3.42	3.07	2.76	2.22
2	7500	3.20	2.73	2.53	2.32	2.04	1.80	1.42
3	7500	3.20	2.73	2.53	2.32	2.04	1.80	1.42
4	6850	2.55	2.10	1.92	1.73	1.49	1.30	0.99
5	7030	2.73	2.27	2.09	1.90	1.65	1.44	1.11
6	6610	2.31	1.86	1.69	1.52	1.29	1.11	0.84
7	6330	2.03	1.59	1.43	1.27	1.06	0.89	0.65
Potrillo								
1	6750	2.45	2.00	1.83	1.64	1.41	1.22	0.93
2	6700	2.40	1.95	1.78	1.60	1.37	1.18	0.90
3	6400	2.10	1.66	1.50	1.33	1.12	0.94	0.70
Water								
1	8400	4.10	3.60	3.38	3.13	2.80	2.51	2.01
2	7400	3.10	2.63	2.44	2.23	1.96	1.73	1.35
3	6600	2.30	1.85	1.69	1.51	1.28	1.10	0.83
4	6500	2.20	1.76	1.59	1.42	1.20	1.02	0.77
5	5700	1.40	0.98	0.84	0.70	0.53	0.39	0.24
Valle								
1	8680	4.38	3.88	3.65	3.38	3.04	2.73	2.19
2	7510	3.21	2.74	2.54	2.33	2.05	1.81	1.43
3	7300	3.00	2.53	2.35	2.14	1.87	1.65	1.29
Ancho								
1	6900	2.60	2.14	1.97	1.78	1.54	1.33	1.03
2	6800	2.50	2.05	1.87	1.69	1.45	1.26	0.96
3	6400	2.10	1.66	1.50	1.33	1.12	0.94	0.70
4	6300	2.00	1.56	1.40	1.24	1.03	0.86	0.64
5	5750	1.45	1.03	0.88	0.74	0.57	0.43	0.28
Chaquehui								
1	6450	2.15	1.71	1.54	1.37	1.16	0.98	0.73
Frijoles								
1	8900	4.60	4.09	3.85	3.58	3.22	2.90	2.33
2	7300	3.00	2.53	2.35	2.14	1.87	1.65	1.29
3	7000	2.70	2.24	2.06	1.87	1.62	1.41	1.09

Appendix C

Table C-1. Guaje Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	34000	3277	55	8.18	9.64	11.30	3.38
2	24000	947	68	4.71	3.95	3.25	2.86
3	46000	3600	69	4.49	7.83	9.59	3.33
4	12750	355	75	3.33	2.78	2.13	1.69
5	9000	215	70	4.29	2.39	1.45	1.59

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

$1/[2(1-x)] < Check < 1/(2x)$ — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	34000	13.60	0.69	2.78	3	2.08	1.33
2	24000	8.70	0.77	3.06	4	3.06	1.00
3	46000	12.25	1.04	4.17	5	5.21	0.80
4	12750	7.31	0.48	1.94	2	0.97	2.00
5	9000	6.77	0.37	1.48	2	0.74	2.00

Table C-2. Rendija Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	12250	2180	58	7.24	17.80	1.15	1.02
2	9750	1520	58	7.24	15.59	0.71	0.91
3	9750	480	58	7.24	4.92	0.75	1.61
4	13000	1500	58	7.24	11.54	1.15	1.33
5	12500	1100	58	7.24	8.80	1.14	1.47
6	7500	215	69	4.49	2.87	1.05	1.29
7	13250	875	69	4.49	6.60	1.24	1.34
8	13250	385	69	4.49	2.91	1.67	2.02
9	6000	520	69	4.49	8.67	0.32	0.62
10	6000	280	69	4.49	4.67	0.41	0.85
All	48750	3540	63	5.78	7.26	9.59	4.20

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 1.00

K = L/(3600*Vel) (hrs) — n = 0.060

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	12250	10.48	0.32	1.30	2	0.65	2.00
2	9750	9.81	0.28	1.10	2	0.55	2.00
3	9750	5.51	0.49	1.97	2	0.98	2.00
4	13000	8.44	0.43	1.71	2	0.86	2.00
5	12500	7.37	0.47	1.89	2	0.94	2.00
6	7500	4.20	0.50	1.98	2	0.99	2.00
7	13250	6.38	0.58	2.31	3	1.73	1.33
8	13250	4.23	0.87	3.48	4	3.48	1.00
9	6000	7.31	0.23	0.91	1	0.23	4.00
10	6000	5.36	0.31	1.24	2	0.62	2.00
All	48750	6.69	2.02	8.09	9	8.20	0.44

Table C-3. Barrancas Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	25500	1245	72	3.89	4.88	1.79	2.42
2	7250	750	76	3.16	10.34	0.33	0.54
3	23000	1267	72	3.89	5.51	2.52	2.10
4	3250	365	76	3.16	11.23	0.21	0.27

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	25500	9.68	0.73	2.93	3	2.20	1.33
2	7250	14.09	0.14	0.57	1	0.14	4.00
3	23000	10.28	0.62	2.49	3	1.86	1.33
4	3250	14.68	0.06	0.25	1	0.06	4.00

Table C-4. Bayo Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	16750	745	65	5.38	4.45	1.57	2.19
2	15250	535	74	3.51	3.51	1.16	1.79
3	12750	945	75	3.33	7.41	1.19	1.04

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) R (ft) = 5.00

K = L/(3600*Vel) (hrs) n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps NMIN = 15.00

NMIN = Minutes from Card IT 1/[2(1-x)]= 0.63

$1/[2(1-x)] < Check < 1/(2x)$ 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	16750	9.24	0.50	2.01	3	1.51	1.33
2	15250	8.20	0.52	2.07	3	1.55	1.33
3	12750	11.92	0.30	1.19	2	0.59	2.00

