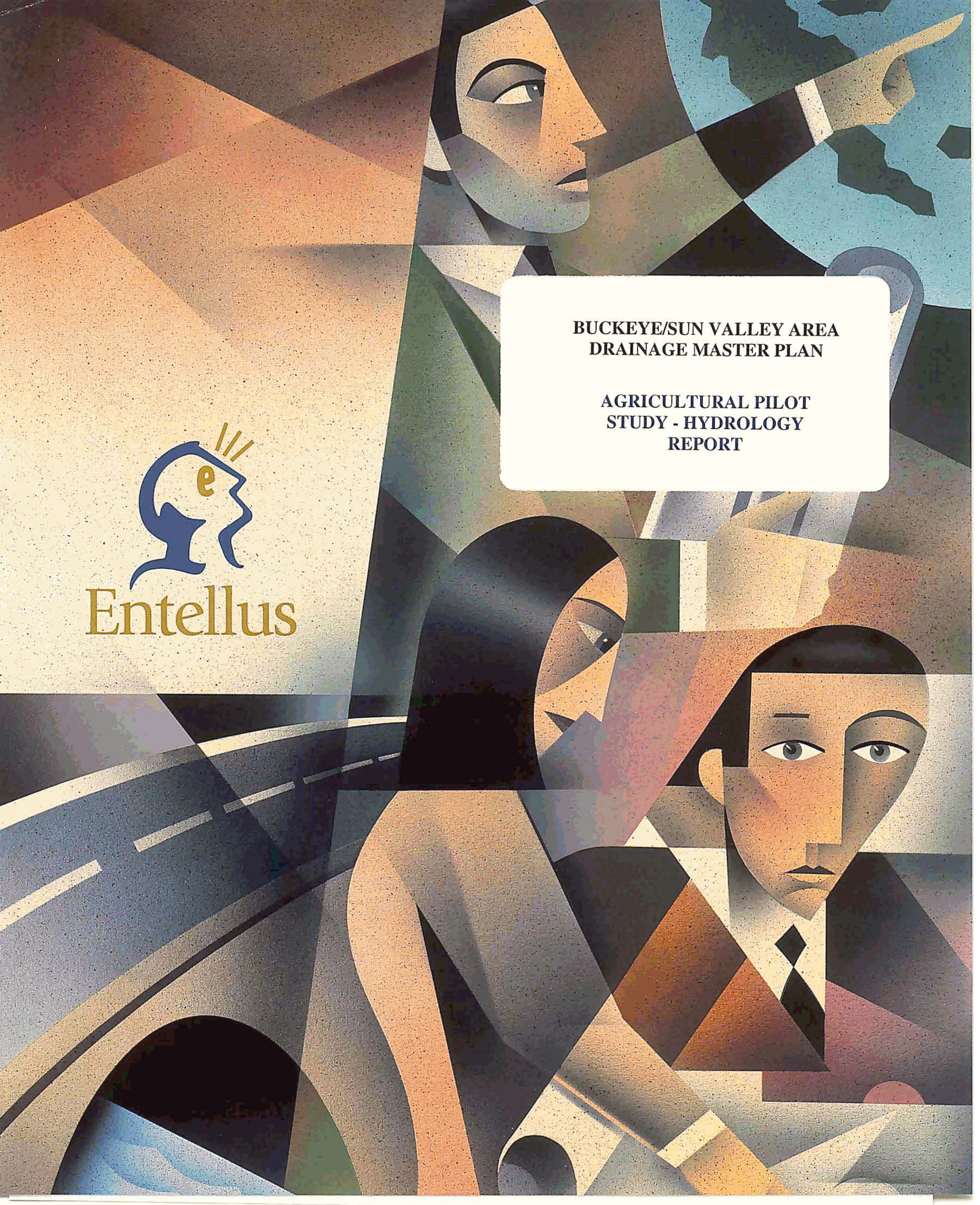

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BUCKEYE/SUN VALLEY AREA DRAINAGE MASTER PLAN

AGRICULTURAL PILOT STUDY - HYDROLOGY REPORT

Flood Control District of Maricopa County

BUCKEYE/SUN VALLEY AREA
DRAINAGE MASTER STUDY

AGRICULTURAL PILOT STUDY
HYDROLOGY REPORT

Contract FCD 2002C029

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Prepared for:

PBS&J

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HFM
Engineering, Inc.

BUCKEYE/SUN VALLEY AREA DRAINAGE MASTER STUDY

AGRICULTURAL PILOT STUDY HYDROLOGY REPORT

Registered Professional Engineer (Civil)
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1: INTRODUCTION

1.1 Background and Purpose

This pilot study was performed by Entellus, Inc., for PBS&J on behalf of the Flood Control District of Maricopa County (District), to refine current methods and assumptions used to determine runoff from irrigated farmlands. The work was performed as part of the Buckeye/Sun Valley Area Drainage Master Study (ADMS), which includes large areas of farmlands surrounding the Town of Buckeye.

Current methods used in Maricopa County assume that agricultural areas are completely saturated with irrigation water prior to a storm. This assumption was intended to produce a worst case scenario because it results in high estimates of peak runoff and volumes and was thought to represent a worst-case scenario for designing downstream conveyance facilities. Recently, the District has become concerned that the current methodology results in artificially high estimates of runoff because it ignores the high retention capability in the irrigated fields. In addition, it was found that the assumption of completely saturated fields needed to be revised because neither the irrigation infrastructure nor water supplies allow for this condition.

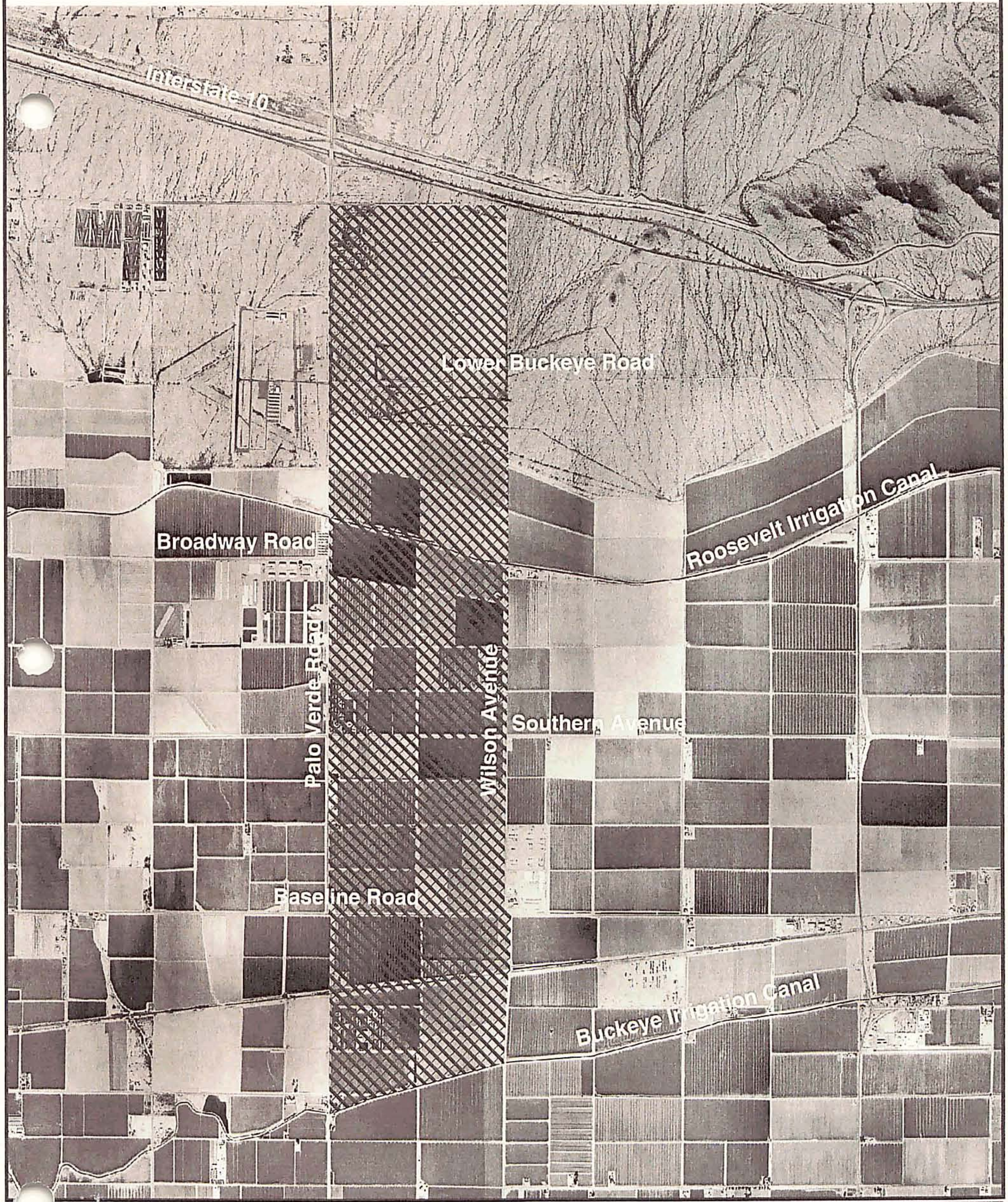
Overestimating the amount of existing runoff from an area can have undesirable consequences. One consequence is that infrastructure constructed to convey runoff may be oversized, or overly restrictive (a floodplain or floodway could be artificially wider than it needs to be). Another consequence is that if farmlands are converted to residential developments, hydrology models may predict that post-development runoff will decrease or stay the same. In fact, the amount of runoff is expected to increase, and as irrigated land is developed flooding problems downstream would increase.

Since many agricultural areas are being converted to residential or urban land uses, overestimating runoff from agricultural areas has significant impacts. This study will address this concern by refining current methods and assumptions used to determine runoff from agricultural areas in Maricopa County. The current District standards were referenced from the *Drainage Design Manual for Maricopa County - Hydrology (Draft), November 2003* (**Reference 1**), hereinafter referred to as the *Hydrology Manual.*

1.2 Study Area

As shown in **Figure 1-1**, a pilot study area was selected within the Buckeye/Sun Valley watershed. This area was selected because of its diverse variety of agricultural scenarios. The study area is about five square miles and is bounded on the north by Lower Buckeye Road, on the south by the Buckeye Canal, on the east by Wilson Avenue, and on the west by Palo Verde Road. Various crops are grown within this area, including barley, alfalfa, soy, cotton, wheat, and corn. Irrigation water is supplied by the Roosevelt Irrigation District (RID) via the Roosevelt Canal. Fields upstream of the canal are irrigated by pumping water from the canal. Water is delivered to downstream fields by a series of header and feeder ditches.

The pilot study area is almost entirely agricultural farm lands, but does include three dairies and several homes. North of the study area there are some abandoned agricultural fields and the small residential community of Hopeville. The natural drainage pattern is from north to south, and there is minimal offsite drainage from the upstream areas because offsite runoff is intercepted by Interstate 10 and Buckeye Flood Retarding Structure #1.



Pilot Study Area

BUCKEYE SUN VALLEY AREA DRAINAGE STUDY

Agricultural Pilot Study

FIGURE 1-1: PILOT STUDY AREA

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1.3 Study Process

The study process was originally defined by the Scope of Work for the Buckeye Sun Valley ADMS, and later detailed in the Proposed Pilot Study Plan dated April 13, 2004. These documents are included in **Appendix B.1.** There were some deviations from the specific methods used during the study process, but the overall process did not change. The study process included the following major steps: Data Collection, Calibration of Parameters, Modeling of the Pilot Study Area, and Recommendations for District Methodology Changes. Data was collected from various sources in order to determine typical hydrologic characteristics of the fields within the study area. Many documents were found that contained data that was useful to the study, and are listed in **Appendix A**. This data was used to calibrate hydrologic parameters. The calibrated hydrologic parameters were used to model the pilot study area. Finally, recommendations were made on how the District methodology could be modified to represent agricultural developments throughout Maricopa County. These processes are documented and described further throughout the remainder of this report. The final section of this report includes suggestions for further studies into the hydrologic modeling of agricultural areas for Maricopa County.

SECTION 2: DATA COLLECTION

2.1 Literature Review

A literature review was performed to obtain data on previous similar studies that could be used to verify results and assumptions. Many sources were found that contained information related to agricultural hydrology in general. These sources were reviewed and the relevant information was used throughout the study. Very little information was found that was specific to the study area. The most relevant sources of information found included:

- A technical memorandum dated January 14th, 1992 to the Flood Control District from Mr. George Sabol **(Reference 2).** The technical memorandum was included in *Appendix BB of the 1992 Buckeye Area Flood Delineation Study,* **(Reference 3)**. The study was prepared by McLaughlin Kmetty Engineers and will be referred to as the *MKE Study.* Likewise, the previously mentioned technical memorandum will be referred to as the *MKE Tech Memo.* As part of the *MKE Study*, a lag time expression for modeling agricultural fields was developed that was based on Manning's roughness values for sheet flow.

- Flood Runoff Analysis by the Corp of Engineers (COE) **(Reference 4).** The initial abstraction for agricultural fields was estimated to be between 0.5 and 1.0 inches.

Table 2.1 lists the various reports, articles, books, and studies that were reviewed.

Table 2.1: Literature Review Summary

Title	Reference Number[1]	Relevant Information
McLaughlin Kmetty Report	2,3	Lag time expression for agricultural fields based on Manning's roughness for overland flows
COE - Flood Runoff Analysis	4	Study findings show that the initial abstractions for agricultural fields can range between 0.5 and 1.5 inches
Effect of Rain Intensity on Infiltration and Surface Runoff Rates	5	Supports the assumption that the infiltration and abstraction characteristics of a field are similar for irrigation and rainfall events
Development and Evaluation of a Dimensionless Unit Hydrograph	6	Study findings show that the SCS method overestimates peak flows for agricultural watersheds.
Guidelines for Designing and Evaluating Surface Irrigation Systems	7	Extensive information on how field efficiency tests are performed, how furrow and border irrigation is designed, and infiltration characteristics of furrow and border irrigated fields.
Using Curve Numbers to Determine Baseline Values of Green-Ampt Effective Hydraulic Conductivities	8	Develops an expression for estimating hydraulic conductivities using SCS curve numbers
Using Field Scale Models to Predict Peak Flows on Agricultural Watersheds	9	Presents a new methodology for determining peak flows from agricultural watersheds (field-scale modeling)
Quantifying Model Output Uncertainty Due to Spatial Variability of Rainfall	10	Discusses how the non-homogenous nature of rainfall affects the accuracy of runoff models on agricultural fields
Adjusting Irrigation Abstraction to Minimize the Impact on Stream Flow	11	Detailed investigation into the determination and management of field abstraction and the subsequent hydrologic response

[1] See Appendix A for complete reference information.

2.2 Irrigation Practices

The area selected for this study includes surface-irrigated fields using both border and furrow configurations. Fields using border irrigation include crops such as alfalfa and barley. Fields using furrow irrigation include crops such as cotton and corn. Irrigation water is supplied to the area by the RID Canal. There are two main lateral ditches that distribute irrigation water to the individual fields. Each field is supplied by its own header ditch. During normal irrigation, the downstream gate is closed to increase the water surface in the ditch and facilitate delivery of water. Water is delivered by opening gates on the side of the canal, or by siphon pipes placed on the side of the ditch. The study area uses a recycling tailwater system, where the irrigation runoff from one field is discharged into the downstream distribution ditch and is available for use somewhere else in the system. The downstream fields use tailwater ponds to store water, and in most cases this water is pumped back upstream and reused. Most of the fields have a structure at the downstream end to collect the tailwater and direct it to downstream distribution ditches.

The irrigation schedule within the study area is not rigid, and the individual farmers have the ability to order water depending on their particular needs. However, there are limitations to the amount of water available and how much water the system can actually deliver. Based on surveys from farmers in the study area, the water supply and delivery system limits the amount available for irrigation, and results in some fields not being planted or being left in fallow. When fields are in fallow or are not planted, they are not irrigated and the soil moisture conditions become dry. According to farmers, typically about 1 out of 10 fields are typically in fallow or not planted. The farmers also indicated that the capacity of the distribution system doesn't allow them to keep more than 1/3 of their fields saturated at any given time. Information collected from farmers and water masters is included in **Appendix B.2**. In order to better estimate how irrigation practices affect typical soil moisture conditions, future studies should include soil sampling and tests. Further discussion regarding recommendations for future studies is included in **Section 6**.

The rest of the Buckeye area, outside of the pilot study area, is either supplied by the RID Canal or the Buckeye Canal, and would have similar limitations and be irrigated in a very similar way. The operation of this system is typical of most of the agricultural areas in Maricopa County, although each system has unique characteristics. For example, some suppliers with surface water sources have more rigorous water delivery schedules, while others use groundwater that allows more flexibility in scheduling irrigation.

Water in Maricopa County is scarce and often relatively expensive. As such, most irrigation practices are geared to make the most of the available supply and it is a common practice to minimize inefficiencies. Typically tailwater is either re-circulated or not allowed to leave the fields. This was observed in the study area and is typical throughout the County.

Surface irrigation is the most common irrigation practice throughout Maricopa County. However, there are some areas that are sprinkle irrigated. This type of irrigation usually uses underground pressurized delivery pipe networks and does not have the canal network typical of surface irrigation. Therefore, runoff may move more freely in agricultural areas with sprinkler irrigation. Typically, sprinkle irrigated areas do not have a tailwater system but are configured to retain the irrigation water. The results of this study may or may not be applicable to these types of irrigation practices, and the current District methodology (except for the adjusted DTHETA value), may be more applicable. It is not expected that the DTHETA value would change in sprinkler irrigated fields because the moisture content of the soil is ultimately limited by the supply of water, which would be the same regardless of sprinkler or surface irrigation.

2.3 Crop Rotation

The Buckeye agricultural area grows several different crops. The most prevalent crops observed in the area are:

Alfalfa	**Cotton**
Wheat	**Corn**
Barley	**Soy**

Fields in the study area are rotated among these crops depending on demand, water availability, and season. A typical alfalfa field is maintained for approximately five years before it needs to be replanted. The other crops can be rotated each harvest season. Typically, fields need to be rotated to maintain crop yield and it is a typical practice through Maricopa County. Photographs of various crops and irrigation infrastructure throughout the study area have been included in **Appendix B.5**.

2.4 Observed Conditions

The Buckeye area is irrigated from water mainly supplied by one of the two main canal companies. The distribution system consists of an interconnected network of canals. The distribution system canals are, for the most part, above-ground concrete lined canals and appear to be in good condition. The fields are typically lower than the surrounding ground and are enclosed by berms ranging from 8 inches to 3 feet.

The weakest part of the infrastructure is the berm at the end of the fields. Most of the fields have an adequate berm at the downstream end of the field to retain significant volumes of water. However, a few of the fields have berms that did not appear to be able to withstand a significant amount of flow. Even though these berms did not have the capability to hold the excess water, in most cases the runoff would cross the road and spill into the downstream distribution ditch.

The study area contains many irrigation and tailwater ditches. These ditches have the ability to move irrigation flow and runoff in and out of the study area. Because the area uses a tailwater recirculation system, runoff from offsite fields could enter the canals or ditches, and flow into the study area. Conversely, flow from the study area could be carried away by the irrigation ditches and flow into a field several miles away. For this study it was assumed that the affects of water entering the system and leaving the system would offset each other.

2.5 Hydrologic Data

There were no measurements of rainfall runoff available in the area. However, the Buckeye/Sun Valley National Resources Conservation District (NRCD) collected irrigation efficiency data for several fields within the study area that included measurements of irrigation flows, tailwater volumes and timing. These measurements were the main source of hydrologic data used in the study. Privacy issues prevented the NRCD from providing detailed efficiency test records to the study team. However, the NRCD did provide three sampled test records for fields within the study that it said were representative of most fields in the area. The NRCD field efficiency tests were performed on a lengthwise strip of each field, referred to as a set. The sets covered the entire length of the fields, but only a portion of the fields' widths. One set from each field was recorded by the NRCD. The test records have been reproduced and included in **Appendix B.4**.

The general information related to irrigation and runoff included in the efficiency tests appeared to be consistent with observed data and information collected from farmers. The specific results of the NRCD data (peak runoff, runoff volume, and advance time) tended to vary for the three obtained test records. The main differences in the data appeared to be related to how the fields were irrigated (furrow or border). The limited amount of data that was available did not allow for distinctions to be made based on crop types.

SECTION 3: CALIBRATION OF PARAMETERS

The goal of the calibration process was to develop modeling parameters and techniques that represented the pilot study area based on information gathered during the data collection process. The first step was to select parameters to be calibrated. The parameters chosen for calibration were those that could be related directly to the physical conditions observed in the fields and were: lag time, soil moisture deficit, and initial abstraction. Data observed from three field sets were used to determine lag times and initial abstractions.

The lag time was calibrated based on irrigation advance times obtained from the NRCD data. It was found that by using a modified Kn value in the District's lag time equation, the lag times estimated using the observed advance times could be reproduced. The resulting Kn values were reasonable, and an average Kn value was determined using the three observed sets.

In the District methodology, the volume of runoff is determined using the Green and Ampt equation and the initial abstraction (IA). The Green and Ampt equation accounts for infiltration and rainfall losses, while the initial abstraction accounts for surface retention, canopy interception, and other losses. Using the observed runoff volume from the NRCD sets, the initial abstraction was calibrated. An average initial abstraction value for the observed field sets was estimated using a Green and Ampt based runoff model referred to as the *Observed Sets Model.*

In order to account for the typical initial soil moisture deficit of the fields within the study area, an average DTHETA value was estimated using data collected from farmers, water masters, and the NRCD.

The calibrated parameters for the sets (IA, DTHETA, Kn) were applied to a complete field. Typically, in the types of hydrologic analysis undertaken by the District, single fields are too small to be modeled as subbasins. Therefore, further adjustment and calibration were required in order to model groups of fields. Two models were developed that simulated a typical system of fields subjected to rainfall events. The first model, referred to as *System Model 1*, used the parameters developed for individual fields to model a system of ten fields modeled as ten subbasins. Each subbasin was routed through the next downstream subbasin, where the outflow was combined and routed through the next downstream subbasin. The model continued this process until the last subbasin was reached, where an outflow hydrograph was estimated. This arrangement of subbasins and routes represented the systems of fields and drainage infrastructure typical throughout the study area.

The second model, referred to as *System Model 2*, modeled the same system of fields as a single subbasin. The initial abstraction and Kn values used in the second model were adjusted until the outflow hydrograph matched the outflow hydrograph from *System Model 1*. The resulting initial abstraction and Kn values were assumed to be representative of typical systems of fields throughout the study area.

The calibration process and results are discussed further throughout the remainder of this section, and are illustrated in **Figure 3-1**.

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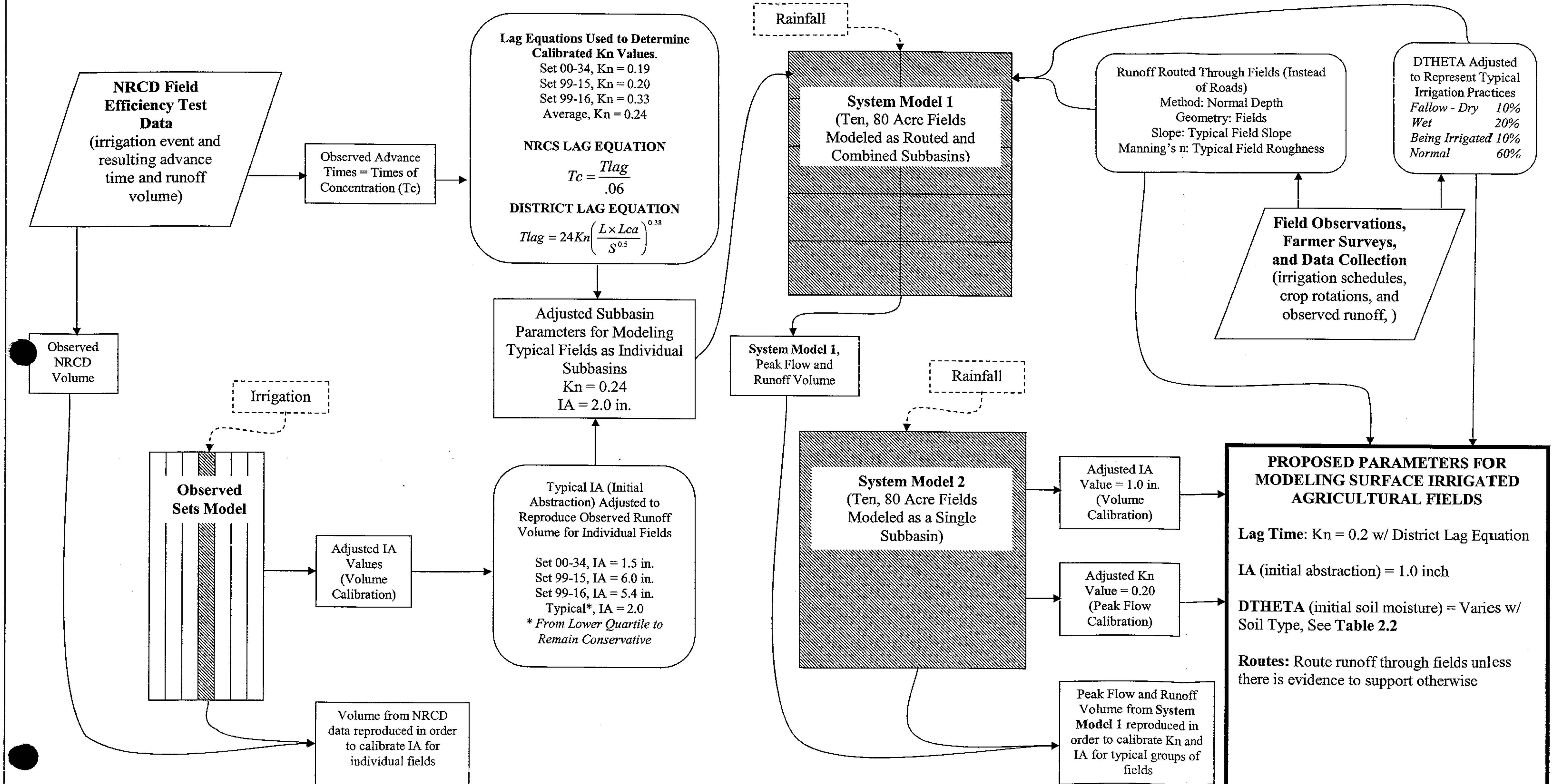
Buckeye Sun Valley Area Drainage Master Study
Agricultural Pilot Study

FIGURE 3-1: CALIBRATION PROCESS



3.1 Calibration of Kn for Observed NRCD Sets/Individual Fields

The NRCD field observations were utilized to develop lag times for individual agricultural fields. The lag time estimates were based on observed advance times through the observed field sets. The advance time was defined as the time elapsed between the start of the irrigation event and the occurrence of measurable tailwater runoff. The field efficiency tests by the NRCD showed the advance times for the sampled sets, and have been included in **Appendix B.4**.

Key Assumption 1: *It was assumed that the time it takes water to move through the field will be similar for both irrigation events and storm events. Thus, the times of concentration for the fields were assumed to be the same as the observed irrigation advance times.*

With the times of concentration assumed to equal the observed advance times, the observed lag time was estimated using *Equation 15.3* from the *National Resources Soil Conservation Service, National Engineering Handbook - Section 4: Hydrology* **(Reference 12)**, hereinafter called the *NRCS NEH,* shown below:

Lag Time = 0.6 x Time of Concentration

This equation is typically used to estimate lag times when the time of concentration is known. Using the assumptions described above, *Equation15.3* translates to:

Lag Time = 0.6 x Observed Advance Time

The District uses an empirical equation to estimate lag times. This equation relates parameters such as watershed slope, roughness and length to the lag time. The current District lag time equation is shown below:

District Lag Time Equation

$$L = C\left(\frac{L_{FP} \times L_{ca}}{S^{p}}\right)^{m}$$

$$C = C_1 Kn$$

Where:

L = lag time, in hours

L_{FP} = length of longest watercourse, in miles

L_{ca} = length along the watercourse slope to a point opposite the centroid, in miles

S = watercourse slope, in feet/mile

m = .38 (Corp of Engineers), m = .33 (USBR), m = .38 (Used for this Study)

p = 0.5 (District Manual)

Kn = Estimated mean Manning's n for all channels within an area = .10 (Average Value Recommended in District Manual for Agricultural Areas)

C_1 = 24 (Corp of Engineers), C_1 = 26 (USBR), C_1 = 24 (Used for this Study)

For each NRCD observed set, the Kn value was adjusted until the District's lag time equation reproduced the lag times estimated using the advance times from the NRCD data. The Kn values were averaged in order to determine a typical Kn value representative of the sampled NRCD field sets. **Table 3.1** shows the observed advance times, estimated lag times, and corresponding Kn values.

Key Assumption 2: *The calibrated values of Kn for the NRCD sets can be used to model a complete field.*

This was considered a reasonable assumption because Kn represents the average subbasin roughness which would be the same for all sets within a field.

Table 3.1: Kn for Observed Field Sets/ Individual Fields

Field Set ID	Observed Advance Time (hrs)	Lag Time[1] (hrs)	Kn Calibrated Using District Lag Time Equation and NRCD Advance Time (hrs)
00-34	1.35	0.81	0.19
99-15	2.00	1.20	0.20
99-16	2.00	1.20	0.33
Average Kn for Observed Field Sets[2]			**0.24**

[1]**Lag Time = 0.6 x Observed Advance Time**

[2]**The average Kn value shown is for individual fields only.** The Kn value was adjusted further in order to account for factors associated with systems of typical fields.

It should be noted that the average Kn value shown in **Table 3.1** was used to estimate lag times for individual fields modeled as single subbasins.

Since hydrology models are not usually created with fields modeled as individual subbasins, it was necessary to evaluate and adjust the average Kn value further. The average Kn value from **Table 3.1** was used along with other adjusted parameters in order to model a typical system of interconnected fields. Further adjustments made to the Kn value and other parameters, and are discussed in **Section 3.4**.

3.2 Calibration of Initial Abstraction for Observed Sets/Individual Fields

The *Observed Sets Model* was developed to reproduce the observed volume of runoff recorded by the NRCD. Observed runoff volumes from test sets of three different fields were used. Two of the NRCD test sets were from fields with furrow irrigated crops, and one was from a field with border irrigated crops.

Key Assumption 3: *It was assumed that the volume lost to infiltration and surface retention during an irrigation event would be similar to volume losses resulting from a rainfall event.*

Entellus found supporting research to the key assumption stated above in the following article: American Society of Agricultural Engineers, *Advances in Infiltration - Proceedings of the National Conference on Advances in Infiltration, Effect of Rain Intensity on Infiltration and Surface Runoff Rates*, Akan and Yen, December, 1983 (**Reference 5**). One of the article's conclusions stated that:

> *"If the rain duration is sufficiently long and the water table is low, the final infiltrability of a homogenous soil and the total volume of infiltrated water do not depend on the rain intensity."* Akan and Yen 1983

Since the abstraction and infiltration parameters are not adjusted for various storm frequencies, durations, and distributions, it follows that they will not change significantly for an irrigation event.

The Green and Ampt parameters used in the *Observed Sets Model* were initially estimated using the District's current methodology. The NRCD observations included detailed soil descriptions for each test set and were used to determine the District-recommended values of the XKSAT and PSIF for each set.

Typically, fields are not irrigated when they are saturated, nor are they allowed to dry. Therefore, it was assumed that the sampled fields were at normal moisture conditions at the beginning of observed irrigation events, and DTHETA was set to the District-recommended value for normal saturation conditions for the particular soil type in each field. The only soil losses parameter adjusted during this calibration process was the initial abstraction.

The model was run, and the estimated runoff volumes were compared to those recorded by the NRCD. Adjustments were then made to the initial abstraction values until the volume from the *Observed Sets Models* were close to those recorded by the NRCD. Calibration of the initial abstraction using the *Observed Sets Model* is documented in **Appendix D.1**.

Special modeling procedures were used to determine the initial abstraction for the furrow fields. These procedures accounted for the irrigation water only inundating the furrow channels, and are discussed in **Section 3.7.5**.

Table 3.2: IA Calibration for Observed Sets/Individual Fields

Field ID	District Recommended IA (in)	District Recommended DTHETA[1]	District Recommended PSIF(in)	District Recommended XKSAT(in/hr)	Calibrated IA (in)
00-34 (Furrow)	0.5	0.25 (normal)	4.3	0.4	1.5
99-15 (Furrow)	0.5	0.25 (normal)	4.3	0.4	6.0
99-16 (Border)	0.5	0.25 (normal)	4.3	0.37	5.4
Typical[2]	0.5	Varies	Varies	Varies	2.0

[1] The District recommends modeling fields using wet conditions (DTHETA=0 for these particular soil types), but the District recommended value for normal conditions (DTHETA=0.25 for these particular soil types) was used because it was assumed that saturated fields would not typically be irrigated.

[2] The typical values for DTHETA, PSIF, and XKSAT will vary based on soil types. The IA for typical fields was assumed to be the lower quartile limit of the calibrated IA values.

As shown on **Table 3.2**, the calibration of the *Observed Sets Model* to reproduce the observed runoff volumes resulted in a wide range of initial abstraction values. The typical initial abstraction value set to the lower quartile limit of the initial abstraction values estimated for each observed field set. The lower quartile limit was used because lower initial abstraction values would produce a larger amount of runoff and therefore could be considered to be a conservative estimate based on observed data.

Key Assumption 4: *The calibrated value of IA for the NRCD sets is the same for individual sets as it is for a complete field.*

The typical IA value from **Table 3.2** was used along with other adjusted parameters in order to model a typical system of interconnected fields. Further adjustments made to the IA value and other parameters, and are discussed in **Section 3.4**.

3.3 Typical Antecedent Soil Moisture Deficit

The *Hydrology Manual* recommends using modeling parameters for agricultural areas that reflect completely saturated conditions. This assumption was made because the agricultural fields experience frequent irrigation. However, irrigation practices actually result in field saturation conditions ranging from completely dry (fallow), to completely saturated (irrigated). At any given time, most fields are somewhere in-between the two extremes. The moisture condition of fields is directly related to irrigation practices. Information collected from farmers and the Roosevelt Irrigation District was used to determine a typical distribution of irrigation water (moisture conditions) throughout the study area. The farmer surveys are included in **Appendix B.2.** **Table 3.3** shows how this distribution was incorporated into the system models.

Table 3.3: Typical Field Moisture Conditions

Field Moisture Condition	Description	DTHETA[1]	Typical Percent of Fields[2]
Dry	Field has been harvested or is not currently being grown, and therefore has not been irrigated for a significant amount of time.	0.35	10%
Normal	Field has not been irrigated recently.	0.25	60%
Wet	Field has been irrigated recently (within 3 - 5 days).	0.0	20%
Irrigated	Field is being irrigated	0.0	10%
Typical	Overall Conditions Within Pilot Study Area	0.19	100%

[1] The values for DTHETA shown are for typical soil types present in the pilot study area.
[2] From farmer surveys

3.4 Calibration of Parameters to Represent Typical Systems

Most hydrology models are configured using a scale that does not allow individual fields to be modeled as independent subbasins. Subbasins are typically delineated with groups of fields included within them. Therefore, the hydrologic parameters calibrated for single fields required additional adjustments to represent groups of fields. Modeling the fields as groups of fields involved accounting for additional factors that were not applicable to individual fields:

- Runoff moving from field to field (flow routing)
- Typical crop distributions

In order to account for the factors above, two additional calibration models were created: *System Model 1* and *System Model 2*.

System Model 1 simulates runoff from ten typical fields that were modeled as individual subbasins using the parameters calibrated for the NRCD observed sets to model rainfall losses. These parameters included the lag time (average Kn value for individual fields) and the initial abstraction. Flows from the individual fields were routed and combined as appropriate for the configurations of typical systems observed in the study area.

The peak flow and runoff volume estimated using *System Model 1* were used to further calibrate the initial abstraction and lag time used to model a system of fields as a single subbasin. The lag time was calibrated by adjusting the Kn variable. *System Model 2* was created with the same system of fields modeled by *System Model 1*. However, *System Model 2* modeled the system of fields and routes as a single subbasin. The initial abstraction used in *System Model 2*, was adjusted until the runoff volume matched the *System Model 1*. The lag time used in *System Model 2* was adjusted until the peak flow matched the *System Model 1*. This process resulted in Kn and initial abstraction values that could be used to model agricultural systems similar to those found in the study area. The results of the calibration are documented in **Section 3.4.4.**

3.4.1 Field Runoff Routing

In *System Model 1*, the outflow from each field was routed through the next downstream field using the normal depth method. It is noted that irrigation headers could carry outflow from the fields to locations outside of the modeled system. However, it is just as likely that runoff from fields outside the system will be brought into fields within the system via the same means. Therefore, it was assumed that generally the inflows and outflows traveling between systems via the ditches will cancel out. The field-to-field routes are documented in **Appendix C.1.**

Survey data was collected in order to verify the flow routing used in *System Model 1*. The survey notes have been reproduced and included in **Appendix B.6**. The point files are included electronically in **Appendix F**.

3.4.2 Typical Crop Distribution Scenarios

There are various types of crops grown throughout the study area. Based on the method of irrigation used for them, the crops were classified into two groups, border or furrow, as discussed in **Section 2.2**. In order to determine how varying percentages of furrow and border crops within an agricultural area could affect runoff from the area, three typical crop distributions were developed: all furrow crops, all border crops, and a mix between border and furrow crops. *System Model 1* included grouped systems representing the three crop distribution scenarios modeled using the 100-year 6-hour storm and the results are shown in **Table 3.4**.

Table 3.4: Typical Crop Distribution Scenarios Results

Scenario Name	Description	# of Border Fields	# of Furrow Fields	Peak Flow (cfs)	Runoff Volume (ac ft)
SCEN1	All Border	10	0	240	80
SCEN2	All Furrow	0	10	200	63
SCEN3	Mixed	5	5	240	80

Each of the three scenarios was modeled with one of the ten fields being irrigated when the storm occurred. It was found that the field being irrigated was the controlling factor in the amount of runoff from the systems. Because border irrigated fields are irrigated at a higher intensity than furrow irrigated fields, the "all border" scenario produced more runoff than the "all furrow" scenario. The "mixed" scenario produced the same amount of runoff as the "all border" scenario because the field modeled as receiving irrigation when the storm occurred was border irrigated. The type of field that was being irrigated when the storm occurred was the only factor that caused the runoff to vary because the typical loss parameters developed in **Sections 3.1 - 3.3** were used for all of the scenarios.

The mixed border and furrow crop scenario is the most likely scenario encountered when modeling systems of fields throughout the project area. Therefore, when adjusting the modeling parameters to account for various crop distributions, the mixed crop scenario (SCEN3) was used.

3.4.3 *Precipitation Input Used for Calibration Models*

The precipitation data used in the calibration of the individual NRCD sets (*Observed Sets Model*) represented irrigation water. However, once the calibrated values from the irrigation events were obtained, all subsequent calibration models used the typical Maricopa County 6-hour distribution and the 100-year rainfall depth determined using the 1973 NOAA Atlas 2 **(Reference 13)**. The only exceptions to this were manipulations of the distribution and depth to account for fields being irrigated at the time of the storm.

Data from the NRCD field efficiency tests was used to develop the precipitation data used in the *Observed Sets Model*. The NRCD field efficiency tests reported the total depth of irrigation water and the time period over which it was applied. As mentioned in **Section 3**, the NRCD categorized the fields in the area as either being furrow or border irrigated. The sampled fields with furrow irrigation had about 6 inches of water applied to the fields over about 12 hours. The sampled border irrigated field had about 6 inches of water applied to the field in about 2 hours. For the calibration of the observed NRCD sets, a cumulative precipitation distribution with a constant rate of increase was used to model the irrigation inflow into the fields.

The models developed to calibrate parameters for typical systems of fields

(*System Model 1 and System Model 2*) used the District's 6-hour rainfall distribution and the 100-year rainfall depth from the NOAA Atlas. *System Model 1* included modified rainfall data for one of the ten fields to simulate the field being irrigated. The rainfall data used in *System Model 2* was not modified to represent one of the ten fields being irrigated. Instead, the initial abstraction and Kn values were adjusted to account for the field being irrigated.

For the field where it was necessary to model the effects of rainfall and irrigation occurring simultaneously, a combined distribution was created. The combined distribution was created by adding the irrigation inflows to the rainfall precipitations. For the 12-hour irrigation event (furrow) occurring during the 6-hour storm, the irrigation that could have occurred before the storm began was accounted for by adjusting the antecedent moisture conditions to "wet." For border irrigated fields, the irrigation event was centered about the most intense portion of the rainfall event. The development of the precipitation data is documented in **Appendix C.2.** Various problems associated with modeling irrigation events as rainfall are addressed in **Section 3.5**.

3.4.4 S-Graphs and Unit Hydrographs Used For Calibration Models

Originally, the calibration models were developed in order to reproduce peak flows and volumes observed from irrigation events (NRCD sets data). The models included unit hydrographs developed using the District's S-Graph methodology. It was later decided that using the unit hydrograph to model peak flows in response to irrigation events could not be justified because the irrigation water was not uniformly applied over the field area. However, the calibration models were still used to model the runoff volumes because the runoff volumes are unaffected by the unit hydrographs.

The unit hydrographs were not removed from the NRCD sets calibration models because the models could not run without them. Therefore, the unit hydrographs included in the NRCD sets calibration models may not be applicable to modeling irrigation events, but had no impact on the study results because they were not used to estimate peak flows or hydrograph timing. The unit hydrographs included in the calibration models are documented in **Appendix C.3.** Various problems associated with modeling irrigation events as rainfall are addressed in **Section 3.5**.

3.4.5 Calibration Results of Parameters to Represent Typical Systems

The initial abstraction and lag times in *System Model 2* were adjusted until the runoff volume and peak flow were within 10% of those from *System Model 1.* **Table 3.5** summarizes the calibration results, and the process is documented in **Appendix D.2**.

Table 3.5: Results for Calibration of Parameters to Represent Typical Systems

Model Name	**Area of Subbasins (sq-miles)**	**Number of Subbasins**	**IA (in)**	**DTHETA**	**Kn**	**Lag Time (hrs)**
System of Fields Modeled with Fields as Individual Subbasins *(System Model 1)*	0.13	10	2.0	0.19	0.24	2.2
System of Fields Modeled as a Single Subbasin *(System Model 2)*	1.25	1	**1.0**	**0.19**	**0.20**	3.0

The calibration results showed that the initial abstraction used to model a system of fields as a single subbasin was smaller than the initial abstraction used to model the same system of fields with the fields modeled as individual subbasins. This was because the single basin included the effects of irrigation water being applied during the rainfall event. Therefore, the additional volume of water supplied to the system from the irrigation was accounted for by decreasing the initial abstraction.

The calibration results also showed that the Kn value used to model the system of fields as a single subbasin was smaller than the Kn value used to model the same system of fields with the fields modeled as individual subbasins. This can be explained by the effect that routing and combining runoff through the system of fields had. As runoff moved throughout the system of fields modeled as individual subbasins, the flow in the routes continued to increase. The increased flow through the routes caused the velocities to increase. In order to account for the increase in velocities in the system when it was modeled as a single subbasin without routes, the Kn value was decreased.

3.5 Special Problems Encountered During the Calibration Process

3.5.1 Consideration of Curve Number Methodology

At the time of this study, there was no recorded data from storm events available to calibrate modeling parameters. Instead, NRCD Field Efficiency Tests that documented irrigation events and the resulting outflow from fields were used to calibrate the modeling parameters. It was assumed that the adjusted volume parameters would not change as a result of storm precipitation. Originally, curve numbers were used because they were specifically developed for agricultural conditions and could be easily adjusted to represent varying conditions.

The curve numbers that generated irrigation runoff comparable to observed data from the fields were much lower than those recommended in the TR-55. Literary research found in *Development and Evaluation of a Dimensionless Unit Hydrograph,* Bruce Wilson and William Brown, Water Resources Bulletin, Vol. 28, No. 2, American Water Resources Association, April 1992 **(Reference 6),** suggests that the SCS methodology may be over-conservative in that it could drastically overestimate the peak flows for at least some agricultural watersheds. The article has been reproduced and is included in **Appendix B.3**.This study utilized 142 rainfall-runoff events from 25 different agricultural watersheds to develop a synthetic unit hydrograph. Outflow estimated using the calibrated unit hydrograph was compared to outflow generated using the SCS method, and was found to be significantly lower. Therefore, the SCS method resulted in much higher flow rates than expected.

Despite the explanation given above, in the case of this study, the cause of the unexpected results was potentially not the curve numbers themselves, but errors caused by using the unit hydrograph to model irrigation events. Since the unit hydrographs may not be adequate for determining peak flows caused by irrigation events, the calibration of curve numbers using peak flows was abandoned. Green and Ampt parameters were selected for use instead of the curve numbers because they offered more controlling variables to help calibrate the runoff volume.

3.5.2 Calibration of DTHETA

The original attempts to calibrate the Green and Ampt parameters were made by adjusting the DTHETA and IA parameters. It was thought that adjusting these parameters would be the ideal method to reproduce the peak runoff, peak volume, and time to peak for each observed set. After many iterations, parameters were developed that could reproduce the peak runoff and peak volumes observed by the NRCD. However, as described below, the resulting DTHETA parameter was not reasonable.

It was assumed that the observed sets were tested when the fields were in a "normal" state of saturation. Therefore, it would be necessary to adjust the calibrated parameters in order to model fields in other saturation states such as "dry" or "wet." The various states of saturation are usually represented by a range of DTHETA values. DTHETA is set to zero when modeling a surface that is completely saturated.

The initial calibration process resulted in DTHETA values of zero, which was not reasonable because the fields were not saturated. Furthermore, the DTHETA value could not be adjusted to represent various moisture conditions because it was already set to zero (saturated). This problem was overcome by recalibrating the observed sets using DTHETA set to the District recommended value for "normal" moisture conditions, and only adjusting the IA parameter. DTHETA was estimated based on either physical conditions (normal for NRCD sets), or expected typical conditions (10% dry, 30% wet, 60% normal).

3.5.3 Applicability of Unit Hydrograph to Irrigation Modeling

There were concerns regarding the use of the unit hydrograph and the irrigation precipitation pattern. The District noted that the unit hydrograph methodology was developed for precipitation that was uniformly distributed over an area. Clearly the irrigation inflow into the fields was not uniformly distributed, and the applicability of the unit hydrograph was questioned. Various sources were searched for information regarding the unit hydrograph and non-uniform precipitation such as irrigation inflow. However, very little applicable information was found. In order to overcome the problem of the unit hydrograph, the irrigation model was only used to calibrate the runoff volume.

The runoff volume is independent of the unit hydrograph, so it would not be affected by the non-uniform application of precipitation to the fields. Similarly, the lag time (unit hydrograph duration) had no effect on subbasin outflow volumes estimated using HEC-1. Thus, even though the applicability of the unit hydrograph to the non-uniform precipitation pattern is uncertain, the losses estimated by the Green and Ampt parameters could still be calibrated to match the observed runoff volume.

3.5.4 Variation from Irrigation to Storm Events

Entellus searched for previous studies or analyses that could support the key assumption that the abstraction and infiltration parameters for a field will not vary between irrigation and precipitation events. Abstraction and infiltration parameters are independent of precipitation patterns and durations and are not adjusted for various storm frequencies and distributions. It follows that the parameters will not change significantly for an irrigation event. This assumption was further validated in American Society of Agricultural Engineers, *Advances in Infiltration - Proceedings of the National Conference on Advances in Infiltration, Effect of Rain Intensity on Infiltration and Surface Runoff Rates*, Akan and Yen, December, 1983 **(Reference 5)**. One of the articles conclusions stated that:

> *"If the rain duration is sufficiently long and the water table is low, the final infiltrability of a homogenous soil and the total volume of infiltrated water do not depend on the rain intensity."* Akan and Yen 1983

Once again, the problem is that the irrigation water is not uniformly distributed over the entire field. Despite this problem, it is still valid to assume that the field will be able to intercept and store the same volume of water, whether the water is uniformly applied or not. Therefore, only the runoff volumes realized by the irrigation events were used to calibrate the abstraction and infiltration parameters.

3.5.5 Initial Abstraction Calibration for Furrow Fields

In order to calibrate the initial abstraction parameter of fields with furrows, some modeling parameters had to be adjusted. When the initial abstraction was initially evaluated for the furrow fields, it was found to be very low. In fact, reducing the initial abstraction to zero, and setting the DTHETA to zero, still resulted in runoff volumes that were much larger than those observed. The reason for this was that the mounds within the furrowed fields are not directly wetted with irrigation water and have less opportunity to cause losses.

Based on field observations, it was assumed that on average the wetted perimeter of the furrows carrying irrigation water through the fields would make up about half of the total surface area. Therefore, the field areas were reduced by half, and the irrigation volumes were kept constant by doubling the irrigation depth. For example, 6 inches over 1 acre becomes 12 inches over ½ acre when the irrigation volume is kept constant. This resulted in an initial abstraction value that was representative of the furrows carrying irrigation water throughout the fields. It was assumed that the mounded portions of the field would have a similar initial abstraction because the soil types would be the same. Therefore, the average initial abstraction for the entire field was set to be equal to the initial abstraction estimated for the furrowed portions of the fields.

3.5.6 Lack of Data

NRCD observations were obtained for three fields. The observations seemed to contain irrigation data that was consistent with field observations and farmer surveys. However, the hydrologic results obtained from modeling each sampled set varied dramatically. For instance, one of the furrow fields showed a significant amount of runoff, while the other showed only a small amount of runoff. There was simply not enough data in order to develop trends or to determine the cause of these variances. This problem could be helped by performing more field tests.

The NRCD has hundreds of observation records for agricultural fields. However, the NRCD was hesitant to release the information because of privacy concerns. If this information could be obtained in the future, it could be used to confirm or refine the calibration results of this study.

The best data to use for calibration would be rainfall/runoff data collected using rainfall and flow gages. At the time of this study, there were no stream gages that could be used for calibration purposes. A District observer gage was installed in 1982 on Southern Avenue in the vicinity of the pilot study area. However, the data from this gage measures rainfall only and not runoff, so it could not be used to calibrate models. In addition, only daily precipitation is recorded from this gage and no storm durations or intensities are available. Recommendations for future studies are discussed further in **Section 6** and include the collection of additional data.

3.5.7 Extrapolation of Calibrated Parameters for Typical Systems

The parameters calibrated for individual field sets do not completely represent lumped parameters for larger areas. These parameters measured physical conditions for single fields only. However, typical agricultural areas include several fields and runoff from the fields move through the area via canals, ditches, or other fields. Additionally, it is likely that some of the individual fields within a large modeling area are being irrigated at the same time as rainfall events. Therefore, we expected the calibrated parameters to change as we modeled a lumped system. *System Models 1 and 2* were created in order to adjust the calibrated parameters to model typical systems.

3.5.8 *Modeling Irrigation during Rainfall Events*

Typical irrigation practices in the study area and Maricopa County are likely to result in one out of ten fields being irrigated at any given time. In order to account for fields being irrigated during a storm event, the irrigation depth was added to the precipitation depth, and the rainfall distribution was modified. Of the ten fields modeled in the typical systems models, one was modeled with the cumulative distribution.