Table C-5. Pueblo Canyon Watershed							
HEC-1 Input Data File Parameter Calculation							
See UD Data Card for SCS Unit Hydrograph Lag Time Definitions							
T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)							
L = Channel Length to Water Divide (ft)							
X = Basin Elevation Change over Length (ft)							
CN = SCS Curve Number for AMC-II Moisture Conditions (dim)							
S = 1000/CN - 10 = Potential Rainfall Retention (in)							
Y = 100X/L = Gross Watershed Slope (%)							
A = Basin Drainage Area (square miles)							
Basin No.	**L (ft)**	**X (ft)**	**CN**	**S**	**Y (%)**	**A (sm)**	**T (hrs)**
1	15000	1930	56	7.86	12.87	2.24	1.48
2	24000	694	65	5.38	2.89	4.61	3.62
3	14000	246	74	3.51	1.76	1.55	2.37
HEC-1 Input Data File Parameter Calculation							
See RM Data Card for Muskingum Routing Parameter Definitions							
0.1 < x < 0.3						x =	0.20
Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)						R (ft) =	5.00
K = L/(3600*Vel) (hrs)						n =	0.100
Nstps = 60K/NMIN (dimensionless)							
NSTPS = Interger Value for Nstps						NMIN =	15.00
NMIN = Minutes from Card IT						1/[2(1-x)]=	0.63
1/[2(1-x)] < Check < 1/(2x)						1/(2x)=	2.50
Check = (60K)/(NMIN*NSTPS)							
Basin No.	**L (ft)**	**Vel**	**K**	**Nstps**	**NSTPS**	**AMSKK**	**Check**
1	15000	15.71	0.27	1.06	2	0.53	2.00
2	24000	7.45	0.90	3.58	4	3.58	1.00
3	14000	5.81	0.67	2.68	3	2.01	1.33

Table C-6. Los Alamos Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	20000	1943	52	9.23	9.72	6.33	2.37
2	10000	531	62	6.13	5.31	0.74	1.43
3	35000	846	68	4.71	2.42	3.31	4.95
4	11750	525	80	2.50	4.47	1.96	1.08
5	5000	100	75	3.33	2.00	0.77	0.95
6	7750	165	75	3.33	2.13	0.67	1.30

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	20000	13.65	0.41	1.63	2	0.81	2.00
2	10000	10.09	0.28	1.10	2	0.55	2.00
3	35000	6.81	1.43	5.71	6	8.57	0.67
4	11750	9.26	0.35	1.41	2	0.71	2.00
5	5000	6.19	0.22	0.90	1	0.22	4.00
6	7750	6.39	0.34	1.35	2	0.67	2.00

Table C-7. Sandia Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	36750	1000	68	4.71	2.72	2.65	4.85
2	11750	370	75	3.33	3.15	0.85	1.49
3	10000	300	76	3.16	3.00	1.32	1.31
4	9000	635	79	2.66	7.06	0.75	0.72

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60*K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 5.00

n = 0.100

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	36750	7.23	1.41	5.65	6	8.48	0.67
2	11750	7.77	0.42	1.68	2	0.84	2.00
3	10000	7.59	0.37	1.46	2	0.73	2.00
4	9000	11.63	0.21	0.86	1	0.21	4.00

Table C-8. Mortandad Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	9000	390	65	5.38	4.33	0.55	1.35
2	10500	277	67	4.93	2.64	0.81	1.86
3	6000	125	72	3.89	2.08	0.36	1.17
4	12250	203	72	3.89	1.66	1.61	2.31
5	16000	465	72	3.89	2.91	0.86	2.16
6	13500	855	74	3.51	6.33	1.72	1.21

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	9000	9.12	0.27	1.10	2	0.55	2.00
2	10500	7.11	0.41	1.64	2	0.82	2.00
3	6000	6.32	0.26	1.05	2	0.53	2.00
4	12250	5.64	0.60	2.41	3	1.81	1.33
5	16000	7.47	0.60	2.38	3	1.79	1.33
6	13500	11.02	0.34	1.36	2	0.68	2.00

Table C-9. Canada del Buey Canyon Watershed							
HEC-1 Input Data File Parameter Calculation							
See UD Data Card for SCS Unit Hydrograph Lag Time Definitions							
T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)							
L = Channel Length to Water Divide (ft)							
X = Basin Elevation Change over Length (ft)							
CN = SCS Curve Number for AMC-II Moisture Conditions (dim)							
S = 1000/CN - 10 = Potential Rainfall Retention (in)							
Y = 100X/L = Gross Watershed Slope (%)							
A = Basin Drainage Area (square miles)							
Basin No.	**L (ft)**	**X (ft)**	**CN**	**S**	**Y (%)**	**A (sm)**	**T (hrs)**
1	29500	836	69	4.49	2.83	2.10	3.88
2	14750	1345	72	3.89	9.12	2.42	1.14
HEC-1 Input Data File Parameter Calculation							
See RM Data Card for Muskingum Routing Parameter Definitions							
0.1 < x < 0.3						x =	0.20
Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)						R (ft) =	5.00
K = L/(3600*Vel) (hrs)						n =	0.100
Nstps = 60K/NMIN (dimensionless)							
NSTPS = Interger Value for Nstps						NMIN =	15.00
NMIN = Minutes from Card IT						1/[2(1-x)]=	0.63
1/[2(1-x)] < Check < 1/(2x)						1/(2x)=	2.50
Check = (60K)/(NMIN*NSTPS)							
Basin No.	**L (ft)**	**Vel**	**K**	**Nstps**	**NSTPS**	**AMSKK**	**Check**
1	29500	7.37	1.11	4.45	5	5.56	0.80
2	14750	13.23	0.31	1.24	2	0.62	2.00

Table C-10. Pajarito Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	17250	2711	52	9.23	15.72	1.99	1.66
2	18250	795	62	6.13	4.36	2.57	2.56
3A(2-Mi N)	7000	2060	61	6.39	29.43	1.29	0.47
3B(2-Mi S)	17750	930	61	6.39	5.24	1.99	2.34
4	11000	205	70	4.29	1.86	0.67	2.12
5	19500	710	67	4.93	3.64	1.70	2.59
6	15000	225	72	3.89	1.50	1.15	2.86
7	15500	1050	73	3.70	6.77	2.24	1.34

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	17250	17.36	0.28	1.10	2	0.55	2.00
2	18250	9.14	0.55	2.22	3	1.66	1.33
3A(2-Mi N)	7000	23.76	0.08	0.33	1	0.08	4.00
3B(2-Mi S)	17750	10.03	0.49	1.97	2	0.98	2.00
4	11000	5.98	0.51	2.04	3	1.53	1.33
5	19500	8.36	0.65	2.59	3	1.94	1.33
6	15000	5.36	0.78	3.11	4	3.11	1.00
7	15500	11.40	0.38	1.51	2	0.76	2.00

Table C-11. Potrillo Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	28500	875	70	4.29	3.07	2.78	3.53
2	18000	630	71	4.08	3.50	1.03	2.23
3	9750	620	75	3.33	6.36	0.96	0.90

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) R (ft) = 5.00

K = L/(3600*Vel) (hrs) n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps NMIN = 15.00

NMIN = Minutes from Card IT 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	28500	7.67	1.03	4.13	5	5.16	0.80
2	18000	8.19	0.61	2.44	3	1.83	1.33
3	9750	11.05	0.25	0.98	1	0.25	4.00

Table C-12. Water Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	18000	2305	54	8.52	12.81	4.07	1.81
2	17750	705	62	6.13	3.97	2.63	2.62
3	19000	405	72	3.89	2.13	1.42	2.90
4	13750	615	72	3.89	4.47	1.97	1.55
5	5000	405	77	2.99	8.10	0.32	0.44

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60*K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 5.00

n = 0.100

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	18000	15.67	0.32	1.28	2	0.64	2.00
2	17750	8.73	0.56	2.26	3	1.69	1.33
3	19000	6.40	0.83	3.30	4	3.30	1.00
4	13750	9.26	0.41	1.65	2	0.82	2.00
5	5000	12.47	0.11	0.45	1	0.11	4.00

Table C-13. Valle Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	22500	2756	53	8.87	12.25	2.33	2.26
2	7500	393	63	5.87	5.24	0.78	1.12
3	12500	477	64	5.63	3.82	1.17	1.92

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) R (ft) = 5.00

K = L/(3600*Vel) (hrs) n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps NMIN = 15.00

NMIN = Minutes from Card IT 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	22500	15.33	0.41	1.63	2	0.82	2.00
2	7500	10.03	0.21	0.83	1	0.21	4.00
3	12500	8.56	0.41	1.62	2	0.81	2.00

Table C-14. Ancho Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	25750	1044	68	4.71	4.05	2.19	2.99
2	22000	1035	69	4.49	4.70	2.48	2.38
3	13000	1102	74	3.51	8.48	1.11	1.01
4	10000	688	75	3.33	6.88	1.04	0.89
5	2500	168	75	3.33	6.72	0.19	0.30

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60*K)/(NMIN*NSTPS)

						x =	0.20
						R (ft) =	5.00
						n =	0.100
						NMIN =	15.00
						1/[2(1-x)]=	0.63
						1/(2x)=	2.50
Basin No.	**L (ft)**	**Vel**	**K**	**Nstps**	**NSTPS**	**AMSKK**	**Check**
1	25750	8.82	0.81	3.24	4	3.24	1.00
2	22000	9.50	0.64	2.57	3	1.93	1.33
3	13000	12.75	0.28	1.13	2	0.57	2.00
4	10000	11.49	0.24	0.97	1	0.24	4.00
5	2500	11.35	0.06	0.24	1	0.06	4.00

Table C-15. Chaquequi Canyon Watershed							
HEC-1 Input Data File Parameter Calculation							
See UD Data Card for SCS Unit Hydrograph Lag Time Definitions							
T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)							
L = Channel Length to Water Divide (ft)							
X = Basin Elevation Change over Length (ft)							
CN = SCS Curve Number for AMC-II Moisture Conditions (dim)							
S = 1000/CN - 10 = Potential Rainfall Retention (in)							
Y = 100X/L = Gross Watershed Slope (%)							
A = Basin Drainage Area (square miles)							
Basin No.	**L (ft)**	**X (ft)**	**CN**	**S**	**Y (%)**	**A (sm)**	**T (hrs)**
1	16500	1292	73	3.70	7.83	1.50	1.31
HEC-1 Input Data File Parameter Calculation							
See RM Data Card for Muskingum Routing Parameter Definitions							
0.1 < x < 0.3						x =	0.20
Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)						R (ft) =	5.00
K = L/(3600*Vel) (hrs)						n =	0.100
Nstps = 60K/NMIN (dimensionless)							
NSTPS = Interger Value for Nstps						NMIN =	15.00
NMIN = Minutes from Card IT						1/[2(1-x)]=	0.63
1/[2(1-x)] < Check < 1/(2x)						1/(2x)=	2.50
Check = (60K)/(NMIN*NSTPS)							
Basin No.	**L (ft)**	**Vel**	**K**	**Nstps**	**NSTPS**	**AMSKK**	**Check**
1	16500	12.26	0.37	1.50	2	0.75	2.00