As discussed in **Section 3.5.3**, the unit hydrograph was not developed to estimate peak flows resulting from precipitation that is not uniformly applied throughout the subbasin area. This was not an issue when modeling the observed NRCD field sets or when calibrating the initial abstraction for typical systems because only the runoff volumes were being calibrated which are independent of the unit hydrograph. However, when calibrating the Kn (lag time) for typical systems using peak flows, the use of the unit hydrograph became a concern because peak flows are influenced by the unit hydrograph. As stated in a memo from the Flood Control District dated November 2nd, 2004 **(Reference 14)**, the unit hydrograph theory should not be used when irrigation water is being treated as rainfall. However, in *System Model 1*, one of the ten fields was modeled using the unit hydrograph theory with precipitation data that represented irrigation and rainfall. The inapplicability of the unit hydrograph for the non-uniform portion (irrigation) of the precipitation data could introduce some error on timing and peak flows. This error would diminish as more basins are added and combined. At the time of this study it was thought that even though some error could be introduced by the use of the unit hydrograph, it was significantly less error than we the effects of irrigation water were ignored.

Further testing and analysis should be performed in order to determine what errors resulted from using the cumulative distribution for one of the ten fields in the typical system model. Recommendations for future studies are summarized in **Section 6**.

SECTION 4: METHODOLOGY RECOMMENDATIONS

4.1 Current Methodology

The *Hydrology Manual* was evaluated and hydrologic procedures and parameters were identified that would be impacted by farming practices. The current methodology uses the Green Ampt method to generate rainfall losses. The *Hydrology Manual* includes the following parameters that were developed for use in agricultural areas:

Parameter	District Recommended Value
Initial Abstraction (IA)	0.5 inches
Soil Moisture Content (DTHETA)	Saturated (0.0)
Impervious areas	0%
Average Subbasin Roughness used in Lag Equation (Kn)	.06 <Kn <0.15

The *Hydrology Manual* recommends these values as a general guideline, but leaves it up to the hydrologist to make any adjustments needed to reproduce actual conditions. However, these parameters are often not adjusted due to the lack of data to verify or justify selecting values outside the recommended ranges. **Appendix B.7** includes reproduced tables and text from the *Hydrology Manual* that show the District's recommended parameters for modeling agricultural areas.

4.2 Field Observations Regarding Current Methodology

The following observations and conclusions were made based on site visits and discussions with local farmers:

1. Several residents who live downstream from areas that were converted from agricultural fields to residential developments have noted a significant

increase in runoff, even though the developments comply with current drainage requirements.

Conclusion: Agricultural fields retain more water than expected and drainage regulations are not completely mitigating the effects of development on agricultural land.

2. Although the land slopes from north to south, individual fields are laser-leveled in order to retain the maximum amount of irrigation water and are terraced from field to field. Also, the irrigation system includes many canals and berms designed to prevent irrigation water loss. These structures tend to impede the movement of runoff though the entire area, and if runoff does occur, the structures tend to trap or at least slow runoff. A typical irrigation event applies more than five inches of water over a one to twelve-hour period with minimal tailwater losses.

   Conclusion: The holding capacity of the fields is substantial, but current methodology does not recognize increased times of concentration or on field retention.

3. The fields are irrigated on a watering schedule with intervals ranging from four to fourteen days. This schedule is maintained for several reasons. First, the irrigation infrastructure is physically incapable of delivering water to all fields simultaneously. Second, existing water rights limit the amount of water allocated. Third, farmers have to pay for water and irrigating on saturated fields results in large water losses to runoff or deep percolation.

   Conclusion: At any given time, individual fields are at varying degrees of saturation ranging from normal to saturated. Therefore, the assumption of 100% saturated fields is not representative of actual conditions.

4. Runoff from fields is either re-circulated to other fields or collected in ponds or tailwater ditches. Irrigation water does not enter the roadway ditches because the irrigation infrastructure (perimeter berms, delivery ditches) impedes the flow.

Conclusion: Typical modeling approaches incorrectly assume that agricultural runoff collects along the roadways. Typically runoff from a field is more likely to flow across the road into the next field.

4.3 Modifying Current Methodology

The District's current methodology was reviewed to identify parameters that could be appropriately modified to more accurately estimate agricultural runoff. The parameters were selected based on physical conditions observed in the field that appeared to be different from those recommended by the current methodology. The parameters selected for modifications or adjustments were:

- Routing Parameters (slope, n-value, geometry)
- Subbasin Roughness (Kn)
- Initial Abstraction (IA)
- Initial Soil Moisture Content (DTHETA)

Table 4.1 shows various parameters typically used when developing hydrology models according to District methodology. The table also shows proposed values for these parameters based on findings of this study. Many parameters did not change, and the current recommended ranges of values appeared to adequately represent agricultural hydrology.

Table 4.1: Proposed Modeling Parameters for Agricultural Areas

Parameter	Current Methodology Value	Recommendation
Flow Routing	Flow routed along roadways	Route flow through fields or ditches unless evidence supports doing otherwise.
Lag Time Equation (Kn)	0.6 < Kn < 0.15	Kn = 0.20.
IA	0.5 inch	1.0 inch.
DTHETA	0	See **Table 4.3**.
PSIF	Varies	Use current ~~District recommended~~ values (See **Appendix B.7** for values)
XKSAT	Varies	Use current District recommended values (See **Appendix B.7** for values)
RTIMP	0%	Use current District recommended values (See **Appendix B.7** for values)

The recommended changes to the District methodology are discussed further in **Sections 4.3.1 through 4.3.4.**

4.3.1 Flow Routing

The first recommendation is to direct the hydrologist to determine how flows move though the agricultural area. The hydrologist should determine if the system recycles tailwater or if it uses a tailwater ditch system, and configure the routing accordingly. This may include using wide shallow cross sections and field slopes or ditch geometries. Routing using roadways should not be used unless demonstrated that the roads actually convey the runoff.

4.3.2 Proposed Lag Time

Observed and extrapolated data indicated that the lag time for hydrographs from agricultural fields was longer than the lag time generated using the current District equation and input values. Calibrated lag times for individual fields ranged between 0.18 and 0.33, and the calibrated lag time of a typical system of several fields was 0.20. It was found that by using a Kn value of 0.20, the District equation generated lag times that were much closer to those observed during irrigation events.

Further justification for setting the Kn value to 0.2 was found in the *MKE Tech Memo* and *MKE Study.* An empirical expression for estimating lag times was developed as part of the *MKE Study,* and documented in the *MKE Tech Memo.* This expression was developed for agricultural fields and was based on the Manning's roughness coefficients for sheet flow documented in the *SCS TR55* **(Reference 15).** The lag time equation documented in the *MKE Tech Memo* is shown below:

Agricultural Lag Time Equation from *MKE Tech Memo (Reference 16)*

$$L = C_L \left(\frac{L_{FP} \times L_{ca}}{S^2} \right)^{0.25}$$

$$C_L = 4.5 A^{0.1} S^{0.3}$$

Where:

L = lag time, in hours

L_{FP} = length of longest watercourse, in miles

L_{ca} = length along the watercourse slope to a point opposite the centroid, in miles

S = watercourse slope, in feet/ mile

A = drainage area, in square miles

Lag times for each of the three field sets were estimated using the District equation and the equation from the *MKE Tech Memo.* The lag times were compared to the lag times estimated using the observed advance times and are shown on **Table 4.2**.

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Table 4.2: Lag Times for Observed Field Sets Using Various Equations

Field Set ID	Lag Time Estimated Using Observed Data (hrs)	Lag Time Estimated Using District Equation (Kn = 0.10) (hrs)	Lag Time Estimated Using MKE Equation (hrs)	Lag Time Using District Equation and Adjusted Kn = 0.2 (hrs)
00-34	0.81	0.44	0.80	0.88
99-15	1.20	0.61	1.00	1.23
99-16	1.20	0.36	0.59	0.73

The current District equation resulted in lag times that were less than the observed lag times. The lag times estimated using the *MKE Tech Memo* equation were similar to the observed lag times, except for the lag time of field 99-16. This difference can be explained by the roughness characteristics of the field. Field 99-16 was a border irrigated field on which it was likely that alfalfa was being grown. Alfalfa fields area very dense and create an exceptionally high resistance to flow. The *MKE Tech Memo* based the lag time equation on the average resistance to flow (average values of Manning's roughness for overland flow) for agricultural fields. Therefore, it makes sense that the observed lag time for the alfalfa field is much larger than the lag time estimated using the lag time equation from the *MKE Tech Memo.*

It should be noted that the lag times used for the *MKE Study* hydrology models were estimated using the District lag equation, with the Kn variable set to 0.2 for agricultural areas. It is not known how the *MKE Study* determined that the Kn value should be set to 0.2. However, it is likely that the study used a Kn value of 0.2 because it resulted in the District equation generating lag times similar to those estimated using the equation for agricultural areas shown in the *MKE Tech Memo.*

Based on the information above, it is recommended that a Kn value of 0.2 be used to estimate the lag time for surface irrigated areas.

4.3.3 Proposed Initial Abstraction

The current District-recommended initial abstraction for agricultural areas is 0.5 inches. Based on observed irrigation events, the very flat slope of the fields, and the storage observed at the lower end of the fields, it appears that some fields have a much larger capacity to store or pond water. When modeling agricultural areas that are surface irrigated, the initial abstraction should be increased accordingly.

Calibration results suggest that increasing the initial abstraction parameter to 1.0 inch accounts for the additional storage capacity for typical areas with a mixture of border and furrow irrigated crops. This value is within the range of total surface storage and abstraction for agricultural fields estimated by the US Army Corp of Engineers (Corps) in *Engineering and Design - Flood-Runoff Analysis* **(Reference 4).** The relevant portions of this document have been included in **Appendix B.3**.

It is noted that much higher initial abstraction rates were estimated from field observations. However, the results varied significantly from field to field in the range of 1.5 to 6.0 inches. Additionally, various assumptions had to be made in order to calibrate the initial abstraction using irrigation events. Although field data were not sufficient to justify a large deviation from the current recommended IA value, based on field observations, it is believed that typical IA values are significantly higher. Due to the lack of supporting data, we recommend increasing this parameter, but only to 1.0 inches for irrigated agricultural areas. As more field data are collected and evaluated, it is expected that additional increases in the initial abstraction parameter could be justified in the future.

4.3.4 Proposed DTHETA

Since not all fields can be irrigated at the same time, and irrigation practices and economics do not allow irrigated fields to dry, it is recommended that the initial soil moisture content in for agricultural areas be modified to a value between wet and normal. The proposed values for DTHETA, the parameter used to represent the initial soil moisture conditions, are shown in **Table 4.3.** The values shown represent conditions in the agricultural portions of the Buckeye/Sun Valley ADMS study area. Further, it is recommended that the weighted DTHETA methodology be used in other agricultural areas in Maricopa County. The proportions of dry, normal, and wet conditions would depend on the irrigation practices in the particular area, but are expected to be similar to that experienced in the Buckeye area. Dry conditions are expected on non-irrigated fields that are either in fallow or are inactive. Wet conditions are expected on fields that have been irrigated in the last three days. Normal conditions are expected on fields that are not wet or dry.

Table 4.3: Recommended Values for DTHETA

Soil Type	Antecedent Moisture Conditions[1]			Current Agricultural (Assumed "Wet")	~~Proposed~~ Weighted DTHETA Agricultural for the Buckeye/Sun Valley ADMS[2]
	Dry	Normal	Wet		
Loamy Sand & Sand	0.35	0.30	0.0	0.0	0.22
Sandy Loam	0.35	0.25	0.0	0.0	0.19
Loam	0.35	0.25	0.0	0.0	0.19
Silty Loam	0.40	0.25	0.0	0.0	0.19
Silt	0.35	0.15	0.0	0.0	0.13
Sandy Clay Loam	0.25	0.15	0.0	0.0	0.12
Clay Loam	0.25	0.15	0.0	0.0	0.12
Silty Clay Loam	0.30	.015	0.0	0.0	0.12
Sandy Clay	0.20	0.10	0.0	0.0	0.08
Silty Clay	0.20	0.10	0.0	0.0	0.08
Clay	0.15	0.05	0.0	0.0	0.05

[1] From District *Hydrology Manual*

[2] Weighted Average Assuming 10% Dry, 60% Normal, 30% Wet (Based on Farmer surveys)

4.4 Effects of Proposed Parameters on Runoff

The proposed modifications to the parameters significantly reduce the amount of runoff estimated from agricultural areas. This is consistent with field observations and data collected. A comparison of the runoff estimated using the proposed modeling parameters, the currently recommended District parameters, and the parameters used in the *MKE Tech Memo* are shown on **Table 4.4**.

Table 4.4: Comparison of Runoff from a Typical System (1.25 Sq. Miles)

Source	IA (in)	DTHETA	Kn	Lag Time (hrs)	Peak Flow (cfs)	% Change in Flow From Current District Methods	Runoff Volume (Ac Ft)	% Change in Volume From Current District Methods
Current District Recommended Parameters	0.5	0	0.10	1.7	849	n/a	149	n/a
MKE Tech Memo Lag Equation	0.5	0	n/a*	2.5	571	-33%	149	0%
Proposed Parameters	**1.0**	**0.19**	**0.20**	**3.0**	**240**	**-72%**	**80**	**-46%**

Note: The peak flows and runoff volumes were estimated using the 100-year 6-hour storm. The calibrated parameters (IA, DTHETA, and Kn), will not change for other storm events.

* The *MKE Study* (**Reference 2**) used the District equation with Kn=0.2, whereas the equation in the *MKE Tech Memo* (**Reference 16**) did not use a Kn value.

SECTION 5: PILOT STUDY HYDROLOGY MODEL

The pilot study area was modeled using the proposed changes to the District methodology discussed in **Section 4**. The results were compared to the results of the previous study of the Buckeye Sun Valley area (*MKE Study*), and the current *Buckeye Sun Valley Area Drainage Master Study* by PBS&J **(Reference 15)**, hereinafter referred to as the *Current ADMS Report*. At the time of this report, the *Current ADMS Report* was not finalized, and the data and results shown in this pilot study could vary from those in the final report.

5.1 Method Description

The hydrology models of the pilot study area were developed using HEC-1 models developed by PBS&J for the Buckeye Sun Valley ADMS, hereinafter referred to as the *PBS&J Models*. The *PBS&J Models* were modified according to the proposed changes to the District methodology described in **Section 4.** Modifications made to the *PBS&J Models* are documented in this report and in-line comments were added to the modified HEC-1 files which are included in **Appendix E**.

Even though the pilot study area extends north beyond the Roosevelt Canal, the *PBS&J Models* were only modified for the areas south of the Roosevelt Canal and north of the Buckeye Canal. Runoff crossing the Roosevelt Canal from the north was modeled by PBS&J using HEC-RAS. The HEC-RAS model generated a hydrograph that was routed through the areas downstream of the canal. The hydrograph generated by HEC-RAS was not modified.

The *PBS&J Models* were developed with the following: Green and Ampt parameters to estimate rainfall losses, the District's S-Graphs to develop unit hydrographs, and normal depths for flow routing. A detailed description of the methodology used to develop the hydrology model is included in the *Current ADMS Report*.

5.2 Mapping and Survey

2-foot contours were used to develop the *PBS&J Models*, and are discussed in the *Current ADMS Report*. Additional survey data was obtained in order to verify the flow routing. The survey notes are included in **Appendix B.6**, and the point files are included electronically in **Appendix F**.

5.3 Parameter Estimation

5.3.1 Concentration Points and Subbasin Boundaries

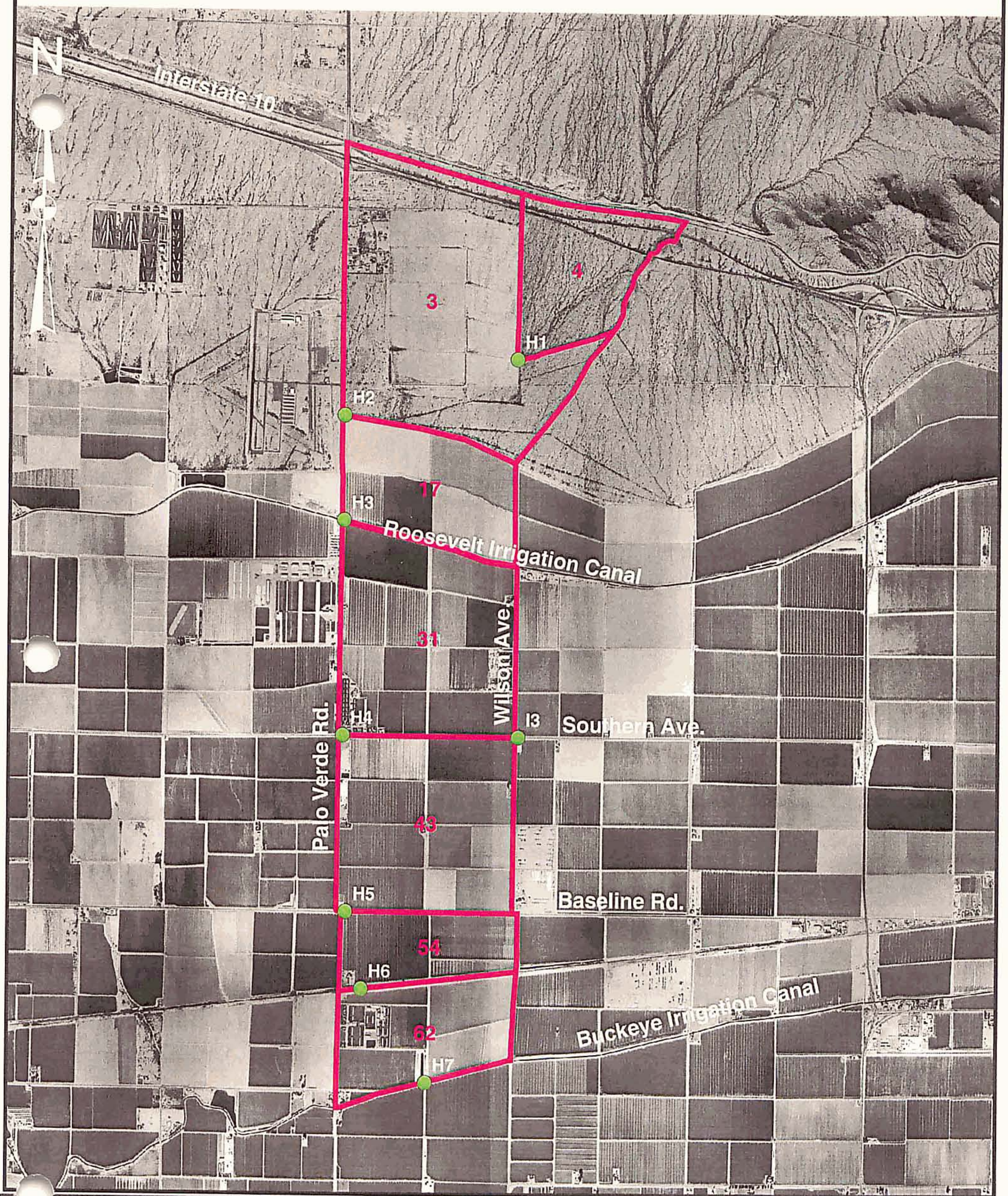
The concentration points and subbasin boundaries used in the *PBS&J Models* were not modified, and are documented in the *Current ADMS Report*. The subbasins and concentration points within the pilot study area are shown in **Figure 5-1**.

5.3.2 Precipitation

The precipitation depths and distributions used in the *PBS&J Models* were not modified and are documented in the *Current ADMS Report*. The models were created to simulate the 100-year 6-hour, and the 100-year 24-hour storm events.

5.3.3 Lag Times

The lag times used in the *PBS&J Models* were developed using the same Kn value proposed in **Section 4** of this report. Therefore, the lag times used to model the pilot study area were not modified and are documented in the *Current ADMS Report*.



Concentration Point
Subbasin Boundary

BUCKEYE SUN VALLEY AREA DRAINAGE STUDY
Agricultural Pilot Study

FIGURE 5-1: PILOT STUDY AREA SUBBASINS AND CONCENTRATION POINTS

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5.3.4 Green and Ampt Parameters

The Green and Ampt parameters used to model the pilot study area were modified from those used in the *PBS&J Models* according to the proposed changes documented in **Section 4**. The modifications made to the parameters were as follows:

- DTHETA was estimated using the weighted average of soil saturation expected in the pilot study area (0.19 for the sandy loams in the pilot study area). The DTHETA values used in the *PBS&J Models* were estimated assuming all of the fields were in a "normal" saturation state (0.25 for the sandy loams in the pilot study area).

- As proposed in **Section 4** of this report, the initial abstraction was set to 1.0 inches for agricultural areas within the pilot study area. The *PBS&J Models* set the initial abstraction to the District recommended value of 0.5 inches.

5.3.5 Unit Hydrographs

The unit hydrographs used in the *PBS&J Models* were not modified and are documented in the *Current ADMS Report*. The unit hydrographs were created using the District's S-graph methodology.

5.3.6 Flow Routes

The flow routes used in the *PBS&J Models* appeared to be consistent with the proposed routing considerations described in **Section 4.3**, and therefore were not modified. Furthermore, the cross section geometries used to model the flow routes appeared to be consistent with the survey information. The flow routes are documented further in the *Current ADMS Report*.

5.3.7 Storage Routes

Runoff attenuation caused by storage throughout the fields in the pilot study area was accounted for using the proposed initial abstraction and Kn values. Storage behind the Roosevelt Canal was accounted for in the *PBS&J Models* using a stage storage distribution modeled in HEC-RAS. The HEC-RAS models generated a hydrograph that was routed through the area downstream of the canal. The development of the HEC-RAS models is documented in the *Current ADMS Report.*

5.4 Special Problems

Special problems encountered during the modeling process are documented in the *Current ADMS Report.*

5.5 Results

The HEC-1 input/output files for the pilot study models are included in **Appendix E.** **Table 5.1** lists the peak flows estimated using the PBS&J Models with the proposed changes to the District parameters at key locations throughout the study area.

Table 5.1: Pilot Study Area Results Using Proposed Methodology

Location (Concentration Point)	100-Year 6-Hour Peak Flow (cfs)	100-Year 24-Hour Peak Flow (cfs)
Palo Verde Rd. and Southern Ave. (H4)	337	293
Palo Verde Rd. and Baseline Rd. (H5)	403	373
Palo Verde Rd. and the Railroad (H6)	406	385
Palo Verde Rd. and the Buckeye Canal (H7)	400	398

5.6 Comparison of Results

Table 5.2 shows a comparison of the unit runoff from subbasins throughout the study area estimated using the *MKE Study*, the *PBS&J Models*, and the *PBS&J Models* with the proposed changes to the District methodology.

Table 5.2: Comparison of 100-Year 6-Hour Results from Various Models

Subbasin ID	Subbasin Area (sq mi)	Previous ADMS - *MKE Study* Unit Peak Flow (cfs/sq mi)	Current ADMS - *PBS&J Models* Unit Peak Flow (cfs/sq mi)	*PBS&J Models* w/Proposed Changes to District Methodology Unit Peak Flow (cfs/sq mi)
31	1.1	283	194	157
43	1.0	264	199	161
54	0.4	382	265	225
62	0.6	498	330	278

The comparison shows that the proposed changes to the District's methodology reduce the peak flows by about 20% compared to the *PBS&J Models*, and by about 40% compared to the *MKE Study*. The decrease in estimated peak flows is consistent with the findings of the calibration process.

SECTION 6: RECOMMENDATIONS FOR FUTURE STUDIES

This study was groundbreaking in the sense that there has never been an evaluation of the District's methodology for modeling agricultural fields using actual data from areas within Maricopa County. The study results indicated that there is a need to further evaluate and possibly modify the current District methodology for modeling agricultural fields.

As part of this study, various parameters were estimated that seemed to represent the hydrologic conditions in the pilot study area. However, these parameters were developed using very limited data and questions linger regarding the applicability of the methods used to analyze the data. Therefore, it is recommended that future studies be conducted in order to further develop the recommended parameters. The list below has been compiled in order to give a general guide for future studies

1. Install rainfall gages near irrigated fields throughout Maricopa County. Measure irrigation and rainfall runoff from the fields, and use the data collected in order to develop calibration models similar to those found in this study. Runoff gages could be installed near the existing rain gage located in the pilot study area (On Southern Avenue between Palo Verde and Miller Roads). The rainfall gage needs to be upgraded to record data in 5 minute intervals.

2. The Natural Resources Conservation Service Buckeye Sun Valley District (NRCD) has been conducting field efficiency tests for a long period of time on many fields throughout the County. However, data from only three field efficiency tests were obtained for this study, and were used to determine the recommended Kn value. Future studies should be coordinated with the NRCD in order to collect as many test records as possible. The person in charge of field efficiency tests at the NRCD at the time of this study was Nathan Melton and his

phone number is 623-386-4631.

3. The Southwest Watershed Research Center (SWRC) in Tucson has sprinkler systems that were designed to simulate rainfall events. Future studies should consider using these sprinklers to simulate rainfall events on agricultural fields in order to calibrate various modeling parameters. The contact person at the SWRC is not known, but their website address is: www.tucson.ars.ag.gov, and their phone number is 520-670-6381.

4. The relationship between the volumetric soil deficit (DTHETA) and irrigation practices could be determined by selecting a few agricultural fields for evaluation. The irrigation practices for the fields would be monitored and the soil moisture deficit could be measured in order to develop a correlation between the two. This could help develop a range of DTHETA values for agricultural fields based on soil types and irrigation practices.

APPENDIX A. LIST OF REFERENCES

1 Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County - Hydrology (Draft)*, November 2003

2 Flood Control District of Maricopa County - McLaughlin Kmetty Engineers LTD. - Buckeye Area Flood Delineation Study Hydrology Report, *Technical Memorandum to Tim Murphy and Steve Waters, From G.V. Sabol, Dated: January, 1992, Regarding Unit Hydrographs for Agricultural Fields and New Lag Relation for Unit Hydrographs*, Appendices AA and BB, May 1992

3 Flood Control District of Maricopa County - McLaughlin Kmetty Engineers LTD., *Buckeye Area Flood Delineation Study Hydrology Report Appendices AA and BB*, May 1992

4 United States Army Corp of Engineers, *Engineering and Design - Flood-Runoff Analysis*, EM 1110-2-1417, August 1994

5 American Society of Agricultural Engineers, *Advances in Infiltration - Proceedings of the National Conference on Advances in Infiltration, Effect of Rain Intensity on Infiltration and Surface Runoff Rates*, Akan and Yen, December, 1983

6 American Water Resources Association, *Development and Evaluation of a Dimensionless Unit Hydrograph*, Bruce Wilson and William Brown, Water Resources Bulletin, Vol. 28, No. 2, April 1992

7 Food and Agriculture Organization of the United Nations, *Guidelines for Designing and Evaluating Surface Irrigation Systems*, Walker, 1989

8 American Water Resources Association, *Using Curve Numbers to Determine Baseline Values of Green-Ampt Hydraulic Conductivities*, Risse, Liu, and Nearing, Water Resources Bulletin, Vol. 31, No. 1, February 1995

9 American Water Resources Association, *Using Field Scale Models to Predict Peak Flows on Agricultural Watersheds*, Gowda, Ward, White, Baker, and Lyon, Water Resources Bulletin, Vol. 35, No. 5, October 1999

10 American Water Resources Association, *Quantifying Model Output Uncertainty Due to Spatial Variability of Rainfall*, Chaubey, Haan, Salisbury, and Grunwald, Water Resources Bulletin, Vol. 35, No. 5, October 1999

11 *Adjusting Irrigation Abstraction to Minimize the Impact on Stream Flow in the East of Scotland*, Dunn, Stalham, Chalmers, and Crabtree, Journal of Environmental Management, Vol. 68, No. 95-107, 2003

12 National Resources Conservation Service, *National Engineering Handbook, Section 4, Hydrology*, May 1972.

13 National Oceanic and Atmospheric Administration, *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume VIII-Arizona*, 1973.

14 Flood Control District of Maricopa County, *Interoffice Memorandum to Valerie Swick, From Julie Cox, Dated: November, 2004, Regarding the Buckeye Sun Valley Agricultural Analysis*

15 United States Department of Agriculture and Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986.

16 Arizona Department of Transportation - NBS/Lowry Engineers & Planners, Inc., *Highway Drainage Design Manual, Hydrology, Report Number FHWA-AZ93-281*, March 1993.

17 United States Department of Army, Corps of Engineers, Hydrologic Engineering Center, *Generalized Computer Program 723-X6-L2010, HEC-1 Flood Hydrograph Package*, California, February 1981, Revised May 1991.

18 PBS&J - Flood Control District of Maricopa County, *Buckeye Sun Valley Area Drainage Study Draft Data and Models*, January 2005

APPENDIX B. DATA COLLECTION

EXHIBIT A

Final Draft

SCOPE OF WORK

CONTRACT FCD 2002C027

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY

2.3.6 The CONSULTANT shall submit all pertinent GIS or CADD Data relating to hydrology as described in Task 2.5.9.

2.3.7 AGRICULTURAL ANALYSIS: The CONSULTANT shall research the agricultural practices in the Buckeye Area and determine the best way to simulate it. A sensitivity analysis shall be done to determine the effects of changing the agriculture fields to urban land uses. Many of the agricultural fields are being converted to residential and commercial developments. There is a concern that the agricultural fields hold more water from larger rainfall events that originally anticipated and that by converting to an urban landuse may actually cause more runoff than the existing conditions. An analysis will be conducted to determine how to more accurately model agriculture fields and the effects they have downstream properties.

2.3.7.1 The CONSULTANT shall determine typical, maximum, and minimum areal coverage of active farming for both summer and winter growing seasons.

2.3.7.2 The CONSULTANT shall collect and review data on irrigation volumes, durations, and rotation and delivery schedules for the summer and winter growing seasons. Collect and review data on crop and soil types, historical flooding, and existing drainage structures.

2.3.7.3 The CONSULTANT shall meet with local irrigation district representatives, farmers, and water masters to obtain information on farming and irrigation practices and potential pilot study boundaries.

2.3.7.4 The CONSULTANT shall conduct field trips to develop an understanding of the geographic connectivity of farmlands and their operational regimes, take measurements, talk to farmers and water-masters in the field, and observe irrigation practices. The CONSULTANT shall conduct additional field trip to identify locations of cross sections to be surveyed and take additional measurements or samples. Four full day field trips and two ½ day trips are anticipated.

2.3.7.5 The CONSULTANT shall evaluate potential pilot study locations and select an area of approximately 5 square miles based on farming practices, irrigation regimes, availability of data, historical flooding problems, locations of drainage structures, and accessibility.

2.3.7.6 The CONSULTANT shall recommend a preliminary methodology for modeling the pilot agricultural hydrology and submit for review. Final determination of the methodology to be used will be decided by the Project Workgroup. This Workgroup will consist of DISTRICT and CONSULTANT personnel.

2.3.7.7 Based on approved methodology, the CONSULTANT shall prepare a hydrologic model for the pilot area. This model shall be detailed enough to allowed modeling of irrigation structures (distribution network, tail water ditches, field dividing dikes, etc.) The CONSULTANT shall develop parameters for and conduct a sensitivity analysis of relevant parameters. If any parameters are not currently in use by the DISTRICT, convert the final model to DISTRICT methodology and calibrate using the results of the pilot model. The CONSULTANT shall select sub-basins with similar natural ground slope in the adjacent Palo Verde watershed, establish unit runoff characteristics (peak runoff per unit area) and apply to the pilot area for comparison purposes.

2.3.7.8 The CONSULTANT shall prepare a stand-alone hydrology report that describes the data collected and evaluated, discussion of methodology and assumptions used, a detailed description of the processes used in the analysis, and recommendations for application to agricultural lands in other parts of Maricopa County. The DISTRICT will distribute a draft version of the report for review and comments by interested parties and shall provide a consolidated set of review comments to the CONSULTANT. The CONSULTANT shall incorporate changes recommended by the workgroup.

2.3.8 The CONSULTANT shall prepare a detailed hydrologic analysis for the **Area 1: Buckeye Watershed** south of I-10, by modifying existing hydrologic models and developing new models as necessary. The watershed area is approximately 85 square miles. Most of the land in this area has been developed as agricultural fields. The natural washes have been eliminated leaving the roads to act as conveyance for runoff.

2.3.8.1 EXISTING CONDITIONS

2.3.8.1.1 The CONSULTANT shall review the Existing Condition 100-year/24-hour, 100-year/6-hour. The CONSULTANT shall use the Buckeye Area Flood Delineation Study (McLaughlin Kmetty and George V. Sable, 1992) as the base model. The CONSULTANT shall modify, update, change, and develop as necessary the following hydrologic parameters.

a. Modify XKSAT and PSIF to comply with the Drainage Design manual for Maricopa County, Volume 1, Hydrology (FCDMC 1995).
b. Update existing land use (RTIMP) to that of 2003 where necessary.
c. Add area between the Buckeye Irrigation District (BID) and the Gila River floodplain.
d. If necessary, modify existing subbasin boundaries based on new mapping.
e. If necessary, add concentration points.
f. Create models for the 10-year 24-hour and 10-year 6-hour storm event.

2.3.8.1.2 **(OPTIONAL TASK)** The CONSULTANT shall review Existing Condition 100-year/24-hour, 100-year/6-hour, 10-year/24-hour, and 10-year/6-hour models, and develop new existing hydrologic models with subbasins and points-of-concentration defined as appropriate for the model frequency. If in the CONSULTANT's judgment, new existing hydrology is required, the CONSULTANT shall prepare and submit a memo justifying the need for new existing hydrology. **The new existing hydrology is not authorized with the Notice to Proceed but may be authorized in writing by the DISTIRCT based upon specific need as determine by the DISTRICT during the contract period. All invoices shall separately identify costs for work done under this paragraph. Implementation of the new**

Buckeye/Sun Valley Area Drainage Master Study

Agricultural Land Hydrologic Modeling
Proposed Pilot Study Plan

April 13, 2004

A potential hydrologic issue within the Buckeye/Sun Valley ADMS study area is the retention effects in areas that have previously been developed as farmland. To address this concern, a detailed pilot study of farmland within the study area is included in the current project scope of work. The pilot study will consider typical irrigation regimes and retention capacities for the area and will generate a subwatershed model to better estimate hydrologic response in active agricultural areas. Our proposed approach will be conducted in four major steps:

Step 1 – Define typical farming practices and field conditions
Step 2 – Develop base hydrologic models using agricultural methodologies (Curve Number, reservoir routing through fields)
Step 3 – Convert base model using methodologies identified in the Hydrology Manual (Green & Ampt)
Step 4 – Document results and recommend supplemental methodologies for analyses in agricultural areas.

Step 1 – Define typical farming practices and field conditions

Irrigation practices have a direct effect on hydrologic modeling parameters (i.e., loss rate and routing parameters). The following subtasks will be performed in order to understand typical farming practices and select appropriate modeling parameters:

- Identify irrigation type (flood, border, sprinkler, or combination)
- Determine how tailwater is handled (reused or discharged)
- Determine water delivery schedules (flow rate and timing)
- Observe typical crop distribution
- Estimate growing season and year-round conditions
- Check Irrigation rotation (which fields and how long)
- Estimate moisture content (portion of area that is saturated, partially saturated, and dry at a given time)

The data will be used to establish the percentage of fields saturated for any given time. Evapotranspiration rates will be obtained and used to establish how dry fields can get. (x% saturated, y% dry, z% in between). The weighted saturation condition will then be used to determine the Antecedent Moisture Condition.

Based on the results, the saturation condition will be applied to the identified crops and weighted curve numbers will be developed. Weighted curve numbers can be obtained by interpolating between available AMC-based tables from SCS TR-55 data. The process will be developed on a per-field basis, then weighted curve numbers can be developed for each sub-basin.

Field conditions will need to be established in order to estimate the area's true ability to retain stormwater on the fields. Therefore, the study area will be toured and locations of additional ground survey will be identified to reflect the conditions of the fields and their ability to contain stormwater. The following data will be collected:

- Location, condition, and ability to contain water upstream of delivery ditches
- Ability to contain/divert water at header ditches
- Tail water system (ponding, tailwater ditches, free runoff)
- Lateral dividing berms
- Roadway layout

For the data collection task, a general comparison of the farming practices will be made within and/or outside of the study area to confirm that the pilot study is a reasonable representation of regional farming activity.

Step 2 – Develop base hydrologic models using agricultural methodologies

As previously noted, we propose to use SCS Curve Number methodology and reservoir routing to estimate soil loss parameters and retention, respectively. The Curve Number approach is recommended because it was developed specifically for agricultural areas and selection of appropriate hydrologic parameters is well-documented. Conversely, other methods such as Green & Ampt have not been tested for applicability to agricultural areas.

Initially, three models of existing conditions will be developed to represent best-case, average, and worst case scenarios of typical farming practices based on the following subtasks:

- Prepare model of pilot area (basin size = field size)
- Model irrigation event and compare results with observed data
- Add precipitation for different moisture contents
- Estimate ability of fields to handle additional water
- Estimate tail water system ability to convey/store runoff
- Adjust the model to incorporate tailwater runoff
- Hydraulically model roadways and fields with potential for conveyance
- Incorporate results into model (routing, diversion and storage)
- Compare results from different moisture contents
- Prepare a larger basin size model to incorporate typical system

However, only one model is needed for the next phase of the analysis. It is noted that a primary function of the District is to provide drainage infrastructure for multi-jurisdictional watersheds. Therefore, it is appropriate to select a conservative yet realistic approach. Therefore, once the three models are developed, the typical model will be compared against the "best" and "worst" case models to see where it falls within the envelope. If the typical model compares favorably with the best case, then the worst-case scenario will be deemed too conservative and the typical model will be selected for additional analysis. However, if the typical model is closer to the worst-case scenario, the worst-case scenario will be used for Task 3 of the pilot study.

Step 3 – Convert base model using methodologies identified in the Hydrology Manual (Green & Ampt)

Once the final model has been selected, the following additional subtasks will be performed:

- Calibrate model based on smaller size basin model
- Adjust the model for typical general area conditions
- Investigate how yearly schedule and crop distribution may affect runoff
- Investigate critical condition (crop stage) for max/min runoff

The calibrated model will then be modified using standard methodologies outlined in the District's Hydrology Manual. Green & Ampt soil loss parameters will be manipulated and surface retention options will be activated so that the model output matches than from the curve number model.

Step 4 – Document results and recommend supplemental methodologies for analyses in agricultural areas.

A report will be prepared that describes the work performed and a comparison will be made with results of other previous analyses that were performed on farmlands using methodologies according to the Hydrology Manual. Differences in results will be evaluated and recommendations will be made for any needed supplements to the current Hydrology Manual to better estimate watershed response in farmlands.

APPENDIX B. DATA COLLECTION

Entellus
2255 N. 44th St., Suite 125
Phoenix, AZ 85008
Phone (602)244-2566
Fax (602)244-8947
Website www.entellus.com

Buckeye/Sun Valley Area Drainage Master Study
FIELD MEETING QUESTIONERRE
Entellus Project No. 110.018
Wednesday, August 11th, 2004, 10:00 a.m.

Flood Control District of Maricopa County

Name: W. Bruce Heiden Phone Number(s): 623-386-4410

IRRIGATION INFORMATION

For each type of crop listed below, please describe how the fields are irrigated:

Crop:	How Often? Summer | Winter	How Long? Summer | Winter	How Much? Summer | Winter
1) Alfalfa	2 weeks | 1 month	80 acres = 64 hrs	.5 acre ft | .5 acre ft
2) Corn	May & June 5 days	80 acres 48 hrs	.3 acre ft
3) Wheat	10 days	80 acres 48 hrs	.3 acre ft
4) Cotton	June July Aug - 6 days	80 acres 48 hrs	.35 acre ft
5) ( )			
6) ( )			
7) ( )			

CROP ROTATION INFORMATION

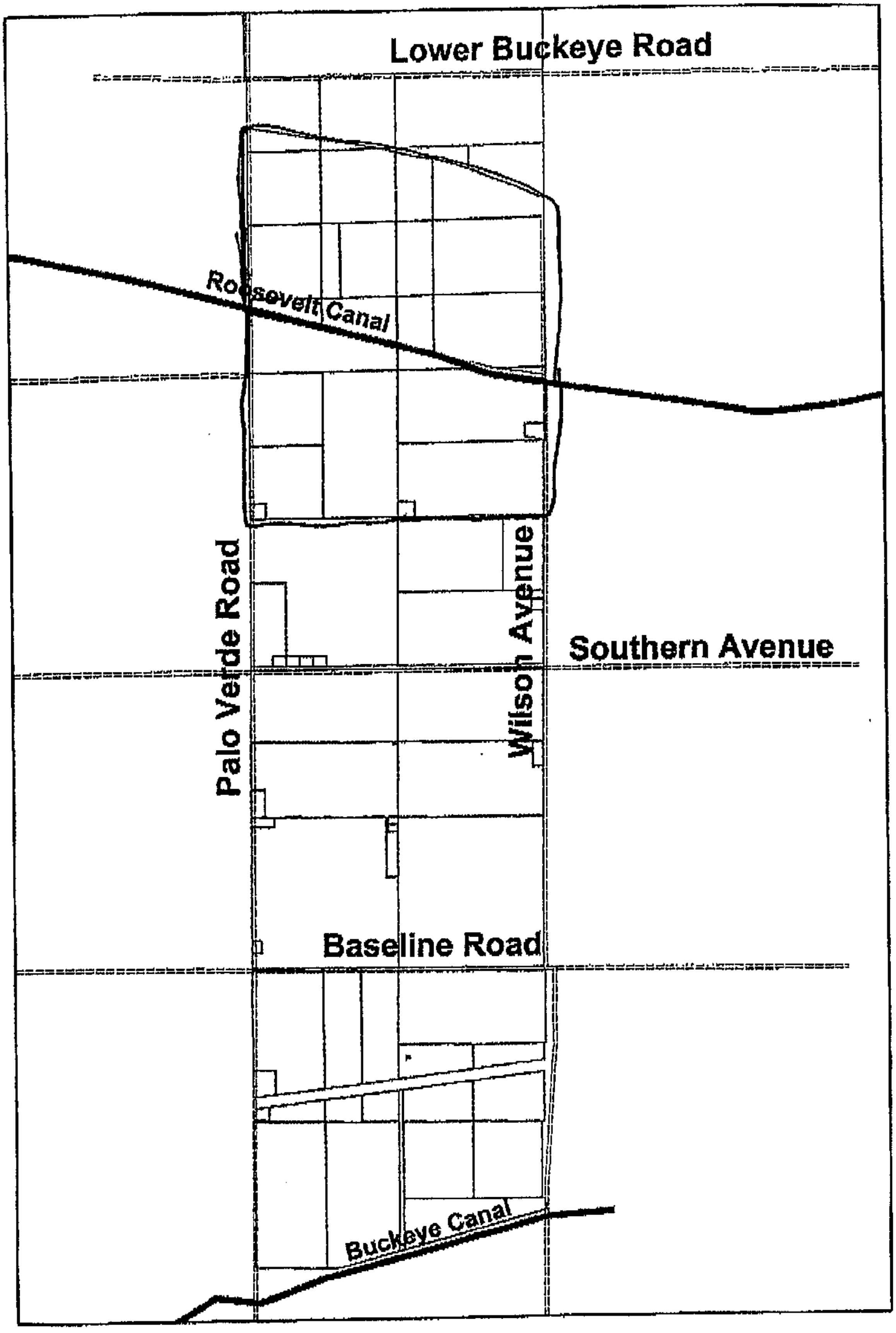
For each type of crop listed below, please describe how the fields are rotated:

Please check the crops you grow:	✓	**Alfalfa**	✓	**Corn**	✓	**Wheat**
	✓	**Cotton**	____	( )	____	( )
	____	( )				
When is each crop planted?	Oct	**Alfalfa**	Mar	**Corn**	Jan	**Wheat**
	May, apr	**Cotton**	____	( )	____	( )
	____	( )				
When is each crop harvested?	12 Month	**Alfalfa**	July	**Corn**	June	**Wheat**
	Oct Nov, Dec	**Cotton**	____	( )	____	( )
	____	( )				
How long is the growing season?	12 Month	**Alfalfa**	130 day	**Corn**	5 Month	**Wheat**
	10 Months	**Cotton**	____	( )	____	( )
	____	( )				
How long is the field in fallow?	- 0 -	**Alfalfa**	6 Month	**Corn**	6 Month	**Wheat**
	2 Month	**Cotton**	____	( )	____	( )
	____	( )				
What % of your fields are?	50 %	**Alfalfa**	20%	**Corn**	18 %	**Wheat**
	12%	**Cotton**	____	( )	____	( )
	____	( )				

What % of your fields are typically in fallow? Corn & Wheat 38% for 6 months

Name: H Four Farms, W. Bruce Heiden Phone: 623 386-4410

Please outline your areas of operation on the map below.



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Flood Control District of Maricopa County

Buckeye/Sun Valley Area Drainage Master Study
FIELD MEETING QUESTIONERRE
Entellus Project No. 110.018
Wednesday, August 11th, 2004, 10:00 a.m.

Name: Gingg Farms Phone Number(s): 602-390-1998

IRRIGATION INFORMATION

For each type of crop listed below, please describe how the fields are irrigated:

Crop:	**How Often?** Summer | Winter	**How Long?** Summer | Winter	**How Much?** Summer | Winter
1) Alfalfa	2X per Month –	Same –	3"-4" / irrigation
2) Corn			
3) Wheat			
4) Cotton			
5) ( )			
6) ( )			
7) ( )			

CROP ROTATION INFORMATION

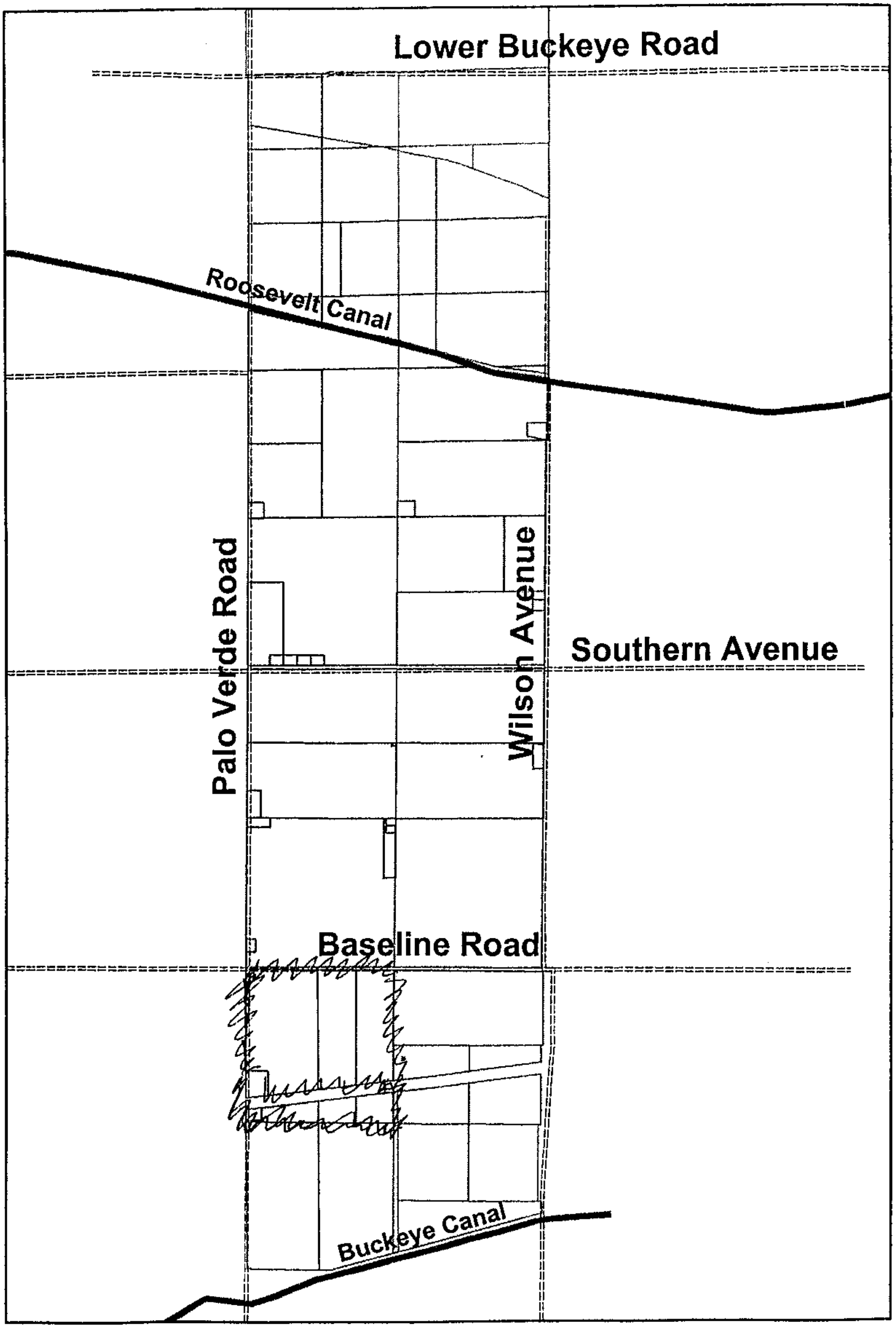
For each type of crop listed below, please describe how the fields are rotated:

Please check the crops you grow:	✓ **Alfalfa**	✓ **Corn**	✓ ~~**Wheat**~~ Barley
	____ **Cotton**	____ ( )	____ ( )
	____ ( )		
When is each crop planted?	Oct. **Alfalfa**	March **Corn**	Dec **Wheat**
	April **Cotton**	____ ( )	____ ( )
	____ ( )		
When is each crop harvested?	monthly **Alfalfa**	July **Corn**	May June **Wheat**
	Nov. **Cotton**	____ ( )	____ ( )
	____ ( )		
How long is the growing season?	Year around **Alfalfa**	5mo **Corn**	6mo **Wheat**
	8mo **Cotton**	____ ( )	____ ( )
	____ ( )		
How long is the field in fallow?	0 **Alfalfa**	8mo **Corn**	6mo. **Wheat**
	4mo. **Cotton**	____ ( )	____ ( )
	____ ( )		
What % of your fields are?	37.5% **Alfalfa**	12.5% **Corn**	12.5% **Wheat**
	37.5% **Cotton**	____ ( )	____ ( )
	____ ( )		

What % of your fields are typically in fallow? 10% ?

Name: Gingg Farms Phone: 602-390-1998

Please outline your areas of operation on the map below.



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Flood Control District of Maricopa County

Buckeye/Sun Valley Area Drainage Master Study
FIELD MEETING QUESTIONERRE
Entellus Project No. 110.018
Wednesday, August 11th, 2004, 10:00 a.m.