Table C-16. Frijoles Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	20200	2499	50	10.00	12.37	4.97	2.23
2	24400	1030	70	4.29	4.22	4.92	2.66
3	24000	633	68	4.71	2.64	8.13	3.50

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 5.00

n = 0.100

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	20200	15.41	0.36	1.46	2	0.73	2.00
2	24400	9.00	0.75	3.01	4	3.01	1.00
3	24000	7.11	0.94	3.75	4	3.75	1.00

Appendix D

Table D-1. Guaje Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	34000	3277	76	3.16	9.64	11.30	1.94
2	24000	947	82	2.20	3.95	3.25	1.91
3	46000	3600	83	2.05	7.83	9.59	2.21
4	12750	355	75	3.33	2.78	2.13	1.69
5	9000	215	70	4.29	2.39	1.45	1.59

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60*K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 5.00

n = 0.100

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	34000	13.60	0.69	2.78	3	2.08	1.33
2	24000	8.70	0.77	3.06	4	3.06	1.00
3	46000	12.25	1.04	4.17	5	5.21	0.80
4	12750	7.31	0.48	1.94	2	0.97	2.00
5	9000	6.77	0.37	1.48	2	0.74	2.00

Table D-2. Rendija Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	12250	2180	58	7.24	17.80	1.15	1.02
2	9750	1520	58	7.24	15.59	0.71	0.91
3	9750	480	58	7.24	4.92	0.75	1.61
4	13000	1500	58	7.24	11.54	1.15	1.33
5	12500	1100	58	7.24	8.80	1.14	1.47
6	7500	215	69	4.49	2.87	1.05	1.29
7	13250	875	69	4.49	6.60	1.24	1.34
8	13250	385	69	4.49	2.91	1.67	2.02
9	6000	520	69	4.49	8.67	0.32	0.62
10	6000	280	69	4.49	4.67	0.41	0.85
All	48750	3540	63.40	5.78	7.26	9.59	4.20

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60*K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 1.00

n = 0.060

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	12250	10.48	0.32	1.30	2	0.65	2.00
2	9750	9.81	0.28	1.10	2	0.55	2.00
3	9750	5.51	0.49	1.97	2	0.98	2.00
4	13000	8.44	0.43	1.71	2	0.86	2.00
5	12500	7.37	0.47	1.89	2	0.94	2.00
6	7500	4.20	0.50	1.98	2	0.99	2.00
7	13250	6.38	0.58	2.31	3	1.73	1.33
8	13250	4.23	0.87	3.48	4	3.48	1.00
9	6000	7.31	0.23	0.91	1	0.23	4.00
10	6000	5.36	0.31	1.24	2	0.62	2.00
All	48750	6.69	2.01	8.09	9	8.20	0.44

Table D-3. Barrancas Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	25500	1245	72	3.89	4.88	1.79	2.42
2	7250	750	76	3.16	10.34	0.33	0.54
3	23000	1267	72	3.89	5.51	2.52	2.10
4	3250	365	76	3.16	11.23	0.21	0.27

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	25500	9.68	0.73	2.93	3	2.20	1.33
2	7250	14.09	0.14	0.57	1	0.14	4.00
3	23000	10.28	0.62	2.49	3	1.86	1.33
4	3250	14.68	0.06	0.25	1	0.06	4.00

Table D-4. Bayo Canyon Watershed							
HEC-1 Input Data File Parameter Calculation							
See UD Data Card for SCS Unit Hydrograph Lag Time Definitions							
T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)							
L = Channel Length to Water Divide (ft)							
X = Basin Elevation Change over Length (ft)							
CN = SCS Curve Number for AMC-II Moisture Conditions (dim)							
S = 1000/CN - 10 = Potential Rainfall Retention (in)							
Y = 100X/L = Gross Watershed Slope (%)							
A = Basin Drainage Area (square miles)							
Basin No.	**L (ft)**	**X (ft)**	**CN**	**S**	**Y (%)**	**A (sm)**	**T (hrs)**
1	16750	745	65	5.38	4.45	1.57	2.19
2	15250	535	74	3.51	3.51	1.16	1.79
3	12750	945	75	3.33	7.41	1.19	1.04
HEC-1 Input Data File Parameter Calculation							
See RM Data Card for Muskingum Routing Parameter Definitions							
0.1 < x < 0.3						x =	0.20
Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)						R (ft) =	5.00
K = L/(3600*Vel) (hrs)						n =	0.100
Nstps = 60K/NMIN (dimensionless)							
NSTPS = Interger Value for Nstps						NMIN =	15.00
NMIN = Minutes from Card IT						1/[2(1-x)]=	0.63
1/[2(1-x)] < Check < 1/(2x)						1/(2x)=	2.50
Check = (60K)/(NMIN*NSTPS)							
Basin No.	**L (ft)**	**Vel**	**K**	**Nstps**	**NSTPS**	**AMSKK**	**Check**
1	16750	9.24	0.50	2.01	3	1.51	1.33
2	15250	8.20	0.52	2.07	3	1.55	1.33
3	12750	11.92	0.30	1.19	2	0.59	2.00

Table D-5. Pueblo Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	15000	1930	90	1.11	12.87	2.24	0.54
2	24000	694	67	4.93	2.89	4.61	3.43
3	14000	246	74	3.51	1.76	1.55	2.37

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

1/[2(1-x)] < Check < 1/(2x)

Check = (60K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 5.00

n = 0.100

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	15000	15.71	0.27	1.06	2	0.53	2.00
2	24000	7.45	0.90	3.58	4	3.58	1.00
3	14000	5.81	0.67	2.68	3	2.01	1.33

Table D-6. Los Alamos Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	20000	1943	69	4.49	9.72	6.33	1.54
2	10000	531	81	2.35	5.31	0.74	0.84
3	35000	846	68	4.71	2.42	3.31	4.95
4	11750	525	80	2.50	4.47	1.96	1.08
5	5000	100	75	3.33	2.00	0.77	0.95
6	7750	165	75	3.33	2.13	0.67	1.30

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	20000	13.65	0.41	1.63	2	0.81	2.00
2	10000	10.09	0.28	1.10	2	0.55	2.00
3	35000	6.81	1.43	5.71	6	8.57	0.67
4	11750	9.26	0.35	1.41	2	0.71	2.00
5	5000	6.19	0.22	0.90	1	0.22	4.00
6	7750	6.39	0.34	1.35	2	0.67	2.00

Table D-7. Sandia Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	36750	1000	75	3.33	2.72	2.65	4.00
2	11750	370	75	3.33	3.15	0.85	1.49
3	10000	300	76	3.16	3.00	1.32	1.31
4	9000	635	79	2.66	7.06	0.75	0.72

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) R (ft) = 5.00

K = L/(3600*Vel) (hrs) n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps NMIN = 15.00

NMIN = Minutes from Card IT 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	36750	7.23	1.41	5.65	6	8.48	0.67
2	11750	7.77	0.42	1.68	2	0.84	2.00
3	10000	7.59	0.37	1.46	2	0.73	2.00
4	9000	11.63	0.21	0.86	1	0.21	4.00

Table D-8. Mortandad Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	9000	390	71	4.08	4.33	0.55	1.15
2	10500	277	68	4.71	2.64	0.81	1.81
3	6000	125	78	2.82	2.08	0.36	0.98
4	12250	203	73	3.70	1.66	1.61	2.25
5	16000	465	72	3.89	2.91	0.86	2.16
6	13500	855	74	3.51	6.33	1.72	1.21

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	9000	9.12	0.27	1.10	2	0.55	2.00
2	10500	7.11	0.41	1.64	2	0.82	2.00
3	6000	6.32	0.26	1.05	2	0.53	2.00
4	12250	5.64	0.60	2.41	3	1.81	1.33
5	16000	7.47	0.60	2.38	3	1.79	1.33
6	13500	11.02	0.34	1.36	2	0.68	2.00

Table D-9. Canada del Buey Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	29500	836	71	4.08	2.83	2.10	3.68
2	14750	1345	72	3.89	9.12	2.42	1.14

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	29500	7.37	1.11	4.45	5	5.56	0.80
2	14750	13.23	0.31	1.24	2	0.62	2.00

Table D-10. Pajarito Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	17250	2711	81	2.35	15.72	1.99	0.76
2	18250	795	79	2.66	4.36	2.57	1.60
3A(2-Mi N)	7000	2060	78	2.82	29.43	1.29	0.30
3B(2-Mi S)	17750	930	74	3.51	5.24	1.99	1.66
4	11000	205	76	3.16	1.86	0.67	1.79
5	19500	710	74	3.51	3.64	1.70	2.14
6	15000	225	72	3.89	1.50	1.15	2.86
7	15500	1050	73	3.70	6.77	2.24	1.34

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)

K = L/(3600*Vel) (hrs)

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps

NMIN = Minutes from Card IT

$1/[2(1-x)] < Check < 1/(2x)$

Check = (60K)/(NMIN*NSTPS)

x = 0.20

R (ft) = 5.00

n = 0.100

NMIN = 15.00

1/[2(1-x)]= 0.63

1/(2x)= 2.50

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	17250	17.36	0.28	1.10	2	0.55	2.00
2	18250	9.14	0.55	2.22	3	1.66	1.33
3A(2-Mi N)	7000	23.76	0.08	0.33	1	0.08	4.00
3B(2-Mi S)	17750	10.03	0.49	1.97	2	0.98	2.00
4	11000	5.98	0.51	2.04	3	1.53	1.33
5	19500	8.36	0.65	2.59	3	1.94	1.33
6	15000	5.36	0.78	3.11	4	3.11	1.00
7	15500	11.40	0.38	1.51	2	0.76	2.00

Table D-11. Potrillo Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	28500	875	77	2.99	3.07	2.78	2.90
2	18000	630	71	4.08	3.50	1.03	2.23
3	9750	620	75	3.33	6.36	0.96	0.90

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

$0.1 < x < 0.3$ x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) R (ft) = 5.00

K = L/(3600*Vel) (hrs) n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps NMIN = 15.00

NMIN = Minutes from Card IT 1/[2(1-x)]= 0.63

$1/[2(1-x)] < Check < 1/(2x)$ 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	28500	7.67	1.03	4.13	5	5.16	0.80
2	18000	8.19	0.61	2.44	3	1.83	1.33
3	9750	11.05	0.25	0.98	1	0.25	4.00

Table D-12. Water Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	18000	2305	89	1.24	12.81	4.07	0.66
2	17750	705	86	1.63	3.97	2.63	1.30
3	19000	405	72	3.89	2.13	1.42	2.90
4	13750	615	72	3.89	4.47	1.97	1.55
5	5000	405	77	2.99	8.10	0.32	0.44

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	18000	15.67	0.32	1.28	2	0.64	2.00
2	17750	8.73	0.56	2.26	3	1.69	1.33
3	19000	6.40	0.83	3.30	4	3.30	1.00
4	13750	9.26	0.41	1.65	2	0.82	2.00
5	5000	12.47	0.11	0.45	1	0.11	4.00