Name: Ken Butler Phone Number(s): 602 918-1501

IRRIGATION INFORMATION

For each type of crop listed below, please describe how the fields are irrigated:

Crop:	How Often? Summer	How Often? Winter	How ~~Long~~ much? Summer	How ~~Long~~ much? Winter	How ~~Much~~ Long? Summer	How ~~Much~~ Long? Winter
1) Alfalfa	7-10 days	when needed	250"-350"	same	2-4½ hrs	same
2) Corn	5 days		250"		12 hrs/set (10-20 AC.	
3) Wheat						
4) Cotton						
5) ( )						
6) ( )						
7) ( )						

CROP ROTATION INFORMATION

For each type of crop listed below, please describe how the fields are rotated:

Please check the crops you grow: ✓ Alfalfa ✓ Corn ____ Wheat ____ Cotton ✓ (Sudan) — (oats) ____ ( )

When is each crop planted? oct Alfalfa March Corn ____ Wheat ____ Cotton summer (Sudan) winter (oats) ____ ( )

When is each crop harvested? Varies Alfalfa July Corn ____ Wheat ____ Cotton ____ (Sudan) ____ (oats) ____ ( )

How long is the growing season? 2-3 yrs Alfalfa — Corn ____ Wheat ____ Cotton 3-4 mo (Sudan) 2-3 mo (oats) ____ ( )

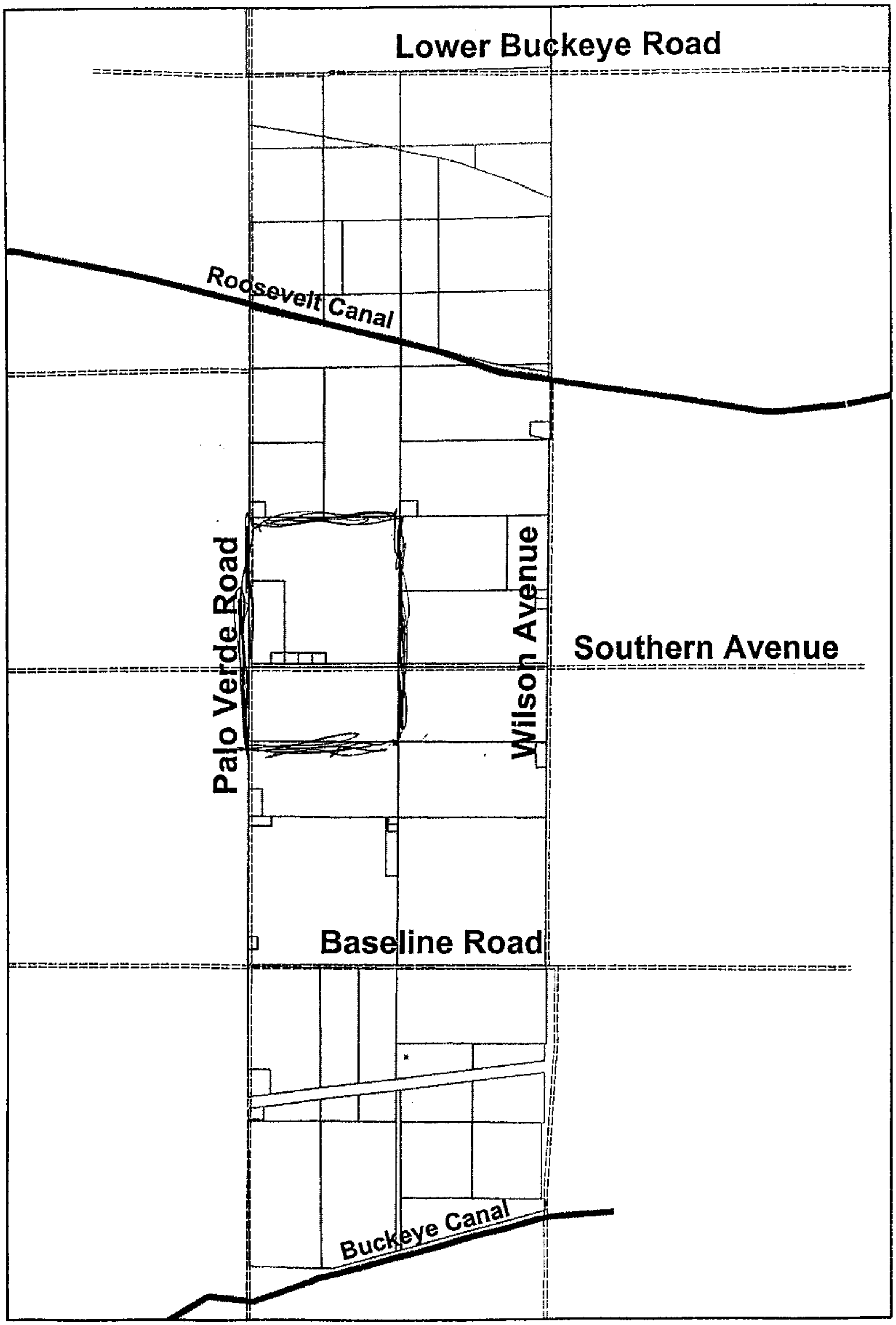
How long is the field in fallow? Varies Alfalfa ____ Corn ____ Wheat ____ Cotton ____ ( ) ____ ( ) ____ ( )

What % of your fields are? 100% Alfalfa 25% Corn ____ Wheat ____ Cotton 10% (Sudan) 40% (oats) ____ ( )

What % of your fields are typically in fallow?________________

Name: Ken Butler Phone: 602 918-1501

Please outline your areas of operation on the map below.



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Buckeye/Sun Valley Area Drainage Master Study
FIELD MEETING QUESTIONERRE
Entellus Project No. 110.018
Wednesday, August 11th, 2004, 10:00 a.m.

Name: Don Gladden / Gladden Farms   Phone Number(s): 602-478-3123 / 623-386-3119

IRRIGATION INFORMATION

For each type of crop listed below, please describe how the fields are irrigated:

Crop:	How Often? Summer | Winter	How Long? Summer | Winter	How Much? Summer | Winter
1) Alfalfa	2/mon 1/mon		.3-.5 ac.ft, per irrigat
2) Corn	5 day cycle		
3) Wheat	—		
4) Cotton	—		
5) ( )			
6) ( )			
7) ( )			

CROP ROTATION INFORMATION

For each type of crop listed below, please describe how the fields are rotated:

Please check the crops you grow: X Alfalfa X Corn X Wheat ___Cotton ___( ) ___( ) ___( )

When is each crop planted? Sept-Nov Alfalfa March Corn Dec Wheat ___Cotton ___( ) ___( ) ___( )

When is each crop harvested? All year Alfalfa July Corn June Wheat ___Cotton ___( ) ___( ) ___( )

How long is the growing season? All year Alfalfa 4 mon Corn 6 mon Wheat ___Cotton ___( ) ___( ) ___( )

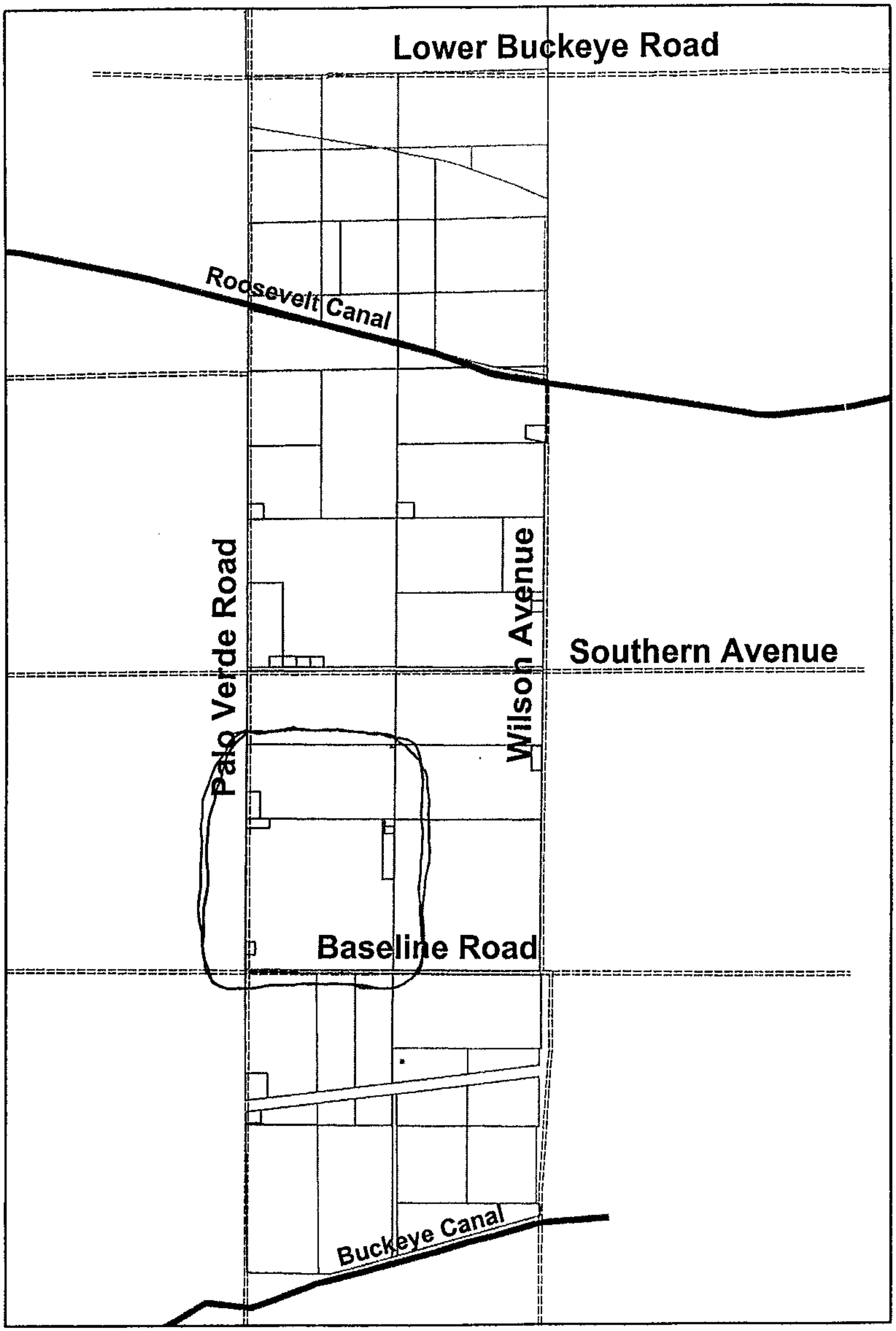
How long is the field in fallow? ___Alfalfa ___Corn ___Wheat ___Cotton ___( ) ___( ) ___( )

What % of your fields are? 66% Alfalfa 33% Corn ___Wheat ___Cotton ___( ) ___( ) ___( )

What % of your fields are typically in fallow? 0% all year 30%-60% 2-3 mon

Name:______________________________Phone:________________

Please outline your areas of operation on the map below.



103 W. Baseline Road
Buckeye, AZ 85326
623-386-2046 Telephone
623-386-4360 Fax

Roosevelt Irrigation District

Fax

To:	Jacob Sweeney Entellus Inc.	**From:**	Stan Ashby
Fax:	602-244-8947	**Pages:**	3 including cover sheet
Phone:		**Date:**	07/28/04
Re:		**CC:**	

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

● **Comments:**

Jacob, attached are the flows for Lateral 21 (Wilson Road and Lateral 22 (Palo Verde Road). The F Lows are reported in Arizona Minor's Inches.

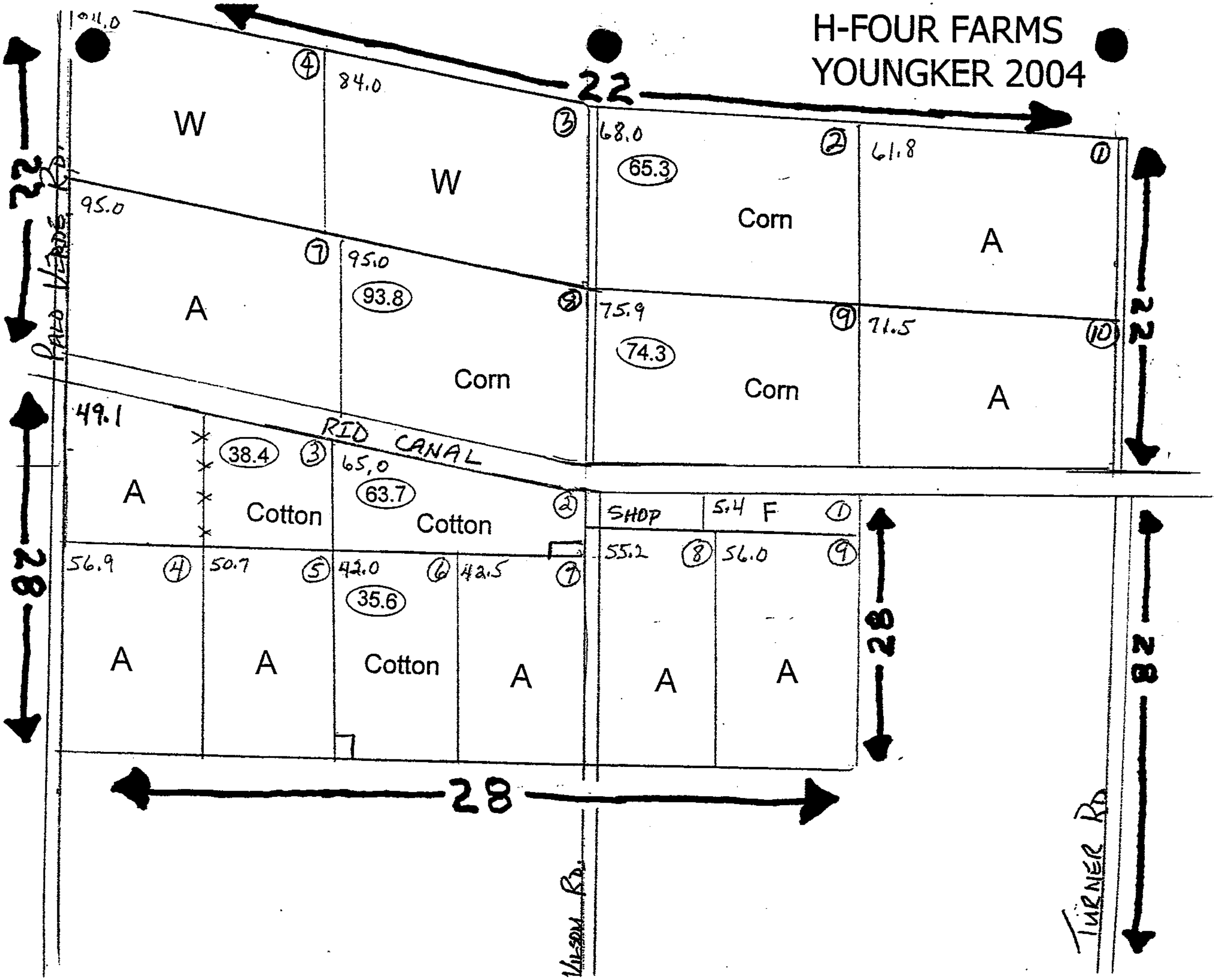
JUNE	2003	LAT 21	LAT 22	JULY	2003	LAT 21	LAT 22
1		200	800	1		400	250
2		200	600	2		400	350
3		100	600	3		500	1050
4		100	400	4		400	800
5		0	400	5		0	350
6		0	250	6		0	625
7		0	400	7		350	375
8		400	150	8		650	375
9		400	300	9		650	775
10		650	650	10		1000	525
11		650	800	11		700	525
12		400	1000	12		400	275
13		0	1000	13		650	250
14		0	1000	14		400	250
15		0	700	15		400	325
16		0	700	16		500	150
17		0	800	17		400	525
18		0	750	18		250	450
19		700	150	19		850	575
20		700	150	20		550	375
21		0	150	21		600	725
22		0	150	22		350	1125
23		0	350	23		250	525
24		100	550	24		0	375
25		450	200	25		250	275
26		600	800	26		250	125
27		350	650	27		250	125
28		500	550	28		0	575
29		400	150	29		0	575
30		400	150	30		350	775
				31		350	775

WATER FLOWS
LATERAL 21 AND LATERAL 22
JUNE AND JULY 2003

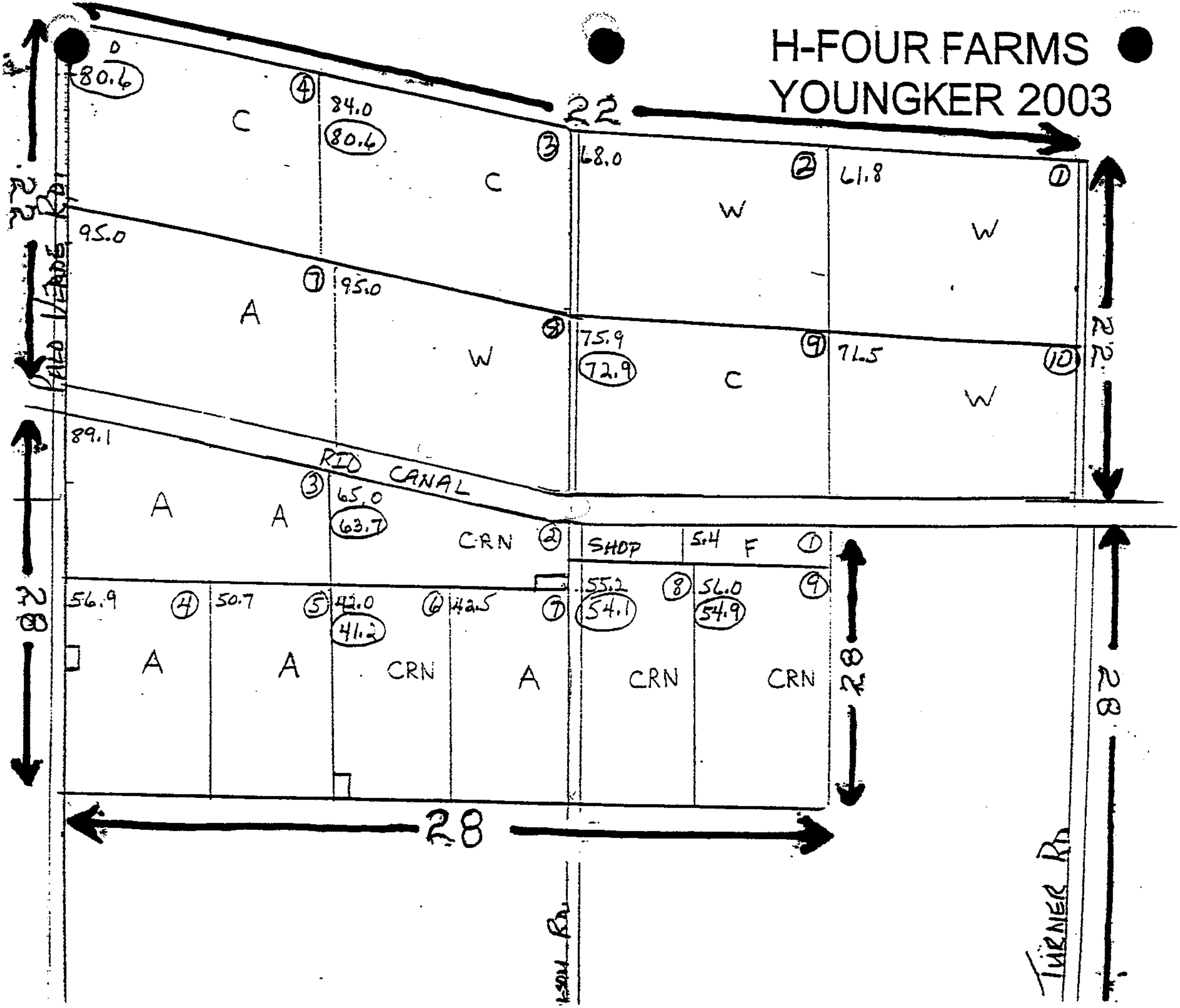
JUNE	2004	LAT 21	LAT 22	JULY	2004	LAT 21	LAT 22
1		425	450	1		375	150
2		125	450	2		125	400
3		50	250	3		125	400
4		125	200	4		325	450
5		125	350	5		325	400
6		0	50	6		325	150
7		125	550	7		325	150
8		125	550	8		325	150
9		126	550	9		200	300
10		125	400	10		325	300
11		125	200	11		125	300
12		375	350	12		325	300
13		475	350	13		325	250
14		676	200	14		325	100
15		400	375	15		125	100
16		625	450	16		125	0
17		375	600	17		275	0
18		375	600	18		275	0
19		0	600	19		325	0
20		0	600	20		350	0
21		0	450	21		400	0
22		0	450	22		400	0
23		0	200	23		325	300
24		0	300	24		325	300
25		0	300	25		325	300
26		426	300	26		0	200
27		525	500	27		0	
28		525	0	28			
29		625	0	29			
30		375	0	30			
				31			

WATER FLOWS
LATERAL 21 AND LATERAL 22
JUNE AND JULY 2004

H-FOUR FARMS
YOUNGKER 2004

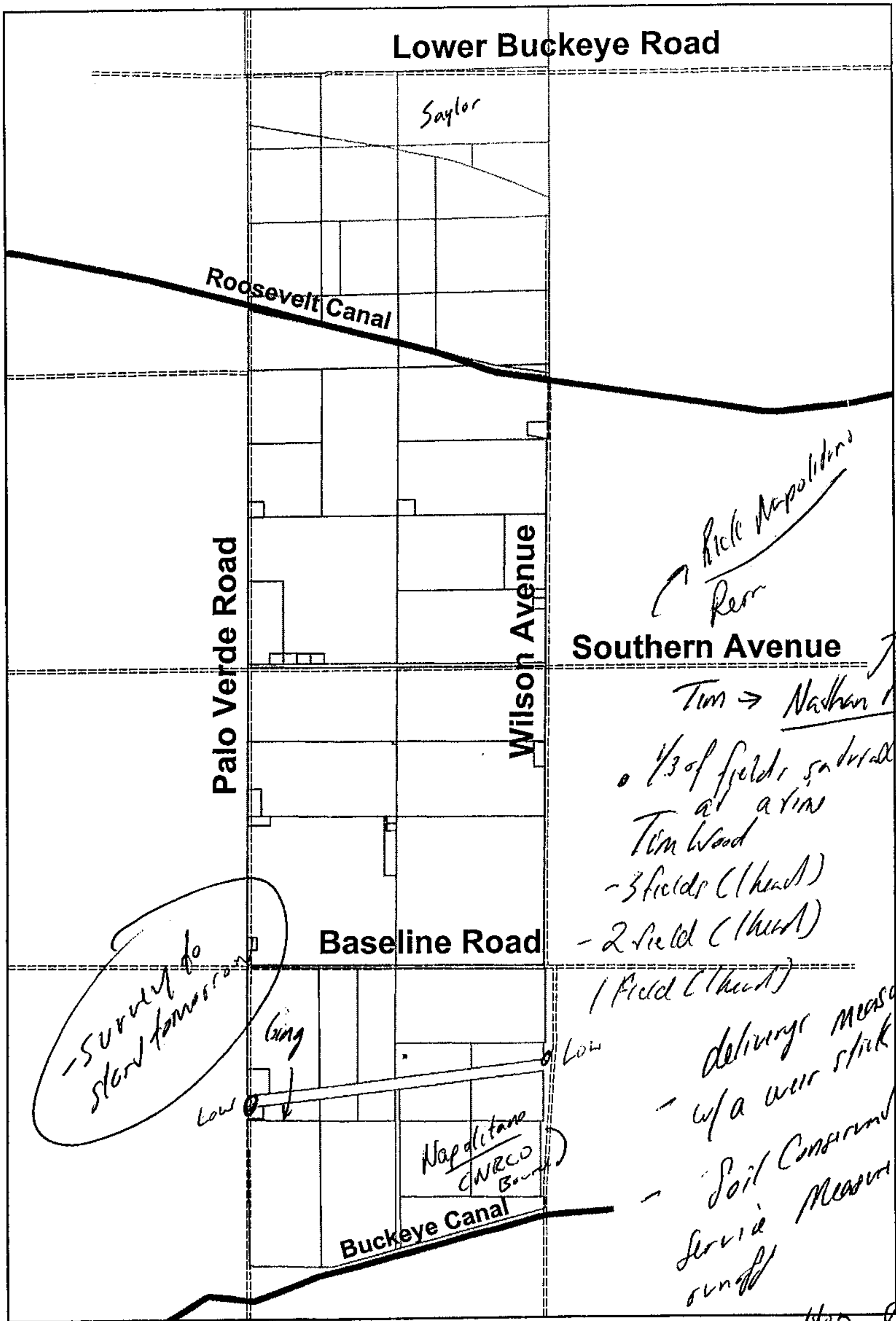


H-FOUR FARMS
YOUNGKER 2003



Name:______________________________ Phone:_________________

Please outline your areas of operation on the map below.



Rick Napolitano
Rem
In Buckeye
Tim → Nathan Mountain
• 1/3 of fields saturated at a time
Tim Wood
- 3 fields (1 head)
- 2 field (1 head)
1 field (1 head)

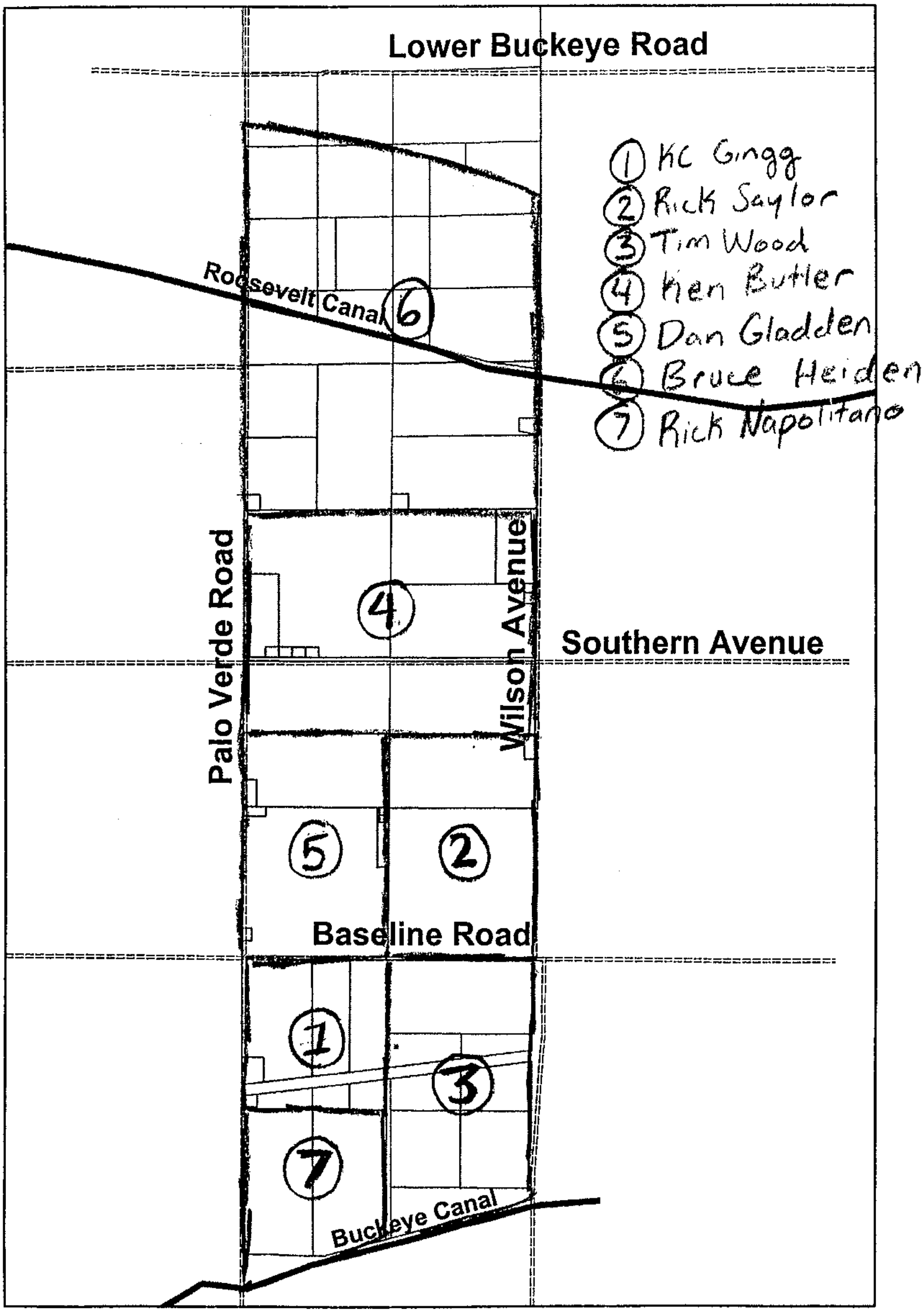
- Survey to start tomorrow

- delivery measure
- w/a weir stick
- Soil Conservation Service Measures water runoff

- Survey - in cotton areas please pre-notify

Name:______________________________Phone:________________

Please outline your areas of operation on the map below.



APPENDIX B. DATA COLLECTION

B.1. Original Study Process/Scope of Work

B.2. Farmer Surveys

B.3. Related Studies

B.4. NRCD Field Efficiency Test Records

B.5. Field Photographs and Observations

B.6. Survey Data

B.7. District Methodology Text and Tables

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY 1959

FLOOD CONTROL DISTRICT

OF

MARICOPA COUNTY

2801 WEST DURANGO STREET PHOENIX, ARIZONA 85009

BUCKEYE AREA

FLOOD DELINEATION STUDY

HYDROLOGY REPORT

APPENDICES AA and BB

FCD CONTRACT NO. 90-69

MAY 1992

PREPARED BY:

McLAUGHLIN KMETTY ENGINEERS, LTD.
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PHOENIX, ARIZONA 85012
(602) 248-7702

IN ASSOCIATION WITH:

GEORGE V. SABOL CONSULTING ENGINEERS, INC.

RECEIVED JAN 1 6 1992

TECHNICAL MEMORANDUM

TO: Tim Murphy (Contract FCD 90-69)
Steve Waters (Contract FCD 90-20)

FROM: G.V. Sabol

DATE: 14 January 1992

SUBJECT: 1.) Unit hydrographs for agricultural fields, and
2.) New Lag relation for unit hydrographs.

REFERENCE: Contract FCD 90-69, Buckeye FIS
Contract FCD 90-20, Hydrology/Hydraulics Advisory Services

INTRODUCTION

This study was initiated as part of the Buckeye FIS Project (Tasks 3.13.A and 3.13.B). However, the work effort and results extend beyond that required by the Buckeye FIS, and some portion of this work was undertaken under contract FCD 90-20 as additional unit hydrograph development for the Manual.

This memorandum presents the following:

1. development of a new Lag relation for unit hydrographs,
2. comparison of four unit hydrographs for four selected subbasins from the Buckeye FIS watershed model,
3. comparison and evaluation of using the new Lag relation with the Phoenix Valley and the Phoenix Mountain S-Graphs for seven watersheds that were used in verification of the Maricopa County Hydrologic Design Manual (Manual),
4. conclusions from these comparisons and evaluations,
5. recommendations, and
6. suggested studies to be undertaken before implementing the recommendations.

DEVELOPMENT OF NEW Lag RELATION

Theory

The general relation for basin Lag as a function of watershed characteristics that is traditionally used is given by Equation 1.

The theoretical justification for Equation 1 is not known but was probably an extension of the results of Snyder's (1940) investigations, wherein he

$$Lag = C\left(\frac{L \times LCA}{S^{1/2}}\right)^{m} \qquad (1)$$

determined the following equation for Lag:

$$Lag = C_t \,(L \times LCA)^{.30} \qquad (2)$$

The value of the exponent, m, in Equation 1, generally has been assigned within the range 0.30 to 0.38. The USBR (Flood Hydrology Manual (Cudworth, 1989)) recommends that m = 0.33 regardless of the location of the drainage basin. The Corps of Engineers typically uses m = 0.38. The coefficient, C, appears to be related to the hydraulic efficiency of the direct storm runoff through the drainage network. For a value of m = 0.33, the USBR recommends that C = 26 K_n, and the Corps uses C = 24 K_n with m = 0.38, where K_n is a resistance coefficient representing the average resistance to flow through the drainage network. The traditional Lag equations in use are:

$$Lag = 26K_n \left(\frac{L \times LCA}{S^{1/2}}\right)^{.33} \quad \textit{by the USBR} \qquad (3)$$

$$Lag = 24K_n \left(\frac{L \times LCA}{S^{1/2}}\right)^{.38} \quad \textit{by the Corps} \qquad (4)$$

It should be noted that there are numerous definitions for Lag. Horner and Flynt (1936) originally defined Lag as the time from center of mass of rainfall to center of mass of runoff. Lag, as defined by Snyder (1940), is the time between the center of mass of rainfall excess of a specified type of storm and the occurrence of peak discharge at the location being studied. This definition indicates that Lag will vary depending on the type of storm or rainfall characteristics such as intensity. The SCS definition of Lag is the same as that used by Snyder. Lag of Equation 1 is determined from an S-graph analysis and is defined as the time from the start of a continuous series of unit rainfall excess increments to the time when the resulting runoff hydrograph reaches 50 percent of the ultimate discharge. The ultimate discharge is an equilibrium rate achieved at the time when the entire drainage basin is contributing runoff at the concentration point from the continuous series of unit rainfall excess increments.

These equations and others for Lag have been developed from data for gaged watersheds and these empirical equations are used to estimate Lag for ungaged watersheds. Theoretically, the equations should satisfy hydraulic similitude for gravity flow with the gaged watersheds being considered as models and the ungaged watersheds as prototypes. The resulting Lag equations should satisfy Froude Number similitude and accordingly the time relation for model to prototype conversion is:

$$T_R \propto L_R^{.5} \tag{5}$$

where T_R is the time ratio and L_R is the scale ratio. The model to prototype time relation of Equation 1 should agree with Equation 5. Therefore the exponent m should be 0.25 as shown in Equation 6:

$$Lag \propto (L \times LCA)^{.25} \tag{6}$$

The relation of Lag to watershed slope is a means of incorporating the runoff velocity, V, in the Lag equation and

$$Lag \propto \frac{1}{V} \tag{7}$$

According to equations of gravity flow

$$V \propto S^{1/2} \tag{8}$$

and therefore

$$Lag \propto \frac{1}{S^{1/2}} \tag{9}$$

which deviates significantly from either Equation 3 or 4.

Combining Equations 6 and 9 results in

$$Lag = CL \left(\frac{L \times LCA}{S^2}\right)^{.25} \tag{10}$$

Where CL is a coefficient.

Lag is a function of many variables that describe the watershed characteristics and possibly also variables that describe the rainfall characteristics as suggested by Snyder (1940). Sufficient data for gaged watersheds are not available to document all the watershed and rainfall characteristics that may be of interest, and certain variables may be too subjective, such as K_n in Equations 3 and 4, to be reliable and reproducible for use in a prediction equation. Therefore, CL may be a surrogate to account for all the unknown and unmeasured variables affecting Lag. For this reason, it may not be possible to develop a CL equation that is dimensionlessly homogeneous using only available and readily obtainable watershed characteristics and measured Lag data. Therefore, empirical equations were developed for CL from available data.

CL Relations

Data on watershed characteristics and Lag as determined by S-graph analysis was obtained from the files of the USBR that was used by the USBR in developing Tables 4-1 through 4-6 of its Flood Hydrology Manual. These data were classified into six categories by the USBR as follows:

1. Great Plains (Table 4-1),
2. Rocky Mountains (Table 4-2),
3. Southwest Desert, Great Basin, and Colorado Plateau (Table 4-3),
4. Sierra Nevada (Table 4-4),
5. Coast and Cascade Ranges of California, Oregon, and Washington, (Table 4-5), and
6. Urbanized basins (Table 4-6).

The data sets for deserts (Table 4-3), the Rocky Mountains (Table 4-2), and urban basins (Table 4-6) are applicable to Arizona and these data are shown in Appendix A. Previous investigations indicated that the desert and Rocky Mountain Lag data are compatible for analysis as a single set. The watershed characteristic data and measured Lag for the desert and Rocky Mountain watersheds that were obtained from the USBR are shown in Table 1. Figure 1 shows a graph of measured Lag versus $L \times LCA/S^2$. Lines are shown in Figure 1 with a slope of 0.25 indicating agreement with the theoretically derived exponent $m = 0.25$. The lines are for CL of 5, 10 and 15, and the data indicate that CL ranges from slightly less than 5 to about 18 with most CLs between 10 and 15.

Multiple regression analyses were performed using the data of Table 1 in an attempt to develop a prediction equation for CL. About 40 CL equations were developed from various combinations of independent variables. The variables were inspected in both untransformed and transformed (log and power functions) states.

Four CL prediction equations were selected for further inspection. These being:

$$CL1 = 11.75 + .006\, DA - .21\, LWR \qquad (11)$$

$$R^2 = 0.70$$

$$CL2 = -18.03 + 3.3 \log DA + 10.5 \log S \tag{12}$$

$$R^2 = 0.69$$

$$CL3 = -14.24 + 3.02 \log DA + 9.04 \log S \tag{13}$$

$$R^2 = 0.68$$

$$CL4 = \text{antilog}\,(.1816 + .103 \log DA + .307 \log S) \tag{14}$$

$$R^2 = 0.65$$

where LWR is watershed length to width ration (L^2/DA),
DA is drainage area in square miles, and
S is watercourse slope in feet/mile.

The square of the multiple correlation coefficient (R^2) measures the portion of total variation about the mean (in this case the mean value of CL) that is explained by the regression equation. A $R^2 = 1.0$ indicates that the regression equation explains 100% of the total variation (the ideal, but virtually never achieved situation). Larger values of R^2 means that the equation better explains variation in the data. R^2 in the 0.5 to 0.8 range are common for hydrologic data. R^2 larger than 0.8 is exceptional. The R^2 for the above equations are reasonable for the type of data that are analyzed. There are many more variables that are needed to "accurately" estimate Lag, but the identification and measurement of these other variables is beyond our present ability.

The CL that is estimated by Equations 11 through 14 are listed in Table 1 and these were plotted against the measured CL in Figures 2 through 5, respectively. These graphs indicate that the four CL prediction equations provide reasonable values for CL.

The results from the four CL prediction equations were used in Equation 10 (the new Lag relation) to estimate Lag for the watersheds that were used to develop the CL prediction equations. The estimated Lag with CL estimated by Equations 11 through 14 are listed in Table 1 and these were plotted against the measured Lag in Figures 6 through 9, respectively.

Inspection of Figures 2 through 9 does not lead to a clearly superior estimator of CL or Lag. However, CL1 seems to be weak at estimating low CLs and short Lags, but seems to be stronger than other CL equations for longer Lags.

Some independent Lag data is identified in the S-Graph Report that was prepared for the Flood Control District of Maricopa County (Sabol, 1987). That data is shown in Table 2. In Table 2, values of Lag are shown for numerous Arizona watersheds that were developed from data for the storms of December 1967, September 1970, and June 1972. Descriptions of those storms are shown in Appendix B. Notice that different values of Lag are shown in Table 2 depending on the storm. This illustrates that [redacted]

Estimated values of Lag by Equation 10 and CL by Equations 11 through 14 were calculated and these are shown in Table 2 and are compared to the measured values of Lag in Figures 10 through 13. Notice in these figures that the Lags for the December 1967 storms are usually longer than the Lag for the September 1970 and June 1972 storms. The December 1967 storm was a general winter storm with lower rainfall intensity than the large local storm of September 1972 and the smaller local storm of June 1972. [redacted] These figures also indicate that the Lag and CL prediction equations perform reasonably well for watersheds that were <u>not</u> used to develop the CL prediction equations.

Quantitative analyses could not distinguish a clearly superior CL prediction equation and a qualitative evaluation of Equations 11 through 14 was performed. Equations 12 and 13 could result in negative values of CL for some combinations of area (DA) and slope (S) and therefore these equations were rejected. Equation 11 seems to be weak for watersheds with low CL values which could yield some unconservative results. Therefore Equation 14 is recommended for use in estimating CL for undeveloped (natural) watersheds of deserts and mountains in Arizona.

A similar analysis was performed for urban watersheds using USBR data (Appendix A) as shown in Table 3. An additional watershed characteristic, impervious area (RTIMP), was included for urban watersheds. A graph of L x LCA/S^2 versus measured Lag for urban watersheds is shown in Figure 14, and that graph illustrates that the theoretical value of m = 0.25 is appropriate and that CL ranges from about 1.0 to 5.0 for urban watersheds. A multiple regression analysis of the urban watershed data resulted in one clearly superior equation to predict CL for such watersheds:

$$CL = antilog\,(0.31 + 0.0955 \log DA + 0.3560 \log S - 0.3610 \log RTIMP)$$

$$R^2 = 0.67 \qquad (15)$$

A comparison of the estimated CL and measured CL is shown in Figure 15 and a comparison of the estimated Lag and measured Lag is shown in Figure 16.

One more general type of watershed exists in Arizona that needs to be considered besides desert/mountain and urban; that being irrigated agricultural watersheds. This was identified by the District prior to initiation of the Buckeye FIS contract. Such watersheds have very flat slopes and may have high resistance to flow due to tillage and vegetation growth. Such watersheds may also be representative of large turf areas such as golf courses and parks. Data are not available to develop a CL prediction equation for such watersheds, therefore, the desert/mountain CL equation was modified based on other considerations as follows: *Resistance factors for overland* flow are provided in the September 1990 HEC-1 Manual and SCS TR-55 (Appendix C). The ratio of resistance factors for various surfaces to the resistance factor for rangeland (natural) from TR-55 are as follows:

Surface	Ratio of Resistance Factors (Rangeland n = 0.13)
Cultivated, residue greater than 20%	1.3
Dense grass	1.8
Bermuda grass	3.2

The ratio of resistance factors for various surfaces to the resistance factor for rangeland (20% cover) from HEC-1 are as follows:

Surface	Ratio of Resistance Factors	
	n = 0.05	n = 0.25
Conventional tillage with residue	3.2 - 4.4	.6 - .9
Dense grass	3.4 - 16.0	.7 - 3.2
Bermuda grass	6.0 - 9.6	1.2 - 1.9

Although there is tremendous variability in these ratios, a composite ratio of agricultural/grass resistance factors to a rangeland (natural) resistance factor of 3.0 seems reasonable. Therefore, the Lag for agricultural/grass watersheds would be about 3 times larger than the Lag for a comparable rangeland watershed. The CL prediction equation for agricultural/grass watersheds is:

$$CL = 3 \times antilog\,(.1816 + .103 \log DA + .307 \log S) \qquad (16)$$

Summary of CL and Lag for use in Arizona

The recommended Lag equation is:

$$Lag = CL\left(\frac{L \times LCA}{S^{2}}\right)^{.25} \qquad (10)$$

where CL is estimated by Equation 14 for desert and mountain watersheds, by Equation 16 for agricultural/grass watersheds, and by Equation 15 for urban watersheds. Those equations, rewritten in more convenient form are:

desert and mountain watersheds,

$$CL = 1.5\ A^{.1}\ S^{.3} \qquad (17)$$

agricultural/grass watersheds,

$$CL = 4.5\ A^{.1}\ S^{.3} \qquad (18)$$

urban watersheds,

$$CL = \frac{2.0\ A^{.1}\ S^{.36}}{RTIMP^{.36}} \qquad (19)$$

where A is drainage area in square miles,
S is watershed slope in feet/mile, and
RTIMP is impervious area in %.

Adjustment of Lag for Return Period

It is assumed that the Lag that is estimated by Equation 10 with CL estimated by Equations 17, 18 and 19 provides an estimate of Lag for severe storms that produce floods of approximately the 100-yr return period. [redacted]. Data are not available to provide definitive guidance for adjusting Lag for flood return period. Previous flood studies (Tucson Arroyo) for the District indicate that the following Lag frequency factors may be appropriate:

Return Period years	F_f
100	1.0
50	1.25
25	1.50
10	1.75
2	2.0

Additional testing of this method using gaged watershed data could be used to confirm or modify the use of flood frequency factors.

Adjustment of Lag for use with SCS Unit Hydrographs

As previously discussed, there are several definitions of Lag and the definition of Lag as used herein is not the same as the SCS definition of Lag used with its unit hydrographs. Appendix D provides a comparison of this definition of Lag to the SCS Lag. The SCS Lag can be estimated by

$$Lag\ (SCS) = 0.77\ Lag \qquad (20)$$

WATER RESOURCES BULLETIN
VOL. 28, NO. 2 AMERICAN WATER RESOURCES ASSOCIATION APRIL 1992

DEVELOPMENT AND EVALUATION OF A DIMENSIONLESS UNIT HYDROGRAPH[1]

Bruce N. Wilson and J. William Brown[2]

ABSTRACT: A generalized unit hydrograph method is developed and evaluated for ungaged watersheds. A key component in this method is the value of a dimensionless storage coefficient. Procedures to estimate this coefficient are given using calibrated values from 142 rainfall-runoff events gaged in watershed located mainly in the Eastern US. Only limited success was obtained in predicting this storage coefficient. Thirty-seven, independent rainfall-runoff events were used to test the proposed technique. The generalized unit hydrograph predicted the observed runoff hydrographs fairly well with considerable improvement in accuracy over the SCS dimensionless unit hydrograph. Approximately one-half of test storms had percent errors in predicted peak flow rates that were less than 34 percent compared to percent error of 88 percent with the SCS method.
(KEY TERMS: agricultural hydrology; hydrograph analysis and modeling; optimization)

INTRODUCTION

The unit hydrograph and the synthetic unit hydrograph are two widely-used methods to represent surface runoff. Unit hydrographs are preferred where there are observed rainfall and streamflow data. Synthetic unit hydrographs are used for ungaged watersheds. The shape of these hydrographs is indirectly determined using watershed and rainfall characteristics. Both types of unit hydrographs are limited by the assumptions of linear systems. Nonetheless, unit hydrographs have been successfully used to predict surface runoff (Howard and Meadows, 1981; Wilson *et al.*, 1984) and are widely used in hydrologic designs (HEC, 1971; SCS, 1972).

Since most small watersheds are ungaged, hydrologists are often limited to synthetic unit hydrographs. Numerous studies have been conducted on this topic ranging from empirical graphs (Snyder, 1938; SCS, 1972) to conceptual linear models (Clark, 1943; Nash, 1957; Dooge, 1959). More recently, attempts have been made to relate unit hydrograph theory to recent advances in geomorphology (Rodriguez-Iturbe and Valdes, 1979; Gupta *et al.*, 1980; Kirshen and Bras, 1983; Troutman and Karlinger, 1985). Some of the above approaches are theoretically more appealing than others. However, the selection of the "best" design method is largely dependent on the ability of the hydrologist to estimate the parameters of the synthetic unit hydrograph. Although there are a few notable exceptions (Gray, 1962; SCS, 1972), most methods provide little practical information for estimating their parameters or have guidelines based on only a few rainfall-runoff events.

In this study, a synthetic unit hydrograph method is proposed and its parameters are evaluated using a large data base of primarily agricultural watersheds. There are three major components of the study. First, a dimensionless unit hydrograph is developed using an analytical solution of Clark's method (Clark, 1943). A key parameter here is a dimensionless storage coefficient. Second, the dimensionless storage coefficient is evaluated using 142 rainfall-runoff events obtained from watersheds located mainly in the Eastern US. Regression relationships are developed from these events. Third, the accuracy of the proposed method is evaluated using an additional 37 independent, rainfall-runoff events. Comparisons are made between predicted and observed values as well as the relative accuracy of other approaches.

[1]Paper No. 91060 of the *Water Resources Bulletin*. Discussions are open until December 1, 1992.
[2]Respectively, Assistant Professor, Agricultural Engineering Department, University of Minnesota, 1390 Eckles Avenue, St. Paul, Minnesota 55108; and Watershed Engineer Lake County Stormwater Management Commission, 333 B Peterson Road, Libertyville, Illinois.

THEORETICAL DEVELOPMENT

Dimensionless Formulation of Clark's Method

A dimensionless unit hydrograph is developed from Clark's (1943) method. Clark proposed that a unit hydrograph for ungaged watersheds could be obtained by routing a time-area curve through a single, linear reservoir. This approach is simple, has parameters that are conceptually connected to the runoff process and has wide-spread use (HEC, 1971). Clark's method is based on the continuity equation for a linear reservoir which can be written as

$$I(t)-O(t)=\frac{dS(t)}{dt}=K\frac{dO(t)}{dt} \tag{1}$$

where $I(t)$ is the inflow hydrograph, $O(t)$ is the outflow hydrograph, $S(t)$ is reservoir storage defined as $S(t)=KO(t)$, K is a storage coefficient and t is time. In Clark's method, the inflow hydrograph is taken as the time-area curve for a watershed and the outflow hydrograph is the unit hydrograph. If the time-area curve is based on an instantaneous excess depth of one unit (i.e., $I=(1)dA/dt$), then the unit hydrograph is an instantaneous unit hydrograph (IUH), that is the outflow in equation (1) is the IUH. This is the assumption used herein.

A dimensionless form of equation (1) can be obtained by multiplying both sides of Equation 1 by t_c/Z_eA_T and rearranging terms as

$$I_*(t_*)-O_*(t_*)=K_*\frac{dO_*(t_*)}{dt_*} \tag{2}$$

where the dimensionless variables are defined as

$$A_*(t_*)=\frac{A(t_*)}{A_T} \tag{3a}$$

$$I_*(t_*)=\frac{dA_*(t_*)}{dt_*} \tag{3c}$$

$$O_*(t_*)=\frac{t_c IUH(t_*)}{(1)A_T} \tag{3d}$$

$$K_*=\frac{K}{t_c} \tag{3e}$$

$$t_*=\frac{t}{t_c} \tag{3b}$$

where $A_*(t_*)$, $I_*(t_*)$, $O_*(t_*)$, K_* and t_* are the dimensionless area, time-area response, IUH, Clark's storage coefficient and time, respectively, A_T is the total watershed area, t_c is the time of concentration and K is the linear storage coefficient. In the above definition of O_*, the rainfall excess depth, Z_e, is taken as one unit.

By multiplying by the integration constant $exp(t_*/K_*)$, equation (2) can be written as

$$exp(t_*/K_*)\frac{dO_*(t_*)}{dt_*}+exp(t_*/K_*)\frac{O_*(t_*)}{K_*}=$$

$$exp(t_*/K_*)\frac{I_*(t_*)}{K_*} \tag{4}$$

and rearranged as

$$d\,[\,O_*(t_*)\,exp(t_*/K_*)\,]=\frac{I_*(t_*)}{K_*}\,exp(t_*/K_*)\,dt_* \tag{5}$$

and evaluated for a dimensionless unit hydrograph value at t_* as

$$O_*(t_*)=exp(-t_*/K_*)\int_0^{t_*}\frac{I_*(\tau_*)}{K_*}\,exp(\tau_*/K_*)\,d\tau_* \tag{6}$$

where τ_* is a dummy integration variable. The above equation assumes that $O_*=0$ at $t_*=0$.

Analytical Solution

A solution to Equation (6) requires an estimate of the time-area response I_*. This response can be estimated from topographic maps using estimates of travel times within the watershed (Linsley *et al.*, 1982). Computations, however, can be tedious and require a numerical solution of Equation (6). Frequently synthetic time-area curves are used to simplify procedures. Theoretically, synthetic time-area curves should be defined such that response is zero at the time of concentration (i.e., $t_*=1$).

O'Kelly (1955) showed that a synthetic curve defined by isosceles triangles could be used to approximate the time-area response without a significant loss of accuracy. The HEC-1 simulation program allows the user to select a symmetrical, nonlinear, curve (HEC, 1971). Brown (1989) evaluated the impact of synthetic time-area response using (1) O'Kelly's curve, (2) HEC-1's curve, (3) an oblique triangular curve where the peak occurred at 25 percent of the time base and (4) an oblique triangular curve where the peak occurred at 75 percent of the time base. He concluded that the oblique curve with the earlier peak best represented his data.