Table D-13. Valle Canyon Watershed							
HEC-1 Input Data File Parameter Calculation							
See UD Data Card for SCS Unit Hydrograph Lag Time Definitions							
T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)							
L = Channel Length to Water Divide (ft)							
X = Basin Elevation Change over Length (ft)							
CN = SCS Curve Number for AMC-II Moisture Conditions (dim)							
S = 1000/CN - 10 = Potential Rainfall Retention (in)							
Y = 100X/L = Gross Watershed Slope (%)							
A = Basin Drainage Area (square miles)							
Basin No.	**L (ft)**	**X (ft)**	**CN**	**S**	**Y (%)**	**A (sm)**	**T (hrs)**
1	22500	2756	92	0.87	12.25	2.33	0.71
2	7500	393	80	2.50	5.24	0.78	0.70
3	12500	477	80	2.50	3.82	1.17	1.23
HEC-1 Input Data File Parameter Calculation							
See RM Data Card for Muskingum Routing Parameter Definitions							
0.1 < x < 0.3						x =	0.20
Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec)						R (ft) =	5.00
K = L/(3600*Vel) (hrs)						n =	0.100
Nstps = 60K/NMIN (dimensionless)							
NSTPS = Interger Value for Nstps						NMIN =	15.00
NMIN = Minutes from Card IT						1/[2(1-x)]=	0.63
1/[2(1-x)] < Check < 1/(2x)						1/(2x)=	2.50
Check = (60K)/(NMIN*NSTPS)							
Basin No.	**L (ft)**	**Vel**	**K**	**Nstps**	**NSTPS**	**AMSKK**	**Check**
1	22500	15.33	0.41	1.63	2	0.82	2.00
2	7500	10.03	0.21	0.83	1	0.21	4.00
3	12500	8.56	0.41	1.62	2	0.81	2.00

Table D-14. Ancho Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	25750	1044	68	4.71	4.05	2.19	2.99
2	22000	1035	70	4.29	4.70	2.48	2.32
3	13000	1102	74	3.51	8.48	1.11	1.01
4	10000	688	75	3.33	6.88	1.04	0.89
5	2500	168	75	3.33	6.72	0.19	0.30

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60*K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	25750	8.82	0.81	3.24	4	3.24	1.00
2	22000	9.50	0.64	2.57	3	1.93	1.33
3	13000	12.75	0.28	1.13	2	0.57	2.00
4	10000	11.49	0.24	0.97	1	0.24	4.00
5	2500	11.35	0.06	0.24	1	0.06	4.00

Table D-15. Chaquequi Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	16500	1292	73	3.70	7.83	1.50	1.31

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	16500	12.26	0.37	1.50	2	0.75	2.00

Table D-16. Frijoles Canyon Watershed

HEC-1 Input Data File Parameter Calculation

See UD Data Card for SCS Unit Hydrograph Lag Time Definitions

T = $(L^{0.8})(S+1)^{0.7}/(1900Y^{0.5})$ = SCS Basin Lag Time (hrs)

L = Channel Length to Water Divide (ft)

X = Basin Elevation Change over Length (ft)

CN = SCS Curve Number for AMC-II Moisture Conditions (dim)

S = 1000/CN - 10 = Potential Rainfall Retention (in)

Y = 100X/L = Gross Watershed Slope (%)

A = Basin Drainage Area (square miles)

Basin No.	L (ft)	X (ft)	CN	S	Y (%)	A (sm)	T (hrs)
1	20200	2499	60	6.67	12.37	4.97	1.73
2	24400	1030	70	4.29	4.22	4.92	2.66
3	24000	633	68	4.71	2.64	8.13	3.50

HEC-1 Input Data File Parameter Calculation

See RM Data Card for Muskingum Routing Parameter Definitions

0.1 < x < 0.3 — x = 0.20

Vel = $1.49R^{0.67}S^{0.5}/n$ (ft/sec) — R (ft) = 5.00

K = L/(3600*Vel) (hrs) — n = 0.100

Nstps = 60K/NMIN (dimensionless)

NSTPS = Interger Value for Nstps — NMIN = 15.00

NMIN = Minutes from Card IT — 1/[2(1-x)]= 0.63

1/[2(1-x)] < Check < 1/(2x) — 1/(2x)= 2.50

Check = (60K)/(NMIN*NSTPS)

Basin No.	L (ft)	Vel	K	Nstps	NSTPS	AMSKK	Check
1	20200	15.41	0.36	1.46	2	0.73	2.00
2	24400	9.00	0.75	3.01	4	3.01	1.00
3	24000	7.11	0.94	3.75	4	3.75	1.00

Appendix E

Appendix E. HEC-HMS input data file for Pajarito Canyon.

```
ID    LOS ALAMOS NATIONAL LABORATORY
ID    POST-CERRO GRANDE WILDFIRE - PAJARITO CANYON WATERSHED
ID    HEC-1 SIMULATION - 100-YR, 6-HR DESIGN STORM FOR LOS ALAMOS
ID    S.G. McLin, ESH-18, MS-K497, 505-665-1721
IT   15 28JUN00    00   197
IO   0    0
PG GAG1   3.91
PG GAG2   2.73
PG GAG3   2.73
PG GAG4   2.10
PG GAG5   2.27
PG GAG6   1.86
PG GAG7   1.59
PG LADS
IN   15    0    0
PC .0000  .0051  .0106  .0167  .0234  .0310  .0397  .0499  .0624  .0784
PC .1012  .1424  .8081  .8797  .9090  .9278  .9418  .9530  .9624  .9705
PC .9777  .9840  .9898  .9951 1.0000
KKPAJ1
KM    PAJARITO C. ABOVE HW-501 AT WEST DOE BOUNDARY
KO                      22
BA 1.99
PR LADS
PW   1
PT GAG1
PW   1
LS   0    84
UD  .69
KKRTE2
KM    ROUTE FLOW THRU PAJ2
KO                      22
RM   3   1.66   0.2
KKPAJ2
KM    PAJARITO C. BELOW HW-501 AND ABOVE 2-MILE CANYON CONFLUENCE
KO                      22
BA 2.57
PR LADS
PW   1
PT GAG2
PW   1
LS   0    83
UD 1.41
KKQP2
KM    COMBINED PAJARITO C. FLOW ABOVE 2-MILE CONFLUENCE
KO                      22
HC   2
KK2-MI
KM    2-MILE CANYON ABOVE PAJARITO CONFLUENCE = PAJARITO BASIN #3
KO                      22
BA 3.28
PR LADS
PW   1
```

Appendix E. HEC-HMS input data file for Pajarito Canyon (continued).

```
PT  GAG3
PW    1
LS    0     81
UD  1.39
KKQ2MI
KM      COMBINED FLOW BELOW PAJARITO-2 MILE CANYON CONFLUENCE
KO                          22
HC    2
KK2MIDAM
KMRESERVOIR AT PAJARITO AND 2MI CONFLUENCE
KO                          22
RS    1   ELEV   6928
SA    0    .37   1.33   4.02   7.46   9.78   13.17   16.9   17.6   26.6
SE 6928   6930   6940   6950   6960   6970   6980   6990   7000   7010
SL6928.7   9.62   0.55   0.5
SS6996.0  200.0    3.1    1.5
KKRTE4
KM      ROUTE FLOW THRU PAJ4
KO                          22
RM    3   1.53    0.2
KKPAJ4
KM      PAJARITO BETWEEN 2-MI & 3-MI CANYONS
KO                          22
BA  0.67
PR  LADS
PW    1
PT  GAG4
PW    1
LS    0     80
UD  1.58
KKQP4
KM      COMBINED PAJARITO C. FLOW ABOVE 3-MILE CONFLUENCE
KO                          22
HC    2
KKPAJ5
KM      3-MILE CANYON = PAJARITO BASIN #5
KO                          22
BA  1.70
PR  LADS
PW    1
PT  GAG5
PW    1
LS    0     79
UD  1.85
KKQ3MI
KM      COMBINED FLOW BELOW PAJARITO-3 MILE CANYON CONFLUENCE
KO                          22
HC    2
KKRTE6
KM      ROUTE FLOW THRU PAJ6
KO                          22
RM    4   3.11    0.2
```

Appendix E. HEC-HMS input data file for Pajarito Canyon (continued).

```
KKPAJ6
KM    PAJARITO C. AT WHITE ROCK ABOVE HW-4
KO                    22
BA 1.15
PR LADS
PW   1
PT GAG6
PW   1
LS   0    76
UD 2.55
KKQHW4
KM    COMBINED PAJARITO C. FLOW AT EAST DOE LINE (HW-4 AT WHITE ROCK)
KO                    22
HC   2
KKRTE7
KM    ROUTE FLOW THRU PAJ7 = PAJARITO ACRES
KO                    22
RM   2   0.76   0.2
KKPAJ7
KM    WHITE ROCK - PAJARITO ACRES BELOW HW-4
KO                    22
BA 2.24
PR LADS
PW   1
PT GAG7
PW   1
LS   0    77    5
UD 1.20
KKQPRIO
KM    COMBINED PAJARITO FLOW INTO RIO GRANDE
KO                    22
HC   2
ZZ
```

Appendix F

Table F-1. Cerro Grande Burned Areages by Watershed

SUMMARY OF BURNED AREAS AND BURN INTENSITY BY DRAINAGE BASIN					
		Fire Intensity			
Basin	Total Sq. Mi.	Low	Moderate	High	Unburned
Los Alamos Canyon					
LA-1	6.36	2.88	0.01	1.82	1.64
LA-2	0.78	0.14	0.03	0.45	0.16
LA-3	3.29				3.29
LA-4	1.98				1.98
LA-5	0.65				0.65
LA-6	0.75				0.75
TOTALS:	**13.81**	**3.02**	**0.04**	**2.28**	**8.47**
Pajarito Canyon					
PAJ-1	1.99	0.70	0.06	1.03	0.20
PAJ-2	2.52	1.94	0.10	0.44	0.05
PAJ-3	3.18	2.08	0.19	0.48	0.44
PAJ-4	0.65	0.64			0.01
PAJ-5	1.68	1.53			0.15
PAJ-6	1.08	0.01			1.07
PAJ-7	2.20				2.20
TOTALS:	**13.30**	**6.90**	**0.35**	**1.94**	**4.11**
Sandia Canyon					
SAN-1	2.64	1.01			1.63
SAN-2	0.87				0.87
SAN-3	1.39				1.39
SAN-4	0.69				0.69
TOTALS:	**5.59**	**1.01**			**4.58**

VARIABILITY IN WEIGHTED AVE CN VALUES BY DRAINAGE BASIN					
		Weighted Ave CN Values			BAER
Basin	Original CN	Min	Expected	Max	FS
Fire Intensity CN					
Low		75	80	85	65
Moderate		80	85	90	85
High		85	90	95	90
Unburned	OCN	OCN-4	OCN	OCN+4	OCN
Los Alamos Canyon					
LA-1	52	71	76	80	69
LA-2	62	77	82	87	80
LA-3	68	64	68	72	68
LA-4	80	76	80	84	80
LA-5	75	71	75	79	75
LA-6	75	71	75	79	75
Pajarito Canyon					
PAJ-1	52	78	82	87	77
PAJ-2	62	77	82	87	70
PAJ-3	61	74	79	84	69
PAJ-4	70	75	80	85	65
PAJ-5	67	74	79	84	65
PAJ-6	72	68	72	76	72
PAJ-7	73	69	73	77	73
Sandia Canyon					
SAN-1	68	68	73	77	67
SAN-2	75	71	75	79	75
SAN-3	76	72	76	80	76
SAN-4	79	75	79	83	79