For a triangular, synthetic time-area curve, Equation (6) can be solved directly for O_* (Brown and Wilson, 1989). This solution, however, is awkward because it results in a set of equations for different time domains. A single equation can be obtained using a gamma probability density function. This is the approach taken here. The parameters of this function were selected so that the mode is located at $0.25t_*$ and that area under the curve for $t_* > 1$ is small. The simplest function that satisfies these two conditions is shown below

$$I_* = 256\, t_*^2\, exp(-8t_*) \tag{7}$$

By substituting Equation (7) into Equation (6) and by integrating by parts, the dimensionless unit hydrograph is obtained as

$$O_*(t_*) = \frac{256}{(1-8K_*)} exp(-8t_*)\left[t_*^2 - \frac{2t_*K_*}{1-8K_*} + \frac{2(K_*)^2}{(1-8K_*)^2}\right] - \frac{512(K_*)^2 exp(-t_*/K_*)}{(1-8K_*)^3} \tag{8}$$

The impact of different K_* values is shown in Figure 1. For the special case of $K_*=0$, equation (8) equals I_* given by Equation (7).

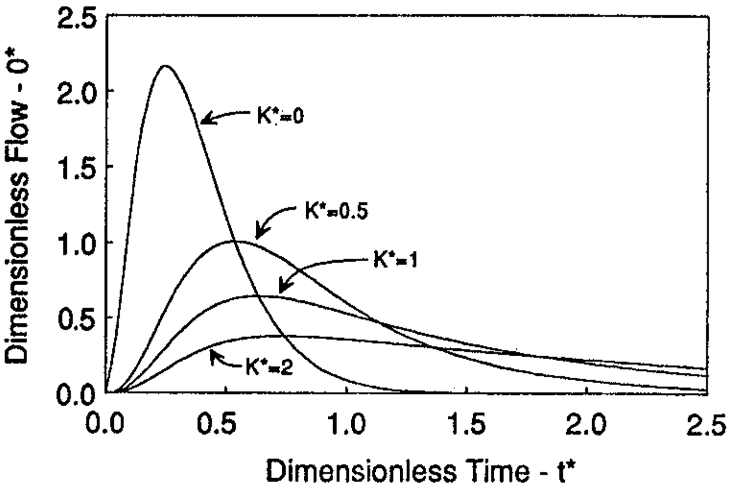


Figure 1. Effects of K_* on Proposed IUH.

The IUH for a particular watershed can now be determined directly from Equation (3d) as

$$IUH(t_*) = O_*(t_*)\ \frac{(1)A_T}{t_c} \tag{9}$$

where terms are as previously defined.

The IUH defined by Equation (9) requires that the watershed area, the time of concentration and the dimensionless storage coefficient K_* be determined for the watershed of interest. Watershed area and time of concentration can be estimated from map data. The impact of various K_* values has previously been shown in Figure 1. Procedures to estimate this parameter are discussed in the next sections.

CALIBRATION AND VALIDATION DATA SETS

Rainfall-Runoff Data

A large rainfall-runoff data base was obtained to estimate the storage coefficient and to evaluate the accuracy of the dimensionless unit hydrograph. Watersheds for this study were selected from information supplied by the United States Department of Agriculture, Agricultural Research Service for experimental agricultural watersheds for the years 1958 through 1977 (USDA, 1958-1977). Watersheds were selected on the basis of geographical location, size, length of record, and the availability of both rainfall and runoff information. Few watersheds were available in the western part of the United States.

The watersheds selected varied in geographical location to allow for regional variability. A map showing the location of the watersheds is given in Figure 2. Between one and five watersheds were selected of varying sizes in a given region. Since the primary use of the dimensionless hydrograph is anticipated to be small, agricultural watersheds, a limitation of 4,000 ha was placed on all watersheds. Also, a record of rainfall-runoff events for at least five years was required. Table 1 presents the location of the watersheds used, number of rainfall events actually used and drainage area. The fifth column in Table 1 identifies whether the watershed will be used in the calibration (C) or validation (V) procedures of this study. The validation watersheds were selected randomly from geographic locations with more than one watershed. As discussed in greater detail later, storms were deleted from the calibration watersheds if the results appeared questionable. No storms were deleted from the validation watersheds.

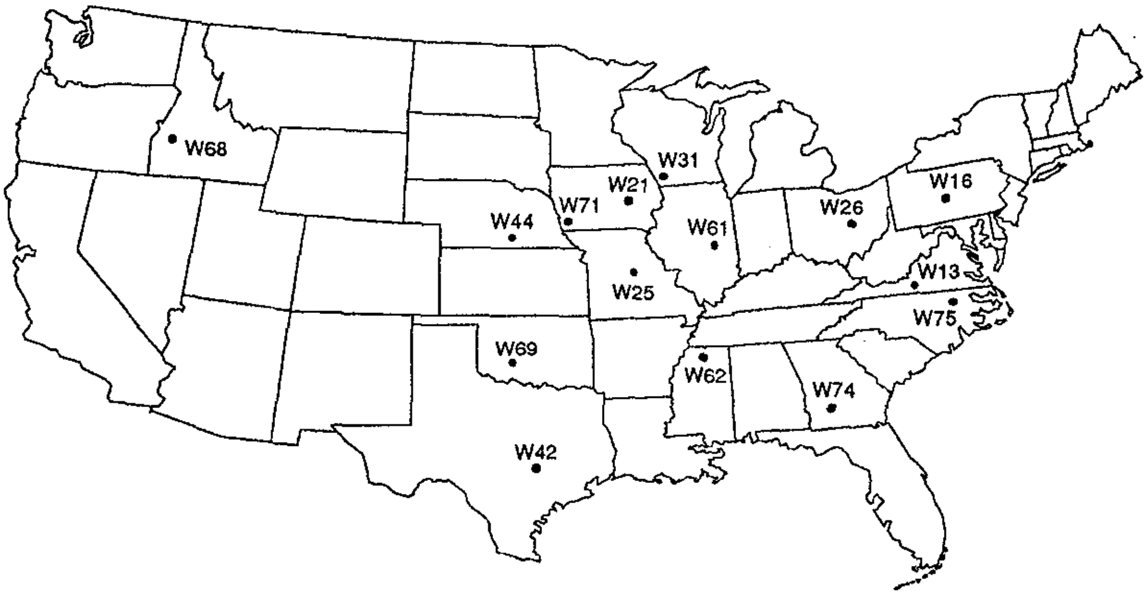


Figure 2. Location of Calibration and Validation Watersheds.

TABLE 1. Watershed Selection Information.

Watershed Location	ID No.	Number of Events	Area (ha)	Use
Blacksburg, VA	W13011	8	225	C
Klingerstown, PA	W16006	9	697	C
Iowa City, IA	W21001	6	781	C
McCredie, MO	W25001	15	62	C
Coshocton, OH	W26027	4	12	V
Coshocton, OH	W26030	10	123	C
Coshocton, OH	W26033	2	372	C
Coshocton, OH	W26036	5	1854	C
Fennimore, WI	W31003	6	21	V
Fennimore, WI	W31004	5	69	C
Riesel, TX	W42002	5	234	C
Hastings, NE	W44001	5	195	C
Monticello, IL	W61001	7	18	C
Oxford, MS	W62001	7	809	V
Oxford, MS	W62007	6	207	C
Reynolds, ID	W68003	5	3175	C
Chickasha, OK	W69009	16	228	C
Chickasha, OK	W69028	3	656	V
Chickasha, OK	W69032	10	18	C
Chickasha, OK	W69042	10	10	C
Treynor, IA	W71001	11	30	C
Tifton, GA	W74004	9	1593	V
Tifton, GA	W74009	4	261	C
Ahoskie, NC	W75003	3	958	C
Ahoskie, NC	W75004	8	665	V

Geomorphic and Storm Parameters

Geomorphic parameters were measured for the watersheds contained in the data set. A summary of these geomorphic parameters is given in Table 2. In addition, storm parameters were determined for each rainfall-runoff event. A summary of storm parameters is given in Table 3. In the next section, these parameters will be used in an attempt to predict the dimensionless storage coefficient K_*.

TABLE 2. Geomophic Parameters.

Area	Perimeter
Time of Concentration	Main Channel Length
Maximum Basin Length	Maximum Basin Width
Maximum Elevation Difference	Overland Slope
Channel Slope	Stream Order
Average Bifurcation Ratio	Relative Relief
Relief Ratio	Ruggedness Number
Elongation Ratio	Circularity Ratio

The geomorphic parameters for each of the watersheds analyzed were taken from maps supplied by the U.S. Department of Agriculture, Agricultural Research Service. Parameters were measured using a digitizer or calculated from digitizer values. Standard procedures were used to define the parameters given in Table 2 (Brown, 1989). Frequently subjective decisions were required for specifying the start or end of flow segments. The time of concentration was calculated using the SCS (1972) upland method extended to account for flows in larger upland channels (Brown and Wilson, 1989).

The storm parameters given in Table 3 are divided into rainfall and rainfall-excess characteristics. Rainfall cumulative depths were obtained from breakpoint data. Rainfall excess values were determined using the SCS curve number method (SCS, 1972). This method can be easily calibrated to a specific storm using total rainfall and runoff depth (Wilson *et al.*, 1984). The standard deviation and skew coefficient were estimated using moments obtained from normalized rainfall and rainfall-excess hyetographs (Brown and Wilson, 1989). Dimensionless duration is the rainfall duration divided by time of concentration; normalized spread is the standard deviation divided by rainfall duration; normalized peak intensity is the peak intensity divided by the average rainfall rate; dimensionless peak intensity is the peak intensity divided by the product of maximum flow length and time of concentration; normalized abstraction is the maximum abstraction divided by the total rainfall depth; and dimensionless average intensity is the average intensity divided by the product of maximum flow length and time of concentration.

EVALUATION OF STORAGE COEFFICIENT

General Approach

A K_* value was estimated from observed rainfall and runoff data for the calibration watersheds and storms. Procedures for determining the optimal K_* are discussed later. After some initial analysis, there were indications that some of the data may be incorrect, probably due to instrumentation errors. As an example, some storms had runoff occurring before the start of rainfall; other events had runoff volumes that exceeded the total rainfall volume. Occasionally, an optimized K_* value differed dramatically from other values for the same watershed with no apparent abnormality in storm characteristics. With the removal of questionable data, 142 storms on 19 different watersheds were used to determine calibrated K_* values. The number of storms per watershed is given in Table 1.

Linear and nonlinear regression techniques were used to obtain predictive relationships for K_*. Emphasis, however, was placed on obtaining the best predictive relationship and not necessarily the best statistical relationship. The best predictive relationship considers whether the results provide conceptually correct trends and are stable and robust for any set of possible values. As shown in Figure 1, the IUH is more sensitive to smaller values of K_*. To produce a predictive relationship

TABLE 3. Rainfall Parameters.

Cumulative Rainfall Depth	Cumulative Rainfall Excess Depth
Duration of Rainfall	Duration of Rainfall Excess
Peak Rainfall Intensity	Peak Excess Intensity
Duration of Peak Rainfall Intensity	Duration of Peak Excess Intensity
Rainfall Standard Deviation	Excess Rainfall Standard Deviation
Rainfall Skew Coefficient	Excess Rainfall Skew Coefficient
Dimensionless Rainfall Duration	Normalized Abstraction Depth
Normalized Rainfall Spread	Normalized Peak Rainfall Intensity
Dimensionless Peak Rainfall Intensity	
Dimensionless Average Rainfall Intensity	

with greater sensitivity for small K_*, the regression equations were obtained using the transformation variable η_* defined as

$$\eta_* = \frac{1}{K_*} \qquad (10)$$

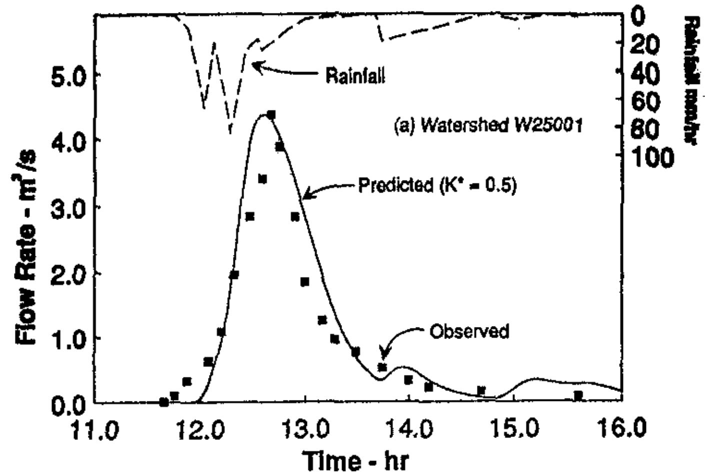
Predictive relationships were obtained using only geomorphic parameters and using geomorphic and storm parameters.

Optimization Procedures

For each storm in the calibration data set, a K_* value was estimated by generalizing the optimization approach given by Brown and Wilson (1989). With Brown and Wilson's approach, a one-dimensional optimization algorithm is coupled with a numerical solution of the convolution of IUH given by Equation (9) and a rainfall excess hyetograph. The rainfall excess hyetograph is obtained from breakpoint rainfall and a calibrated SCS curve number.

The storage parameter K_* was optimized using Brent's procedure (Press *et al.*, 1986) using bracket values of zero and five. A lower limit of zero corresponds to no storage effects. As shown by Figure 1, an upper limit of five corresponds to a very flat unit hydrograph probably reflecting errors in the rainfall-runoff data or a runoff mechanism dominated by subsurface flows. The optimized K_* was determined by the minimum square deviation between observed and predicted peak flows. An objective function using peak flow and time to peak was also tried but rejected because of the apparent difference in timing of rainfall and runoff data. The optimization procedure using Brent's method was stable and efficient in converging to the optimal K_*.

Typical predicted and observed runoff hydrographs are shown in Figure 3. The typical predicted hydrograph is obtained using the optimal K_* value. A comparison of predicted and observed peak flow rates for the runoff events is shown in Figure 4. The largest deviations from the perfect line correspond to K_* values that were close to the bracket values of zero and five. The optimization procedures worked well in representing observed runoff hydrographs.



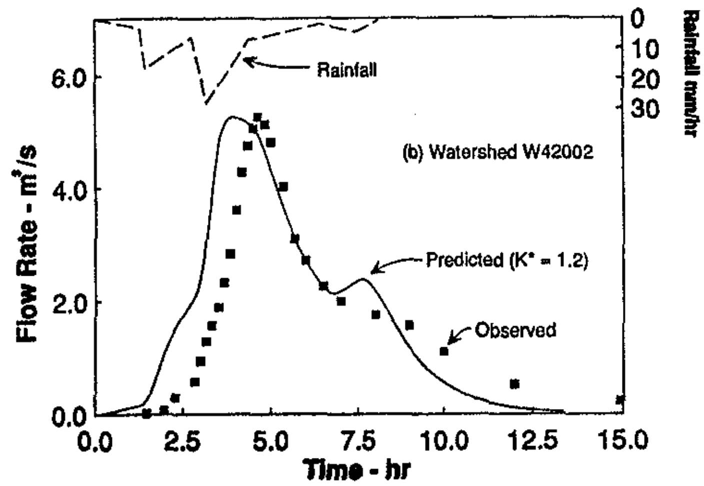


Figure 3. Typical Fit of Observed Hydrographs Using Optimization Procedures.

Relationship Using Geomorphic Parameters

A predictive relationship for K_* was first attempted using only the geomorphic parameters given in Table 2. For a particular watershed, these parameters were considered constant. Calibrated K_* values, however, were found to vary with storms. A representative value was taken as an estimate of the median.

The following generalized equation was selected

$$\bar{\eta}_* = 0.2 + exp(u) \qquad (11)$$

where $\bar{\eta}_*$ is the predicted average value of $\bar{\eta}_*$ for a particular watershed, u is a function of geomorphic parameters determined from regression analysis.

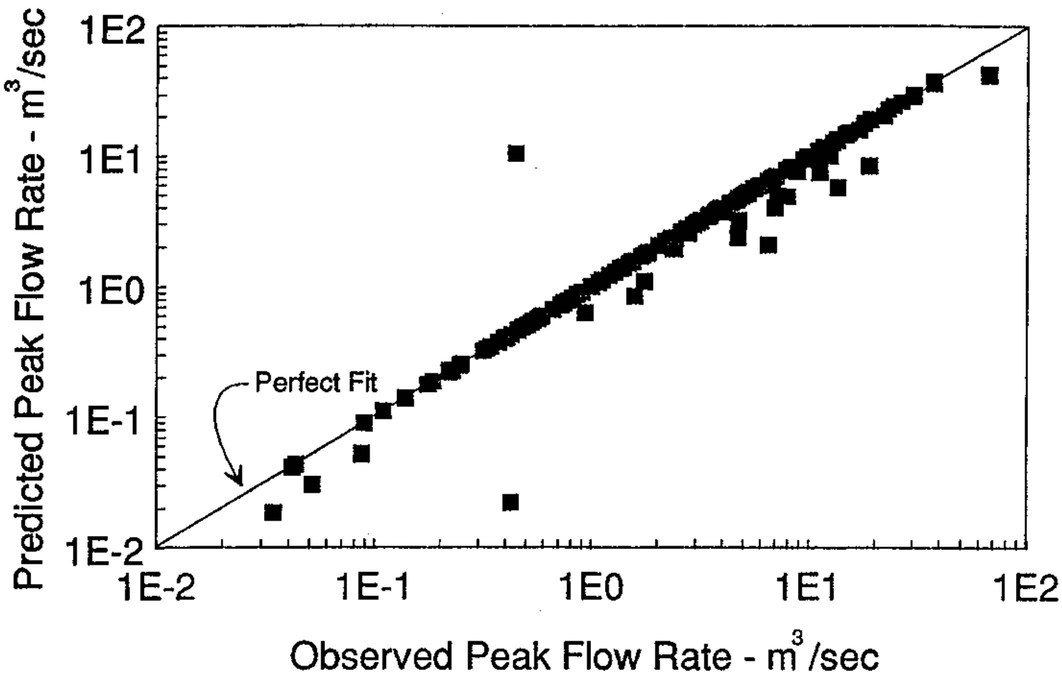


Figure 4. Observed and Predicted Peak Flow Rates Using Optimization Procedures.

Equation (11) has a robust form where the corresponding value of K_* varies between zero and five.

The function u in Equation (11) was initially evaluated using the nonlinear regression techniques available in SYSTAT (Wilkinson, 1987). Numerous functions were tried using different geomorphic parameters and combination of parameters. Only functions that resulted in physically-correct trends were considered acceptable. If two parameters gave equally good fit, the parameter that was easier to measure was selected. The final form of u was selected using linear regression technique for the transformed variable $\ln(\bar{\eta}_* - 0.2)$ which allowed standard statistical inferences. Using this approach, u was determined as

$$u = -4.2 + 5.6A_T^{-0.1} + 1.7\frac{(RF)^{1/2}}{(ELONG)^{4.5}} \tag{12}$$

where A_T is the watershed area in ha, RF is the relief ratio defined as the ratio of maximum elevation difference to the maximum length of the watershed, and *ELONG* is the elongation ratio defined as the ratio between the diameter of a circle with the same area as the basin to the maximum length of the watershed.

The overall accuracy of Equation (12) was poor with a coefficient of determination of only 0.25. Slope coefficients in Equation (12) are, however, still significantly different than zero at the 10 percent level. In addition, the predictive relationship appears rational. Predicted K_* increases with watershed area and decreases with watershed slope, trends supported by other studies (Dooge, 1973). Equation (12) also predicts that a long, narrow watershed would have a smaller K_* than a wide, short watershed (if other factors are constant).

Relationship Using Storm Parameters

Calibrated K_* values were found to vary widely within a particular watershed. It was hoped that this variation could be correlated to one or more of the storm parameters shown in Table 3. This analysis was conducted by examining the 142 normalized residuals defined as

$$\eta' = \frac{\eta_* - \hat{\eta}_*}{\hat{\eta}_*} \tag{13}$$

where η' is the normalized residual, η_* is the calibrated value for a particular storm and $\hat{\eta}_*$ is the observed median value for a given watershed.

Trends in η' were examined for the storm parameters in Table 3 for each watershed. No dominate trend in any of the storm parameters could be identify. The most promising parameter was the normalized peak rainfall intensity defined as

$$i_p^* = \frac{i_p}{(P/D)} \tag{14}$$

where i_p^* is the normalized peak rainfall intensity (dimensionless), i_p is the observed peak intensity from breakpoint data, P is the total rainfall depth and D is the storm duration. About one-third of the watersheds showed a trend of η' with i_p^*; two-third showed no apparent trend. The following rational relationship was selected to represent the trend

$$\eta' = (1 - exp(-(\widehat{\eta_*} - 0.2)))\left[\frac{i_p^* - 9.5}{9.5}\right] \tag{15}$$

where the first term increases the importance of i_p^* with $\widehat{\eta_*}$. The constant of 9.5 is the average value of i_p^* for all storms. The above form predicts that K_* decreases with an increase in the normalized peak rainfall intensity.

Using Equation (15) with Equation (13) and using $\widehat{\eta_*} = \overline{\eta_*}$, the predictive relationship for η_* can be obtained as

$$\eta_* = \overline{\eta_*} + \overline{\eta_*} = (1 - exp(-(\overline{\eta_*} - 0.2)))\left[\frac{i_p^* - 9.5}{9.5}\right] \tag{16}$$

where the value of $\overline{\eta_*}$ is obtained from Equation (11). The above equation is robust. It confines the predicted values of K_* between zero and five.

The predicted values of K_* using Equation (16) is plotted against calibrated values in Figure 5. Clearly the prediction is quite poor. Trends identified for individual watersheds are masked by the large variation in calibrated K_* values. This variation may be partly due to (1) experimental errors in the rainfall-runoff data, (2) a linear theoretical model to represent nonlinear response and/or (3) natural variability in hydrologic response of the watershed such as spatially varied rainfall depths within the watershed. Storm movement over the watershed was not considered in any of the storm parameters.

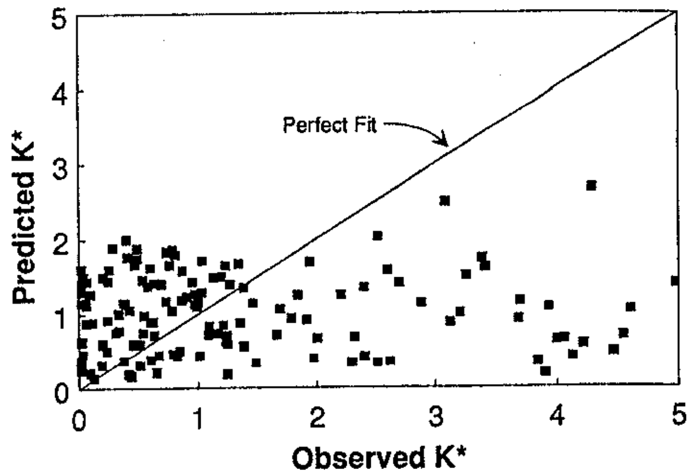


Figure 5. Predicted and Observed K^* Using Geomorphic and Storm Parameters.

Random Storage Coefficient

The relatively poor fits of the two regression results suggest that an accurate deterministic relationship may not be possible. An alternative to deterministic representation is to view K_* as a random variable. A point estimate of a random variable can be taken as the median. The median value for this data set was 0.8; that is, half of the storms had K_* greater than this value and half less.

Random variables are represented by probability density functions. Normal, log-normal, extreme value type I and log-Pearson type III distributions were fitted to the 142 observed K_* values. The extreme value type I and log-Pearson type III distribution appeared to represent the data better than the other two distributions. Exceedance probabilities of these two distribution are plotted with the observed data in Figure 6. The exceedance probabilities of the observed data was obtained using standard plotting position methods (Haan, 1977). The extreme value type I parameter can be defined from the mean of K_* of 1.26 and a variance of 1.65. The log-Pearson type III parameters are defined from the mean of the log-transformed data of –0.54, variance of 2.39 and the skew coefficient of –0.81.

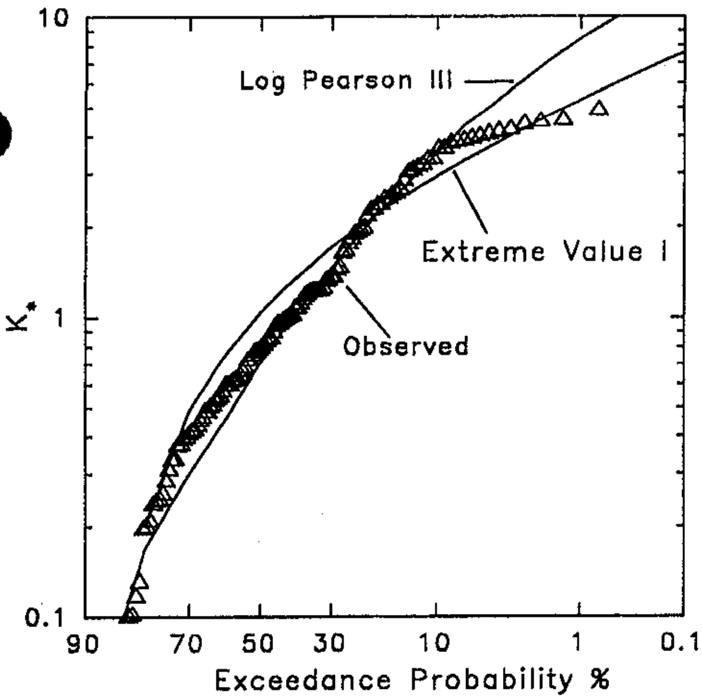


Figure 6. Exceedance Probability of K^* Values.

VALIDATION OF UNIT HYDROGRAPH PROCEDURE

Validation Procedures

Eight of the watersheds given in Table 1 were used to test the unit hydrograph procedures. In contrast to the calibration procedures, all storms were used. A total of 37 storms was considered.

Five different unit hydrograph methods were compared to the observed runoff hydrographs. The SCS dimensionless unit hydrograph (SCS, 1972) was selected as a standard design technique from which to compare the proposed unit hydrographs. Howard and Meadows (1981) found that the SCS method was the most accurate of four techniques they considered in predicting peak flows for 270 rainfall-runoff events on 38 watersheds. Its shape was estimated using the equation given by Barfield *et al.* (1981).

The four other methods use the proposed IUH given by Equation (9). They differ in the procedure used to determine K_*. The CONSTANT method uses a constant K_* value taken as the median value of 0.8. The GEO method uses Equation (11) that is based on only geomorphic parameters. The STORM method uses Equation (16) to estimate K_*. Finally, the predictive relationship proposed by Brown and Wilson (1989) was also evaluated. Brown and Wilson suggest the following relationship for K_*

$$K_* = 5\left\{1 - exp(-exp(-216S_c)) + 0.092\, ln\left[\frac{0.447D}{t_c}\right]\right\}$$

$$for\ K_* > 0.1 \qquad (17a)$$

and

$$K_* = 0.1 \quad for\ K_* < 0.1 \qquad (17b)$$

where S_c is the channel slope, D is storm duration and t_c is the time of concentration.

The objective here is to compare different unit hydrograph techniques. Other components of the runoff process are handled identically between methods. A summary of the procedures to determine the predicted runoff hydrograph is given below.

(1) Parameters: Watershed area, time of concentration, relief ratio, elongation ratio, channel slope, peak rainfall intensity, total storm depth, and storm duration were determined from map and storm data. These values were used to estimate the SCS dimensionless unit hydrograph and K_* which in turn was used to determine the IUH given by Equation (9). Time to peak in the SCS method was estimated as $0.6t_c$ plus one-half the convolution time step.

(2) Convolution time step: To use the IUH directly, this time step should be selected small compared to the time of concentration (O'Kelly, 1955). The convolution time step was selected as $0.05t_c$. The SCS method was evaluated using their recommended time step of $0.133t_c$ (SCS, 1972). The SCS method was also tried with a time step of $0.05t_c$. Differences in predicted values between the two time steps were relatively small.

(3) Rainfall excess: The SCS curve number model was selected to determine the rainfall excess depth. The curve number for each storm was determined directly from observed rainfall and runoff depths (Wilson *et al.*, 1984).

(4) Convolution: The unit hydrograph for each time step was numerically convoluted with the rainfall excess pattern to determine the runoff hydrograph.

The accuracy among the different methods was compared using percent error defined as

$$\%\,error = 100\,\frac{|X_o - X_p|}{X_o} \qquad (18)$$

where X_o and X_p are the observed and predicted statistic, respectively.

Peak flow rate and a spread parameter will be used for X in Equation (18). The spread parameter is a standard-deviation-type term defined as the square root of the integration

$$s_t^2 = \int_{t_1}^{t_u} (t - t_p)^2 \, Q(t) dt \tag{19}$$

where $Q(t)$ is volumetric flow rate and t_p is the time to peak. The upper and lower integration limits were defined as to reduce the impact of poorly defined hydrograph tails. The lower limit was determined as the point when the cumulative volume was greater than 5 percent or when the first flow value was greater than 5 percent of the peak. The upper limit was defined similarly only using a cumulative volume of 95 percent. (Equation 19) was integrated numerically.

Results and Discussion

Table 4 summarizes the results obtained with the five different unit hydrograph methods using percent error given by (Equation 18). The average percent error in peak flow rate for 37 storms was, 103 percent using the SCS method, 70 percent using a constant K_*, 39 percent using geomorphic parameters (Equation 11)) 44 percent using geomorphic and storm parameters (Equation 16) and 34 percent using Brown and Wilson's equations (Equation 7). The cumulative percentiles are given to show the distribution of percent errors. For example, the 25 percentile indicates that one-fourth of the total storms had a percent error less than the value given in the table. Trends in the average percent error can be influenced by a poor result for one or two storms.

Table 4 shows that all four techniques based on Equation (9) performed better than the SCS method. For example, the median (50 percentile) percent error in peak flow rate of the SCS method was 88 percent compared to 55 percent, 27 percent, 34 percent and 34 percent to the other four methods. Although not as dramatic, similar trends are also apparent in the spread statistic. It also appears that using a predictive equation for K_* is more accurate than using a constant value. The median percent error in peak flow rate drop from 55 percent to approximately 30 percent Similar trends again hold for the spread statistic. The GEO, STORM and Brown and Wilson's methods appear to have about the same level accuracy.

A plot of predicted and observed peak flow rates for the SCS, CONSTANT and GEO methods are shown in Figure 7. A plot of typical predicted and observed hydrographs are shown in Figure 8. The CONSTANT and GEO methods again appear to be superior to the SCS method. The GEO method appears superior to the CONSTANT method.

An important question is which procedure should be used to estimate K_*. If a deterministic approach is preferred, the GEO, STORM and Brown and Wilson methods were the most accurate. Since they were approximately of equal accuracy, the GEO method is recommended because it does not require storm parameters and is therefore simpler to use.

Although the GEO method represents an improvement over the SCS method, the uncertainty in accurately predicting K_* is still considerable. Probably the best approach is treat to K_* as a random variable defined by the extreme value type I distribution or possibly the log-Pearson type III distribution if the prediction of nonzero values becomes problemsome. Uncertainty in K_* can then be incorporated into the

TABLE 4. Percent Error Statisics.

Statistic	Method	Average (percent)	Cumulative Percentile 25 (percent)	50 (percent)	75 (percent)	Max (percent)
PEAK FLOW	SCS	103	25	88	161	298
	CONSTANT	70	28	55	101	188
	GEO	39	13	27	52	233
	STORM	44	11	34	59	271
	Brown-Wilson	34	9	340	52	117
TIME SPREAD	SCS	56	36	59	80	88
	CONSTANT	45	22	45	66	81
	GEO	48	18	37	52	238
	STORM	53	11	36	52	317
	Brown-Wilson	40	21	34	56	131

prediction process using Monte Carlo or other statistical techniques (Haan, 1977). The resulting hydrograph should be interpreted from a probabilistic perspective.

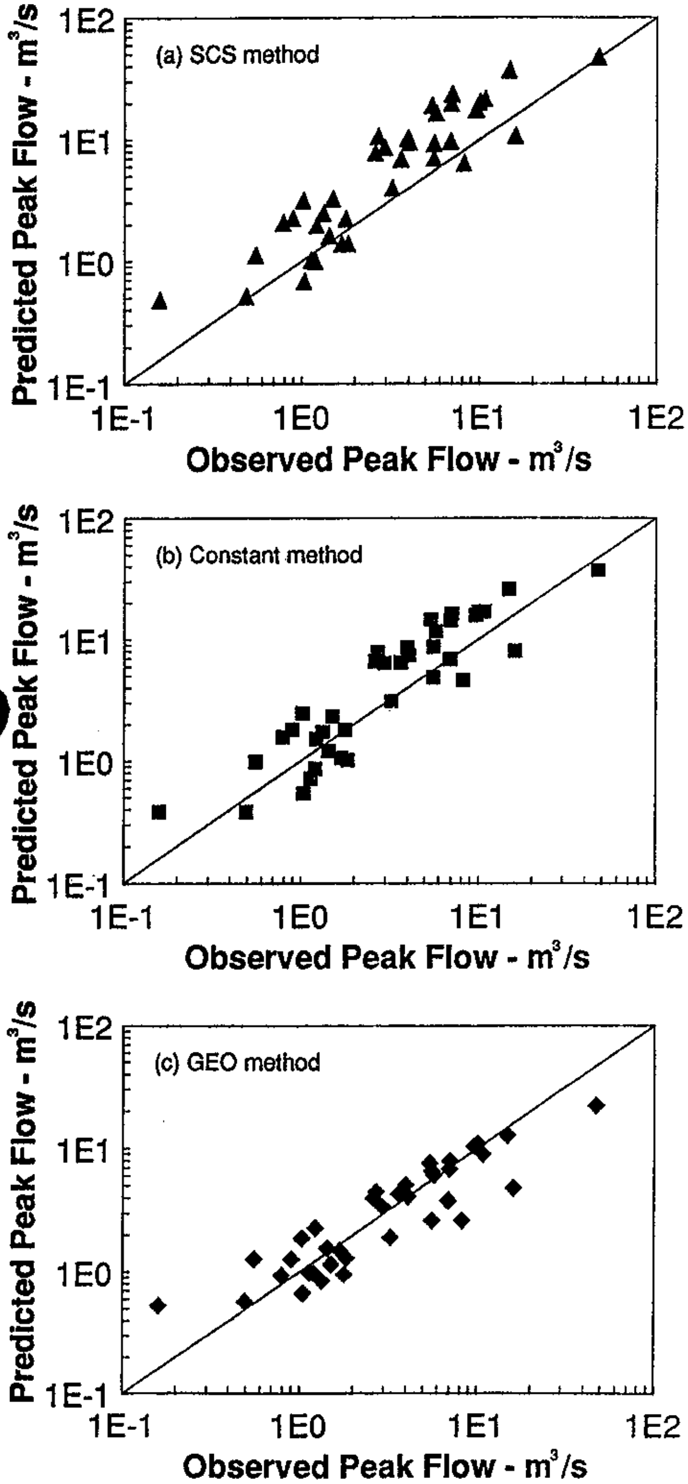


Figure 7. Predicted and Observed Peak Flow Rates.

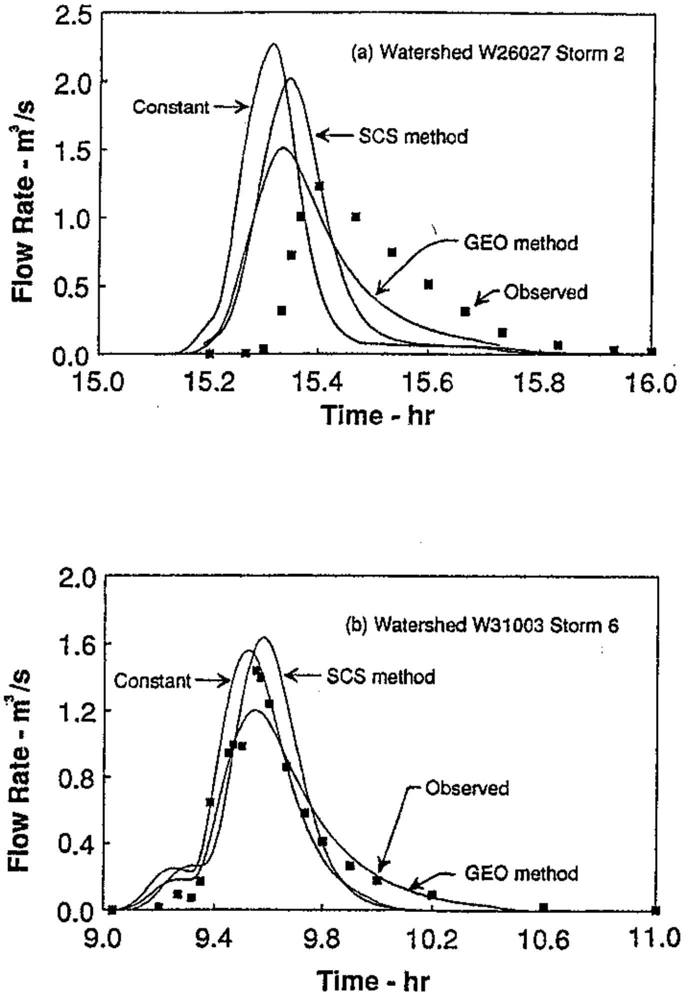


Figure 8. Typical Predicted and Observed Hydrographs.

SUMMARY AND CONCLUSIONS

A unit hydrograph method was developed for predicting runoff hydrographs from ungaged watersheds. A generalized IUH was developed using Clark's concepts (1943). A key component in this theory is the value of a dimensionless storage coefficient, K_*. Procedures to estimate K_* were proposed using calibrated values from 142 rainfall-runoff events. Equations were developed using only geomorphic parameters and using a combination of storm and geomorphic parameters. Both approaches resulted in substantial uncertainty in the estimation of K_*. Information was presented to represent K_* as a random variable.

Thirty-seven, independent rainfall-runoff events were used to test the method. Five different unit hydrographs were considered. The SCS dimensionless unit hydrograph (SCS, 1972) was selected as a standard design technique from which to compare relative accuracy. The other four methods differ only in the procedure to estimate K_*. For this test data set, the all four methods more accurately predicted the observed runoff hydrograph than the SCS method. The method that estimated K_* using only geomorphic parameters was recommended. With this method, approximately one-half of the test storms had percent errors in predicted peak flow rates was less than 30 percent compared to 105 percent of the SCS method.

Although the prediction accuracy of the proposed method is better than the SCS method, the uncertainty in accurately predicting K_* suggests the need to represent K_* as a random variable. Monte Carlo or other statistical techniques could be used to reflect the uncertainty in K_* in the resulting runoff hydrograph. Incorporation of uncertainty in hydrologic parameters remains a fertile area for additional research.

ACKNOWLEDGMENTS

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c. Certainly, the techniques for establishing AMC are varied and subject to some argument. When gauged information is not available, reliance on regional information is essential in establishing an AMC. Otherwise, the engineer may be forced to assume a conservative estimate for this parameter.

6-4. Surface Loss Estimation

a. Rainfall losses are due to both surface storage and soil infiltration. In the field, the surface storage and infiltration of rainwater are dynamically interconnected. The interconnection occurs primarily via surface depression and detention storage. Detention storage increases infiltration rate by adding a small (less than an inch) pressure head to the wetting front. This additional head is insignificant when compared to the suction head which drives soil infiltration. Detention storage increases apparent infiltration by delaying surface flow and providing more catchment retention time for water to infiltrate. In general, these effects are minor when compared to the problem of estimating the magnitude of surface loss and the in-situ capacity of soils to infiltrate water. Consequently, the typical approach is to separate these two contributions to rainfall loss unless surface losses are empirically included in the loss rate method. For example, the SCS curve number method includes surface losses directly into the method.

b. Surface loss is a function of land use and differs greatly between forested, agricultural, and urban areas. According to Viessman et al. (1977), interception of rainfall by surface cover is greatest for a forest and decreases for agricultural and urban land uses. Schomaker's (1966) measured values of interception for a spruce forest were 30 percent of the annual rainfall and for a birch forest were 9.5 percent of annual rainfall. Horton (1919) reported that the interception for rainfall events greater that 0.25 in. is approximately 25 percent of the total rainfall. The Viessman et al. (1977) conclusion from this information is that interception for forested regions is approximately 10 to 20 percent of the total precipitation, at least for rainfall events less than 2.0 in. In general, one should not expect interception losses to exceed 0.5 in. for a particular rainfall event.

c. Agricultural watershed surface losses are a function of crop development and management practice. Interception of rainfall by crops was computed by Linsley, Kohler, and Paulhus (1975) using equations developed by Horton (1919). They found that for a storm depth of 1.0 in., the interception ranged from 3 to 16 percent for small grain crops such as wheat and milo. This compares well to the study by Schomaker (1966), since interception by these crops should be less than that of a forest due to the smaller leaves and sparser cover provided by these crops.

d. Detention storage in agricultural areas is strongly affected by the time since tillage occurred and the overall management practice. Linden (1979) used random roughness and land surface slope in microrelief models to predict depression storage due to tillage (note random roughness is essentially a measure of the variation of soil heights from the surface plane). He predicted that depression storage could be as high as 0.5 in. immediately after tillage. The depression storage will decrease with time after tillage due to the impact of rainfall. Linden's results do not account for increased storage capabilities due to management practice such as contour plowing. Horton (1935) estimated that detention storage for agricultural lands, natural grass lands, and forests range from 0.5 to 1.5 in.

e. Surface losses in urban areas differ for open and impervious areas. Interception losses for open areas (lawns, parks etc.) can probably be considered of the same magnitudes as forest or pasture land. However, the depression storage in the open areas is probably not as great as in natural areas because grading has taken place and there is probably less surface litter. The surface loss for impervious areas is small and usually taken as 0.1 to 0.2 in. Table 6-1 summarizes the surface losses that can be used for each land use type. The values listed in Table 6-1 are a suggested range based on previous research work and experience. If these values are not in line with local experience of a particular watershed, the modeler should by all means use any local information.

6-5. Infiltration Methods

a. Green and Ampt. The Green and Ampt method is explained and illustrated in detail below.

(1) Method development. The Green and Ampt (GA) method (Mein and Larson 1973) assumes the same simple soil model and initial conditions as that of the Richards equation, a uniform soil profile of infinite extent, and constant initial water content. As the water content at the soil surface increases, the method models the movement of the infiltrated water by approximating the wetting front with a piston type displacement (Figure 6-5).

(a) The piston displacement model, as originally developed, must be modified to account for surface losses and variable rainfall rates (time varying surface moisture

COE 1994 (Reference 11)

Table 6-1
Surface Losses

Interception Losses
Agricultural Areas

Crop	Height ft.	Interception in.
Corn	6	0.03
Cotton	4	0.33
Tobacco	4	0.07
Small grains	3	0.16
Meadow grass	1	0.08
Alfalfa	1	0.11

(from Linsley, Kohler, and Paulhus 1975)

<u>Forest Areas</u> (from Viessman et al. 1977)
10-20% total rainfall, maximum 0.5 in.

<u>Detention Storage</u> (from Horton 1935)

Agricultural Areas (Depending on time sense tillage)	0.5 - 1.5 in.
Forests/Grasslands	0.5 - 1.5 in.

<u>Total Surface Loss</u>

Urban Areas Open Areas	0.1 - 0.5 in.
Impervious Areas	0.1- 0.2 in.

conditions). The surface loss is modeled for an initial loss as follows:

$$r(t) = 0 \quad for \quad P(t) \le I_a \quad t \ge 0 \qquad (6\text{-}1)$$

$$r(t) = r_o(t) \quad for \quad P(t) > I_a \quad t \ge 0 \qquad (6\text{-}2)$$

where

$P(t)$ = cumulative precipitation over the watershed

$r(t)$ = rainfall intensity adjusted for surface losses

t = time since the start of rainfall

$r_o(t)$ and I_a = depth of surface loss assumed to be uniform over the watershed

The cumulative infiltration loss is calculated by the GA method:

$$I = \frac{S_f}{[(i/K) - 1]} = \frac{KS_f}{[(dI/dt) - K]} \quad i > K \qquad (6\text{-}3)$$

where

$dI/dt = i(t)$ = infiltration rate

K = soil's hydraulic conductivity

S_f = product of the wetting front suction, h_f, and the soil volumetric deficit at the beginning of the storm

$\Delta\theta$ and I = cumulative infiltration

COE 1994 (Reference 11)

Flood Control District
of Maricopa County

INTEROFFICE MEMORANDUM

Date: November 2, 2004

To: Valerie Swick, Project Manager
Planning & Project Management Division

From: Julie Cox, Hydrologist
Engineering Division

Subject: Entellus Agricultural Analysis

Introduction

The current FCDMC's rainfall-runoff modeling approach may over-estimate flow rates for agricultural lands. The pilot study for agricultural fields in Buckeye areas attempts to study the rainfall-runoff modeling process for agricultural fields by collecting farmland data and investigating rainfall initial abstraction, lag time, routing, and ponding areas in the agricultural fields. The pilot study attempts to use the observed data to calibrate the HEC-1 models. However, due to the lack of observed rainfall data, the calibration process is not recommended since the S-graph unit hydrograph approach (UI cards) should not be used in the proposed approach where the irrigation ditch water is treated as the rainfall. After FCDMC's own literature search, it is concluded that the current FCDMC rainfall-runoff modeling approach for agricultural fields should be used except that the Kn values (Manning's roughness for drainage areas) should be increased. The data collected in the pilot study can be used to estimate Kn values.

Literature Search

FCDMC did a literature search and found that higher roughness coefficients should be used for agricultural fields. Based on Soil Conservation Service (June, 1986), the Manning's n values are as follows:

Table 3-1 *Roughness coefficients (Manning's n) for sheet flow*
Smooth surfaces (concrete, asphalt,
gravel, or bare soil) 0.011
Fallow (no residue) 0.05
Cultivated soils:
Residue cover δ20% 0.06
Residue cover >20% 0.17
Grass:

Short grass prairie 0.15
Dense grasses 2/ 0.24
Bermudagrass 0.41
Range (natural) 0.13
Woods:3/
Light underbrush 0.40
Dense underbrush 0.80
1 The n values are a composite of information compiled by Engman (1986).
2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Based on Hydrologic Engineering Center (September, 1990), the Manning's n values for overland flows are as follows:

Resistance Factor for Overland Flow

Asphalt/Concrete* 0.05 - 0.15 a
Bare Packed Soil Free of Stone 0.10 c
Fallow - No Residue 0.008 - 0.012 b
Convential Tillage - No Residue 0.06 - 0.12 b
Convential Tillage - With Residue 0.16 - 0.22 b
Chisel Plow - No Residue 0.06 - 0.12 b
Chisel Plow - With Residue 0.10 - 0.16 b
Fall Disking - With Residue 0.30 - 0.50 b
No Till - No Residue 0.04 - 0.10 b
No Till (20-40 percent residue cover) 0.07 - 0.17 b
No Till (60-100 percent residue cover) 0.17 - 0.47 b
Sparse Rangeland with Debris:
0 Percent Cover 0.09 - 0.34 b
20 Percent Cover 0.05 - 0.25 b
Sparse Vegetation 0.053 - 0.13 f
Short Grass Prairie 0.10 - 0.20 f
Poor Grass Cover On Moderately Rough 0.30 c
Bare Surface
Light Turf 0.20 a
Average Grass Cover 0.4 c
Dense Turf 0.17 - 0.80 a,c,e,f
Dense Grass 0.17 - 0.30 d
Bermuda Grass 0.30 - 0.48 d
Dense Shrubbery and Forest Litter 0.4 a
Legend: a) Harley (1975), b) Engman (1986), c) Hathaway (1945), d) Palmer (1946),e) Ragan and Duru
(1972), f) Woolhiser (1975). (See Hjemfelt, 1986)

*Asphalt/Concrete n value for open channel flow 0.01 - 0.016

Based on McLaughlin Kmetty Engineers and George Sabol Consulting Engineers (May, 1992), the lag time for agricultural/grass watersheds would be about 3 times larger than the lag for a comparable rangeland watershed and a Kn value of 0.2 was used in the flood insurance study for the Buckeye areas.

The data collected in the pilot study can be used to estimate the Kn values. Some of the data include the advance time which measues the time period between the time when the irrigation ditches are opened at the upstream boundary of the field and the time when the wave arrives at the downstream outlet. If the advance time is assumed to be reasonably close to the time of concentration, then the lag time can be estimated by using LagTime=0.6*TimeOfConcentration. The value of 0.6 is based on Soil Conservation Service (Chow et al., 1988). Then, the Kn values can be estimated by solving for Kn value in the current District's lag time equation. FCDMC did a preliminary analysis for one area (99-16) and found Kn is 0.3.

McLaughlin Kmetty Engineers and George Sabol Consulting Engineers (May, 1992) also recommended the use of Muskingum-Cunge method for channel routing (Appendix BB in their report).

Recommendation

1. Kn values (watershed average roughness values) need to be estimated based on the advance time collected in the pilot study. The advance time can be considered as time of concentration. The lag time can be obtained by multiplying 0.6 with the time of concentration. The current District's lag time equation should be used when estimating Kn values. This task should not take more than 1 hour. The averaged Kn value may be used for the Buckeye ADMS HEC-1 S-graph agricultural unit hydrograph modeling. Muskingum-Cunge method should be used for channel routing.

2. The consultant needs to finalize the pilot study report by organizing the collected data and estimating the Kn values.

References

Chow, V.T., Maidment, D., Mays, L. (1988). "Applied Hydrology," McGraw-Hill.

Soil Conservation Service (June, 1986). "Urban Hydrology for Small Watershed,", Technical Release 55.

Hydrologic Engineering Center (September, 1990). "HEC-1 Flood Hydrograph Package," User's Manual.

McLaughlin Kmetty Engineers LTD and George V. Sabol Consulting Engineers INC (May 1992). "Buckeye Area Flood Delineation Study Hydrology Report," FCD Contract No. 90-69.

cc: Bing Zhao, Acting Manager, Hydrology & Hydraulics Branch, FCDMC

APPENDIX B. DATA COLLECTION

FURROW IRRIGATION EVALUATION SUMMARY SHEET No. 00-34

***Irrigation Goal:* Replenish soil moisture in the root zone**

FIELD INFORMATION:

		Plant Date:	4/2000	*Today's Date:*	08/10/2000
Length(ft):	1021	*Width(ft):*	1143	*Set Width(ft):*	569
Field size(ac):	26.79	*Set Area(ac):*	13.34	*Field ID #:*	31-3
Grade(ft/100ft):	0.43	*Side Grade:*	0.13	*Crop ID #:*	3

WATER SOURCE:

Supply Source: RID

Salinity(ppm): (estimate) ~1000

SOILS INFORMATION:

Primary Soil Series: Coolidge *Texture:* Sandy Loam

Average AWHC for a 4 foot root zone:	6.40	inches
Leaching Needs:	0.00	inches
Average Amount to Refill Root Zone:	2.52	inches
Total Amount Needed:	2.52	inches

Other Soil Info: Lime and gravel at second foot.