Table F-1. Cerro Grande Burned Areages by Watershed

SUMMARY OF BURNED AREAS AND BURN INTENSITY BY DRAINAGE BASIN					
		Fire Intensity			
Basin	Total Sq. Mi.	Low	Moderate	High	Unburned
Mortandad Canyon					
MOR-1	0.56	0.28	0.14		0.14
MOR-2	0.82	0.81	0.02		0.00
MOR-3	0.37	0.23	0.14		0.00
MOR-4	1.56	0.73	0.11		0.72
MOR-5	0.89	0.09	0.01		0.79
MOR-6	1.69				1.69
TOTALS:	**5.89**	**2.13**	**0.42**		**3.34**
Canada del Buey					
CAN-1	2.05	0.64	0.21		1.21
CAN-2	2.41		0.00		2.41
TOTALS:	**4.47**	**0.64**	**0.21**		**3.61**
Potrillo Canyon					
POT-1	2.69	0.62			2.07
POT-2	0.98	0.01			0.98
POT-3	0.97				0.97
TOTALS:	**4.64**	**0.63**			**4.01**
Canon de Valle					
VAL-1	2.35	1.69	0.10	0.42	0.13
VAL-2	0.82	0.79	0.03		0.00
VAL-3	1.15	1.11	0.05		0.00
TOTALS:	**4.32**	**3.59**	**0.18**	**0.42**	**0.13**
Water Canyon					
WAT-1	3.85	1.99	0.19	1.62	0.05
WAT-2	2.58	1.92	0.60		0.07
WAT-3	1.36	0.21			1.15
WAT-4	1.90				1.90
WAT-5	0.32				0.32
TOTALS:	**10.01**	**4.12**	**0.78**	**1.62**	**3.47**

VARIABILITY IN WEIGHTED AVE CN VALUES BY DRAINAGE BASIN					
		Weighted Ave CN Values			BAER
Basin	Original CN	Min	Expected	Max	FS
Mortandad Canyon					
MOR-1	65	73	77	82	70
MOR-2	67	75	80	85	65
MOR-3	72	77	82	87	73
MOR-4	72	72	77	81	70
MOR-5	72	69	73	77	71
MOR-6	74	70	74	78	74
Canada del Buey					
CAN-1	69	70	74	78	69
CAN-2	72	68	72	76	72
Potrillo Canyon					
POT-1	70	68	72	77	69
POT-2	71	67	71	75	71
POT-3	75	71	75	79	75
Canon de Valle					
VAL-1	53	76	81	85	70
VAL-2	63	75	80	85	66
VAL-3	64	75	80	85	66
Water Canyon					
WAT-1	54	79	84	89	76
WAT-2	62	76	81	86	70
WAT-3	72	69	73	77	71
WAT-4	72	68	72	76	72
WAT-5	77	73	77	81	77

Table F-1. Cerro Grande Burned Areages by Watershed

SUMMARY OF BURNED AREAS AND BURN INTENSITY BY DRAINAGE BASIN						VARIABILITY IN WEIGHTED AVE CN VALUES BY DRAINAGE BASIN					
		Fire Intensity						Weighted Ave CN Values			BAER
Basin	Total Sq. Mi.	Low	Moderate	High	Unburned	Basin	Original CN	Min	Expected	Max	FS
Ancho Canyon						***Ancho Canyon***					
ANC-1	2.24				2.24	ANC-1	68	64	68	72	68
ANC-2	2.42	0.18			2.24	ANC-2	69	66	70	74	69
ANC-3	1.11				1.11	ANC-3	74	70	74	78	74
ANC-4	1.04				1.04	ANC-4	75	71	75	79	75
ANC-5	0.19				0.19	ANC-5	75	71	75	79	75
TOTALS:	**7.01**	**0.18**			**6.83**						
Frijoles Canyon						***Frijoles Canyon***					
FRI-1	5.10	1.25	0.06	0.05	3.74	FRI-1	50	54	58	62	54
FRI-2	5.04	0.07	0.04	0.02	4.91	FRI-2	70	66	70	74	70
FRI-3	8.30	0.31	0.01	0.08	7.89	FRI-3	68	65	69	73	68
TOTALS:	**18.43**	**1.63**	**0.12**	**0.15**	**16.54**						
Pueblo Canyon						***Pueblo Canyon***					
PUE-1	2.27	0.04	0.03	2.18	0.01	PUE-1	56	85	90	95	89
PUE-2	4.61	0.13	0.08	0.24	4.16	PUE-2	65	63	67	71	67
PUE-3	1.55				1.55	PUE-3	74	70	74	78	74
TOTALS:	**8.42**	**0.17**	**0.11**	**2.42**	**5.72**						
Guaje Canyon						***Guaje Canyon***					
G-1	11.37	6.27		2.28	2.82	G-1	55	71	76	81	68
G-2	3.20	1.47	0.13	1.07	0.53	G-2	68	77	82	86	75
G-4	2.18				2.18	G-4	75	71	75	79	75
G-5	1.45				1.45	G-5	70	66	70	74	70
TOTALS:	**18.20**	**7.74**	**0.13**	**3.35**	**6.99**						
Rendija Canyon						***Rendija Canyon***					
REND	9.58	1.26	0.59	5.43	2.30	REND	69	79	83	88	81