IRRIGATION INFORMATION:

Irrigation system: Graded furrow *Furrows per set:* 94

Flow Rate: (measured)
- 254 Miner's Inches — 254 Miner's Inches (amount ordered)
- 6.35 Cubic Feet per Second
- 2850 Gallons per Minute
- 30 Gallons per Minute per Furrow

Set Time, hours: 12.00 *Total Depth Applied :* 5.71 inches *Runoff(initial):* 38.3%

Amount Infiltrated: (Amount Applied - Amount of Runoff): 3.53 inches *Runoff(avail):* 0.0%

Water Beneficially Used = Total Amount Needed + Assumed Reused Runoff
****Initial runoff is tailwater measured leaving the field.*
****Available runoff assumes a 15% loss, due to seepage and evaporation, from the initial amount.*
****AWHC - Available Water Holding Capacity*

RESULTS:

Application Efficiency(AE) = Total Amount Needed / Total Depth Applied

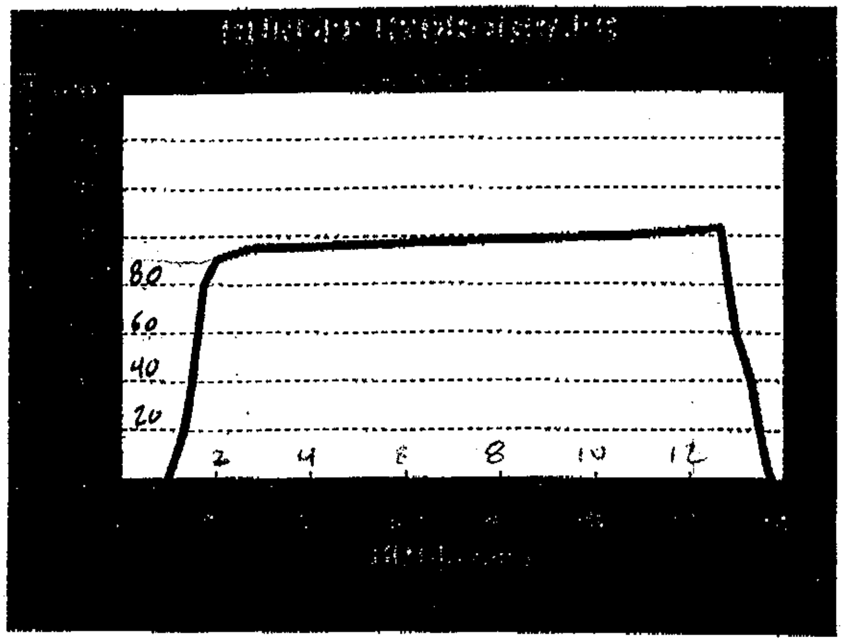
AE = 44.1%

Irrigation Efficiency(IE): = Water Beneficially Used / Total Depth Applied

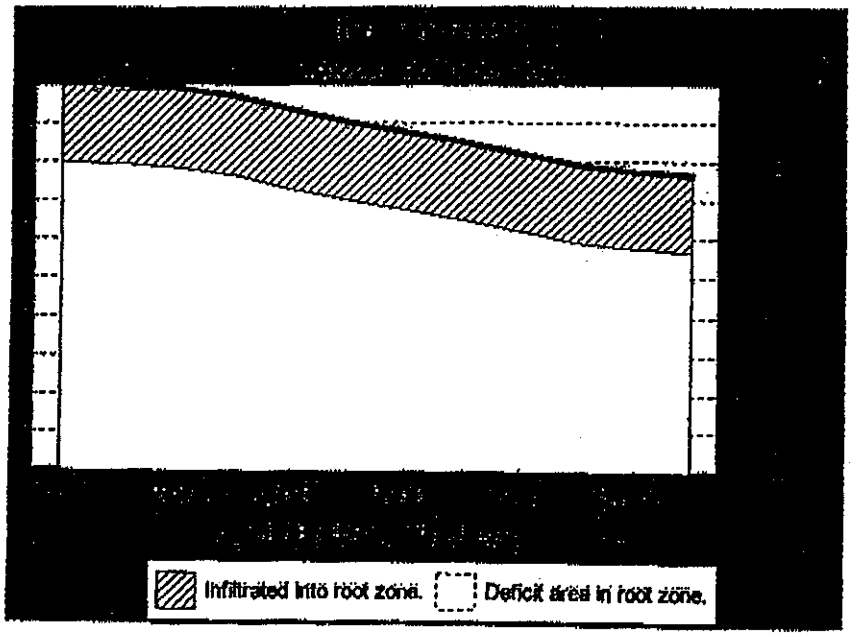
IE = 44.1%

Was irrigation goal achieved? Yes

FURROW IRRIGATION EVALUATION SUMMARY SHEET No. 00-34



Advance Times: Min.: 59 min Max.: 1hr 43min Avg.: 1hr 21min



Targeted depth of water penetration: 4 ft Was this targeted depth met?: Yes.

FURROW IRRIGATION EVALUATION SUMMARY SHEET No. 99-15

Irrigation Goal: Replenish soil moisture in the root zone

FIELD INFORMATION:

		Plant Date:	05/05/99	*Today's Date:*	06/15/99
Length(ft):	2526	*Width(ft):*	1516	*Set Width(ft):*	226
Field size(ac):	87.91	*Set Area(ac):*	13.11	*Field ID #:*	[redacted]
Grade(ft/100ft):	0.50	*Side Grade:*	0.60	*Crop ID #:*	3

WATER SOURCE:

Supply Source: RID *Irrigation #:* 2 *Salinity(ppm): (estimate)* ____

SOILS INFORMATION:

Primary Soil Series: Laveen *Texture:* Sandy Loam

Average AWHC for a 4 foot root zone: ~~2.07~~ 5.63 inches

Leaching Needs: 0.176 inches

Average Amount to Refill Root Zone: 1.76 inches

Total Amount Needed: 2.11 inches

Other Soil Info: ____

IRRIGATION INFORMATION:

Irrigation Interval: ____

Irrigation system: Graded furrow with tailwater recovery system *Furrows per set:* 43

Flow Rate: 264 **Miner's Inches** 220 **Miner's Inches (amount ordered)**

(measured) → 6.60 **Cubic Feet per Second**

6.6 2962 **Gallons per Minute**

69 **Gallons per Minute per Furrow**

Set Time, hours: 12.00 *Total Depth Applied:* 6.04 inches *Runoff(initial):* 16.8%

Amount Infiltrated: *(Amount Applied - Amount of Runoff):* 5.03 inches *Runoff(avail):* 0.0%

Water Beneficically Used = Total Amount Needed + Assumed Reused Runoff

****Initial runoff is tailwater measured leaving the field.*

****Available runoff assumes a 15% loss, due to seepage and evaporation, from the initial amount.*

****AWHC - Available Water Holding Capacity*

RESULTS:

Application Efficiency(AE) = Total Amount Needed / Total Depth Applied

AE = 29.2%

Irrigation Efficiency(IE): = Water Beneficially Used / Total Depth Applied

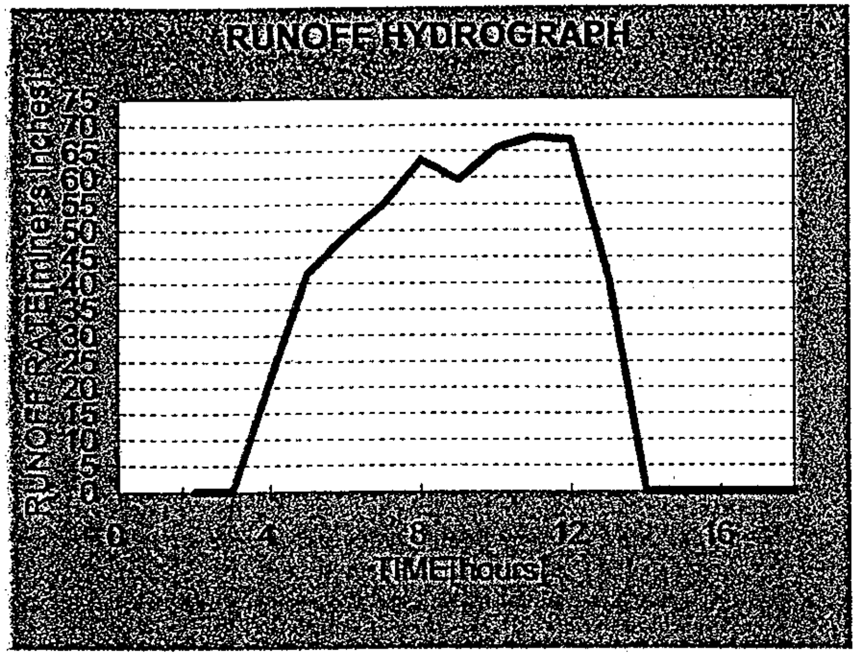
IE = 29.2%

Was irrigation goal achieved? Yes

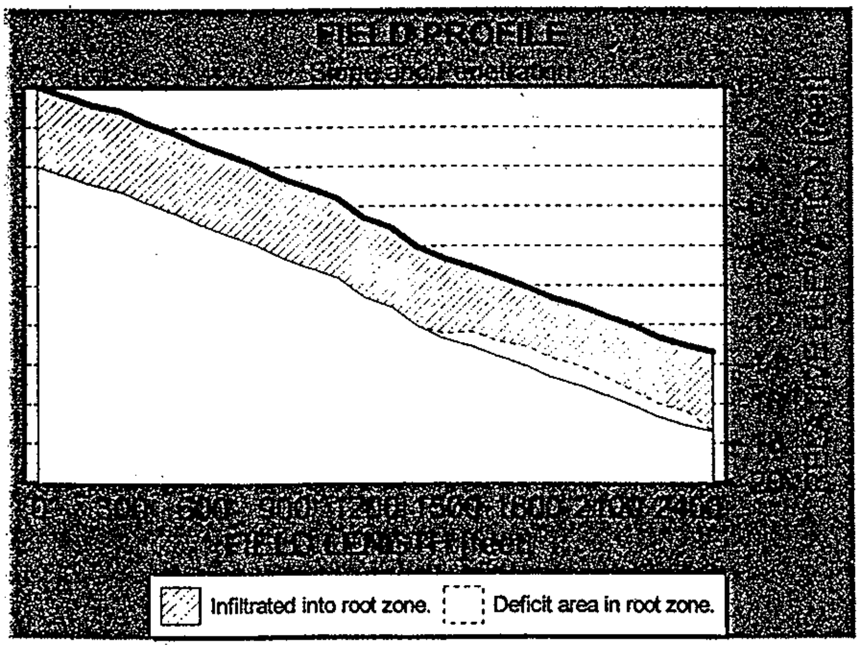
6.6 cf/s × 12.0 h × 3600 s/h = 285120 c.f.

6.54 Ac ft

FURROW IRRIGATION EVALUATION SUMMARY SHEET No. 99-15



Advance Times: **Min.:** 53 min **Max.:** 3 hr 50 min **Avg.:** 2 hr 5 min



Targeted depth of water penetration: 4 ft Was this targeted depth met?: No

BORDER IRRIGATION EVALUATION SUMMARY SHEET No. 99-16

Irrigation Goal: *To replenish soil moisture deficit.*

FIELD INFORMATION:

		Plant Date:	10/95	*Today's Date:*	06/15/99
Length(ft):	1200	*Width(ft):*	1514	*Set Width(ft):*	70
Field size(ac):	41.71	*Set Area(ac):*	1.93 ←	*Field ID #:*	[illegible]
Grade(ft/100ft):	0.34	*Side Grade:*	1.70	*Crop ID #:*	1

WATER SOURCE:

Supply Source:	RID	*Irrigation #:*	2	*Salinity(ppm):* *(estimate)*	1100

SOILS INFORMATION:

Primary Soil Series: **Perryville** *Texture:* **Gravelly Loam**

Average AWHC for a 4 ft Root Zone:	~~7.33~~ 5.8	inches
Leaching Needs:	0.73	inches
Average Amount to Refill Root Zone:	1.83	inches
Total Amount Needed:	2.57	inches

Other Soil Info: **Soil was sandy with cobbles with a caliche layer at about the 2 to three foot level**

IRRIGATION INFORMATION:

Irrigation system: **Graded border** *Borders per set:* 2

Flow Rate:	330	Miner's Inches	300 Miner's Inches (amount ordered)
(measured)	8.25	Cubic Feet per Second	
	3703	Gallons per Minute	
	1851	Gallons per Minute per Border	

Set Time, hours:	1.45	*Total Depth Applied :*	6.20	inches	*Runoff(initial):*	5.9%
Amount Infiltrated:	*(Amount Applied - Amount of Runoff).*		5.84	inches	*Runoff(avail):*	0.0%

Water Beneficially Used = Total Amount Needed + Assumed Reused Runoff
****Initial runoff is tailwater measured leaving the field.*
****Available runoff assumes a 15% loss, due to seepage and evaporation, from the initial amount.*
****AWHC - Available Water Holding Capacity*

RESULTS:

Application Efficiency(AE) = Total Amount Needed / Total Depth Applied

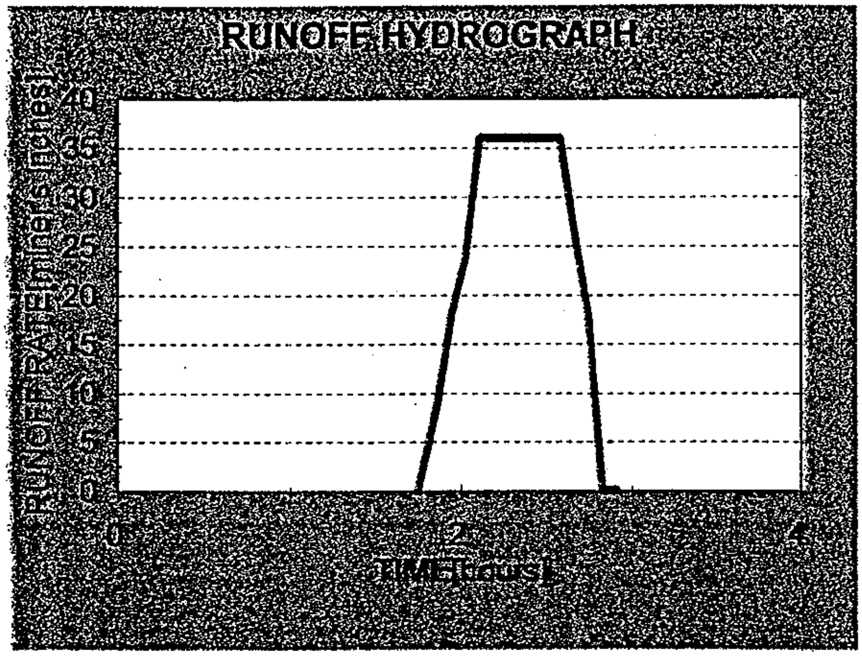
AE = 29.6%

Irrigation Efficiency(IE): = Water Beneficially Used / Total Depth Applied

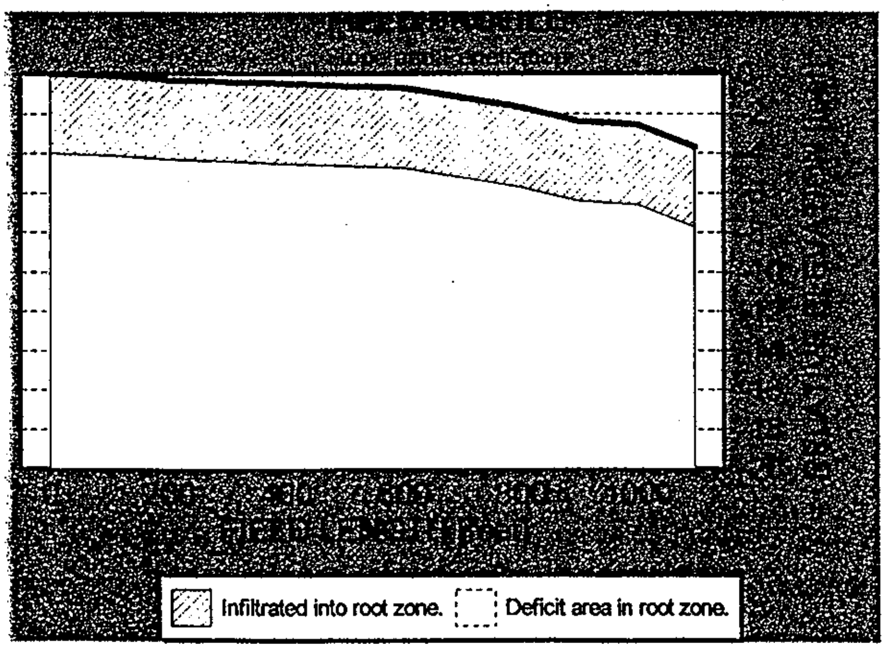
IE = 29.6%

Was irrigation goal achieved? In theory, yes.

BORDER IRRIGATION EVALUATION SUMMARY SHEET No. 99-16



Advance Times: **Min.:** 2 **Max.:** 2 **Avg.:** 2



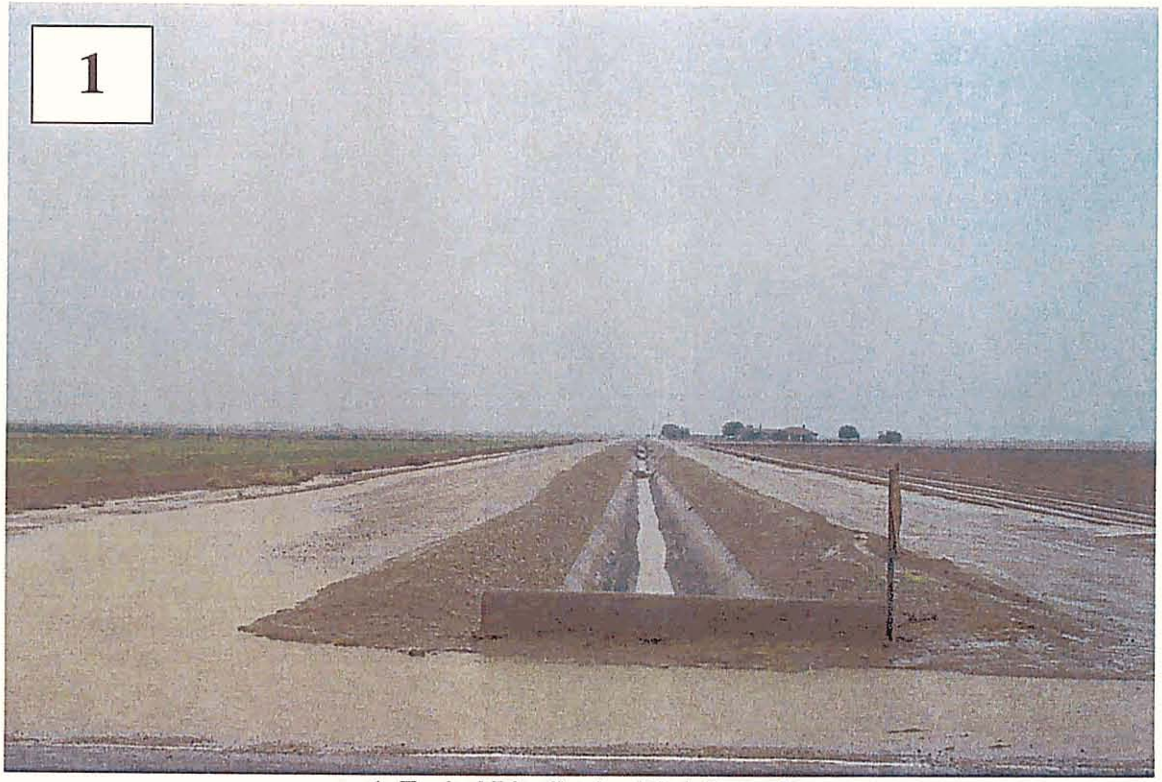
Targeted depth of water penetration: 4 ft Was this targeted depth met?: Yes,

APPENDIX B. DATA COLLECTION

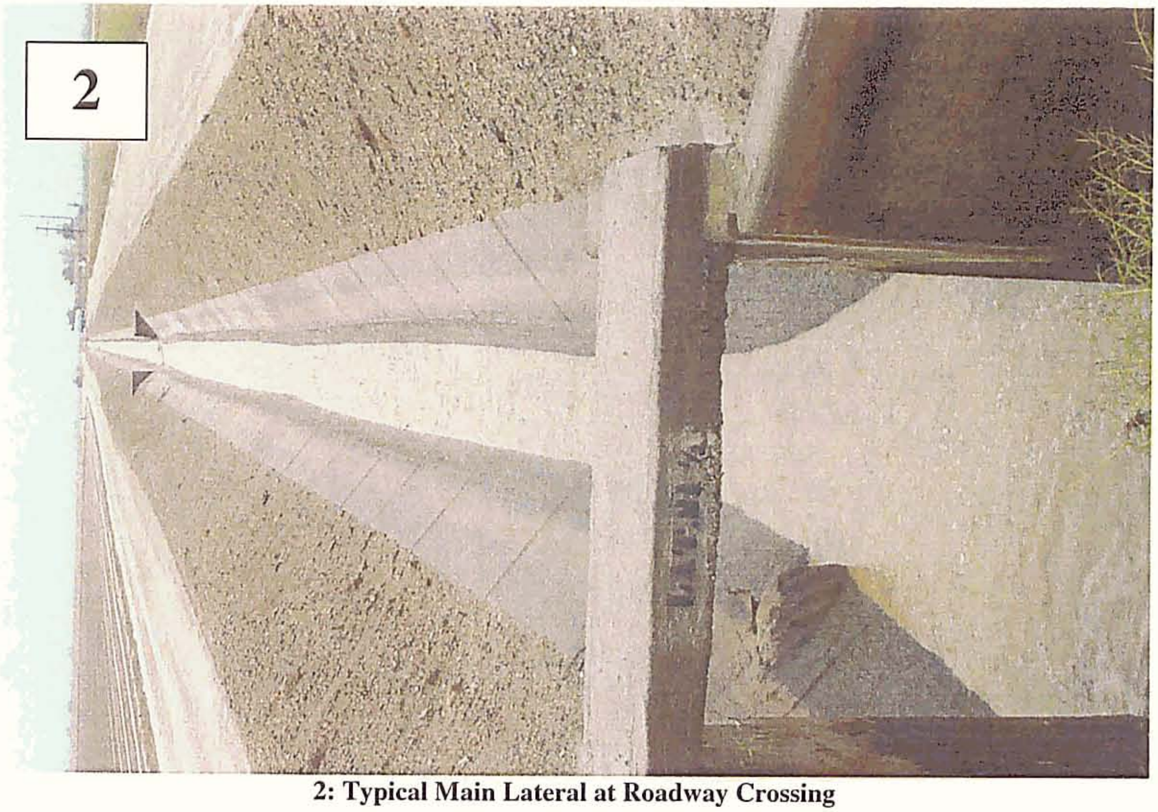
Buckeye Sunvalley Agricultural Study

4-2-4 Field Photo Summary

Picture Group	Picture ID	Direction Facing	Description
A	9	Southwest	Crop shot
A	12	Northwest	Crop shot
A	11	Northeast	Crop shot
A	10	Southeast	Crop shot
A	3	West	V-Section header ditch w/ gated field inlets
A	2	South	V-Section feeder ditch
A	1	North	V-Section feeder ditch
B	13	Southwest	Crop shot w/mounds
B	14	South	Feeder ditch at drop
B	15	Northeast	Crop shot
C	18	Southwest	Crop shot
C	16	Northwest	Crop shot
D	21	Northwest	Header ditch/ Crop shot
D	19	South	V-Section feeder ditch at drop crossing
D	22	North	Ponding Location along Baseline and crop shot
D	25	Northwest	Crop shot
D	23	East	Tailwater pond
D	24	East	Tailwater pond
D	20	Southwest	Crop shot
E	4	North	V-Section feeder ditch
F	6	Southeast	Crop shot
F	5	East	V-Section header ditch w/gated field inlets
F	8	East	Tail berm w/ ponding water along Southern at PV Rd
F	7	Northeast	Crop shot
G	27	East	Crop shot



1: Typical Distribution Ditch Lateral



2: Typical Main Lateral at Roadway Crossing

3: Pumped Tailwater Return into Feeder Ditch

4: Header Ditch

5: Header Ditch w/ Only Distribution Ditch Flowing

6: Overflow Structure

7: Border Irrigated Field

8: Ponding at Downstream End of System

9: Border Irrigated Crops

10: Furrow Irrigated Crops - Early Planting Stage

11: Ponding at Downstream End of System

12: Roadway Runoff Ponding Along Edge of Border Irrigated Field

13

13: Furrow Irrigated Crops Just After Planting

14

14: Berm Along Edge of Field

15: Fully Grown Corn (Furrow Crop)

16: Berm Along Edge of Border Irrigated Field

18

18: Tailwater Recycling Pipe Into Feeder Ditch for Alfalfa Field (Border)

19

19: Distribution Ditch - Siphon Crossing Under Roadway

20: Ditch and Berm Along Edge of Field

21

21: Overflow Spillway

22: Roadway Ponding Along Field Edge

23

23: Tailwater Pond

24: Tailwater Pond

25: Young Alfalfa Field

27

27: Roadway Ponding Along Field Edge

APPENDIX B. DATA COLLECTION

B.1. Original Study Process/Scope of Work

B.2. Farmer Surveys

B.3. Related Studies

B.4. NRCD Field Efficiency Test Records

B.5. Field Photographs and Observations

B.6. Survey Data

B.7. District Methodology Text and Tables

8-12-04

Agricultural Field
Cross Sections & Topo
Area Bounded By
Palo Verde to Wilson
From Railroad Tracks
to Roosevelt Canal

R. Wiese
R. Creach

Overcast
90°

8-12-04

Base set up on Base "E"

Ant. Base Height = 1.481 m (4.86'±)

Check in @ 4AI1 HR= 6.562 ift

N. -0.013
E. 0.007
Z. -0.077

Found "base b" 0.7 miles W. of Oglesby Rd. 4'± N. of large ditch along N. side of canal road. Rebar was disturbed and ± 0.17 low. Observed again as "base b2 new"

Start # 3614 @ N.W. corner of Project across from Desert Skydiving Center

End # 3649

Cloudy 85°
5-10mph Winds
R. Wiese, R. Creach

8-16-04

Base @ "base b2 new" (4.938 ift)

Ant. Base Height = 1.505 m (~~4.859 ift~~)

√ in @ "base e" HR= 10.562 ift. (4' extension)

S. 0.049
E. 0.025
Z. 0.295
EL = 875.844

ΔN ~~-0.079~~ -0.067
ΔE ~~0.014~~ 0.016
ΔZ 0.148

Start # 3650

End #

8-16-04

Base @ "base b2 new"

Ant. Base Height = 1.505 m (4.938 ift)

✓ in @ 4AG1 HR= 10.562

//

Rich Wiese
Rob CREACH

8-17-04

Base @ "base A" ½ mile N.E. of Johnson Rd. and Broadway

Ant. Base Height = 1.498 m (4.915 ift)

Rod Height = 1.997 (6.552 ift)
+4' ext. (10.552 ift)

✓ @ "base b2 new"
ΔN 0.031
ΔE -0.036
ΔZ -0.003

Start # 3650 End # 3782

8-18-04

Base @ "base A"

Ant. Base Height = 1.590 m (5.217 ift)

HR = 1.997 m (6.552 ift)

✓ @ "base E" HR= 10.552 ift

ΔN 0.059
ΔE 0.104 EL= 876.089
ΔZ 0.039

✓ @ "4AI1"

ΔN 0.031
ΔE 0.127 EL= 920.722
ΔZ 0.046

Set RB 0.5 miles E. of Palo Verde Rd. on Southern. NE intersection of Southern and a canal 3'± NE of headwall & reflector sign. #"chk rb"

Start # 3783 End # 3999

8-19-04

Base @ "base A"

Base Ant. Height = 1.566m (5.138 ift)

HR = 1.997m (6.552 ift)

✓ @ "chk rb"

ΔN -0.054
ΔE -0.138 EL = 943.793
ΔZ -0.004

START = 4000 END = 4368

~~8-20-04~~

8-26-04 Clear & Sunny 90°

Base @ "base A"

Base Ant. Height = 1.637 m (5.371 ift)

HR = 1.997 m (6.552 ift)

✓ @ "chk rb"

ΔN -0.025
ΔE 0.040 EL = 943.785
ΔZ 0.018

Start # 4369 (xsec 20) End # 4807

Set "base Z" rebar on S.W. corner of canals & dirt roads ½ mile E. of Palo Verde Road and ¾ mile N. of Southern (Broadway) →

X-Sec # 32 had bad HR. Add 4.0' to HR #'s 4760 - 4807

8-27-04

Base @ "base Z"

Base Ant. Height = 1.606 m (5.269 ift)

HR = 1.997 m (6.552 ift)

✓ @ "chk rb"

ΔN -0.039
ΔE 0.014
ΔZ 0.002

EL = 943.801 ift

Start # 4808 (x-sec #33)

End # 5222 (x-sec #46)

8-30-04

Base @ "base Z"

Base Ant. Height = 1.606 (5.269 ift)

HR = 1.997 m (6.552 ift)

✓ @ "chk rb"

ΔN -0.043
ΔE 0.010
ΔZ -0.005

EL = 943.808 ift

Start # 5223 (x-sec #47)

End # 5712 (x-sec #66)

9-1-04

Base @ "base E"

Base Ant. Height = 1.547 m (5.075 ift)

HR = 1.997 m (6.552 ift)

✓ @ "chk rb"

ΔN -0.007
ΔE 0.050 EL = 943.859
ΔZ -0.056

✓ @ "base A"

ΔN -0.026
ΔE 0.055 EL = 982.480
ΔZ -0.075

✓ @ "4AI1"

ΔN -0.067
ΔE 0.050 EL = 920.782
ΔZ -0.014

Start # 5713 (X-Sec # 67)

End # 6239 (X-Sec # 86)

We did 3 X-sections at the N. end of Butler's Dairy 1/4 mile +/- N. of Southern and Palo Verde Road. It appears that water collects around the N. end of the dairy & drains through an Irrigation structure on the N.E. corner of the dairy. Draining south under the first dirt road N. of Southern and then to the East down a canal.

Found and shot in a chiseled "X" on centerline of headwall on SE. corner of RR Tracks and Palo Verde Road. Occupied point as an "observed control point" for check in refrencing.

7-2-04

Base @ "base E"

Base Ant. Height = 1.517m (4.977ift)

HR= 1.997m (6.552ift)

✓ @ "CHK X"

ΔN 0.012
ΔE 0.023
ΔZ -0.049

EL= 893.450ift

Start # 6240 (X-Sec #87)

End # 6545 (X-Sec #93)

6544 - 6545 Bridge B/C & Turner

7-3-04

Base @ "base E"

Base Ant. Height = 1.567m (5.141ift)

HR = 1.997m (6.552 ift)

✓ @ "CHK X"

ΔN -0.016
ΔE -0.013
ΔZ -0.091

✓ @ "Chk RB"

ΔN -0.036
ΔE 0.079
ΔZ -0.040

EL= 943.843

Start # 6546 (X-sec # 94)

End # 6753 (X-Sec # 99)

6752 - 6753 (4th Ave. Bridge)

Bad HR. Was at 6.552 & should have been 10.552. Subtract 4' off shot el's.

4-7-04 (Windy) Clear & Sunny 80°

Base @ "base E"

Base Ant. Height = 1.474 (4.836 ift)

HR = 1.997 m (6.552 ift)

✓ @ "chk X"

ΔN -0.007
ΔE -0.007 EL = 893.473 ift.
ΔZ -0.072

✓ @ "4AI1"

ΔN 0.019
ΔE 0.006 EL = 920.812 ift
ΔZ -0.044

Start # 6754 End # 7095
(X-Sec # 100) (X-Sec #114)

(Last shots were actually 5. ½ of # 93)

4-7-04 Windy & Clear 100°

Base @ "base C"

Base Ant. Height = 1.408 m (4.619 ift)

HR = 1.997 m (6.552 ift)

✓ @ "base B2 new"

ΔN -0.003
ΔE -0.022 EL = 990.327 ift
ΔZ -0.050

Start # 7096 End # 7101

APPENDIX B. DATA COLLECTION

B.1. Original Study Process/Scope of Work

B.2. Farmer Surveys

B.3. Related Studies

B.4. NRCD Field Efficiency Test Records

B.5. Field Photographs and Observations

B.6. Survey Data

B.7. District Methodology Text and Tables

4.4.1 Green and Ampt Infiltration Equation

This model, first developed in 1911 by W.H. Green and G.A. Ampt, has since the early 1970s, received increased interest for estimating rainfall infiltration losses. The model has the form:

$$f = K_S\left(1+\frac{\psi\theta}{F}\right) \quad \text{for } f < i \tag{4.1}$$

$$f = i \quad \text{for } f \geq i$$

where:

f	=	infiltration rate (L/T),
i	=	rainfall intensity (L/T),
K_s	=	hydraulic conductivity, wetted zone, steady-state rate (L/T),
y	=	average capillary suction in the wetted zone (L),
q	=	soil moisture deficit (dimensionless), equal to effective soil porosity times the difference in final and initial volumetric soil saturations, and
F	=	depth of rainfall that has infiltrated into the soil since the beginning of rainfall (L).

A sound and concise explanation of the Green and Ampt equation is provided by Bedient and Huber (1988).

It is important to note that as rain continues, F increases and f approaches K_s, and therefore, f is inversely related to time. Equation (4.1) is implicit with respect to f which causes computational difficulties. Eggert (1976) simplified Equation (4.1) by expanding the equation in a power series and truncating all but the first two terms of the expansion. The simplified solution (Li and others, 1976) is:

$$F = -0.5(2F - K_S\Delta t) + 0.5\left[(2F - K_S\Delta t)^2 + 8K_S\Delta t(\theta\psi + F)\right]^{1/2} \tag{4.2}$$

where:

Δt	=	the computation interval, and
F	=	accumulated depth of infiltration at the start of Δt.

The average filtration rate is:

$$f = \frac{\Delta F}{\Delta t} \tag{4.3}$$

Use of the Green and Ampt equation as coded in HEC-1 involves the simulation of rainfall loss as a two phase process, as illustrated in Figure 4.2. The first phase is the simulation of the surface retention loss as previously described; this loss is called the initial loss (IA) in HEC-1. During this first phase, all rainfall is lost (zero rainfall excess generated) during the period from the start of rainfall up to the time that the accumulated rainfall equals the value of IA. It is assumed, for modeling purposes, that no infiltration of rainfall occurs during the first phase. Initial loss (IA) is primarily a function of land-use and surface cover, and recommended values of IA for use with the Green and Ampt equation are presented in Table 4.2. For example, about 0.35 inches of rainfall will be lost to runoff due to surface retention for desert and rangelands on relatively flat slopes in Maricopa County.

The second phase of the rainfall loss process is the infiltration of rainfall into the soil matrix. For modeling purposes, the infiltration begins immediately after the surface retention loss (IA) is completely satisfied, as illustrated in Figure 4.2. The three Green and Ampt equation infiltration parameters as coded in HEC-1 are:

- hydraulic conductivity at natural saturation (XKSAT) equal to K_s in Equation (4.1);
- wetting front capillary suction (PSIF) equal to ψ in Equation (4.1); and
- volumetric soil moisture deficit at the start of rainfall (DTHETA) equal to θ in Equation (4.1).

The three infiltration parameters are functions of soil characteristics, ground surface characteristics, and land management practices. The soil characteristics of interest are particle size distribution (soil texture), organic matter, and bulk density. The primary soil surface characteristics are vegetation canopy cover, ground cover, and soil crusting. The land management practices are identified as various tillages as they result in changes in soil porosity.

Values of Green and Ampt equation parameters as a function of soil characteristics alone (bare ground condition) have been obtained from published reports (Rawls and others, 1983; Rawls and Brakensiek, 1983), and average values of XKSAT and PSIF for each of the soil texture classes are shown in columns (2) and (3) of Table 4.1. A best-fit plot of columns (2), (3), (4) and (5) is shown on Figure 4.3. Figure 4.3 should be used for selection of values of PSIF and DTHETA based on XKSAT. The values of XKSAT and PSIF from Table 4.1 or Figure 4.3 should be used if general soil texture classification of the drainage area is available. References used to create Table 4.1 can be found in the Documentation Manual.

In Table 4.1, loamy sand and sand are combined. The parameter values that are shown in the table are for loamy sand. The hydraulic conductivity (XKSAT) for sand is often used as 4.6 inches/hour, and the capillary suction (PSIF) is often used as 1.9 inches. Using those parameters values for drainage areas can result in the generation of no rainfall excess which may or may not be correct. Incorrect results could cause serious consequences for flood control planning and design. Therefore, it is recommended that, for watersheds consisting of relatively small subareas of sand, the Green and Ampt parameter values for loamy sand be used for the sand portion of the watershed. If the area contains a large portion of sand, then either the Green and Ampt method should be used with the parameter values for loamy sand or the IL+ULR method should be used with the appropriately determined values for the parameters.

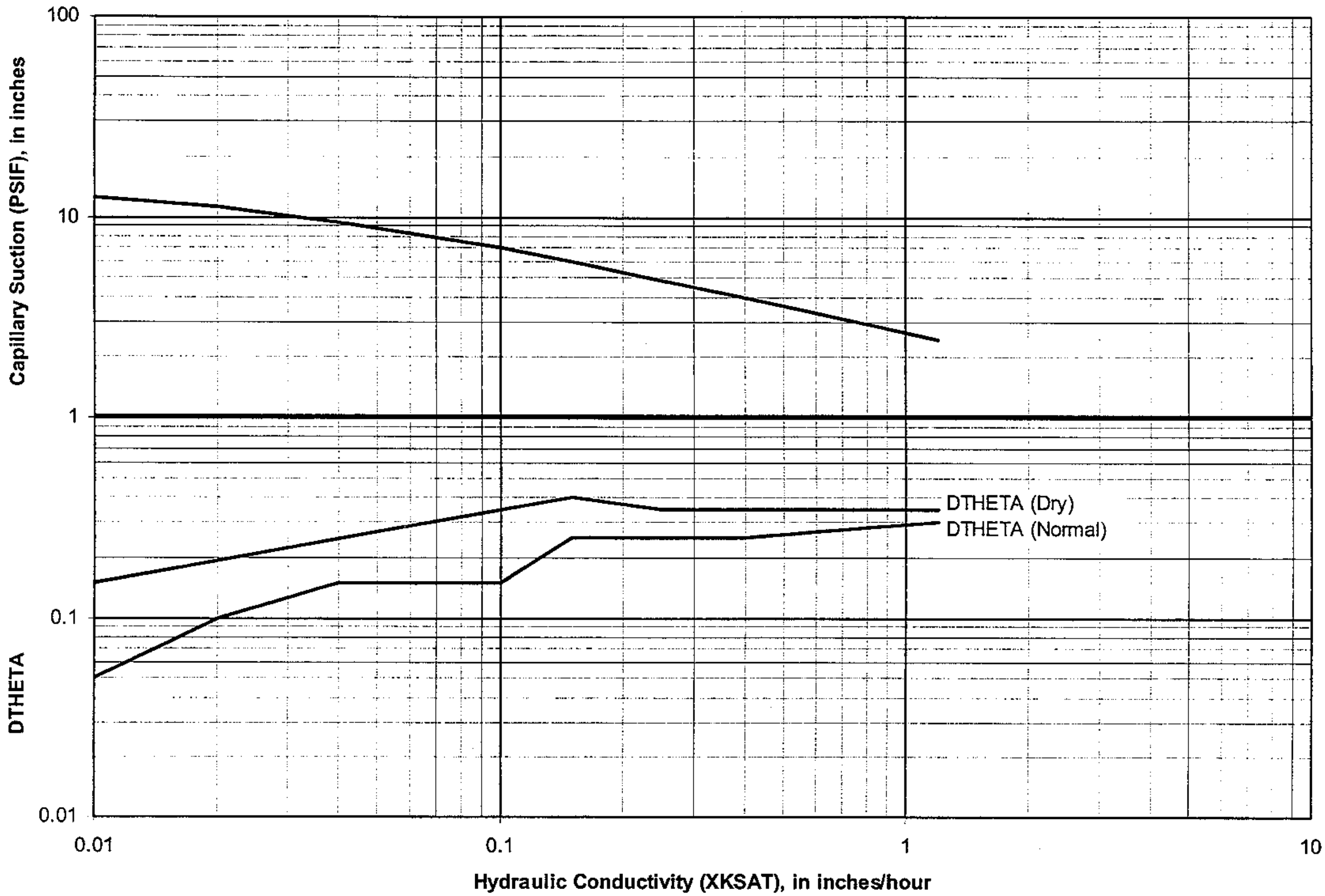
Table 4.1
GREEN AND AMPT LOSS RATE PARAMETER VALUES FOR BARE GROUND

Soil Texture Classification (1)	XKSAT inches/hour (2)	PSIF inches (3)	DTHETA[1] Dry (4)	DTHETA[1] Normal (5)	DTHETA[1] Saturated (6)
loamy sand & sand	1.20	2.4	0.35	0.30	0
sandy loam	0.40	4.3	0.35	0.25	0
loam	0.25	3.5	0.35	0.25	0
silty loam	0.15	6.6	0.40	0.25	0
silt	0.10	7.5	0.35	0.15	0
sandy clay loam	0.06	8.6	0.25	0.15	0
clay loam	0.04	8.2	0.25	0.15	0
silty clay loam	0.04	10.8	0.30	0.15	0
sandy clay	0.02	9.4	0.20	0.10	0
silty clay	0.02	11.5	0.20	0.10	0
clay	0.01	12.4	0.15	0.05	0

Notes:
1. Selection of DTHETA

Dry	=	Nonirrigated lands, such as desert and rangeland;
Normal	=	Irrigated lawn, turf, and permanent pasture;
Saturated	=	Irrigated agricultural land.

FIGURE 4.3
COMPOSITE VALUES OF PSIF AND DTHETA AS A FUNCTION OF XKSAT
(TO BE USED FOR AREA-WEIGHTED AVERAGING OF GREEN AND AMPT PARAMETERS)



The soil moisture deficit (DTHETA) is a volumetric measure of the soil moisture storage capacity that is available at the start of the rainfall. DTHETA is a function of the effective porosity of the soil. The range of DTHETA is 0.0 to the effective porosity. If the soil is effectively saturated at the start of rainfall then DTHETA equals 0.0; if the soil is devoid of moisture at the start of rainfall then DTHETA equals the effective porosity of the soil.

Under natural conditions, soil seldom reaches a state of soil moisture less than the wilting point of vegetation. Due to the rapid drainage capacity of most soils in Maricopa County, at the start of a design storm the soil would not be expected to be in a state of soil moisture greater than the field capacity.

However, Maricopa County also has a large segment of its land area under irrigated agriculture, and it is reasonable to assume that the design frequency storm could occur during or shortly after certain lands have been irrigated. Therefore, it would be reasonable to assume that soil moisture for irrigated lands could be at or near effective saturation during the start of the design rainfall.

Three conditions for DTHETA have been defined for use in Maricopa County based on antecedent soil moisture condition that could be expected to exist at the start of the design rainfall. These three conditions are:

- "Dry" for antecedent soil moisture near the vegetation wilting point
- "Normal" for antecedent soil moisture condition near field capacity due to previous rainfall or irrigation applications on nonagricultural lands; and
- "Saturated" for antecedent soil moisture near effective saturation due to recent irrigation of agricultural lands.

Values of DTHETA have been estimated by subtracting the initial volumetric soil moisture for each of the three conditions from the soil porosity.

The value of DTHETA "Saturated" is always equal to 0.0 because for this condition there is no available pore space in the soil matrix at the start of rainfall. Values of DTHETA for the three antecedent soil moisture conditions are shown in Table 4.1. DTHETA "Dry" should be used for soil that is usually in a state of low soil moisture such as would occur in the desert and rangelands of Maricopa County. DTHETA "Normal" should be used for soil that is usually in a state of moderate soil moisture such as would occur in irrigated lawns, golf courses, parks, and irrigated pastures. DTHETA "Saturated" should be used for soil that can be expected to be in a state of high soil moisture such as irrigated agricultural land. However, judgement should be exercised when using a "Saturated" condition, particularly for large areas of irrigated land as it is unlikely that the entire area is being irrigated at the same time.

Procedure for Areally Averaging Green and Ampt Parameter Values

Most drainage areas or modeling subbasins will be composed of several subareas containing soils of different textures. Therefore, a composite value for the Green and Ampt parameters that are to be applied to the drainage areas for modeling subbasins needs to be determined. The procedure for determining the composite value is to average the area-weighted logarithms of the XKSAT values and to select the PSIF and DTHETA values from a graph.

The XKSAT value (and naturally occurring rock outcrop percentage) for each map unit as identified by the National Resources Conservation Service (NRCS) is provided in Appendix C. The data contained in this appendix covers the majority of the northern portion of Maricopa County. The values for XKSAT listed in the appendix are weighted based on the percentage of each unique soil texture present in the map unit and take into consideration the horizon depth of the unique soil textures in regard to the expected depth of infiltration during the design storm duration. An example of the weighting procedure along with other assumptions and criteria used in developing the XKSAT values are provided at the front of Appendix C. The composite XKSAT is calculated by Equation (4.4):

$$\overline{XKSAT} = a\log\left(\frac{\Sigma A_i \log XKSAT_i}{A_T}\right) \tag{4.4}$$

where:

$\overline{XKSAT}$	=	composite subarea hydraulic conductivity, inches/hour
$XKSAT_i$	=	hydraulic conductivity of a map unit, inches/hour (from Appendix C)
A_i	=	size of subarea
A_T	=	size of the watershed or modeling subbasin

After XKSAT is calculated, the values of PSIF and DTHETA (normal or dry) are selected from Figure 4.3, at the corresponding value of XKSAT.

Procedures for Adjusting XKSAT for Vegetation Cover

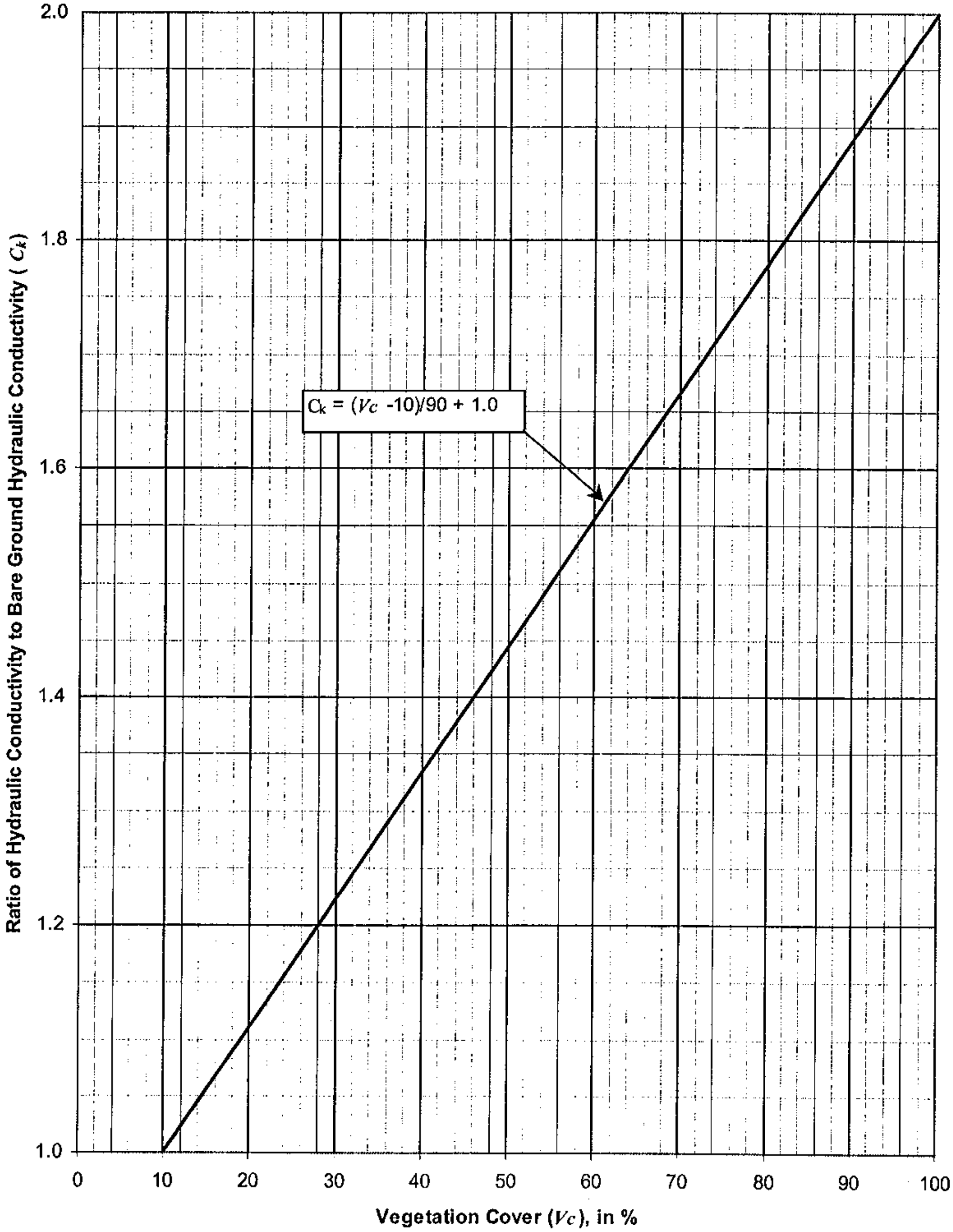
The hydraulic conductivity (XKSAT) can be affected by several factors besides soil texture. For example, hydraulic conductivity is reduced by soil crusting, increased by tillage, and increased by the influence of ground cover and canopy cover. The values of XKSAT that are presented for bare ground as a function of soil texture alone should be adjusted under certain soil cover conditions.

Ground cover, such as grass, litter, and gravel, will generally increase the infiltration rate over that of bare ground conditions. Similarly, canopy cover – such as from trees, brush, and tall grasses – can also increase the bare ground infiltration rate. The procedures and data that are presented are for estimating the Green and Ampt parameters based solely on soil texture and would be applicable for bare ground conditions. Past research has shown that the wetting front capillary suction parameter (PSIF) is relatively insensitive in comparison with the hydraulic conductivity parameter (XKSAT); therefore only the hydraulic conductivity parameter is adjusted for the influences of cover over bare ground.

Procedures have been developed (Rawls and others, 1989) for incorporating the effects of soil crusting, ground cover, and canopy cover into the estimation of hydraulic conductivity for the Green and Ampt equation; however, those procedures are not recommended for use in Maricopa County at this time. A simplified procedure to adjust the bare ground hydraulic conductivity for vegetation cover is shown in Figure 4.4. This figure is based on the documented increase in hydraulic conductivity due to various soil covers as reported by investigators using rainfall simulators on native western rangelands (Kincaid and others, 1964; Sabol and others, 1982a; Sabol and others, 1982b; Bach, 1984; Ward, 1986; Lane and others, 1987; Ward and Bolin, 1989). This correction factor can be used based on an estimate of vegetation cover as used by the NRCS in soil surveys; that is, vegetation cover is evaluated on basal area for grass and forbs, and is evaluated on canopy cover for trees and shrubs. Note that this correction can be applied only to soils other than sand and loamy sand.

The influence of tillage results in a change in total porosity and therefore a need to modify the three Green and Ampt equation infiltration parameters. The effect of tillage systems on soil porosity and the corresponding changes to hydraulic conductivity, wetting front capillary suction, and water retention is available (Rawls and Brakensiek, 1983). Although this information is available, it is not presented in this manual, nor is it recommended that these adjustments be made to the infiltration parameters for design purpose use in Maricopa County, because for most flood estimation purposes it cannot be assumed that the soil will be in any particular state of tillage at the time of storm occurrence and therefore the base condition infiltration parameters, as presented, should be used for flood estimation purposes. However, appropriate adjustment to the infiltration parameters can be made, as necessary, for special flood studies such as reconstitution of storm events.

FIGURE 4.4
EFFECT OF VEGETATION COVER ON HYDRAULIC CONDUCTIVITY
FOR HYDRAULIC SOIL GROUPS B, C, AND D, AND FOR ALL SOIL TEXTURES
***OTHER THAN* SAND AND LOAMY SAND**



Selection of IA, RTIMP, and Percent Vegetation Cover for Urban Areas

Table 4.2 contains suggested values for IA, RTIMP, and percent vegetation cover for various natural conditions and urban land use types. The values in Table 4.2 are meant as guidelines and are not to be taken as prescribed values for these parameters. Note that the values for RTIMP reflect effective impervious areas not total impervious areas. Also, note that the values for percent vegetation cover are for pervious areas only. These three parameter values are used in the calculation of average subbasin parameters for the Green and Ampt loss method as described above. Sound engineering judgement and experience should always be used when selecting rainfall loss parameters and assigning land use categories for any given watershed.

Table 4.2
IA, RTIMP, AND VEGETATIVE COVER DENSITY FOR REPRESENTATIVE LAND USES IN MARICOPA COUNTY

Land Use[1] Code	Land Use Category	Description	IA[2] inches	RTIMP[2,3] %	Vegetation Cover[2,4] %
VLDR	Very Low Density Residential[3]	40,000 sq. feet and greater lot size	0.30	5	30
LDR	Low Density Residential[3]	12,000 – 40,000 sq. feet lot size	0.30	15	50
MDR	Medium Density Residential[3]	6,000 – 12,000 sq. feet lot size	0.25	30	50
MFR	Multiple Family Residential[3]	1,000 – 6,000 sq. feet lot size (# du/ac)	0.25	45	50
I1	Industrial 1[3]	Light and General	0.15	55	60
I2	Industrial 2[3]	General and Heavy	0.15	55	60
C1	Commercial 1[3]	Light, Neighborhood, Residential	0.10	80	75
C2	Commercial 2[3]	Central, General, Office, Intermediate	0.10	80	75
P	Pavement and Rooftops	Asphalt and Concrete, Sloped Rooftops	0.05	95	0
GR	Gravel Roadways & Shoulders	Graded and Compacted, Treated and Untreated	0.10	5	0
AG	Agricultural	Tilled Fields, Irrigated Pastures, slopes < 1%	0.50	0	85
LPC	Lawns/Parks/Cemeteries	Over 80% maintained lawn	0.20	Varies[5]	80
DL1	Desert Landscaping 1	Landscaping with impervious under treatment	0.10	95	30
DL2	Desert Landscaping 2	Landscaping without impervious under treatment	0.20	0	30
NDR	Undeveloped Desert Rangeland	Little topographic relief, slopes < 5%	0.35	Varies[5]	Varies[6]
NHS	Hillslopes, Sonoran Desert	Moderate topographic relief, slopes > 5%	0.15	Varies[5]	Varies[6]
NMT	Mountain Terrain	High topographic relief, slopes > 10%	0.25	Varies[5]	Varies[6]

Notes:
1. Other land use or zoning classifications, such as Planned Area Development and Schools must be evaluated on a case by case basis.
2. These values have been selected to fit many typical settings in Maricopa County; however, the engineer/hydrologist should always evaluate the specific circumstances in any particular watershed for hydrologic variations from these typical values.
3. RTIMP = Percent Effective Impervious Area, including right-of-way. Effective means that all impervious areas are assumed to be hydraulically connected. The RTIMP values may need to be adjusted based on an evaluation of hydraulic connectivity.
4. Vegetation Cover = Percent vegetation cover for pervious areas only.
5. RTIMP values must be estimated on a case by case basis.
6. Vegetation Cover values must be estimated on a case by case basis.

APPENDIX C. MODEL INPUT DATA

C.1. **Routes**

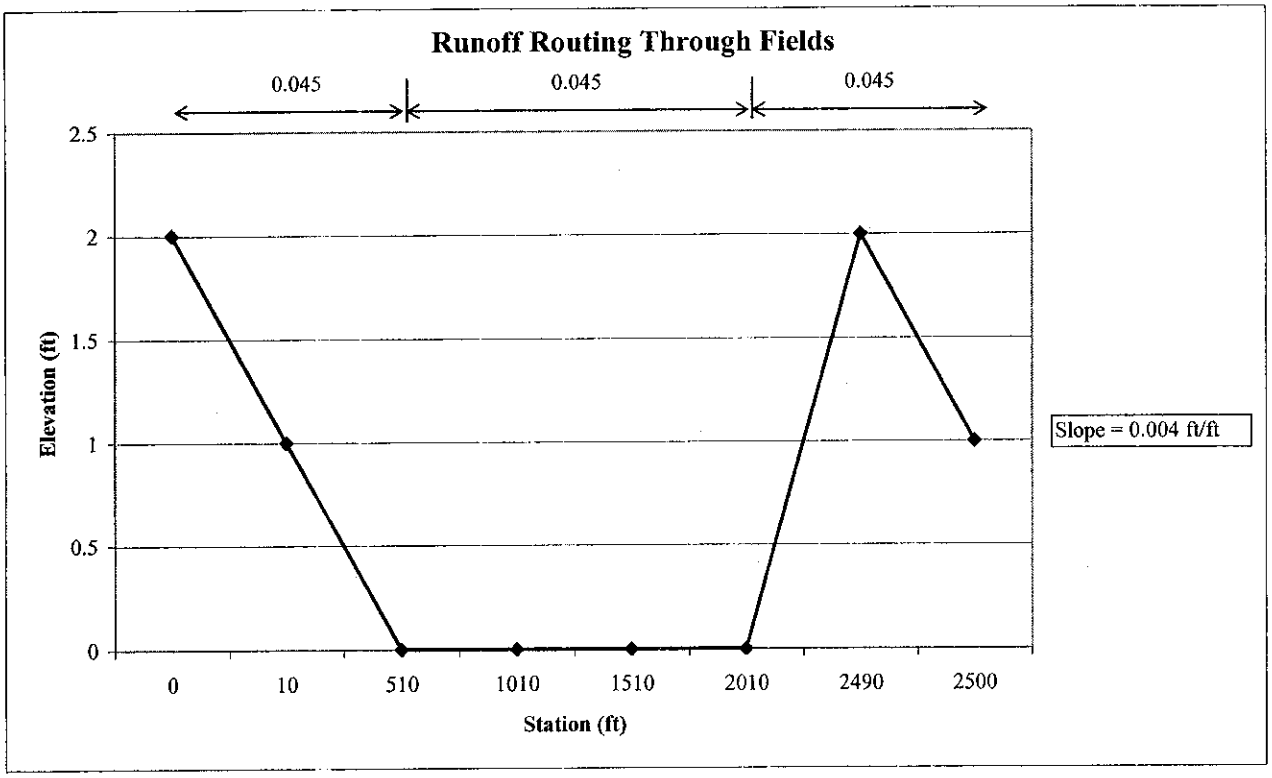
C.2. **Precipitation Data**

C.3. **S-Graphs and Unit Hydrographs**

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY JCS	DATE	11/1/2004
CHECK	DATE	
JOB # 118.001		
SHEET	OF	

Route Geometry for System Model
Route data development for routing through fields



Station (ft)	Elevation (ft)
0	2
10	1
510	0
1010	0
1510	0
2010	0
2490	2
2500	1

APPENDIX C. MODEL INPUT DATA

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY GA		**DATE**	10/1/2004
CHECK	JF	**DATE**	11/1/4
JOB #	118.001		
SHEET		**OF**	

Development of Precipitation Distributions Hydrology Models
Precipitation Distribution for Furrow Irrigated Field and 6-Hour Storm
Note: For combined 6-hour storm and 12-hour furrow irrigation event, antecendant moisture condition should be set to "Wet."

Time (hrs)	Percent of Rainfall Depth	Rainfall Depth (in)	Irrigation Depth (in)	Total Precipitation Depth (in)	Percent of Total Precipitation Depth
0:00	0%	0.0	0.1	0.1	2%
0:15	1%	0.0	0.3	0.3	4%
0:30	2%	0.1	0.4	0.4	7%
0:45	3%	0.1	0.5	0.6	9%
1:00	3%	0.1	0.6	0.7	11%
1:15	4%	0.1	0.8	0.9	14%
1:30	5%	0.2	0.9	1.1	16%
1:45	6%	0.2	1.0	1.2	18%
2:00	7%	0.2	1.1	1.4	21%
2:15	7%	0.3	1.3	1.5	23%
2:30	9%	0.3	1.4	1.7	26%
2:45	10%	0.3	1.5	1.9	28%
3:00	12%	0.4	1.6	2.0	31%
3:15	14%	0.5	1.8	2.2	34%
3:30	22%	0.7	1.9	2.6	40%
3:45	38%	1.3	2.0	3.3	50%
4:00	83%	2.8	2.1	5.0	76%
4:15	91%	3.1	2.3	5.4	82%
4:30	93%	3.2	2.4	5.6	85%
4:45	95%	3.2	2.5	5.8	88%
5:00	96%	3.3	2.6	5.9	90%
5:15	97%	3.3	2.8	6.1	93%
5:30	98%	3.3	2.9	6.2	95%
5:45	99%	3.4	3.0	6.4	98%
6:00	100%	3.4	3.1	6.6	100%

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY GA		**DATE**	10/1/2004
CHECK	JS	**DATE**	11/1/4
JOB #	118.001		
SHEET		**OF**	

Development of Precipitation Distributions Hydrology Models
Precipitation Distribution for Border Irrigated Field and 6-Hour Storm

Time (hrs)	Percent of Rainfall Depth	Rainfall Depth (in)	Irrigation Depth (in)	Total Precipitation Depth (in)	Percent of Total Precipitation Depth
0:00	0%	0.0	0.0	0.0	0%
0:15	1%	0.0	0.0	0.0	0%
0:30	2%	0.1	0.0	0.1	1%
0:45	3%	0.1	0.0	0.1	1%
1:00	3%	0.1	0.0	0.1	1%
1:15	4%	0.1	0.0	0.1	1%
1:30	5%	0.2	0.0	0.2	2%
1:45	6%	0.2	0.0	0.2	2%
2:00	7%	0.2	0.0	0.2	2%
2:15	7%	0.3	0.0	0.3	3%
2:30	9%	0.3	0.0	0.3	3%
2:45	10%	0.3	0.0	0.3	4%
3:00	12%	0.4	0.0	0.4	4%
3:15	14%	0.5	1.0	1.5	16%
3:30	22%	0.7	2.1	2.8	29%
3:45	38%	1.3	3.1	4.4	46%
4:00	83%	2.8	4.1	7.0	73%
4:15	91%	3.1	5.2	8.3	86%
4:30	93%	3.2	6.2	9.4	98%
4:45	95%	3.2	6.2	9.4	98%
5:00	96%	3.3	6.2	9.5	99%
5:15	97%	3.3	6.2	9.5	99%
5:30	98%	3.3	6.2	9.5	99%
5:45	99%	3.4	6.2	9.6	100%
6:00	100%	3.4	6.2	9.6	100%

Figure 1: Mass Curve for 6-Hour, 100-Year Storm and Furrow Irrigated Field

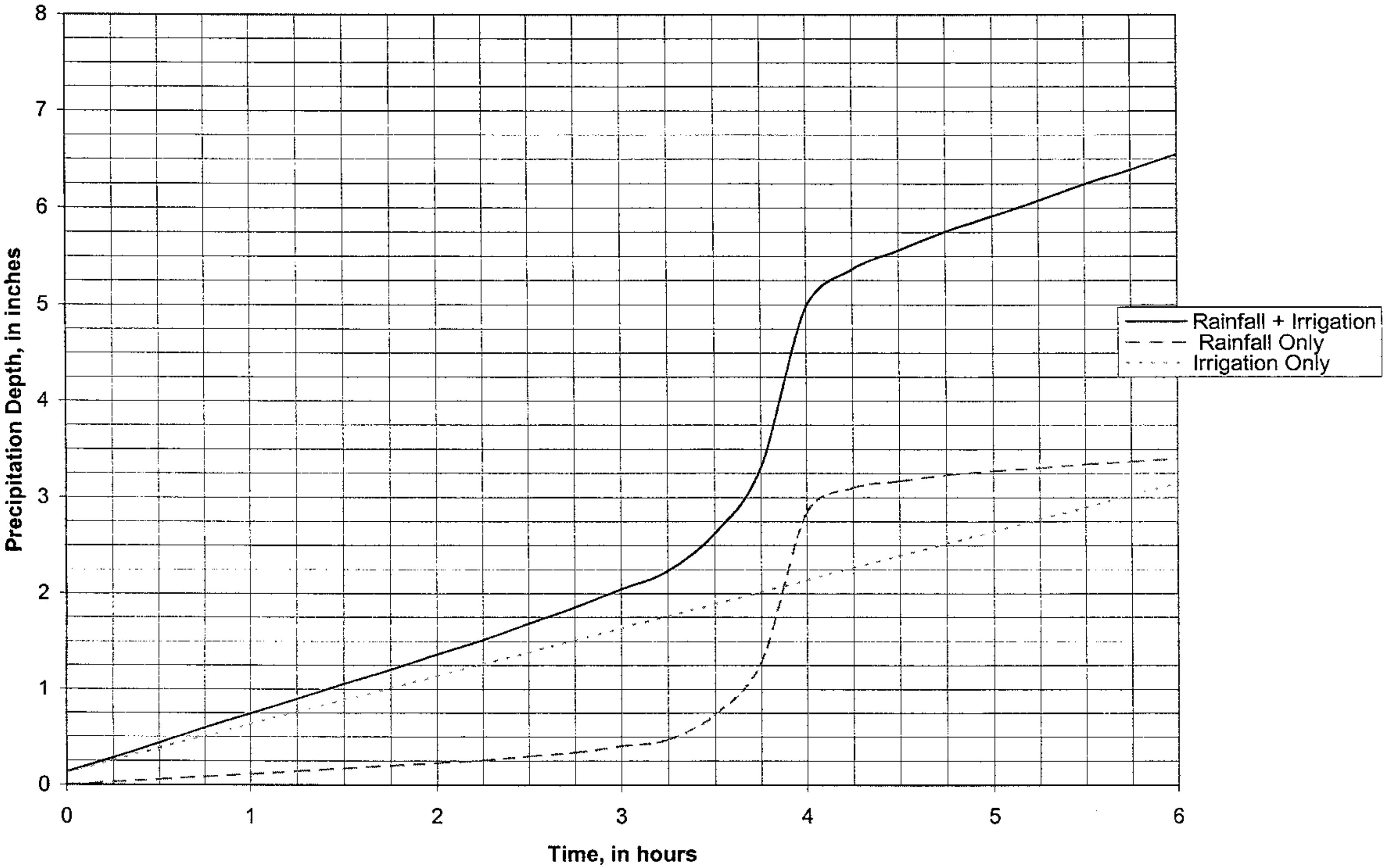
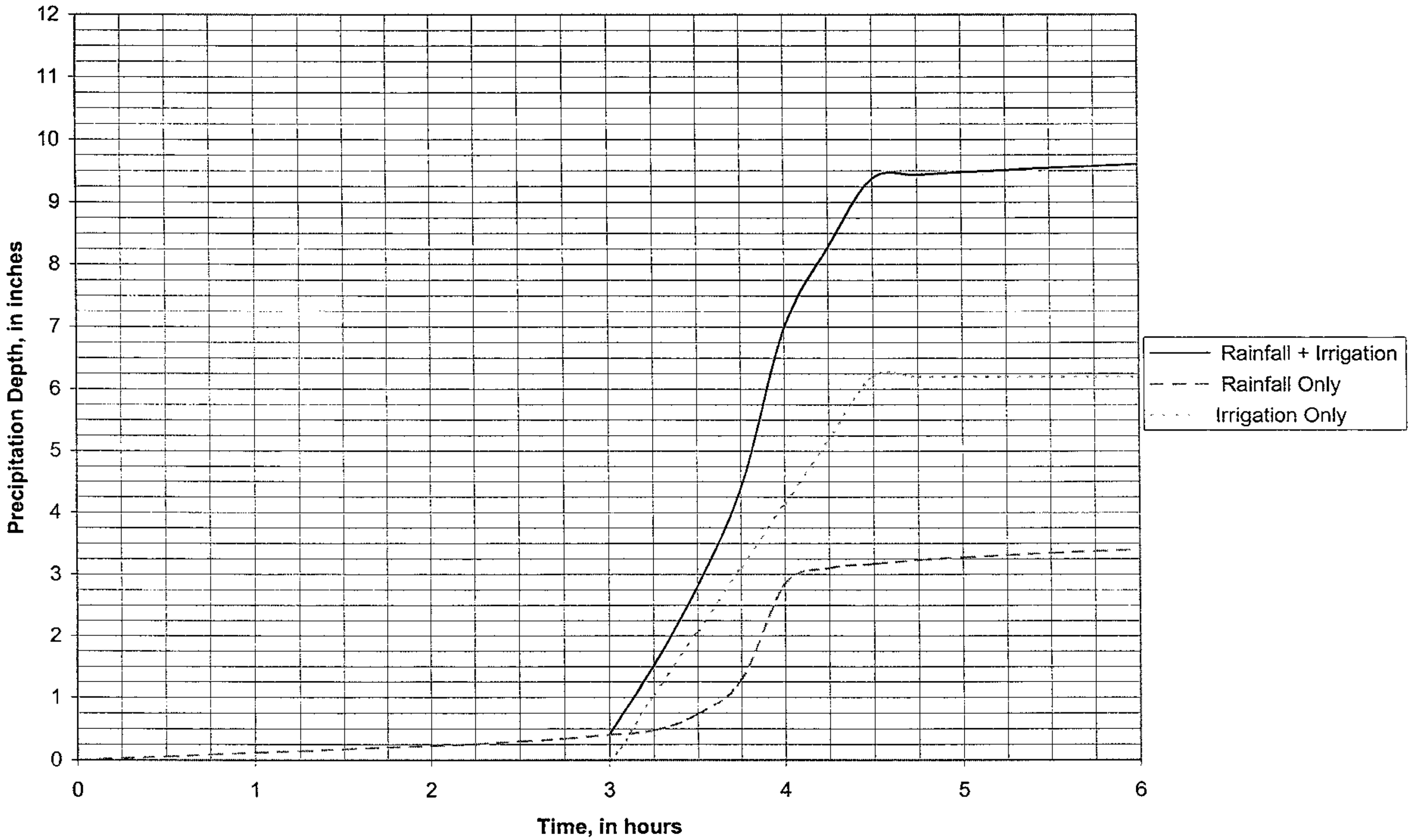


Figure 2: Mass Curve for 6-hour, 100-Year Storm and Border Irrigated Field



APPENDIX C. MODEL INPUT DATA

C.1. Routes

C.2. Precipitation Data

C.3. S-Graphs and Unit Hydrographs

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
CHECK	HAA	**DATE**	
JOB #	118.001		
SHEET		**OF**	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

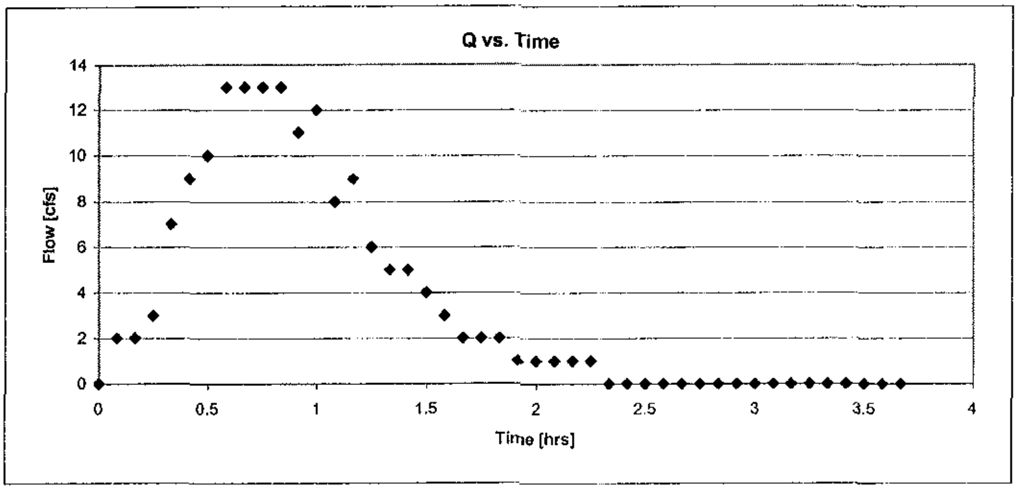
MODEL: sets.txt (Observed Sets Model)
FIELD: 00-34
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

S-Graph Parameters

Basin Name	00-34
Basin Area [mi^2]	0.021
Basin Lag [hr]	0.81
Time Step [min]	*5*
Time Step [hr]	0.0833
Q_{ult}	163
S-Graph Type	Agricultural

These unit hydrographs are irrelevant because the model was used for calibrating the runoff volume only.

```
UI AND COMMENT CARDS
* Agricultural S-Graph for Basin 00-34
* Basin Area [mi2] = 0.021
* Basin Lag [hr] = 0.81
* Time Step [min] = 5
* Qult = 163
*
UI      0      2      2      3      7      9     10     13     13     13
UI     13     11     12      8      9      6      5      5      4      3
UI      2      2      2      1      1      1      1      1      0      0
UI      0      0      0      0      0      0      0      0      0      0
UI      0      0      0      0      0
```



Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
CHECK		**DATE**	
JOB #	118.001		
SHEET		**OF**	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

MODEL: sets.txt (Observed Sets Model)
SUBBASIN: 00-34
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

Time (hrs)	Time (min)	% Q_{ult}	Q	% Lag Agricultural
0.000	0.00	0	0	0.00
0.170	10.21	2	3	21.00
0.251	15.07	4	7	31.00
0.300	17.98	6	10	37.00
0.332	19.93	8	13	41.00
0.365	21.87	10	16	45.00
0.389	23.33	12	20	48.00
0.421	25.27	14	23	52.00
0.454	27.22	16	26	56.00
0.478	28.67	18	29	59.00
0.502	30.13	20	33	62.00
0.518	31.10	22	36	64.00
0.547	32.81	24	39	67.50
0.567	34.02	26	42	70.00
0.587	35.24	28	46	72.50
0.608	36.45	30	49	75.00
0.628	37.67	32	52	77.50
0.648	38.88	34	55	80.00
0.668	40.10	36	59	82.50
0.689	41.31	38	62	85.00
0.709	42.53	40	65	87.50
0.729	43.74	42	68	90.00
0.749	44.96	44	72	92.50
0.770	46.17	46	75	95.00
0.790	47.39	48	78	97.50
0.810	48.60	50	81	100.00
0.834	50.06	52	85	103.00
0.859	51.52	54	88	106.00
0.883	52.97	56	91	109.00
0.907	54.43	58	94	112.00
0.932	55.89	60	98	115.00
0.952	57.11	62	101	117.50
0.976	58.56	64	104	120.50
0.996	59.78	66	107	123.00
1.029	61.72	68	111	127.00
1.061	63.67	70	114	131.00
1.094	65.61	72	117	135.00
1.123	67.36	74	120	138.60
1.150	69.01	76	124	142.00
1.191	71.44	78	127	147.00
1.235	74.12	80	130	152.50
1.280	76.79	82	133	158.00
1.337	80.19	84	137	165.00
1.397	83.84	86	140	172.50
1.450	86.99	88	143	179.00
1.539	92.34	90	146	190.00
1.644	98.66	92	150	203.00
1.782	106.92	94	153	220.00
1.968	118.10	96	156	243.00
2.268	136.08	98	159	280.00
3.629	217.73	100	163	448.00

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
CHECK		**DATE**	
JOB #	118.001		
SHEET		**OF**	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

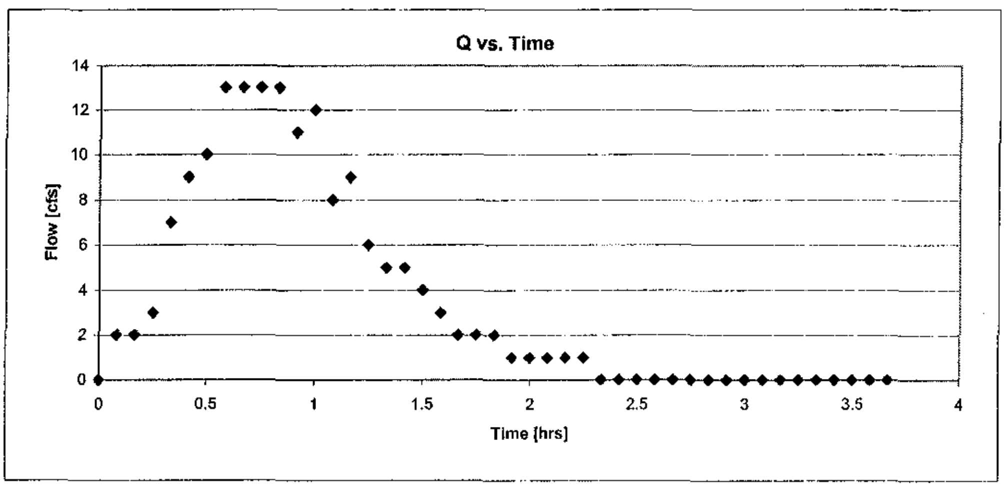
MODEL: *sets.txt (Observed Sets Model)*
FIELD: 00-34 (Area Halved to Account For Furrows)
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

S-Graph Parameters

Basin Name	00-34
Basin Area [mi^2]	0.011
Basin Lag [hr]	0.81
Time Step [min]	5
Time Step [hr]	0.0833
Q_{ult}	85
S-Graph Type	Agricultural

These unit hydrographs are irrelevant because the model was used for calibrating the runoff volume only.

```
UI AND COMMENT CARDS
* Agricultural S-Graph for Basin 00-34
* Basin Area [mi2] = 0.011
* Basin Lag [hr] = 0.81
* Time Step [min] = 5
* Qult = 85
*
UI      0       1       1       2       3       5       5       7       7       7
UI      7       6       6       4       5       3       3       2       2       1
UI      1       1       1       1       1       0       0       0       0       0
UI      0       0       0       0       0       0       0       0       0       0
UI      0       0       0       0       0
```



Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
CHECK		**DATE**	
JOB #	118.001		
SHEET		**OF**	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

MODEL: sets.txt (Observed Sets Model)
SUBBASIN: 00-34 (Area Halved to Account For Furrows)
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

				% Lag
Time (hrs)	**Time (min)**	**% Q_{ult}**	**Q**	**Agricultural**
0.000	0.00	0	0	0.00
0.170	10.21	2	2	21.00
0.251	15.07	4	3	31.00
0.300	17.98	6	5	37.00
0.332	19.93	8	7	41.00
0.365	21.87	10	9	45.00
0.389	23.33	12	10	48.00
0.421	25.27	14	12	52.00
0.454	27.22	16	14	56.00
0.478	28.67	18	15	59.00
0.502	30.13	20	17	62.00
0.518	31.10	22	19	64.00
0.547	32.81	24	20	67.50
0.567	34.02	26	22	70.00
0.587	35.24	28	24	72.50
0.608	36.45	30	26	75.00
0.628	37.67	32	27	77.50
0.648	38.88	34	29	80.00
0.668	40.10	36	31	82.50
0.689	41.31	38	32	85.00
0.709	42.53	40	34	87.50
0.729	43.74	42	36	90.00
0.749	44.96	44	37	92.50
0.770	46.17	46	39	95.00
0.790	47.39	48	41	97.50
0.810	48.60	50	43	100.00
0.834	50.06	52	44	103.00
0.859	51.52	54	46	106.00
0.883	52.97	56	48	109.00
0.907	54.43	58	49	112.00
0.932	55.89	60	51	115.00
0.952	57.11	62	53	117.50
0.976	58.56	64	55	120.50
0.996	59.78	66	56	123.00
1.029	61.72	68	58	127.00
1.061	63.67	70	60	131.00
1.094	65.61	72	61	135.00
1.123	67.36	74	63	138.60
1.150	69.01	76	65	142.00
1.191	71.44	78	66	147.00
1.235	74.12	80	68	152.50
1.280	76.79	82	70	158.00
1.337	80.19	84	72	165.00
1.397	83.84	86	73	172.50
1.450	86.99	88	75	179.00
1.539	92.34	90	77	190.00
1.644	98.66	92	78	203.00
1.782	106.92	94	80	220.00
1.968	118.10	96	82	243.00
2.268	136.08	98	83	280.00
3.629	217.73	100	85	448.00

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
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JOB #	118.001		
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Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

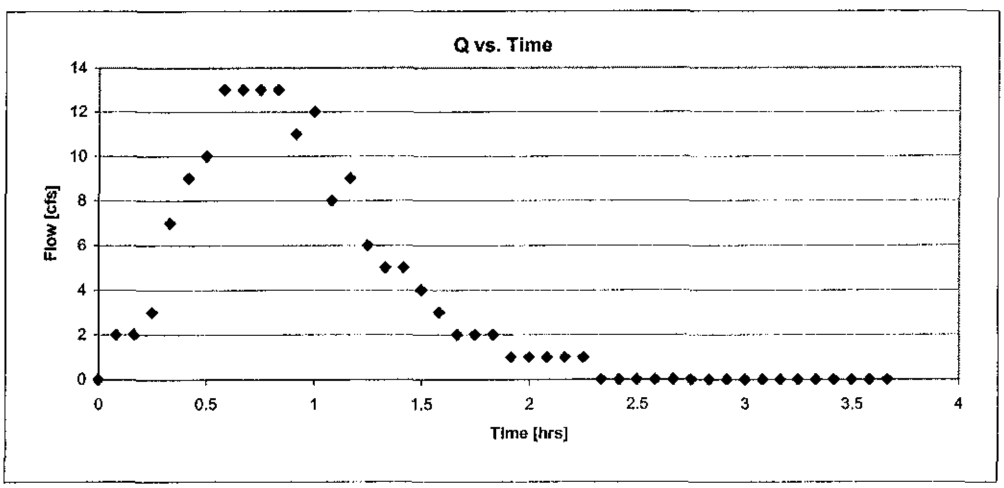
MODEL: sets.txt (Observed Sets Model)
FIELD: 99-15
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

S-Graph Parameters

Basin Name	99-15
Basin Area [mi^2]	0.02
Basin Lag [hr]	1.20
Time Step [min]	5
Time Step [hr]	0.0833
Q_{ult}	155
S-Graph Type	Agricultural

These unit hydrographs are irrelevant because the model was used for calibrating the runoff volume only.

```
UI AND COMMENT CARDS
* Agricultural S-Graph for Basin 99-15
* Basin Area [mi2] = 0.02
* Basin Lag [hr] = 1.2
* Time Step [min] = 5
* Qult = 155
*
UI     0     1     1     1     2     3     5     6     5     7
UI     8     9     9     9     9     8     7     8     7     5
UI     6     5     4     4     3     3     3     2     2     2
UI     1     1     1     1     1     1     1     1     1     1
UI     1     0     0     0     0     0     0     0     0     0
UI     0     0     0     0     0     0     0     0     0     0
UI     0     0     0     0     0     0
```



Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
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JOB #	118.001		
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Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

MODEL: sets.txt (Observed Sets Model)
SUBBASIN: 99-15
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

Time (hrs)	Time (min)	% Q_{ult}	Q	% Lag Agricultural
0.000	0.00	0	0	0.00
0.252	15.12	2	3	21.00
0.372	22.32	4	6	31.00
0.444	26.64	6	9	37.00
0.492	29.52	8	12	41.00
0.540	32.40	10	15	45.00
0.576	34.56	12	19	48.00
0.624	37.44	14	22	52.00
0.672	40.32	16	25	56.00
0.708	42.48	18	28	59.00
0.744	44.64	20	31	62.00
0.768	46.08	22	34	64.00
0.810	48.60	24	37	67.50
0.840	50.40	26	40	70.00
0.870	52.20	28	43	72.50
0.900	54.00	30	46	75.00
0.930	55.80	32	50	77.50
0.960	57.60	34	53	80.00
0.990	59.40	36	56	82.50
1.020	61.20	38	59	85.00
1.050	63.00	40	62	87.50
1.080	64.80	42	65	90.00
1.110	66.60	44	68	92.50
1.140	68.40	46	71	95.00
1.170	70.20	48	74	97.50
1.200	72.00	50	77	100.00
1.236	74.16	52	81	103.00
1.272	76.32	54	84	106.00
1.308	78.48	56	87	109.00
1.344	80.64	58	90	112.00
1.380	82.80	60	93	115.00
1.410	84.60	62	96	117.50
1.446	86.76	64	99	120.50
1.476	88.56	66	102	123.00
1.524	91.44	68	105	127.00
1.572	94.32	70	108	131.00
1.620	97.20	72	112	135.00
1.663	99.79	74	115	138.60
1.704	102.24	76	118	142.00
1.764	105.84	78	121	147.00
1.830	109.80	80	124	152.50
1.896	113.76	82	127	158.00
1.980	118.80	84	130	165.00
2.070	124.20	86	133	172.50
2.148	128.88	88	136	179.00
2.280	136.80	90	139	190.00
2.436	146.16	92	142	203.00
2.640	158.40	94	146	220.00
2.916	174.96	96	149	243.00
3.360	201.60	98	152	280.00
5.376	322.56	100	155	448.00

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY JCS	DATE
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JOB # 118.001	
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Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

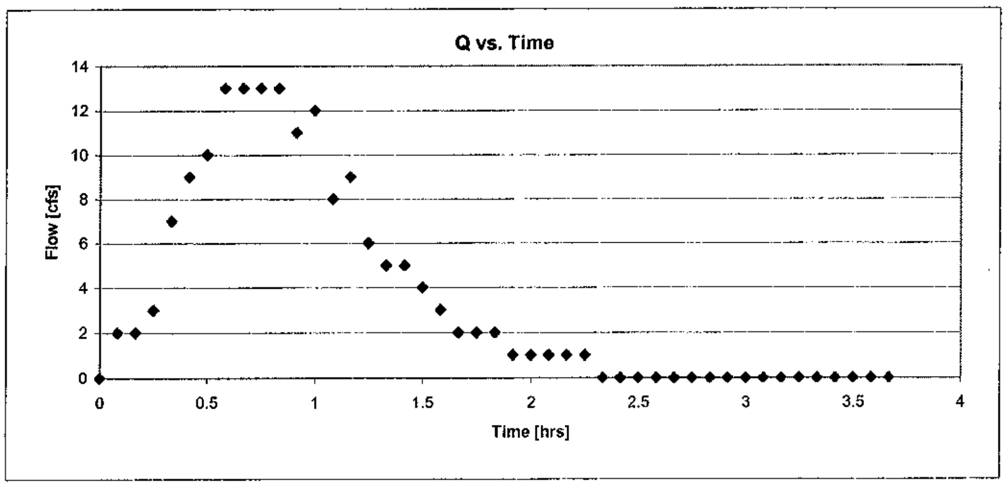
MODEL: sets.txt (Observed Sets Model)
FIELD: 99-16
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

S-Graph Parameters

Basin Name	99-16
Basin Area [mi^2]	0.02
Basin Lag [hr]	1.20
Time Step [min]	5
Time Step [hr]	0.0833
Q_{ult}	155
S-Graph Type	Agricultural

These unit hydrographs are irrelevant because the model was used for calibrating the runoff volume only.

```
UI AND COMMENT CARDS
* Agricultural S-Graph for Basin 99-16
* Basin Area [mi2] = 0.02
* Basin Lag [hr] = 1.2
* Time Step [min] = 5
* Qult = 155
*
UI      0       1       1       1       2       3       5       6       5       7
UI      8       9       9       9       9       8       7       8       7       5
UI      6       5       4       4       3       3       3       2       2       2
UI      1       1       1       1       1       1       1       1       1       1
UI      1       0       0       0       0       0       0       0       0       0
UI      0       0       0       0       0       0       0       0       0       0
UI      0       0       0       0       0       0
```



Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
CHECK		**DATE**	
JOB #	118.001		
SHEET		**OF**	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

MODEL: sets.txt (Observed Sets Model)
SUBBASIN: 99-16
DESCRIPTION: Calibration of Initial Abstraction to Reproduce Observed Runoff Volume

Time (hrs)	Time (min)	% Q_{ult}	Q	% Lag Agricultural
0.000	0.00	0	0	0.00
0.252	15.12	2	3	21.00
0.372	22.32	4	6	31.00
0.444	26.64	6	9	37.00
0.492	29.52	8	12	41.00
0.540	32.40	10	15	45.00
0.576	34.56	12	19	48.00
0.624	37.44	14	22	52.00
0.672	40.32	16	25	56.00
0.708	42.48	18	28	59.00
0.744	44.64	20	31	62.00
0.768	46.08	22	34	64.00
0.810	48.60	24	37	67.50
0.840	50.40	26	40	70.00
0.870	52.20	28	43	72.50
0.900	54.00	30	46	75.00
0.930	55.80	32	50	77.50
0.960	57.60	34	53	80.00
0.990	59.40	36	56	82.50
1.020	61.20	38	59	85.00
1.050	63.00	40	62	87.50
1.080	64.80	42	65	90.00
1.110	66.60	44	68	92.50
1.140	68.40	46	71	95.00
1.170	70.20	48	74	97.50
1.200	72.00	50	77	100.00
1.236	74.16	52	81	103.00
1.272	76.32	54	84	106.00
1.308	78.48	56	87	109.00
1.344	80.64	58	90	112.00
1.380	82.80	60	93	115.00
1.410	84.60	62	96	117.50
1.446	86.76	64	99	120.50
1.476	88.56	66	102	123.00
1.524	91.44	68	105	127.00
1.572	94.32	70	108	131.00
1.620	97.20	72	112	135.00
1.663	99.79	74	115	138.60
1.704	102.24	76	118	142.00
1.764	105.84	78	121	147.00
1.830	109.80	80	124	152.50
1.896	113.76	82	127	158.00
1.980	118.80	84	130	165.00
2.070	124.20	86	133	172.50
2.148	128.88	88	136	179.00
2.280	136.80	90	139	190.00
2.436	146.16	92	142	203.00
2.640	158.40	94	146	220.00
2.916	174.96	96	149	243.00
3.360	201.60	98	152	280.00
5.376	322.56	100	155	448.00

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	DATE	
CHECK		DATE	
JOB #	118.001		
SHEET		OF	

Unit Hydrograph Development Using District S-Graphs

Unit-Hydrographs for Calibration Models

MODEL: system1.txt (System of Fields Modeled as Routed and Combined Subbasins)
SUBBASIN: System
DESCRIPTION: Generation of typical scenarios of grouped fields

Time (hrs)	Time (min)	% Q_{ult}	Q	% Lag Agricultural
0.000	0.00	0	0	0.00
0.462	27.72	2	19	21.00
0.682	40.92	4	39	31.00
0.814	48.84	6	58	37.00
0.902	54.12	8	77	41.00
0.990	59.40	10	97	45.00
1.056	63.36	12	116	48.00
1.144	68.64	14	136	52.00
1.232	73.92	16	155	56.00
1.298	77.88	18	174	59.00
1.364	81.84	20	194	62.00
1.408	84.48	22	213	64.00
1.485	89.10	24	232	67.50
1.540	92.40	26	252	70.00
1.595	95.70	28	271	72.50
1.650	99.00	30	290	75.00
1.705	102.30	32	310	77.50
1.760	105.60	34	329	80.00
1.815	108.90	36	348	82.50
1.870	112.20	38	368	85.00
1.925	115.50	40	387	87.50
1.980	118.80	42	407	90.00
2.035	122.10	44	426	92.50
2.090	125.40	46	445	95.00
2.145	128.70	48	465	97.50
2.200	132.00	50	484	100.00
2.266	135.96	52	503	103.00
2.332	139.92	54	523	106.00
2.398	143.88	56	542	109.00
2.464	147.84	58	561	112.00
2.530	151.80	60	581	115.00
2.585	155.10	62	600	117.50
2.651	159.06	64	620	120.50
2.706	162.36	66	639	123.00
2.794	167.64	68	658	127.00
2.882	172.92	70	678	131.00
2.970	178.20	72	697	135.00
3.049	182.95	74	716	138.60
3.124	187.44	76	736	142.00
3.234	194.04	78	755	147.00
3.355	201.30	80	774	152.50
3.476	208.56	82	794	158.00
3.630	217.80	84	813	165.00
3.795	227.70	86	832	172.50
3.938	236.28	88	852	179.00
4.180	250.80	90	871	190.00
4.466	267.96	92	891	203.00
4.840	290.40	94	910	220.00
5.346	320.76	96	929	243.00
6.160	369.60	98	949	280.00
9.856	591.36	100	968	448.00

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	DATE	
CHECK		DATE	
JOB #	118.001		
SHEET		OF	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

MODEL: system2.txt (System of Fields Modeled as Single Subbasin)
FIELD: System
DESCRIPTION: Calibration of Initial Abstraction and Lag Time to Reproduce Results from System 1 Model

S-Graph Parameters

Basin Name	SYSTEM
Basin Area [mi^2]	1.25
Basin Lag [hr]	3.30
Time Step [min]	5
Time Step [hr]	0.0833
Q_{ult}	9680
S-Graph Type	Agricultural

```
UI AND COMMENT CARDS
* Agricultural S-Graph for Basin SYSTEM
* Basin Area [mi2] = 1.25
* Basin Lag [hr] = 3.3
* Time Step [min] = 5
* Qult = 9680
* Unit Hydrograph was truncated to 150 ordinates (max number allowed by HEC-1)
UI      0      23     23     23     23     23     23     23     23     41
UI     49      49     49     72     81     96    122    122    130    163
UI    123     122    122    156    163    199    176    155    196    196
UI    196     196    196    196    196    196    196    196    196    196
UI    183     163    163    163    163    163    178    180    172    174
UI    122     122    122    122    130    137    144    108     98     91
UI     89      89     89     81     70     70     67     65     65     72
UI     75      72     44     44     44     44     39     38     38     38
UI     38      32     29     29     29     29     29     29     22     21
UI     21      21     21     21     21     21     21     15     13     13
UI     13      13     13     13     13     13     13     13     13     13
UI     13      12      3      3      3      3      3      3      3      3
UI      3       3      3      3      3      3      3      3      3      3
UI      3       3      3      3      3      3      3      3      3      3
UI      3       3      3      3      3      3      3      3      3      3
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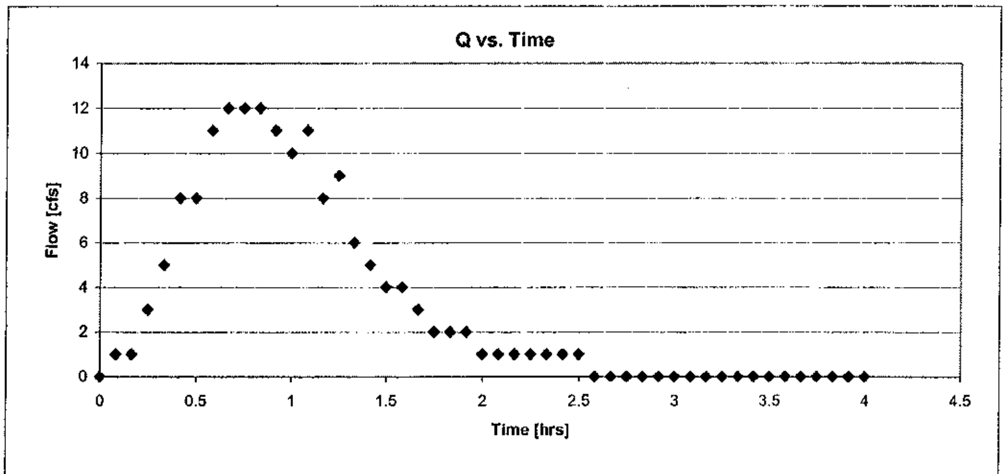

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY	JCS	**DATE**	
CHECK		**DATE**	
JOB #	118.001		
SHEET		**OF**	

Unit Hydrograph Development Using District S-Graphs
Unit-Hydrographs for Calibration Models

MODEL: system2.txt (System of Fields Modeled as Single Subbasin)
SUBBASIN: System
DESCRIPTION: Calibration of Initial Abstraction and Lag Time to Reproduce Results from System 1 Model

Time (hrs)	Time (min)	% Q_{ult}	Q	% Lag Agricultural
0.000	0.00	0	0	0.00
0.693	41.58	2	194	21.00
1.023	61.38	4	387	31.00
1.221	73.26	6	581	37.00
1.353	81.18	8	774	41.00
1.485	89.10	10	968	45.00
1.584	95.04	12	1162	48.00
1.716	102.96	14	1355	52.00
1.848	110.88	16	1549	56.00
1.947	116.82	18	1742	59.00
2.046	122.76	20	1936	62.00
2.112	126.72	22	2130	64.00
2.228	133.65	24	2323	67.50
2.310	138.60	26	2517	70.00
2.393	143.55	28	2710	72.50
2.475	148.50	30	2904	75.00
2.558	153.45	32	3098	77.50
2.640	158.40	34	3291	80.00
2.723	163.35	36	3485	82.50
2.805	168.30	38	3678	85.00
2.888	173.25	40	3872	87.50
2.970	178.20	42	4066	90.00
3.053	183.15	44	4259	92.50
3.135	188.10	46	4453	95.00
3.218	193.05	48	4646	97.50
3.300	198.00	50	4840	100.00
3.399	203.94	52	5034	103.00
3.498	209.88	54	5227	106.00
3.597	215.82	56	5421	109.00
3.696	221.76	58	5614	112.00
3.795	227.70	60	5808	115.00
3.878	232.65	62	6002	117.50
3.977	238.59	64	6195	120.50
4.059	243.54	66	6389	123.00
4.191	251.46	68	6582	127.00
4.323	259.38	70	6776	131.00
4.455	267.30	72	6970	135.00
4.574	274.43	74	7163	138.60
4.686	281.16	76	7357	142.00
4.851	291.06	78	7550	147.00
5.033	301.95	80	7744	152.50
5.214	312.84	82	7938	158.00
5.445	326.70	84	8131	165.00
5.693	341.55	86	8325	172.50
5.907	354.42	88	8518	179.00
6.270	376.20	90	8712	190.00
6.699	401.94	92	8906	203.00
7.260	435.60	94	9099	220.00
8.019	481.14	96	9293	243.00
9.240	554.40	98	9486	280.00
14.784	887.04	100	9680	448.00

APPENDIX D. CALBRATION ITERATION SHEETS

Entellus™

SHEET ______ OF ______

BY ______ DATE ______

CHECK ______ DATE ______

CLIENT: Flood Control District of Maricopa County

JOB NAME: Buckeye Sun Valley ADMS: Ag Study

JOB NO.: 118.001

OBSERVED SETS MODEL

CALIBRATION OF GREEN AND AMPT PARAMETERS TO OBSERVED FIELDS-SETS MODEL

FIELD ID: 00-34
FIELD WIDTH: 569 ft (ref)
FIELD LENGTH: 1021 ft
FIELD SLOPE: .0043 ft/ft
SET AREA = 13.34 Acres
WETTED AREA = 6.7 acres

IRRIGATION TYPE: Furrow
IRRIGATION DEPTH: 5.71 inches
IRRIGATION DURATION: 12 hrs
EFF IRR DEPTH: 11.42 inches

STORM FREQUENCY: X
STORM DURATION: X
STORM DEPTH: X

TARGET RESULTS (FROM FIELDS-SETS MODEL)
Q: X Tp: X Vol: 2.1 AcFt

ITERATION #	NMIN (min)	LAG (Hrs)	IA (in)	DTHETA (Normal)	PSIF (in)	XKSAT (in/hr)	RTIMP %	Qp (cfs)	Q_{error}	Tp (hrs)	T_{error}	Vol (AcFt)	Vol_{error}
BA = .021 sq miles, Precip Depth = 5.71 inches													
1	5	.88	.5	.25	4.3	.40	0	X		X		0	
1a	5	.88	0	.25	4.3	.40	0	X		X		0	
DID NOT CONVERGE!													
BA = .011 sq miles, Precip Depth = 11.41 inches													
2	5	.88	.5	.25	4.3	.40	0	X		X		2.3	
2a	5	.88	1.5	.25	4.3	.40	0	X		X		2.1	0

IA (Field Channels) = 1.5, IA (Field Furrows) = 0, IA (Average) = 0.75 in.

Entellus™

SHEET ____ OF ____

BY ____ DATE ____

CHECK ____ DATE ____

CLIENT Flood Control District of Maricopa County

JOB NAME Buckey Sun Valley ADMS: Ag Study JOB NO. 118.001

OBSERVED SETS MODEL

CALIBRATION OF GREEN AND AMPT PARAMETERS TO OBSERVED FIELDS-SETS MODEL

FIELD ID: 99-15 IRRIGATION TYPE: Furrow STORM FREQUENCY: X

FIELD WIDTH: 226 ft (set) IRRIGATION DEPTH: 6.04 inches STORM DURATION: X

FIELD LENGTH: 2526 (ft) IRRIGATION DURATION: 12.0 hrs STORM DEPTH: X

FIELD SLOPE: .0050 ft/ft EFF IRR DEPTH: 12.1 inch

SET AREA = 13.1 Acres

WETTED AREA = 6.6 Acres

TARGET RESULTS (FROM FIELDS-SETS MODEL)

Q: X Tp: X Vol: 1.07 Ac-Ft

ITERATION #	NMIN (min)	LAG (Hrs)	IA (in)	DTHETA	PSIF (in)	XKSAT (in/hr)	RTIMP %	Q_p (cfs)	Q_{error}	T_p (hrs)	T_{error}	Vol (Ac-Ft)	Vol_{error}
BA = .02 sq miles, Precip Depth = 6.04 inches													
1	5	1.0	.5	.25	4.3	.4	0	X		X		.04	
1a	5	1.0	0	.25	4.3	.4	0	X		X		.07	
DID NOT CONVERGE!													
BA = .01 sq mile, Precip Depth = 12.08 in													
2	5	1.0	.5	.25	4.3	.4	0	X		X		2.6	
2a	5	1.0	1.5	.25	4.3	.4	0	X		X		2.3	
2b	5	1.0	3.5	.25	4.3	.4	0	X		X		1.8	
2c	5	1.0	5.5	.25	4.3	.4	0	X		X		1.2	
2d	5	1.0	6.5	.25	4.3	.4	0	X		X		.97	
2e	5	1.0	6.0	.25	4.3	.4	0	X		X		1.1	≈0

IA (Field Channel) = 6.0, IA (Field Furrows) = 0, IA (Average) = 3.0 in

Entellus™

SHEET ____ OF ____

BY ____ DATE ____

CHECK ____ DATE ____

CLIENT Flood Control District of Maricopa County

JOB NAME Buckeye Sun Valley ADMS: Ag Study

JOB NO. 118.001

OBSERVED SETS MODEL

CALIBRATION OF GREEN AND AMPT PARAMETERS TO OBSERVED FIELDS-SETS MODEL

FIELD ID: 99-16

FIELD WIDTH: 70 ft (set)

FIELD LENGTH: 1200 ft

FIELD SLOPE: .0034 ft/ft

SET AREA = 1.93 Acres

EFF. SET AREA = 1.93 Acres

IRRIGATION TYPE: Border

IRRIGATION DEPTH: 6.20 inches

IRRIGATION DURATION: 1.45 hrs

EFF IRRIGATION DEPTH = 6.20 inches

STORM FREQUENCY: n/A

STORM DURATION: n/A

STORM DEPTH: n/A

TARGET RESULTS (FROM FIELDS-SETS MODEL)
Q: n/A Tp: n/A Vol: .06 Ac-Ft

ITERATION #	NMIN (min)	LAG (Hrs)	IA (in)	DTHETA	PSIF (in)	XKSAT (in/hr)	RTIMP %	Qp (cfs)	Qerror	Tp (hrs)	Terror	Vol (Ac-Ft)	Vol error
BA = .003 sq miles, After Unit hydro- Graph = .003 sq miles, Precip. Depth = 6.20 inches													
1	5	1.13	.5	.25	4.3	.37	0	x		x		.67	
1a	5	1.13	5.5	.25	4.3	.37	0	x		x		.05	
1b	5	1.13	5.0	.25	4.3	.37	0	x		x		.10	
1c	5	1.13	5.4	.25	4.3	.37	0	x		x		.06	

APPENDIX D. CALBRATION ITERATION SHEETS

D.1. Observed Sets Calibration

D.2. System Models 1 and 2 Calibration

D.3. Lag time Calibration

Entellus™

SYSTEM
MODEL 2

SHEET ______ OF ______

BY ______ DATE ______

CHECK ______ DATE ______

CLIENT Flood Control District of Maricopa County

JOB NAME Buckeye Sun Valley ADMS: Ag Study

JOB NO. 118.001

TYPICAL FIELDS MODEL

CALIBRATION OF GREEN AND AMPT PARAMETERS TO TYPICAL FIELD SCENARIOS

SCENARIO ID: Mixed

FIELDS IN FALLOW: 1

NORMAL FURROW: 3

FLOW PATH LENGTH: 1.5 mile

FURROW w/IRRIGATION: 0

BORDER w/IRRIGATION 1

AVERAGE FIELD SLOPE: 23 ft/mile

WET FURROW: 1

WET BORDER: 1

NORMAL BORDER: 3

SYSTEM AREA: 1.25 sq miles

From SYSTEM MODEL 1 → TARGET RESULTS (FROM TYPICAL FIELDS MODEL)
Q: 240 cfs Tp: x Vol: 80 Ac-Ft

ITERATION #	NMIN (min)	LAG (Hrs)	IA (in)	DTHETA	PSIF (in)	XKSAT (in/hr)	RTIMP %	Qp (cfs)	Qerror	Tp (hrs)	Terror	Vol (Ac-Ft)	Volerror
1	5	4.3	2	.19	4.3	.4	0	84		x		32	
2	5	4.3	1	.19	4.3	.4	0	197		x		86	
3	5	3.3	1	.19	4.3	.4	0	257	7%	x		86	8%

APPENDIX D. CALBRATION ITERATION SHEETS

D.1. Observed Sets Calibration

D.2. System Models 1 and 2 Calibration

D.3. Lag time Calibration

Entellus Inc.
CLIENT: Flood Control District of Maricopa County
JOB: Buckeye Sun Valley Agricultural Pilot Study

BY JCS **DATE** 11/1/2004
JOB # 118.001

Development of Lag Time Equation for Groups of Fields
Uses observed and extrapolated lag times to develop adjusted Kn Value for use in Agricultural Areas

The uncalibrated lag times were estimated using the District equation with the Kn set to the average District recommended value of 0.10. The observed lag times were estimated using the field advance times which were set to be 0.6 x the observed advance times. These are the first three lag times shown below in the observed or extrapolated lag column. The extrapolated lag times were estimated using the average of the three observed lag times. These are the fourth and fifth lag times shown below in the observed or extrapolated lag column. The sixth lag time shown in the same column was estimated by calibrating the lag time for a group of fields modeled as a lumped subbasin.

Subbasin Description	Subbasin Area (Sq. Miles)	Length (ft)	Width (ft)	Flow Path Length (ft)	Flow Path Length (miles)	Longitudinal Slope (ft/mile)	Lateral Slope (ft/mile)	Average Slope (ft/mile)	L_{ca} (Miles)	District Recommended K_n	Uncalibrated Lag, Using Kn = 0.1 (Hours)	Observed or Extrapolated Lag (Hours)	Adjusted K_n	Lag Time Estimated Using Average Kn = 0.2 (Hours)
Set From Sampled Field 00-34 (Furrow)	0.02	1021	569	1590	0.30	22.7	2	15.3	0.151	0.100	0.44	**0.81**	0.18	0.88
Set From Sampled Field 99-15 (Furrow)	0.02	2526	226	2752	0.52	26.4	2	24.4	0.261	0.100	0.61	**1.20**	0.20	1.23
Set From Sampled Field 99-16 (Border)	0.003	1200	70	1270	0.24	18	2	17.1	0.120	0.100	0.36	**1.20**	0.33	0.73
1/8 Sq Mile Furrow Field	0.125	660	2640	3300	0.63	23	2	6.2	0.313	0.100	0.91	**2.19**	0.24	1.82
1/8 Sq Mile Border Field	0.125	660	2640	3300	0.63	23	2	6.2	0.313	0.100	0.91	**2.19**	0.24	1.82
Typical System of Fields	1.25	6600	5280	9240	1.75	23	2	17.0	0.875	0.100	1.65	**3.29**	0.20	3.29

Eq. A

$$Lu = C\left(\frac{L * Lca}{S^{p}}\right)^{m}$$

$$C = 24\,Kn$$

$$m = 0.38$$

$$p = 0.5$$

Notes:

Equation A is the District equation for estimating lag time.

The lengths, widths, and Lca values are in miles. The slopes are in feet / mile. The lag times are in hours

L = length of the longest watercourse, in miles (estimated using longitudinal and lateral flow movement)

Lca = length along the watercourse to a point opposite the centroid, in miles

S = watercourse slope, in feet per mile (estimated using longitudinal and lateral slope)

APPENDIX E. HEC-1 MODELS

Observed Sets Model
Calibration of Initial Abstraction Variable Using Observed Runoff Volumes
HEC-1 Input/Output

```
*****************************************                    *****************************************
*                                       *                    *                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *   U.S. ARMY CORPS OF ENGINEERS        *
*             JUN   1998                *                    *   HYDROLOGIC ENGINEERING CENTER       *
*           VERSION 4.1                 *                    *        609 SECOND STREET              *
*                                       *                    *      DAVIS, CALIFORNIA 95616          *
*  RUN DATE   02NOV04  TIME  09:31:36   *                    *         (916) 756-1104                *
*                                       *                    *                                       *
*****************************************                    *****************************************


                    X     X  XXXXXXX   XXXXX          X
                    X     X  X        X     X        XX
                    X     X  X        X               X
                    XXXXXXX  XXXX     X        XXXXX  X
                    X     X  X        X               X
                    X     X  X        X     X         X
                    X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
```

```
1                                     HEC-1 INPUT                                                  PAGE  1

        LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

          1         ID     ************************************************************************
          2         ID     ************************************************************************
          3         ID     Project: Buckeye Sunvalley Agricultural Study
          4         ID     Client: Flood Control District of Maricopa County
          5         ID     Prepared By: Entellus Inc.                  Modelers: J.S. and H.A.
          6         ID     Entellus 118.001
          7         ID     File Name: sets.txt                      Last Updated: 11/2/2004
          8         ID     Storm: Irrigation
          9         ID     Development Conditions: Existing Conditions at time of NRCD Observation
         10         ID
         11         ID     ***********          PRELIMINARY CALIBRATION MODEL          ***************
         12         ID     ******** THIS MODEL IS PRELIMINARY AND IS SUBJECT TO CHANGE ************
         13         ID     ************************ C A L I B R A T I O N ************************
         14         ID     * This model was created as part of the Buckeye Sun Valley Area        *
         15         ID     * Drainage Master Study - Pilot Agricultural Study. The purpose of the *
         16         ID     * pilot study is to examine the District's methodology for modeling    *
         17         ID     * storm runoff from agricultural areas  and recommend any possible     *
         18         ID     * improvements to the methodology. This HEC-1 model was created to     *
         19         ID     * calibrate hydrologic modeling parameters so that they accuratley     *
         20         ID     * simulate real life runoff conditions as observed in the field.      *
         21         ID     *                                                                      *
         22         ID     * THIS MODEL WAS USED TO CALIBRATE THE INITIAL ABSTRACTION VARIABLE    *
         23         ID     * BY ADJUSTING IT UNTIL THE OBSERVED RUNOFF VOLUME FROM THE FIELD SETS *
         24         ID     * WERE REPRODUCED. THE LAG TIME WAS NOT CALIBRATED WITH THIS MODEL     *
         25         ID     *                                                                      *
         26         ID     * It was assumed that all fields were in a "normal" state of saturation*
         27         ID     * when the NRCD tests were conducted. All other Green and Ampt         *
         28         ID     * parameters besides the initial abstraction were estimated using the  *
         29         ID     * current District methodology. The exact locations of the test fields *
         30         ID     * was not known. However  the NRCD recorded the specific soil class    *
         31         ID     * present within the sampled field  which was used to determine the    *
         32         ID     * District recommended Green and Ampt parameters for the field.        *
         33         ID     *                                                                      *
         34         ID     *                                                                      *
         35         ID     * The pilot study area consists of various types of crops that are     *
         36         ID     * rotated and irrigated differently. The observed data was collected   *
         37         ID     * from field effeciency tests by the NRCD. Based on the observed data  *
         38         ID     * the fields were grouped into two hydrologic groups: FURROW IRRIGATED *
         39         ID     * and BORDER IRRIGATED. Furrow irrigated crops in the study area       *
         40         ID     * include corn and cotton. Border irrigated crops in the study area    *
```

```
 41        ID     * include wheat and alfalfa. According to observed data for the sampled*
 42        ID     * fields, the furrow irrigation is about 6 inches applied over about   *
 43        ID     * 12 hours, and the border irrigation is about 6 inches applied over   *
 44        ID     * about 1.5 hours.The precipitation input data reflects these          *
 45        ID     * irrigation events only and any storm event. Therefore a key          *
 46        ID     * assumption is that the initial abstraction will not vary between     *
 47        ID     * the irrigation events and storm events.                              *
 48        ID     ************************************************************************
 49        ID     *                    VOLUME CALIBRATION RESULTS                        *
 50        ID     * Field      Code   IA         Notes                                   *
 51        ID     * 00-34       1a    --    Volume did not converge                      *
 52        ID     * 00-34       2a    1.5   Actual IA = 0.75 to account for furrows      *
 53        ID     * 99-15       1a    --    Volume did not converge                      *
 54        ID     * 99-15       2e    6.0   Actual IA = 3.0 to account for furrows       *
 55        ID     * 99-16       1c    5.4   Border Irrigation                            *
1                                         HEC-1 INPUT                                          PAGE  2

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 56        ID     ************************************************************************
           *
           *
           *
           *DIAGRAM
 57        IT       5                    1000
 58        IO       5
           *
           *
           *
           *
           *
           *
           *
           *

 59        KK     0034
 60        KO       0       0       0       1      21
 61        KM    ***********************************************************************
 62        KM    *********** FIELD 00-34: Furrow Irrigated Field ***********************
 63        KM    ****************** Irrigation Event Only *****************************
 64        KM    *Initial Abstraction calibrated to Observed Runoff Volume             *
 65        KM    *************Normal Antecedant Moisture Conditions *******************
 66        KM    ***********************************************************************
 67        KM    Calibration Code: 1A (See Appendix Calibration Sheet)
 68        KM    Target Runoff Volume: 2.1 Acre Feet
 69        KM
 70        BA    0.021
 71        PB     5.71
 72        IN       60
 73        PC        0    .476   0.952   1.430   1.906   2.382   2.858   3.334   3.810   4.286
 74        PC    4.757   5.233   5.710
 75        LG        0     .25     4.3      .2       0
 76        KM    Observed Lag Time Used (0.6 x Advance Time)
 77        KM    Agricultural S-Graph for Basin 00-34
 78        KM    Basin Area [mi2] = 0.021
 79        KM    Basin Lag [hr] = 0.88
 80        KM    Time Step [min] = 5
 81        KM    Qult = 162.62
 82        KM
 83        UI        0    1.47    1.47    2.73    4.81    8.34     8.1      11   11.87   12.32
 84        UI    12.32   11.42   10.27   11.32     7.7    8.51    5.89    5.22    4.23    4.41
 85        UI      2.8     2.4    2.06    1.81    1.45    1.34    1.17    0.83    0.83    0.83
 86        UI     0.55    0.18    0.18    0.18    0.18    0.18    0.18    0.18    0.18    0.18
 87        UI     0.18    0.18    0.18    0.18    0.18    0.18    0.18    0.18       0
           *
           *
           *
           *
1                                         HEC-1 INPUT                                          PAGE  3

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 88        KK   SR0034
 89        KO       0       0       0       1      21
 90        KM    Storage route used to estimate volume of runoff from 0034
 91        RS       1    STOR       0
 92        SQ       0       0       0
 93        SE       0       1     500
```

```
  94            SV      0       1     500
  95            SE      0       1     500
                *
                *
                *
                *

  96            KK     0034
  97            KO      0       0       0       1      21
  98            KM    ****************************************************************
  99            KM    *********** FIELD 00-34: Furrow Irrigated Field *******************
 100            KM    ****************** Irrigation Event Only *************************
 101            KM    *Initial Abstraction calibrated to Observed Runoff Volume         *
 102            KM    *************Normal Antecedant Moisture Conditions ****************
 103            KM    ****************************************************************
 104            KM    Calibration Code: 2a (See Appendix Calibration Sheet)
 105            KM    Target Runoff Volume: 2.1 Acre Feet
 106            KM    Area was halved in order to account for non-wetted furrow portions
 107            KM    of the field. In order to maintain the same inflow volume, the
 108            KM    precipitation depth was doubled.
 109            KM
 110            BA    0.011
 111            PB    11.42
 112            IN      60
 113            PC      0    .952   1.904   2.856   3.808    4.76   5.712   6.664   7.616   8.568
 114            PC    9.52  10.472  11.424
 115            LG     1.5     .25     4.3      .4       0
 116            KM    Observed Lag Time Used (0.6 x Advance Time)
 117            KM    Agricultural S-Graph for Basin 00-34
 118            KM    Basin Area [mi2] = 0.011
 119            KM    Basin Lag [hr] = 0.88
 120            KM    Time Step [min] = 5
 121            KM    Qult = 85.18
 122            KM
 123            UI      0    0.77    0.77    1.43    2.52    4.37    4.24    5.76    6.22    6.45
 124            UI   6.45    5.98    5.38    5.93    4.03    4.46    3.09    2.74    2.22    2.31
 125            UI   1.47    1.26    1.08    0.95    0.76     0.7    0.61    0.44    0.44    0.44
 126            UI   0.29     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1
 127            UI    0.1     0.1     0.1     0.1     0.1     0.1     0.1     0.1       0
                *
                *
                *
                *
1                                              HEC-1 INPUT                                          PAGE  4

LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 128            KK  SR0034
 129            KO      0       0       0       1      21
 130            KM    Storage route used to estimate volume of runoff from 0034
 131            RS      1    STOR       0
 132            SQ      0       0       0
 133            SE      0       1     500
 134            SV      0       1     500
 135            SE      0       1     500
                *
                *
                *
                *

 136            KK     9915
 137            KO      0       0       0       1      21
 138            KM    ****************************************************************
 139            KM    *********** FIELD 99-15: Furrow Irrigated Field *******************
 140            KM    ****************** Irrigation Event Only *************************
 141            KM    *Initial Abstraction calibrated to Observed Runoff Volume         *
 142            KM    *************Normal Antecedant Moisture Conditions ****************
 143            KM    ****************************************************************
 144            KM    Calibration Code: 1d (See Appendix Calibration Sheet)
 145            KM    Target Runoff Volume: 1.07 Acre Feet
 146            KM
 147            BA     0.02
 148            PB    6.04
 149            IN      60
 150            PC      0    .503   1.007   1.510   2.013   2.516   3.019   3.522   4.025   4.528
 151            PC    5.03   5.533   6.040
 152            LG     2.4     .25    4.30      .2       0
 153            KM    Observed Lag Time Used (0.6 x Advance Time)
```

```
154          KM    Agricultural S-Graph for Basin 99-15 Calibrated
155          KM    Basin Area [mi2] = 0.02
156          KM    Basin Lag [hr] = 1.01
157          KM    Time Step [min] = 5
158          KM    Qult = 154.88
159          KM
160          UI       0     1.22    1.22    1.83    2.97    5.36    7.16    6.84    9.26    9.69
161          UI   10.22    10.22   10.22    8.72    8.62    9.25    6.39    6.93    5.53    4.65
162          UI     3.8     3.46    3.44    2.32    1.98    1.78     1.5    1.37    1.11    1.11
163          UI    0.88     0.69    0.69    0.69    0.66    0.15    0.15    0.15    0.15    0.15
164          UI    0.15     0.15    0.15    0.15    0.15    0.15    0.15    0.15    0.15    0.15
165          UI    0.15     0.15    0.15    0.15    0.15       0
             *
             *
             *
             *

166          KK   SR9915
167          KO       0        0       0       1      21
168          KM    Storage route used to estimate volume of runoff from 9915
169          RS       1     STOR       0
170          SQ       0        0       0
171          SE       0        1     500
1                                     HEC-1 INPUT                                                  PAGE  5

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

172          SV       0        1     500
173          SE       0        1     500
             *
             *
             *
             *

174          KK     9915
175          KO       0        0       0       1      21
176          KM    ******************************************************************
177          KM    *********** FIELD 99-15: Furrow Irrigated Field ******************
178          KM    ***************** Irrigation Event Only *************************
179          KM    *Initial Abstraction calibrated to Observed Runoff Volume        *
180          KM    *************Normal Antecedant Moisture Conditions ***************
181          KM    ******************************************************************
182          KM    Calibration Code: 2e (See Appendix Calibration Sheet)
183          KM    Target Runoff Volume: 1.07 Acre Feet
184          KM    Area was halved in order to account for non-wetted furrow portions
185          KM    of the field. In order to maintain the same inflow volume, the
186          KM    precipitation depth was doubled.
187          KM
188          BA     0.01
189          PB     12.0
190          IN      60
191          PC       0        1       2       3       4       5       6       7       8       9
192          PC      10       11      12
193          LG     6.0      .25    4.30      .4       0
194          KM    Observed Lag Time Used (0.6 x Advance Time)
195          KM    Agricultural S-Graph for Basin 99-15 Calibrated
196          KM    Basin Area [mi2] = 0.01
197          KM    Basin Lag [hr] = 1.01
198          KM    Time Step [min] = 5
199          KM    Qult = 77.44
200          KM
201          UI       0     0.61    0.61    0.91    1.48    2.68    3.58    3.42    4.63    4.85
202          UI    5.11     5.11    5.11    4.36    4.31    4.62    3.19    3.46    2.77    2.32
203          UI     1.9     1.73    1.72    1.16    0.99    0.89    0.75    0.69    0.56    0.56
204          UI    0.44     0.35    0.35    0.35    0.33    0.08    0.08    0.08    0.08    0.08
205          UI    0.08     0.08    0.08    0.08    0.08    0.08    0.08    0.08    0.08    0.08
206          UI    0.08     0.08    0.08    0.08    0.08       0
             *
             *
             *
             *

207          KK   SR9915
208          KO       0        0       0       1      21
209          KM    Storage route used to estimate volume of runoff from 9915
210          RS       1     STOR       0
211          SQ       0        0       0
212          SE       0        1     500
213          SV       0        1     500
```

```
     214          SE      0       1     500
                  *
                  *
                  *
                  *
1                                       HEC-1 INPUT                                         PAGE  6

    LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


     215          KK    9916
     216          KO      0       0       0       1      21
     217          KM    ******************************************************************
     218          KM    *********** FIELD 99-16: Border Irrigated Field ******************
     219          KM    ****************** Irrigation Event Only *************************
     220          KM    *Initial Abstraction calibrated to Observed Runoff Volume        *
     221          KM    *************Normal Antecedant Moisture Conditions ***************
     222          KM    ******************************************************************
     223          KM    Calibration Code: 1c (See Appendix Calibration Sheet)
     224          KM    Target Runoff Volume: 0.06 Acre Feet
     225          KM
     226          BA    .0034
     227          PB    6.21
     228          IN      15
     229          PC      0   1.033   2.067     3.1   4.133   5.167     6.2     6.2     6.2     6.2
     230          PC    6.2     6.2     6.2     6.2     6.2     6.2     6.2     6.2     6.2     6.2
     231          PC    6.2     6.2     6.2     6.2     6.2     6.2     6.2     6.2     6.2    6.21
     232          LG    5.0     .25     4.3    .685       0
     233          KM    Observed Lag Time Used (0.6 x Advance Time)
     234          KM    Agricultural S-Graph for Basin 99-16 Calibrated
     235          KM    Basin Area [mi2] = 0.003
     236          KM    Basin Lag [hr] = 1.13
     237          KM    Time Step [min] = 5
     238          KM    Qult = 23.23
     239          KM
     240          UI      0    0.16    0.16    0.19    0.34    0.52    0.85    0.97    0.97    1.24
     241          UI   1.31    1.37    1.37    1.37    1.27    1.14    1.22    1.13    0.86    0.93
     242          UI   0.76    0.62    0.55    0.47     0.5    0.37     0.3    0.26    0.23     0.2
     243          UI   0.19    0.15    0.15    0.15    0.09    0.09    0.09    0.09    0.09    0.02
     244          UI   0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02
     245          UI   0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02
     246          UI   0.02       0
                  *
                  *
                  *
                  *

     247          KK  SR9916
     248          KO      0       0       0       1      21
     249          KM    Storage route used to estimate volume of runoff from 9916
     250          RS      1    STOR       0
     251          SQ      0       0       0
     252          SE      0       1     500
     253          SV      0       1     500
     254          SE      0       1     500
                  *
                  *
                  *
                  *
                  *
                  *
                  *
                  *
                  *
                  *
                  *
1                                       HEC-1 INPUT                                         PAGE  7

    LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

     255          ZZ
1
          SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
   5     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.    (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  59      0034
```

```
             V
             V
  88    SR0034
             .
             .
  96         .      0034
             .         V
             .         V
 128         .    SR0034
             .         .
             .         .
 136         .         .      9915
             .         .         V
             .         .         V
 166         .         .    SR9915
             .         .         .
             .         .         .
 174         .         .         .      9915
             .         .         .         V
             .         .         .         V
 207         .         .         .    SR9915
             .         .         .         .
             .         .         .         .
 215         .         .         .         .      9916
             .         .         .         .         V
             .         .         .         .         V
 247         .         .         .         .    SR9916

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
*                                        *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*              JUN   1998                *
*            VERSION 4.1                 *
*                                        *
*  RUN DATE   02NOV04  TIME  09:31:36    *
*                                        *
******************************************

***************************************
*                                     *
*   U.S. ARMY CORPS OF ENGINEERS      *
*   HYDROLOGIC ENGINEERING CENTER     *
*        609 SECOND STREET            *
*     DAVIS, CALIFORNIA 95616         *
*         (916) 756-1104              *
*                                     *
***************************************

**************************************************************************
**************************************************************************
Project: Buckeye Sunvalley Agricultural Study
Client: Flood Control District of Maricopa County
Prepared By: Entellus Inc.               Modelers: J.S. and H.A.
Entellus 118.001
File Name: sets.txt                     Last Updated: 11/2/2004
Storm: Irrigation
Development Conditions: Existing Conditions at time of NRCD Observation

***********          PRELIMINARY CALIBRATION MODEL          ***************
******** THIS MODEL IS PRELIMINARY AND IS SUBJECT TO CHANGE ************
************************ C A L I B R A T I O N ************************
* This model was created as part of the Buckeye Sun Valley Area         *
* Drainage Master Study - Pilot Agricultural Study. The purpose of the *
* pilot study is to examine the District's methodology for modeling    *
* storm runoff from agricultural areas  and recommend any possible     *
* improvements to the methodology. This HEC-1 model was created to     *
* calibrate hydrologic modeling parameters so that they accuratley     *
* simulate real life runoff conditions as observed in the field.       *
*                                                                      *
* THIS MODEL WAS USED TO CALIBRATE THE INITIAL ABSTRACTION VARIABLE    *
* BY ADJUSTING IT UNTIL THE OBSERVED RUNOFF VOLUME FROM THE FIELD SETS *
* WERE REPRODUCED. THE LAG TIME WAS NOT CALIBRATED WITH THIS MODEL     *
*                                                                      *
* It was assumed that all fields were in a "normal" state of saturation*
* when the NRCD tests were conducted. All other Green and Ampt         *
* parameters besides the initial abstraction were estimated using the  *
* current District methodology. The exact locations of the test fields *
* was not known. However  the NRCD recorded the specific soil class    *
* present within the sampled field  which was used to determine the    *
* District recommended Green and Ampt parameters for the field.        *
*                                                                      *
*                                                                      *
* The pilot study area consists of various types of crops that are     *
* rotated and irrigated differently. The observed data was collected   *
```

```
                    * from field effeciency tests by the NRCD. Based on the observed data  *
                    * the fields were grouped into two hydrologic groups: FURROW IRRIGATED *
                    * and BORDER IRRIGATED. Furrow irrigated crops in the study area       *
                    * include corn and cotton. Border irrigated crops in the study area    *
                    * include wheat and alfalfa. According to observed data for the sampled*
                    * fields, the furrow irrigation is about 6 inches applied over about   *
                    * 12 hours, and the border irrigation is about 6 inches applied over   *
                    * about 1.5 hours.The precipitation input data reflects these          *
                    * irrigation events only and any storm event. Therefore a key          *
                    * assumption is that the initial abstraction will not vary between     *
                    * the irrigation events and storm events.                              *
                    ************************************************************************
                    *                 VOLUME CALIBRATION RESULTS                           *
                    * Field     Code  IA        Notes                                      *
                    * 00-34      1a   --    Volume did not converge                        *
                    * 00-34      2a   1.5   Actual IA = 0.75 to account for furrows        *
                    * 99-15      1a   --    Volume did not converge                        *
                    * 99-15      2e   6.0   Actual IA = 3.0 to account for furrows         *
                    * 99-16      1c   5.4   Border Irrigation                              *
                    ************************************************************************

  58 IO        OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

     IT        HYDROGRAPH TIME DATA
                      NMIN          5  MINUTES IN COMPUTATION INTERVAL
                     IDATE      1   0  STARTING DATE
                     ITIME       0000  STARTING TIME
                        NQ       1000  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      4   0  ENDING DATE
                    NDTIME       1115  ENDING TIME
                     ICENT         19  CENTURY MARK

                 COMPUTATION INTERVAL     .08 HOURS
                      TOTAL TIME BASE   83.25 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
  59 KK     *     0034   *
            *            *
            **************

  60 KO        OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE
                     IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                      IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2       1000  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT       .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
  88 KK     *   SR0034   *
            *            *
            **************
```

```
 89 KO         OUTPUT CONTROL VARIABLES
                     IPRNT           5  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           1  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        1000  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          **************
          *            *
 96 KK    *     0034   *
          *            *
          **************

 97 KO         OUTPUT CONTROL VARIABLES
                     IPRNT           5  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           1  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        1000  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          **************
          *            *
128 KK    *   SR0034   *
          *            *
          **************

129 KO         OUTPUT CONTROL VARIABLES
                     IPRNT           5  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           1  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        1000  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          **************
          *            *
136 KK    *     9915   *
          *            *
          **************

137 KO         OUTPUT CONTROL VARIABLES
                     IPRNT           5  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           1  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        1000  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .083  TIME INTERVAL IN HOURS
```

```
*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

              **************
              *            *
166 KK        *   SR9915   *
              *            *
              **************

167 KO            OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2       1000  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT       .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

              **************
              *            *
174 KK        *     9915   *
              *            *
              **************

175 KO            OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2       1000  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT       .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

              **************
              *            *
207 KK        *   SR9915   *
              *            *
              **************

208 KO            OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2       1000  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT       .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

              **************
              *            *
215 KK        *     9916   *
              *            *
              **************

216 KO            OUTPUT CONTROL VARIABLES
                      IPRNT          5  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
```

```
                    QSCAL          0.  HYDROGRAPH PLOT SCALE
                    IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                     IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                    ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                    ISAV2       1000  LAST ORDINATE PUNCHED OR SAVED
                   TIMINT       .083  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
  247 KK    *   SR9916   *
            *            *
            **************

  248 KO          OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL          0.  HYDROGRAPH PLOT SCALE
                    IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                     IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                    ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                    ISAV2       1000  LAST ORDINATE PUNCHED OR SAVED
                   TIMINT       .083  TIME INTERVAL IN HOURS

1
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
	HYDROGRAPH AT	0034	3.	12.08	3.	1.	0.	.02		
+ +	ROUTED TO	SR0034	0.	.00	0.	0.	0.	.02	2.01	16.00
+	HYDROGRAPH AT	0034	3.	12.08	3.	1.	0.	.01		
+ +	ROUTED TO	SR0034	0.	.00	0.	0.	0.	.01	2.26	16.00
+	HYDROGRAPH AT	9915	3.	12.08	2.	1.	0.	.02		
+ +	ROUTED TO	SR9915	0.	.00	0.	0.	0.	.02	1.03	16.58
+	HYDROGRAPH AT	9915	3.	12.08	2.	1.	0.	.01		
+ +	ROUTED TO	SR9915	0.	.00	0.	0.	0.	.01	1.10	16.58
+	HYDROGRAPH AT	9916	1.	2.42	0.	0.	0.	.00		
+ +	ROUTED TO	SR9916	0.	.00	0.	0.	0.	.00	.07	6.58

NORMAL END OF HEC-1 ***

APPENDIX E. HEC-1 MODELS

E.1. Observed Sets Input/Output

E.2. System Models 1 and 2 Input/Output

E.3. Pilot Study Area Model Input/ Output

```
1*****************************************
****************************************
 *                                       *
*
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*
 *             JUN   1998                *
*
 *            VERSION 4.1                *
*
 *                                       *
*
 *  RUN DATE   03NOV04  TIME  16:30:26   *
*
 *                                       *
*
 *****************************************
****************************************

                                         *
                                         *   U.S. ARMY CORPS OF ENGINEERS
                                         *   HYDROLOGIC ENGINEERING CENTER
                                         *          609 SECOND STREET
                                         *       DAVIS, CALIFORNIA 95616
                                         *           (916) 756-1104
                                         *


X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
```

```
1                                   HEC-1 INPUT                                          PAGE  1

           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           ID      ************************************************************************
           ID      ************************************************************************
           ID      Project: Buckeye Sunvalley Agricultural Study
           ID      Client: Flood Control District of Maricopa County
           ID      Prepared By: Entellus Inc.                    Modelers: J.S. and H.A.
           ID      Entellus 118.001
           ID      File Name: system1.txt                        Created 10/28/2004
           ID
           ID      **EXTRAPOLATION OF OBSERVED SET DATA TO TYPICAL SYSTEMS MODEL          **
           ID      ******** THIS MODEL IS PRELIMINARY AND IS SUBJECT TO CHANGE ************
           ID      *********************** E X T R A P O L A T I O N *********************
           ID      * This model was created as part of the Buckeye Sun Valley Area        *
           ID      * Drainage Master Study - Pilot Agricultural Study. The purpose of the *
           ID      * pilot study is to examine the District's methodology for modeling    *
           ID      * storm runoff from agricultural areas  and recommend any possible     *
           ID      * improvements to the methodology. This HEC-1 model was created to     *
           ID      * calibrate hydrologic modeling parameters so that they accuratley     *
           ID      * simulate real life runoff conditions as observed in the field.       *
           ID      *                                                                      *
           ID      * This model was created in order to extrapolate the data calibrated   *
           ID      * using observed field sets to systems of typical fields. The typical  *
           ID      * fields each had an area of 80 acres and a slope of 23 feet per mile. *
           ID      * Each system included 10 typical fields that were configured with into*
           ID      * two paralell strips of five fields. Runoff from one field was routed *
           ID      * through the next downstream field and combined with that fields      *
           ID      * runoff. This was repeated until the the farthest downstream field at *
           ID      * which point runoff from the two strips of five fields was combined.  *
           ID      * The lag time for each typical field was estimated using the lag time *
           ID      * developed using the observed advance times (Kn=0.24).                *
           ID      * The average initial abstraction obtained from the observed sets      *
           ID      * calibration model was used for all of the typical fields. DTHETA was *
           ID      * set to each field according to the data collection and field         *
```

```
 33    ID    * observations that suggested the following moisture distribution    *
 34    ID    * throughout typical systems in the area:                            *
 35    ID    *                                                                    *
 36    ID    *          10% of the Fields Are Being Irrigated DTHETA=0 to 0.35    *
 37    ID    *          20% of the Fields Are Wet - DTHETA=0                      *
 38    ID    *          60% of the Fields Are Normal - DTHETA=0.25                *
 39    ID    *          10% of the Fields Are Dry-Fallow - DTHETA=0.35            *
 40    ID    * Three systems were modeled: SCEN1 (All Border Crops)               *
 41    ID    *                             SCEN2 (All Furrow Crops)               *
 42    ID    *                             SCEN3 (Mixed Border and Furrow Crops)  *
 43    ID    *                                                                    *
 44    ID    * The subbasins are numbered named according to the type of crop and *
 45    ID    * the moisture condition it represents. The table below shows the    *
 46    ID    * subbasin names and what field condition the subbasin models.       *
 47    ID    *                                                                    *
 48    ID    * FC1 = Furrow Crop - Being irrigated                                *
 49    ID    * FC2 = Furrow Crop - Wet                                            *
 50    ID    * FC3 = Furrow Crop - Normal                                         *
 51    ID    * FC4 = Furrow in Fallow - Dry                                       *
 52    ID    * FC5 = Border Crop - Being irrigated                                *
 53    ID    * FC6 = Border Crop - Wet                                            *
 54    ID    * FC7 = Border Crop - Normal                                         *
 55    ID    * FC8 = Border in Fallow - Dry                                       *
1                                   HEC-1 INPUT                                          PAGE  2

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 56        ID    ********************************************************************
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           *DIAGRAM
 57        IT       5                 1000
 58        IO       5
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 59        KK     FC5
 60        KO       0       0       0       1      21
 61        KM    Description: Irrigation and Storm Simultaneously
 62        KM    Antecedant Moisture Condition: Normal
 63        KM    Irrigation Type: Border
 64        BA   0.125
 65        PB    9.60
 66        IN      15
 67        PC       0    0.03    0.05    0.09    0.11    0.14    0.17     0.2    0.22    0.25
 68        PC    0.34     0.4     1.5     2.8    4.38    6.97    8.26    9.43    9.47     9.5
 69        PC    9.54    9.57     9.6
 70        KM    Precipitation represents Border Irrigation and 100-year 6-hour storm
 71        LG       2    0.25     4.3     0.4       0
 72        KM   Agricultural S-Graph for Field Conditions FC5
 73        KM   Basin Area [mi2] = 0.125
 74        KM   Basin Lag [hr] = 2.2
 75        KM   Time Step [min] = 5
 76        KM   Qult = 968
           *
 77        UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 78        UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 79        UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 80        UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
 81        UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 82        UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 83        UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 84        UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 85        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 86        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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1                                   HEC-1 INPUT                                          PAGE  3
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System Model 1
Extrapolation of Observed Field Data to Systems of Typical Fields
HEC-1 Input/Output

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 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   87           KK      RF
   88           RS      10    FLOW      -1
   89           RC   0.045   0.045   0.045    1320   0.004
   90           RX       0      10     510    1010    1510    2010    2490    2500
   91           RY       2       1       0       0       0       0       2       1
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   92           KK     FC7
   93           KO       0       0       0       1      21
   94           KM     Description: Storm on a field that has been recently irrigated
   95           KM     Antecedant Moisture Condition: Normal
   96           KM     Irrigation Type: Border
   97           BA   0.125
   98           PB     3.4
   99           IN      15
  100           PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
  101           PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
  102           PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
  103           KM     Precipitation represents 100-year 6-hour storm
  104           LG       2    0.25     4.3     0.4       0
  105           KM   Agricultural S-Graph for Field Conditions FC7
  106           KM   Basin Area [mi2] = 0.125
  107           KM   Basin Lag [hr] = 2.2
  108           KM   Time Step [min] = 5
  109           KM   Qult = 968
                *
  110           UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
  111           UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
  112           UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
  113           UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                              HEC-1 INPUT                                            PAGE  4

 LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  114           UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
  115           UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
  116           UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
  117           UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
  118           UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
  119           UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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  120           KK      CF
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 121        KO       0       0       0       1      21
 122        HC       2
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1                                     HEC-1 INPUT                                         PAGE  5

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 123        KK      RF
 124        RS      10    FLOW      -1
 125        RC   0.045   0.045   0.045    1320   0.004
 126        RX       0      10     510    1010    1510    2010    2490    2500
 127        RY       2       1       0       0       0       0       2       1
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 128        KK     FC7
 129        KO       0       0       0       1      21
 130        KM    Description: Storm on a field that has been recently irrigated
 131        KM    Antecedant Moisture Condition: Normal
 132        KM    Irrigation Type: Border
 133        BA   0.125
 134        PB     3.4
 135        IN      15
 136        PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
 137        PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
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138        PC      .3      .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
139        KM    Precipitation represents 100-year 6-hour storm
140        LG       2    0.25     4.3     0.4       0
141        KM    Agricultural S-Graph for Field Conditions FC7
142        KM    Basin Area [mi2] = 0.125
143        KM    Basin Lag [hr] = 2.2
144        KM    Time Step [min] = 5
145        KM    Qult = 968
           *
146        UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
147        UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
148        UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
149        UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                       HEC-1 INPUT                                                PAGE 6

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

150        UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
151        UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
152        UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
153        UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
154        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
155        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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156        KK      CF
157        KO       0       0       0       1      21
158        HC       2
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1                                       HEC-1 INPUT                                                PAGE 7

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

159        KK      RF
160        RS      10    FLOW      -1
161        RC   0.045   0.045   0.045    1320   0.004
162        RX       0      10     510    1010    1510    2010    2490    2500
163        RY       2       1       0       0       0       0       2       1
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164           KK     FC7
165           KO      0       0       0       1      21
166           KM     Description: Storm on a field that has been recently irrigated
167           KM     Antecedant Moisture Condition: Normal
168           KM     Irrigation Type: Border
169           BA    0.125
170           PB      3.4
171           IN      15
172           PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
173           PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
174           PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
175           KM     Precipitation represents 100-year 6-hour storm
176           LG       2    0.25     4.3     0.4       0
177           KM    Agricultural S-Graph for Field Conditions FC7
178           KM    Basin Area [mi2] = 0.125
179           KM    Basin Lag [hr] = 2.2
180           KM    Time Step [min] = 5
181           KM    Qult = 968
              *
182           UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
183           UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
184           UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
185           UI   24.44   27.57   25.46   23.53   18.33   19.07   20.86   18.03   14.41
1                                          HEC-1 INPUT                                         PAGE  8

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

186           UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
187           UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
188           UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
189           UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
190           UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
191           UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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192           KK      CF
193           KO       0       0       0       1      21
194           HC       2
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1                                          HEC-1 INPUT                                                 PAGE  9

       LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


        195             KK      RF
        196             RS      10    FLOW      -1
        197             RC   0.045   0.045   0.045    1320   0.004
        198             RX       0      10     510    1010    1510    2010    2490    2500
        199             RY       2       1       0       0       0       0       2       1
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        200             KK     FC6
        201             KO       0       0       0       1      21
        202             KM     Description: Storm on a field that was just irrigated
        203             KM     Antecedant Moisture Condition: Wet
        204             KM     Irrigation Type: Border
        205             BA   0.125
        206             PB     3.4
        207             IN      15
        208             PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
        209             PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
        210             PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
        211             KM     Precipitation represents 100-year 6-hour storm
        212             LG       2       0     4.3     0.4       0
        213             KM    Agricultural S-Graph for Field Conditions FC6
        214             KM    Basin Area [mi2] = 0.125
        215             KM    Basin Lag [hr] = 2.2
        216             KM    Time Step [min] = 5
        217             KM    Qult = 968
                        *
        218             UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
        219             UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
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 220     UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 221     UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                      HEC-1 INPUT                                         PAGE 10

LINE     ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 222     UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 223     UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 224     UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 225     UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 226     UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 227     UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 228     KK      CF
 229     KO       0       0       0       1      21
 230     HC       2
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 231     KK     FC7
 232     KO       0       0       0       1      21
 233     KM     Description: Storm on a field that has been recently irrigated
 234     KM     Antecedant Moisture Condition: Normal
 235     KM     Irrigation Type: Border
 236     BA   0.125
 237     PB     3.4
 238     IN      15
1                                      HEC-1 INPUT                                         PAGE 11

LINE     ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 239     PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
 240     PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 241     PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 242     KM     Precipitation represents 100-year 6-hour storm
 243     LG       2    0.25     4.3     0.4       0
 244     KM   Agricultural S-Graph for Field Conditions FC7
 245     KM   Basin Area [mi2] = 0.125
 246     KM   Basin Lag [hr] = 2.2
 247     KM   Time Step [min] = 5
 248     KM   Qult = 968
         *
 249     UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 250     UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 251     UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
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252       UI    24.44    27.57    25.46    23.53    18.33    18.33    19.07    20.86    18.03    14.41
253       UI    13.33    13.33    12.51    10.48    10.17     9.78    10.47    11.28     7.85     6.67
254       UI     6.67     5.81     5.64     5.64      5.1     4.31     4.31     4.31     4.31     3.28
255       UI     3.19     3.19     3.19     3.19     3.19     2.17     1.98     1.98     1.98     1.98
256       UI     1.98     1.98     1.98     1.98     1.86     0.44     0.44     0.44     0.44     0.44
257       UI     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
258       UI     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
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259       KK       RF
260       RS       10     FLOW       -1
261       RC    0.045    0.045    0.045     1320    0.004
262       RX        0       10      510     1010     1510     2010     2490     2500
263       RY        2        1        0        0        0        0        2        1
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1                                        HEC-1 INPUT                                                    PAGE 12

LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

264       KK      FC7
265       KO        0        0        0        1       21
266       KM     Description: Storm on a field that has been recently irrigated
267       KM     Antecedant Moisture Condition: Normal
268       KM     Irrigation Type: Border
269       BA    0.125
270       PB      3.4
271       IN       15
272       PC        0        0       .1       .1       .1       .2       .2       .2       .3       .3
273       PC       .0      .03      .05      .09      .11      .14      .17      .20      .22      .25
274       PC       .3      .40      .47      .73     1.28     2.84     3.10     3.17     3.27     3.40
275       KM     Precipitation represents 100-year 6-hour storm
276       LG        2     0.25      4.3      0.4        0
277       KM    Agricultural S-Graph for Field Conditions FC7
278       KM    Basin Area [mi2] = 0.125
279       KM    Basin Lag [hr] = 2.2
280       KM    Time Step [min] = 5
281       KM    Qult = 968
          *
282       UI        0     3.49     3.49     3.49     3.49     3.49     5.24     7.33     7.33    11.32
283       UI    13.64    18.33    19.07    22.44    18.33    19.65    24.44    30.53    22.46    29.33
284       UI    29.33    29.33    29.33    29.33    29.33    29.33    29.33     26.4    24.44    24.44
285       UI    24.44    27.57    25.46    23.53    18.33    18.33    19.07    20.86    18.03    14.41
286       UI    13.33    13.33    12.51    10.48    10.17     9.78    10.47    11.28     7.85     6.67
287       UI     6.67     5.81     5.64     5.64      5.1     4.31     4.31     4.31     4.31     3.28
288       UI     3.19     3.19     3.19     3.19     3.19     2.17     1.98     1.98     1.98     1.98
289       UI     1.98     1.98     1.98     1.98     1.86     0.44     0.44     0.44     0.44     0.44
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 290      UI   0.44   0.44   0.44   0.44   0.44   0.44   0.44   0.44   0.44   0.44
 291      UI   0.44   0.44   0.44   0.44   0.44   0.44   0.44   0.44   0.44   0.44
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 292      KK     CF
 293      KO      0      0      0      1     21
 294      HC      2
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1                                  HEC-1 INPUT                                        PAGE 13

 LINE     ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 295      KK     RF
 296      RS     10   FLOW     -1
 297      RC  0.045  0.045  0.045   1320  0.004
 298      RX      0     10    510   1010   1510   2010   2490   2500
 299      RY      2      1      0      0      0      0      2      1
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   300      KK     FC7
   301      KO      0       0       0       1      21
   302      KM     Description: Storm on a field that has been recently irrigated
   303      KM     Antecedant Moisture Condition: Normal
   304      KM     Irrigation Type: Border
   305      BA    0.125
   306      PB      3.4
   307      IN      15
   308      PC      0       0      .1      .1      .1      .2      .2      .2      .3      .3
   309      PC     .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
   310      PC     .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
   311      KM     Precipitation represents 100-year 6-hour storm
   312      LG      2    0.25     4.3     0.4       0
   313      KM    Agricultural S-Graph for Field Conditions FC7
   314      KM    Basin Area [mi2] = 0.125
   315      KM    Basin Lag [hr] = 2.2
   316      KM    Time Step [min] = 5
   317      KM    Qult = 968
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   318      UI      0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
   319      UI  13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
   320      UI  29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
   321      UI  24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                      HEC-1 INPUT                                              PAGE 14

 LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   322      UI  13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
   323      UI   6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
   324      UI   3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
   325      UI   1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
   326      UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
   327      UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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   328      KK     CF
   329      KO      0       0       0       1      21
   330      HC      2
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                                        HEC-1 INPUT                                          PAGE 15
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LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 331      KK      RF
 332      RS      10    FLOW      -1
 333      RC   0.045   0.045   0.045    1320   0.004
 334      RX       0      10     510    1010    1510    2010    2490    2500
 335      RY       2       1       0       0       0       0       2       1
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 336      KK     FC4
 337      KO       0       0       0       1      21
 338      KM     Description: Storm on a dry field
 339      KM     Antecedant Moisture Condition: Dry
 340      KM     Irrigation Type: Furrow
 341      BA   0.125
 342      PB     3.4
 343      IN      15
 344      PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
 345      PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 346      PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 347      KM     Precipitation represents 100-year 6-hour storm
 348      LG     0.5    0.35     4.3     0.4       0
 349      KM   Agricultural S-Graph for Field Conditions FC4
 350      KM   Basin Area [mi2] = 0.125
 351      KM   Basin Lag [hr] = 2.2
 352      KM   Time Step [min] = 5
 353      KM   Qult = 968
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 354      UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 355      UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 356      UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 357      UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                       HEC-1 INPUT                                          PAGE 16

LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 358      UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 359      UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 360      UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 361      UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 362      UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 363      UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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364          KK      CF
365          KO       0        0        0        1       21
366          HC       2
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1                                              HEC-1 INPUT                                             PAGE 17

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

367          KK      RF
368          RS      10     FLOW      -1
369          RC   0.045    0.045   0.045     1320   0.004
370          RX       0       10     510     1010    1510    2010    2490    2500
371          RY       2        1       0        0       0       0       2       1
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372          KK     FC6
373          KO       0        0        0        1       21
374          KM    Description: Storm on a field that was just irrigated
375          KM    Antecedant Moisture Condition: Wet
376          KM    Irrigation Type: Border
377          BA   0.125
378          PB     3.4
379          IN      15
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 380        PC        0       0      .1      .1      .1      .2      .2      .2      .3      .3
 381        PC       .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 382        PC       .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 383        KM    Precipitation represents 100-year 6-hour storm
 384        LG        2       0     4.3     0.4       0
 385        KM    Agricultural S-Graph for Field Conditions FC6
 386        KM    Basin Area [mi2] = 0.125
 387        KM    Basin Lag [hr] = 2.2
 388        KM    Time Step [min] = 5
 389        KM    Qult = 968
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 390        UI        0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 391        UI    13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 392        UI    29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 393        UI    24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                         HEC-1 INPUT                                              PAGE 18

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 394        UI    13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 395        UI     6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 396        UI     3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 397        UI     1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 398        UI     0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 399        UI     0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 400        KK       CF
 401        KO        0       0       0       1      21
 402        HC        2
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1                                         HEC-1 INPUT                                              PAGE 19

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 403        KK   CSCEN1
 404        KO        0       0       0       1      21
 405        HC        2
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 406             KK  SRSCEN1
 407             KO        0         0         0         1        21
 408             RS        1      STOR         0
 409             SQ        0         0         0
 410             SE        0         1       500
 411             SV        0         1       500
 412             SE        0         1       500
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1                                         HEC-1 INPUT                                                  PAGE 20

LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 413             KK      FC1
 414             KO        0         0         0         1        21
 415             KM    Description: Irrigation and Storm Simultaneously
 416             KM    Antecedant Moisture Condition: Wet
 417             KM    Irrigation Type: Furrow
 418             BA    0.125
 419             PB     6.55
 420             IN       15
 421             PC     0.13      0.28      0.43      0.59      0.74      0.89      1.05       1.2      1.36      1.51
 422             PC     1.85      2.04      2.23      2.62       3.3      4.97      5.36      5.75      5.91      6.07
 423             PC     6.24      6.39      6.55
 424             KM    Precipitation represents Furrow Irrigation and 100-year 6-hour storm
 425             LG        2         0       4.3       0.4         0
 426             KM    Agricultural S-Graph for Field Conditions FC1
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427           KM    Basin Area [mi2] = 0.125
428           KM    Basin Lag [hr] = 2.2
429           KM    Time Step [min] = 5
430           KM    Qult = 968
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431           UI        0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
432           UI    13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
433           UI    29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
434           UI    24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
435           UI    13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
436           UI     6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
437           UI     3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
438           UI     1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
439           UI     0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
440           UI     0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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441           KK       RF
442           RS       10    FLOW      -1
443           RC    0.045   0.045   0.045    1320   0.004
444           RX        0      10     510    1010    1510    2010    2490    2500
445           RY        2       1       0       0       0       0       2       1
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1                                         HEC-1 INPUT                                              PAGE 21

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

446           KK      FC3
447           KO        0       0       0       1      21
448           KM    Description: Storm on a field that has been recently irrigated
449           KM    Antecedant Moisture Condition: Normal
450           KM    Irrigation Type: Furrow
451           BA    0.125
452           PB      3.4
453           IN       15
454           PC        0       0      .1      .1      .1      .2      .2      .2      .3      .3
455           PC       .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
456           PC       .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
457           KM    Precipitation represents 100-year 6-hour storm
458           LG        2    0.25     4.3     0.4       0
459           KM    Agricultural S-Graph for Field Conditions FC3
460           KM    Basin Area [mi2] = 0.125
461           KM    Basin Lag [hr] = 2.2
462           KM    Time Step [min] = 5
463           KM    Qult = 968
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464        UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
465        UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
466        UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
467        UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
468        UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
469        UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
470        UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
471        UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
472        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
473        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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474        KK      CF
475        KO       0       0       0       1      21
476        HC       2
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LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

477        KK      RF
478        RS      10    FLOW      -1
479        RC   0.045   0.045   0.045    1320   0.004
480        RX       0      10     510    1010    1510    2010    2490    2500
481        RY       2       1       0       0       0       0       2       1
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482           KK     FC3
483           KO      0       0       0       1      21
484           KM     Description: Storm on a field that has been recently irrigated
485           KM     Antecedant Moisture Condition: Normal
486           KM     Irrigation Type: Furrow
487           BA    0.125
488           PB      3.4
489           IN      15
490           PC      0       0      .1      .1      .1      .2      .2      .2      .3      .3
491           PC     .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
492           PC     .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
493           KM     Precipitation represents 100-year 6-hour storm
494           LG      2    0.25     4.3     0.4       0
495           KM    Agricultural S-Graph for Field Conditions FC3
496           KM    Basin Area [mi2] = 0.125
497           KM    Basin Lag [hr] = 2.2
498           KM    Time Step [min] = 5
499           KM    Qult = 968
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500           UI      0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
501           UI  13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
502           UI  29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
503           UI  24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                           HEC-1 INPUT                                         PAGE 23

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

504           UI  13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
505           UI   6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
506           UI   3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
507           UI   1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
508           UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
509           UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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510           KK      CF
511           KO      0       0       0       1      21
512           HC      2
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1                                         HEC-1 INPUT                                       PAGE 24

 LINE               ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  513               KK      RF
  514               RS      10    FLOW      -1
  515               RC   0.045   0.045   0.045    1320   0.004
  516               RX       0      10     510    1010    1510    2010    2490    2500
  517               RY       2       1       0       0       0       0       2       1
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  518               KK     FC3
  519               KO       0       0       0       1      21
  520               KM     Description: Storm on a field that has been recently irrigated
  521               KM     Antecedant Moisture Condition: Normal
  522               KM     Irrigation Type: Furrow
  523               BA   0.125
  524               PB     3.4
  525               IN      15
  526               PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
  527               PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
  528               PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
  529               KM     Precipitation represents 100-year 6-hour storm
  530               LG       2    0.25     4.3     0.4       0
  531               KM    Agricultural S-Graph for Field Conditions FC3
  532               KM    Basin Area [mi2] = 0.125
  533               KM    Basin Lag [hr] = 2.2
  534               KM    Time Step [min] = 5
  535               KM    Qult = 968
                    *
  536               UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
  537               UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
  538               UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
  539               UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                         HEC-1 INPUT                                       PAGE 25

 LINE               ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  540               UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
  541               UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
  542               UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
  543               UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
  544               UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
  545               UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 546              KK      CF
 547              KO       0         0         0         1        21
 548              HC       2
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1                                              HEC-1 INPUT                                               PAGE 26

 LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 549              KK      RF
 550              RS      10      FLOW        -1
 551              RC   0.045     0.045     0.045      1320     0.004
 552              RX       0        10       510      1010      1510      2010      2490      2500
 553              RY       2         1         0         0         0         0         2         1
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554          KK     FC2
555          KO      0        0        0        1       21
556          KM     Description: Storm on a field that was just irrigated
557          KM     Antecedant Moisture Condition: Wet
558          KM     Irrigation Type: Furrow
559          BA    0.125
560          PB      3.4
561          IN      15
562          PC      0        0       .1       .1       .1       .2       .2       .2       .3       .3
563          PC      .0      .03      .05      .09      .11      .14      .17      .20      .22      .25
564          PC      .3      .40      .47      .73     1.28     2.84     3.10     3.17     3.27     3.40
565          KM     Precipitation represents 100-year 6-hour storm
566          LG      2        0      4.3      0.4       0
567          KM    Agricultural S-Graph for Field Conditions FC2
568          KM    Basin Area [mi2] = 0.125
569          KM    Basin Lag [hr] = 2.2
570          KM    Time Step [min] = 5
571          KM    Qult = 968
             *
572          UI      0     3.49     3.49     3.49     3.49     3.49     5.24     7.33     7.33    11.32
573          UI   13.64    18.33    19.07    22.44    18.33    19.65    24.44    30.53    22.46    29.33
574          UI   29.33    29.33    29.33    29.33    29.33    29.33    29.33     26.4    24.44    24.44
575          UI   24.44    27.57    25.46    23.53    18.33    18.33    19.07    20.86    18.03    14.41
1                                          HEC-1 INPUT                                                  PAGE 27

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

576          UI   13.33    13.33    12.51    10.48    10.17     9.78    10.47    11.28     7.85     6.67
577          UI    6.67     5.81     5.64     5.64      5.1     4.31     4.31     4.31     4.31     3.28
578          UI    3.19     3.19     3.19     3.19     3.19     2.17     1.98     1.98     1.98     1.98
579          UI    1.98     1.98     1.98     1.98     1.86     0.44     0.44     0.44     0.44     0.44
580          UI    0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
581          UI    0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
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582          KK     CF
583          KO      0        0        0        1       21
584          HC      2
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585          KK     FC3
586          KO      0        0        0        1       21
587          KM     Description: Storm on a field that has been recently irrigated
588          KM     Antecedant Moisture Condition: Normal
589          KM     Irrigation Type: Furrow
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590        BA   0.125
591        PB     3.4
592        IN      15
1                                   HEC-1 INPUT                                                  PAGE 28

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

593        PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
594        PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
595        PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
596        KM     Precipitation represents 100-year 6-hour storm
597        LG       2    0.25     4.3     0.4       0
598        KM   Agricultural S-Graph for Field Conditions FC3
599        KM   Basin Area [mi2] = 0.125
600        KM   Basin Lag [hr] = 2.2
601        KM   Time Step [min] = 5
602        KM   Qult = 968
           *
603        UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
604        UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
605        UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
606        UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
607        UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
608        UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
609        UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
610        UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
611        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
612        UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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613        KK      RF
614        RS      10    FLOW      -1
615        RC   0.045   0.045   0.045    1320   0.004
616        RX       0      10     510    1010    1510    2010    2490    2500
617        RY       2       1       0       0       0       0       2       1
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1                                   HEC-1 INPUT                                                  PAGE 29

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


618        KK     FC3
619        KO       0       0       0       1      21
620        KM     Description: Storm on a field that has been recently irrigated
621        KM     Antecedant Moisture Condition: Normal
622        KM     Irrigation Type: Furrow
623        BA   0.125
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624          PB     3.4
625          IN      15
626          PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
627          PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
628          PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
629          KM     Precipitation represents 100-year 6-hour storm
630          LG       2    0.25     4.3     0.4       0
631          KM    Agricultural S-Graph for Field Conditions FC3
632          KM    Basin Area [mi2] = 0.125
633          KM    Basin Lag [hr] = 2.2
634          KM    Time Step [min] = 5
635          KM    Qult = 968
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636          UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
637          UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
638          UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
639          UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
640          UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
641          UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
642          UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
643          UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
644          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
645          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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646          KK      CF
647          KO       0       0       0       1      21
648          HC       2
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1                                           HEC-1 INPUT                                          PAGE 30

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

649          KK      RF
650          RS      10    FLOW      -1
651          RC   0.045   0.045   0.045    1320   0.004
652          RX       0      10     510    1010    1510    2010    2490    2500
653          RY       2       1       0       0       0       0       2       1
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 654                  KK     FC3
 655                  KO      0       0       0       1      21
 656                  KM     Description: Storm on a field that has been recently irrigated
 657                  KM     Antecedant Moisture Condition: Normal
 658                  KM     Irrigation Type: Furrow
 659                  BA    0.125
 660                  PB      3.4
 661                  IN      15
 662                  PC      0       0      .1      .1      .1      .2      .2      .2      .3      .3
 663                  PC     .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 664                  PC     .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 665                  KM     Precipitation represents 100-year 6-hour storm
 666                  LG      2    0.25     4.3     0.4       0
 667                  KM    Agricultural S-Graph for Field Conditions FC3
 668                  KM    Basin Area [mi2] = 0.125
 669                  KM    Basin Lag [hr] = 2.2
 670                  KM    Time Step [min] = 5
 671                  KM    Qult = 968
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 672                  UI      0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 673                  UI  13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 674                  UI  29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 675                  UI  24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                                 HEC-1 INPUT                                           PAGE 31

LINE                  ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 676                  UI  13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 677                  UI   6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 678                  UI   3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 679                  UI   1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 680                  UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 681                  UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 682                  KK     CF
 683                  KO      0       0       0       1      21
 684                  HC      2
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1                                   HEC-1 INPUT                                              PAGE 32

      LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


       685          KK      RF
       686          RS      10    FLOW      -1
       687          RC   0.045   0.045   0.045    1320   0.004
       688          RX       0      10     510    1010    1510    2010    2490    2500
       689          RY       2       1       0       0       0       0       2       1
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       690          KK     FC4
       691          KO       0       0       0       1      21
       692          KM     Description: Storm on a dry field
       693          KM     Antecedant Moisture Condition: Dry
       694          KM     Irrigation Type: Furrow
       695          BA   0.125
       696          PB     3.4
       697          IN      15
       698          PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
       699          PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
       700          PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
       701          KM     Precipitation represents 100-year 6-hour storm
       702          LG     0.5    0.35     4.3     0.4       0
       703          KM   Agricultural S-Graph for Field Conditions FC4
       704          KM   Basin Area [mi2] = 0.125
       705          KM   Basin Lag [hr] = 2.2
       706          KM   Time Step [min] = 5
       707          KM   Qult = 968
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       708          UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
       709          UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
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 710          UI   29.33    29.33    29.33    29.33    29.33    29.33    29.33     26.4    24.44    24.44
 711          UI   24.44    27.57    25.46    23.53    18.33    18.33    19.07    20.86    18.03    14.41
1                                            HEC-1 INPUT                                                    PAGE 33

 LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 712          UI   13.33    13.33    12.51    10.48    10.17     9.78    10.47    11.28     7.85     6.67
 713          UI    6.67     5.81     5.64     5.64      5.1     4.31     4.31     4.31     4.31     3.28
 714          UI    3.19     3.19     3.19     3.19     3.19     2.17     1.98     1.98     1.98     1.98
 715          UI    1.98     1.98     1.98     1.98     1.86     0.44     0.44     0.44     0.44     0.44
 716          UI    0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
 717          UI    0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
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 718          KK      CF
 719          KO       0        0        0        1       21
 720          HC       2
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1                                            HEC-1 INPUT                                                    PAGE 34

 LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 721          KK      RF
 722          RS      10     FLOW       -1
 723          RC   0.045    0.045    0.045     1320    0.004
 724          RX       0       10      510     1010     1510     2010     2490     2500
 725          RY       2        1        0        0        0        0        2        1
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 726             KK     FC2
 727             KO      0       0       0       1      21
 728             KM     Description: Storm on a field that was just irrigated
 729             KM     Antecedant Moisture Condition: Wet
 730             KM     Irrigation Type: Furrow
 731             BA    0.125
 732             PB     3.4
 733             IN     15
 734             PC      0       0      .1      .1      .1      .2      .2      .2      .3      .3
 735             PC     .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 736             PC     .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 737             KM     Precipitation represents 100-year 6-hour storm
 738             LG      2       0     4.3     0.4       0
 739             KM    Agricultural S-Graph for Field Conditions FC2
 740             KM    Basin Area [mi2] = 0.125
 741             KM    Basin Lag [hr] = 2.2
 742             KM    Time Step [min] = 5
 743             KM    Qult = 968
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 744             UI      0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 745             UI   13.64  18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 746             UI   29.33  29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 747             UI   24.44  27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
                                          HEC-1 INPUT                                              PAGE 35

LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 748             UI   13.33  13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 749             UI    6.67   5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 750             UI    3.19   3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 751             UI    1.98   1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 752             UI    0.44   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 753             UI    0.44   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 754             KK     CF
 755             KO      0       0       0       1      21
 756             HC      2
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1                                  HEC-1 INPUT                                                  PAGE 36

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           757      KK  CSCEN2
           758      KO       0       0       0       1      21
           759      HC       2
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           760      KK  SRSCEN2
           761      KO       0       0       0       1      21
           762      RS       1    STOR       0
           763      SQ       0       0       0
           764      SE       0       1     500
           765      SV       0       1     500
           766      SE       0       1     500
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1                                         HEC-1 INPUT                                        PAGE 37

LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 767             KK     FC5
 768             KO       0       0       0       1      21
 769             KM     Description: Irrigation and Storm Simultaneously
 770             KM     Antecedant Moisture Condition: Normal
 771             KM     Irrigation Type: Border
 772             BA   0.125
 773             PB    9.60
 774             IN      15
 775             PC       0    0.03    0.05    0.09    0.11    0.14    0.17     0.2    0.22    0.25
 776             PC    0.34     0.4     1.5     2.8    4.38    6.97    8.26    9.43    9.47     9.5
 777             PC    9.54    9.57     9.6
 778             KM     Precipitation represents Border Irrigation and 100-year 6-hour storm
 779             LG       2    0.25     4.3     0.4       0
 780             KM    Agricultural S-Graph for Field Conditions FC5
 781             KM    Basin Area [mi2] = 0.125
 782             KM    Basin Lag [hr] = 2.2
 783             KM    Time Step [min] = 5
 784             KM    Qult = 968
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 785             UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 786             UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 787             UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 788             UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
 789             UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 790             UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 791             UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 792             UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 793             UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 794             UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 795             KK      RF
 796             RS      10    FLOW      -1
 797             RC   0.045   0.045   0.045    1320   0.004
 798             RX       0      10     510    1010    1510    2010    2490    2500
 799             RY       2       1       0       0       0       0       2       1
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                                          HEC-1 INPUT                                        PAGE 38

LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
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800         KK     FC7
801         KO      0        0        0        1       21
802         KM     Description: Storm on a field that has been recently irrigated
803         KM     Antecedant Moisture Condition: Normal
804         KM     Irrigation Type: Border
805         BA    0.125
806         PB      3.4
807         IN      15
808         PC      0        0       .1       .1       .1       .2       .2       .2       .3       .3
809         PC     .0      .03      .05      .09      .11      .14      .17      .20      .22      .25
810         PC     .3      .40      .47      .73     1.28     2.84     3.10     3.17     3.27     3.40
811         KM     Precipitation represents 100-year 6-hour storm
812         LG      2     0.25      4.3      0.4        0
813         KM    Agricultural S-Graph for Field Conditions FC7
814         KM    Basin Area [mi2] = 0.125
815         KM    Basin Lag [hr] = 2.2
816         KM    Time Step [min] = 5
817         KM    Qult = 968
            *
818         UI      0     3.49     3.49     3.49     3.49     3.49     5.24     7.33     7.33    11.32
819         UI  13.64    18.33    19.07    22.44    18.33    19.65    24.44    30.53    22.46    29.33
820         UI  29.33    29.33    29.33    29.33    29.33    29.33    29.33     26.4    24.44    24.44
821         UI  24.44    27.57    25.46    23.53    18.33    18.33    19.07    20.86    18.03    14.41
822         UI  13.33    13.33    12.51    10.48    10.17     9.78    10.47    11.28     7.85     6.67
823         UI   6.67     5.81     5.64     5.64      5.1     4.31     4.31     4.31     4.31     3.28
824         UI   3.19     3.19     3.19     3.19     3.19     2.17     1.98     1.98     1.98     1.98
825         UI   1.98     1.98     1.98     1.98     1.86     0.44     0.44     0.44     0.44     0.44
826         UI   0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
827         UI   0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
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828         KK     CF
829         KO      0        0        0        1       21
830         HC      2
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1                                       HEC-1 INPUT                                             PAGE 39

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
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831          KK      RF
832          RS      10    FLOW      -1
833          RC   0.045   0.045   0.045    1320   0.004
834          RX       0      10     510    1010    1510    2010    2490    2500
835          RY       2       1       0       0       0       0       2       1
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836          KK     FC7
837          KO       0       0       0       1      21
838          KM     Description: Storm on a field that has been recently irrigated
839          KM     Antecedant Moisture Condition: Normal
840          KM     Irrigation Type: Border
841          BA   0.125
842          PB     3.4
843          IN      15
844          PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
845          PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
846          PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
847          KM     Precipitation represents 100-year 6-hour storm
848          LG       2    0.25     4.3     0.4       0
849          KM    Agricultural S-Graph for Field Conditions FC7
850          KM    Basin Area [mi2] = 0.125
851          KM    Basin Lag [hr] = 2.2
852          KM    Time Step [min] = 5
853          KM    Qult = 968
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854          UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
855          UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
856          UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
857          UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                              HEC-1 INPUT                                      PAGE 40

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

858          UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
859          UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
860          UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
861          UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
862          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
863          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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864          KK      CF
865          KO       0       0       0       1      21
866          HC       2
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1                                          HEC-1 INPUT                                      PAGE 41

 LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  867      KK      RF
  868      RS      10    FLOW      -1
  869      RC   0.045   0.045   0.045    1320   0.004
  870      RX       0      10     510    1010    1510    2010    2490    2500
  871      RY       2       1       0       0       0       0       2       1
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  872      KK     FC7
  873      KO       0       0       0       1      21
  874      KM   Description: Storm on a field that has been recently irrigated
  875      KM   Antecedant Moisture Condition: Normal
  876      KM   Irrigation Type: Border
  877      BA   0.125
  878      PB     3.4
  879      IN      15
  880      PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
  881      PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
  882      PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
  883      KM   Precipitation represents 100-year 6-hour storm
  884      LG       2    0.25     4.3     0.4       0
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885           KM    Agricultural S-Graph for Field Conditions FC7
886           KM    Basin Area [mi2] = 0.125
887           KM    Basin Lag [hr] = 2.2
888           KM    Time Step [min] = 5
889           KM    Qult = 968
                *
890           UI        0     3.49     3.49     3.49     3.49     3.49     5.24     7.33     7.33    11.32
891           UI    13.64    18.33    19.07    22.44    18.33    19.65    24.44    30.53    22.46    29.33
892           UI    29.33    29.33    29.33    29.33    29.33    29.33    29.33     26.4    24.44    24.44
893           UI    24.44    27.57    25.46    23.53    18.33    18.33    19.07    20.86    18.03    14.41
1                                              HEC-1 INPUT                                               PAGE 42

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

894           UI    13.33    13.33    12.51    10.48    10.17     9.78    10.47    11.28     7.85     6.67
895           UI     6.67     5.81     5.64     5.64      5.1     4.31     4.31     4.31     4.31     3.28
896           UI     3.19     3.19     3.19     3.19     3.19     2.17     1.98     1.98     1.98     1.98
897           UI     1.98     1.98     1.98     1.98     1.86     0.44     0.44     0.44     0.44     0.44
898           UI     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
899           UI     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44     0.44
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900           KK       CF
901           KO        0        0        0        1       21
902           HC        2
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1                                              HEC-1 INPUT                                               PAGE 43

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

903           KK       RF
904           RS       10     FLOW       -1
905           RC    0.045    0.045    0.045     1320    0.004
906           RX        0       10      510     1010     1510     2010     2490     2500
907           RY        2        1        0        0        0        0        2        1
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 908                KK     FC6
 909                KO       0       0       0       1      21
 910                KM     Description: Storm on a field that was just irrigated
 911                KM     Antecedant Moisture Condition: Wet
 912                KM     Irrigation Type: Border
 913                BA   0.125
 914                PB     3.4
 915                IN      15
 916                PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
 917                PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 918                PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 919                KM     Precipitation represents 100-year 6-hour storm
 920                LG       2       0     4.3     0.4       0
 921                KM    Agricultural S-Graph for Field Conditions FC6
 922                KM    Basin Area [mi2] = 0.125
 923                KM    Basin Lag [hr] = 2.2
 924                KM    Time Step [min] = 5
 925                KM    Qult = 968
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 926                UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 927                UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 928                UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 929                UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                                   HEC-1 INPUT                                          PAGE 44

LINE                ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 930                UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 931                UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 932                UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 933                UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 934                UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 935                UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 936                KK      CF
 937                KO       0       0       0       1      21
 938                HC       2
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 939          KK     FC3
 940          KO      0       0       0       1      21
 941          KM     Description: Storm on a field that has been recently irrigated
 942          KM     Antecedant Moisture Condition: Normal
 943          KM     Irrigation Type: Furrow
 944          BA    0.125
 945          PB      3.4
 946          IN       15
1                                      HEC-1 INPUT                                                    PAGE 45

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 947          PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
 948          PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 949          PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 950          KM     Precipitation represents 100-year 6-hour storm
 951          LG       2    0.25     4.3     0.4       0
 952          KM    Agricultural S-Graph for Field Conditions FC3
 953          KM    Basin Area [mi2] = 0.125
 954          KM    Basin Lag [hr] = 2.2
 955          KM    Time Step [min] = 5
 956          KM    Qult = 968
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 957          UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
 958          UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
 959          UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
 960          UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
 961          UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
 962          UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
 963          UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
 964          UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
 965          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
 966          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 967          KK      RF
 968          RS      10    FLOW      -1
 969          RC   0.045   0.045   0.045    1320   0.004
 970          RX       0      10     510    1010    1510    2010    2490    2500
 971          RY       2       1       0       0       0       0       2       1
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 LINE     ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  972     KK     FC3
  973     KO      0       0       0       1      21
  974     KM     Description: Storm on a field that has been recently irrigated
  975     KM     Antecedant Moisture Condition: Normal
  976     KM     Irrigation Type: Furrow
  977     BA    0.125
  978     PB     3.4
  979     IN      15
  980     PC      0       0      .1      .1      .1      .2      .2      .2      .3      .3
  981     PC     .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
  982     PC     .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
  983     KM     Precipitation represents 100-year 6-hour storm
  984     LG      2    0.25     4.3     0.4       0
  985     KM    Agricultural S-Graph for Field Conditions FC3
  986     KM    Basin Area [mi2] = 0.125
  987     KM    Basin Lag [hr] = 2.2
  988     KM    Time Step [min] = 5
  989     KM    Qult = 968
          *
  990     UI      0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
  991     UI  13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
  992     UI  29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
  993     UI  24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
  994     UI  13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
  995     UI   6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
  996     UI   3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
  997     UI   1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
  998     UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
  999     UI   0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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 1000     KK     CF
 1001     KO      0       0       0       1      21
 1002     HC      2
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  LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1003      KK      RF
  1004      RS      10     FLOW      -1
  1005      RC   0.045    0.045   0.045    1320   0.004
  1006      RX       0       10     510    1010    1510    2010    2490    2500
  1007      RY       2        1       0       0       0       0       2       1
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  1008      KK     FC3
  1009      KO       0        0       0       1      21
  1010      KM      Description: Storm on a field that has been recently irrigated
  1011      KM      Antecedant Moisture Condition: Normal
  1012      KM      Irrigation Type: Furrow
  1013      BA   0.125
  1014      PB     3.4
  1015      IN      15
  1016      PC       0        0      .1      .1      .1      .2      .2      .2      .3      .3
  1017      PC      .0      .03     .05     .09     .11     .14     .17     .20     .22     .25
  1018      PC      .3      .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
  1019      KM      Precipitation represents 100-year 6-hour storm
  1020      LG       2     0.25     4.3     0.4       0
  1021      KM    Agricultural S-Graph for Field Conditions FC3
  1022      KM    Basin Area [mi2] = 0.125
  1023      KM    Basin Lag [hr] = 2.2
  1024      KM    Time Step [min] = 5
  1025      KM    Qult = 968
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  1026      UI       0     3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
  1027      UI   13.64    18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
  1028      UI   29.33    29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
  1029      UI   24.44    27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                     HEC-1 INPUT                                        PAGE 48

  LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1030      UI   13.33    13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
  1031      UI    6.67     5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
  1032      UI    3.19     3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
  1033      UI    1.98     1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
  1034      UI    0.44     0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
  1035      UI    0.44     0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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1036             KK      CF
1037             KO       0         0         0         1        21
1038             HC       2
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1                                       HEC-1 INPUT                                              PAGE 49

LINE             ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1039             KK      RF
1040             RS      10      FLOW        -1
1041             RC   0.045     0.045     0.045      1320     0.004
1042             RX       0        10       510      1010      1510      2010      2490      2500
1043             RY       2         1         0         0         0         0         2         1
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1044          KK      FC4
1045          KO       0       0       0       1      21
1046          KM      Description: Storm on a dry field
1047          KM      Antecedant Moisture Condition: Dry
1048          KM      Irrigation Type: Furrow
1049          BA     0.125
1050          PB       3.4
1051          IN        15
1052          PC         0       0      .1      .1      .1      .2      .2      .2      .3      .3
1053          PC        .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
1054          PC        .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
1055          KM      Precipitation represents 100-year 6-hour storm
1056          LG       0.5    0.35     4.3     0.4       0
1057          KM     Agricultural S-Graph for Field Conditions FC4
1058          KM     Basin Area [mi2] = 0.125
1059          KM     Basin Lag [hr] = 2.2
1060          KM     Time Step [min] = 5
1061          KM     Qult = 968
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1062          UI         0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
1063          UI     13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
1064          UI     29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
1065          UI     24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                          HEC-1 INPUT                                              PAGE 50

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1066          UI     13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
1067          UI      6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
1068          UI      3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
1069          UI      1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
1070          UI      0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
1071          UI      0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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1072          KK      CF
1073          KO       0       0       0       1      21
1074          HC       2
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1                                          HEC-1 INPUT                                              PAGE 51
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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1075          KK      RF
1076          RS      10    FLOW      -1
1077          RC   0.045   0.045   0.045    1320   0.004
1078          RX       0      10     510    1010    1510    2010    2490    2500
1079          RY       2       1       0       0       0       0       2       1
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1080          KK     FC2
1081          KO       0       0       0       1      21
1082          KM      Description: Storm on a field that was just irrigated
1083          KM      Antecedant Moisture Condition: Wet
1084          KM      Irrigation Type: Furrow
1085          BA   0.125
1086          PB     3.4
1087          IN      15
1088          PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
1089          PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
1090          PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
1091          KM      Precipitation represents 100-year 6-hour storm
1092          LG       2       0     4.3     0.4       0
1093          KM     Agricultural S-Graph for Field Conditions FC2
1094          KM     Basin Area [mi2] = 0.125
1095          KM     Basin Lag [hr] = 2.2
1096          KM     Time Step [min] = 5
1097          KM     Qult = 968
              *
1098          UI       0    3.49    3.49    3.49    3.49    3.49    5.24    7.33    7.33   11.32
1099          UI   13.64   18.33   19.07   22.44   18.33   19.65   24.44   30.53   22.46   29.33
1100          UI   29.33   29.33   29.33   29.33   29.33   29.33   29.33    26.4   24.44   24.44
1101          UI   24.44   27.57   25.46   23.53   18.33   18.33   19.07   20.86   18.03   14.41
1                                                 HEC-1 INPUT                                        PAGE 52

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

1102          UI   13.33   13.33   12.51   10.48   10.17    9.78   10.47   11.28    7.85    6.67
1103          UI    6.67    5.81    5.64    5.64     5.1    4.31    4.31    4.31    4.31    3.28
1104          UI    3.19    3.19    3.19    3.19    3.19    2.17    1.98    1.98    1.98    1.98
1105          UI    1.98    1.98    1.98    1.98    1.86    0.44    0.44    0.44    0.44    0.44
1106          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
1107          UI    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44    0.44
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1108          KK      CF
1109          KO       0       0       0       1      21
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 1110          HC       2
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1                                       HEC-1 INPUT                                        PAGE 53

 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 1111          KK  CSCEN3
 1112          KO       0       0       0       1      21
 1113          HC       2
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 1114          KK  SRSCEN3
 1115          KO       0       0       0       1      21
 1116          RS       1    STOR       0
 1117          SQ       0       0       0
 1118          SE       0       1     500
 1119          SV       0       1     500
 1120          SE       0       1     500
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1                                                         HEC-1 INPUT                                          PAGE 54

           LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           1121          ZZ
1
                 SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

   NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    59         FC5
                V
                V
    87         RF
                .
                .
    92          .          FC7
                .            .
                .            .
   120         CF............
                V
                V
   123         RF
                .
                .
   128          .          FC7
                .            .
                .            .
   156         CF............
                V
                V
   159         RF
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   164          .          FC7
                .            .
                .            .
   192         CF............
                V
                V
   195         RF
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   200          .          FC6
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   228         CF............
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   231          .          FC7
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                 .                V
                 .                V
 259             .               RF
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 264             .                .           FC7
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 292             .               CF............
                 .                V
                 .                V
 295             .               RF
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                 .                .
 300             .                .           FC7
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 328             .               CF............
                 .                V
                 .                V
 331             .               RF
                 .                .
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 336             .                .           FC4
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 364             .               CF............
                 .                V
                 .                V
 367             .               RF
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 372             .                .           FC6
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 400             .               CF............
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 403          CSCEN1.............
                 V
                 V
 406          SRSCEN
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 413             .              FC1
                 .                V
                 .                V
 441             .               RF
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 446             .                .           FC3
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 474             .               CF............
                 .                V
                 .                V
 477             .               RF
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 482             .                .           FC3
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 510             .               CF............
                 .                V
                 .                V
 513             .               RF
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 518             .                .           FC3
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 546             .               CF............
                 .                V
                 .                V
 549             .               RF
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 554             .                .           FC2
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582           .          CF............
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585           .           .         FC3
              .           .           V
              .           .           V
613           .           .          RF
              .           .           .
              .           .           .
618           .           .           .         FC3
              .           .           .           .
              .           .           .           .
646           .           .          CF............
              .           .           V
              .           .           V
649           .           .          RF
              .           .           .
              .           .           .
654           .           .           .         FC3
              .           .           .           .
              .           .           .           .
682           .           .          CF............
              .           .           V
              .           .           V
685           .           .          RF
              .           .           .
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690           .           .           .         FC4
              .           .           .           .
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718           .           .          CF............
              .           .           V
              .           .           V
721           .           .          RF
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726           .           .           .         FC2
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754           .           .          CF............
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757           .     CSCEN2............
              .           V
              .           V
760           .     SRSCEN
              .           .
              .           .
767           .           .         FC5
              .           .           V
              .           .           V
795           .           .          RF
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800           .           .           .         FC7
              .           .           .           .
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828           .           .          CF............
              .           .           V
              .           .           V
831           .           .          RF
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836           .           .           .         FC7
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864           .           .          CF............
              .           .           V
              .           .           V
867           .           .          RF
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872           .           .           .         FC7
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900           .           .          CF............
              .           .           V
              .           .           V
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 903         .         .        RF
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 908         .         .         .        FC6
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 936         .         .        CF............
             .         .         .
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 939         .         .         .        FC3
             .         .         .         V
             .         .         .         V
 967         .         .         .        RF
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 972         .         .         .         .        FC3
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1000         .         .         .        CF............
             .         .         .         V
             .         .         .         V
1003         .         .         .        RF
             .         .         .         .
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1008         .         .         .         .        FC3
             .         .         .         .         .
             .         .         .         .         .
1036         .         .         .        CF............
             .         .         .         V
             .         .         .         V
1039         .         .         .        RF
             .         .         .         .
             .         .         .         .
1044         .         .         .         .        FC4
             .         .         .         .         .
             .         .         .         .         .
1072         .         .         .        CF............
             .         .         .         V
             .         .         .         V
1075         .         .         .        RF
             .         .         .         .
             .         .         .         .
1080         .         .         .         .        FC2
             .         .         .         .         .
             .         .         .         .         .
1108         .         .         .        CF............
             .         .         .         .
             .         .         .         .
1111         .         .     CSCEN3............
             .         .         V
             .         .         V
1114         .         .     SRSCEN
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	FC5	172.	5.58	80.	20.	7.	.13		
+	ROUTED TO	RF	171.	6.00	79.	20.	7.	.13		
+									.17	6.00
+	HYDROGRAPH AT	FC7	13.	7.67	6.	1.	0.	.13		
+	2 COMBINED AT	CF	171.	6.00	85.	22.	7.	.25		
+	ROUTED TO	RF	170.	6.42	84.	22.	7.	.25	.17	6.42

	HYDROGRAPH AT									
+		FC7	13.	7.67	6.	1.	0.	.13		
	2 COMBINED AT									
+		CF	171.	6.42	90.	23.	8.	.38		
	ROUTED TO									
+		RF	170.	6.75	90.	23.	8.	.38		
+									.17	6.75
	HYDROGRAPH AT									
+		FC7	13.	7.67	6.	1.	0.	.13		
	2 COMBINED AT									
+		CF	173.	6.83	95.	25.	8.	.50		
	ROUTED TO									
+		RF	173.	7.25	95.	25.	8.	.50		
+									.17	7.25
	HYDROGRAPH AT									
+		FC6	28.	8.33	13.	3.	1.	.13		
	2 COMBINED AT									
+		CF	193.	7.58	108.	28.	9.	.63		
	HYDROGRAPH AT									
+		FC7	13.	7.67	6.	1.	0.	.13		
	ROUTED TO									
+		RF	13.	8.92	6.	1.	0.	.13		
+									.02	8.92
	HYDROGRAPH AT									
+		FC7	13.	7.67	6.	1.	0.	.13		
	2 COMBINED AT									
+		CF	24.	8.83	11.	3.	1.	.25		
	ROUTED TO									
+		RF	23.	9.42	11.	3.	1.	.25		
+									.03	9.42
	HYDROGRAPH AT									
+		FC7	13.	7.67	6.	1.	0.	.13		
	2 COMBINED AT									
+		CF	32.	8.83	17.	4.	1.	.38		
	ROUTED TO									
+		RF	31.	9.83	17.	4.	1.	.38		
+									.04	9.83
	HYDROGRAPH AT									
+		FC4	41.	8.08	18.	5.	2.	.13		
	2 COMBINED AT									
+		CF	57.	8.83	35.	9.	3.	.50		
	ROUTED TO									
+		RF	54.	9.50	34.	9.	3.	.50		
+									.08	9.50
	HYDROGRAPH AT									
+		FC6	28.	8.33	13.	3.	1.	.13		
	2 COMBINED AT									
+		CF	76.	8.83	46.	12.	4.	.63		
	2 COMBINED AT									
+		CSCEN1	238.	7.92	154.	40.	13.	1.25		
	ROUTED TO									
+		SRSCEN	0.	.00	0.	0.	0.	1.25		
									79.94	19.25
	HYDROGRAPH AT									
+		FC1	93.	5.67	45.	12.	4.	.13		

System Model 1
Extrapolation of Observed Field Data to Systems of Typical Fields
HEC-1 Input/Output

+ +	ROUTED TO	RF	92.	6.00	45.	12.	4.	.13	.12	6.00
+	HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
+	2 COMBINED AT	CF	92.	6.00	50.	13.	4.	.25		
+ +	ROUTED TO	RF	93.	6.42	50.	13.	4.	.25	.12	6.42
+	HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
+	2 COMBINED AT	CF	94.	6.42	56.	15.	5.	.38		
+ +	ROUTED TO	RF	92.	7.08	56.	15.	5.	.38	.12	7.08
+	HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
+	2 COMBINED AT	CF	102.	8.00	61.	16.	5.	.50		
+ +	ROUTED TO	RF	102.	8.42	61.	16.	5.	.50	.12	8.42
	HYDROGRAPH AT	FC2	28.	8.33	13.	3.	1.	.13		
+	2 COMBINED AT	CF	130.	8.33	74.	19.	6.	.63		
+	HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
+ +	ROUTED TO	RF	13.	8.92	6.	1.	0.	.13	.02	8.92
+	HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
+	2 COMBINED AT	CF	24.	8.83	11.	3.	1.	.25		
+ +	ROUTED TO	RF	23.	9.42	11.	3.	1.	.25	.03	9.42
+	HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
+	2 COMBINED AT	CF	32.	8.83	17.	4.	1.	.38		
+ +	ROUTED TO	RF	31.	9.83	17.	4.	1.	.38	.04	9.83
+	HYDROGRAPH AT	FC4	41.	8.08	18.	5.	2.	.13		
+	2 COMBINED AT	CF	57.	8.83	35.	9.	3.	.50		
	ROUTED TO	RF	54.	9.50	34.	9.	3.	.50	.08	9.50
	HYDROGRAPH AT									

	FC2	28.	8.33	13.	3.	1.	.13		
2 COMBINED AT	CF	76.	8.83	46.	12.	4.	.63		
2 COMBINED AT	CSCEN2	200.	8.83	120.	32.	11.	1.25		
ROUTED TO	SRSCEN	0.	.00	0.	0.	0.	1.25	62.57	19.25
HYDROGRAPH AT	FC5	172.	5.58	80.	20.	7.	.13		
ROUTED TO	RF	171.	6.00	79.	20.	7.	.13	.17	6.00
HYDROGRAPH AT	FC7	13.	7.67	6.	1.	0.	.13		
2 COMBINED AT	CF	171.	6.00	85.	22.	7.	.25		
ROUTED TO	RF	170.	6.42	84.	22.	7.	.25	.17	6.42
HYDROGRAPH AT	FC7	13.	7.67	6.	1.	0.	.13		
2 COMBINED AT	CF	171.	6.42	90.	23.	8.	.38		
ROUTED TO	RF	170.	6.75	90.	23.	8.	.38	.17	6.75
HYDROGRAPH AT	FC7	13.	7.67	6.	1.	0.	.13		
2 COMBINED AT	CF	173.	6.83	95.	25.	8.	.50		
ROUTED TO	RF	173.	7.25	95.	25.	8.	.50	.17	7.25
HYDROGRAPH AT	FC6	28.	8.33	13.	3.	1.	.13		
2 COMBINED AT	CF	193.	7.58	108.	28.	9.	.63		
HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
ROUTED TO	RF	13.	8.92	6.	1.	0.	.13	.02	8.92
HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
2 COMBINED AT	CF	24.	8.83	11.	3.	1.	.25		
ROUTED TO	RF	23.	9.42	11.	3.	1.	.25	.03	9.42
HYDROGRAPH AT	FC3	13.	7.67	6.	1.	0.	.13		
2 COMBINED AT	CF	32.	8.83	17.	4.	1.	.38		
ROUTED TO									

+		RF	31.	9.83	17.	4.	1.	.38		
+									.04	9.83
	HYDROGRAPH AT									
+		FC4	41.	8.08	18.	5.	2.	.13		
	2 COMBINED AT									
+		CF	57.	8.83	35.	9.	3.	.50		
	ROUTED TO									
+		RF	54.	9.50	34.	9.	3.	.50		
+									.08	9.50
	HYDROGRAPH AT									
+		FC2	28.	8.33	13.	3.	1.	.13		
	2 COMBINED AT									
+		CF	76.	8.83	46.	12.	4.	.63		
	2 COMBINED AT									
+		CSCEN3	238.	7.92	154.	40.	13.	1.25		
	ROUTED TO									
+		SRSCEN	0.	.00	0.	0.	0.	1.25		
+									79.94	19.25

*** NORMAL END OF HEC-1 ***

System Model 2
Calibration of Observed Field Data to Systems of Typical Fields
HEC-1 Input/Output

```
1*****************************************
***************************************
 *                                       *                                                *
*
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                *   U.S. ARMY CORPS OF ENGINEERS
*
 *             JUN   1998                *                                                *   HYDROLOGIC ENGINEERING CENTER
*
 *           VERSION 4.1                 *                                                *          609 SECOND STREET
*
 *                                       *                                                *      DAVIS, CALIFORNIA 95616
*
 *  RUN DATE   03NOV04  TIME  16:49:41   *                                                *          (916) 756-1104
*
 *                                       *                                                *
*
 *****************************************
***************************************




                                                  X     X  XXXXXXX   XXXXX          X
                                                  X     X  X        X     X        XX
                                                  X     X  X        X               X
                                                  XXXXXXX  XXXX     X       XXXXX   X
                                                  X     X  X        X               X
                                                  X     X  X        X     X         X
                                                  X     X  XXXXXXX   XXXXX         XXX



            THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

            THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
            THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
            NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
            DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
            KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


1                                                HEC-1 INPUT                                               PAGE  1

            LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              1           ID     ************************************************************************
              2           ID     ************************************************************************
              3           ID     Project: Buckeye Sunvalley Agricultural Study
              4           ID     Client: Flood Control District of Maricopa County
              5           ID     Prepared By: Entellus Inc.                 Modelers: J.S. and H.A.
              6           ID     Entellus 118.001
              7           ID     File Name: system2.txt                     Created 11/1/2004
              8           ID
              9           ID     **********  CALIBRATION OF INITIAL ABSTRACTION AND LAG TIME   **********
             10           ID     ******** THIS MODEL IS PRELIMINARY AND IS SUBJECT TO CHANGE ************
             11           ID     * This model was created as part of the Buckeye Sun Valley Area        *
             12           ID     * Drainage Master Study - Pilot Agricultural Study. The purpose of the *
             13           ID     * pilot study is to examine the District's methodology for modeling    *
             14           ID     * storm runoff from agricultural areas  and recommend any possible     *
             15           ID     * improvements to the methodology. This HEC-1 model was created to     *
             16           ID     * calibrate hydrologic modeling parameters so that they accuratley     *
             17           ID     * simulate real life runoff conditions as observed in the field.       *
             18           ID     *                                                                      *
             19           ID     * This model was created in order to calibrate the parameters adjusted *
             20           ID     * using observed field set data (initial abstraction and lag time) to  *
             21           ID     * conditions typical of systems of fields. The peak flow and volume    *
             22           ID     * from a system of typical fields was estimated using System Model 1.  *
             23           ID     * The initial abstraction and lag times were adjusted until those      *
             24           ID     * results were achieved. The initial abstraction was adjusted to obtain*
             25           ID     * the volume and the lag time was adjusted to obtain the peak flow.    *
             26           ID     *                                                                      *
             27           ID     * The DTHETA value used in this model represents typical moisture      *
             28           ID     * conditions throughout agricultural systems. DTHETA was set to 0.19   *
             29           ID     * which is somewhere between wet and dry conditions.                   *
             30           ID     *                                                                      *
             31           ID     ***************C A L I B R A T I O N     R E S U L T S ****************
             32           ID     * IA = 1.0 inch                                                        *
```

```
 33    ID    * Lag = 3.0 Hours                                                   *
 34    ID    *********************************************************************
       *
       *
       *
       *
       *DIAGRAM
 35    IT       5                 1000
 36    IO       5
       *
       *
       *
       *
       *
       *

 37    KK  SYSTEM
 38    KO      0       0       0       1      21
 39    KM   ***************************************************************
 40    KM   *     Typical 1.25 Square Mile Agricultural Land                *
 41    KM   *            Border and Furrow Crops Mixed                      *
 42    KM   *************** 100-Year 6-Hour Storm     **********************
 43    KM   ************* District Green and Ampt Method *********************
1                                   HEC-1 INPUT                                          PAGE  2

LINE   ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 44    KM   *        Lag Time and Initial Abstraction Adjusted              *
 45    KM   *        Average Antecedant Moisture Condition (DTHETA) = 0.19  *
 46    KM   ***************************************************************
 47    KM   Calibration Code: 4 (See Appendix Calibration Sheet)
 48    KM
 49    BA    1.25
 50    PB     3.4
 51    IN      15
 52    PC       0       0      .1      .1      .1      .2      .2      .2      .3      .3
 53    PC      .0     .03     .05     .09     .11     .14     .17     .20     .22     .25
 54    PC      .3     .40     .47     .73    1.28    2.84    3.10    3.17    3.27    3.40
 55    LG     1.0     .19    4.30      .4       0
       * Agricultural S-Graph for Basin SYSTEM
       * Basin Area [mi2] = 1.25
       * Basin Lag [hr] = 3.3
       * Time Step [min] = 5
       * Qult = 9680
       * Unit Hydrograph was truncated to 150 ordinates (max number allowed by HEC-1)
 56    UI       0      23      23      23      23      23      23      23      23      41
 57    UI      49      49      49      72      81      96     122     122     130     163
 58    UI     123     122     122     156     163     199     176     155     196     196
 59    UI     196     196     196     196     196     196     196     196     196     196
 60    UI     183     163     163     163     163     163     178     180     172     174
 61    UI     122     122     122     122     130     137     144     108      98      91
 62    UI      89      89      89      81      70      70      67      65      65      72
 63    UI      75      72      44      44      44      44      39      38      38      38
 64    UI      38      32      29      29      29      29      29      29      22      21
 65    UI      21      21      21      21      21      21      21      15      13      13
 66    UI      13      13      13      13      13      13      13      13      13      13
 67    UI      13      12       3       3       3       3       3       3       3       3
 68    UI       3       3       3       3       3       3       3       3       3       3
 69    UI       3       3       3       3       3       3       3       3       3       3
 70    UI       3       3       3       3       3       3       3       3       3       3
       *
       *
       *
       *

 71    KK  SYSTEM
 72    KO       0       0       0       1      21
 73    KM   Storage route used to estimate volume of runoff from GA
 74    RS       1    STOR       0
 75    SQ       0       0       0
 76    SE       0       1     500
 77    SV       0       1     500
 78    SE       0       1     500
       *
       *
       *
       *
       *
       *
```

```
                         *
                         *
          79             ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

   NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

    37      SYSTEM
                V
                V
    71      SYSTEM

1
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+										
	HYDROGRAPH AT									
+		SYSTEM	257.	8.83	159.	44.	15.	1.25		
	ROUTED TO									
+		SYSTEM	0.	.00	0.	0.	0.	1.25		
+									86.86	19.00

*** NORMAL END OF HEC-1 ***

APPENDIX E. HEC-1 MODELS

- **E.1. Observed Sets Input/Output**
- **E.2. System Models 1 and 2 Input/Output**
- **E.3. Pilot Study Area Model Input/ Output**

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
1*****************************************
****************************************
 *                                       *                                                                     *
*
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                                     *    U.S. ARMY CORPS
OF ENGINEERS      *
 *              JUN   1998               *                                                                     *    HYDROLOGIC
ENGINEERING CENTER    *
 *             VERSION 4.1               *                                                                     *          609 SECOND
STREET           *
 *                                       *                                                                     *       DAVIS,
CALIFORNIA 95616       *
 *  RUN DATE   06JAN05  TIME  14:39:03   *                                                                     *            (916)
756-1104          *
 *                                       *                                                                     *
*
 *****************************************
****************************************
```

```
X       X  XXXXXXX   XXXXX           X
X       X  X        X     X         XX
X       X  X        X                X
XXXXXXX   XXXX      X          XXXXX  X
X       X  X        X                X
X       X  X        X     X          X
X       X  XXXXXXX   XXXXX          XXX
```

```
          THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND
HEC1KW.

          THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE
INPUT STRUCTURE.
          THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77
VERSION
          NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE
FREQUENCY,
          DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
          KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM
```

```
1                                              HEC-1 INPUT
PAGE  1

         LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           1           ID   Buckeye/Sun Valley ADMS - November 2004
           2           ID   PBS&J - Modelers: Jacob Lesue & Wen Chen
           3           ID   100-year 6-hour
           4           ID   Existing Conditions
           5           ID   Area 1 - RID to BIC (West)
           6           ID   Rainfall Loss Method - Green & Ampt
           7           ID   Unit Hydrograph Method - FCDMC S-Graph
           8           ID   Channel Routing Method - Normal Depth
           9           ID   Land Use - FCDMC GIS Data: mag_landuse (2000)
          10           ID   Soil Data - USDA SCS Soil Survey (1972 & 1981)
          11           ID   Units - L(mi)   Lca(mi)   S(ft/mi)   LAG(min)
                       *DIAGRAM
          12           IT      15 02JAN94       0     400
          13           IO       3
          14           IN      15 02JAN94       0
          15           JD     3.3    0.01
                       * 6-hour distribution, pattern 1.0
          16           PC     0.0   0.008   0.016   0.025   0.033   0.041    0.05   0.058   0.066   0.074
          17           PC   0.087   0.099   0.118   0.138   0.216   0.377   0.834   0.911   0.931    0.95
          18           PC   0.962   0.972   0.983   0.991     1.0
          19           IN      15 02JAN94       0
          20           JD    3.28     0.5
                       * 6-hour distribution, pattern 1.0
          21           PC     0.0   0.008   0.016   0.025   0.033   0.041    0.05   0.058   0.066   0.074
          22           PC   0.087   0.099   0.118   0.138   0.216   0.377   0.834   0.911   0.931    0.95
          23           PC   0.962   0.972   0.983   0.991     1.0
          24           IN      15 02JAN94       0
```

```
           25          JD   3.257     1.0
                       * 6-hour distribution, pattern 1.4
           26          PC     0.0  0.0084   0.016   0.025  0.0334  0.0414  0.0504  0.0584  0.0664  0.0748
           27          PC   0.087  0.0994  0.1188   0.148  0.2304  0.4067  0.7778  0.8813  0.9186  0.9452
           28          PC  0.9572  0.9684  0.9798  0.9898     1.0
           29          IN      15 02JAN94       0
           30          JD   3.168     5.0
                       * 6-hour distribution, pattern 2.3
           31          PC     0.0   0.011  0.0173  0.0267  0.0387   0.049  0.0593  0.0693  0.0797  0.0903
           32          PC   0.103  0.1173  0.1383  0.1827  0.2693   0.458   0.686  0.8233  0.8893  0.9293
           33          PC  0.9487   0.962  0.9743  0.9877     1.0
           34          IN      15 02JAN94       0
           35          JD   3.102    10.0
                       * 6-hour distribution, pattern 2.7
           36          PC     0.0  0.0134  0.0189  0.0287  0.0443  0.0574  0.0694  0.0818  0.0949  0.1076
           37          PC  0.1223  0.1382  0.1604  0.2063  0.2902  0.4664  0.6764  0.8069  0.8765  0.9189
           38          PC  0.9471  0.9608  0.9735  0.9873     1.0

           39          KK      68
           40          KM   ************************************************************************
           41          KM   **   SUB-WATERSHED E   ***************************************************
           42          KM   ************************************************************************
           43          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
           44          KM   L=0.96      Lca=0.33     S=45.58      Kn=0.050      LAG=22
           45          KM   S-GRAPH TYPE=DESERT RANGELAND
           46          KO       0       0     0.0       1      22
           47          BA  0.4130
           48          LG   0.374   0.334   4.366   0.374     0.0
1                                                      HEC-1 INPUT
PAGE  2

         LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           49          UI     0.0  257.36  526.31   199.5   61.33   15.58     0.0

           50          KK   E1-E2   CNAME      E1
           51          KM   STORAGE ROUTE FROM E1 TO E2 THROUGH SPRR TRESTLE
           52          KO       0       0     0.0       0      22
           53          RS       1    ELEV   871.0     0.0
           54          SV     0.0    1.39    5.84   13.36   41.09   96.81  182.04   292.0  426.27  581.71
           55          SV  756.67  957.16  1179.1  1179.1  1179.1  1179.1  1179.1  1179.1  1179.1  1179.1
           56          SE   872.0   874.0   876.0   878.0   880.0   882.0   884.0   886.0   888.0   890.0
           57          SE   892.0   894.0   896.0   896.0   896.0   896.0   896.0   896.0   896.0   896.0
           58          SQ     0.0   100.0   240.0   360.0   480.0   600.0  1020.0  2000.0  2760.0  2760.0
           59          SQ  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0
           60          SE  873.07  874.07  875.07  876.07  877.07  878.07  879.07  880.07  881.07  881.07
           61          SE  881.07  881.07  881.07  881.07  881.07  881.07  881.07  881.07  881.07  881.07

           62          KK      59
           63          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
           64          KM   L=0.50      Lca=0.17     S=49.34      Kn=0.200      LAG=53
           65          KM   S-GRAPH TYPE=AGRICULTURE
           66          KO       0       0     0.0       1      22
           67          BA  0.2519
           68          LG    0.46    0.23   4.174   0.497   8.088
           69          UI     0.0    22.5   84.15  139.94  135.77  109.93   62.24   38.79   21.52    13.5
           70          UI    9.12    2.19    2.19    2.19    2.19    2.19     0.0

           71          KK      E2
           72          KM   COMBINE STORAGE HYDROGRAPH FROM E1 WITH RUNOFF FROM 59 @ E2
           73          ZW   A=RBW B=E2 C=FLOW E=15MIN F=100Y6H-EX
           74          KO       0       0     0.0       0      22
           75          HC       2

           76          KK   RIDF
           77          KM   ************************************************************************
           78          KM   **   SUB-WATERSHED F   ***************************************************
           79          KM   ************************************************************************
           80          KM   FALSE BASIN TO SIMULATE INFLOW FROM RID
           81          BA  0.0001
           82          ZR  =QI A=RID RID B=8199 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID-100-06E

           83          KK  F1S-F2   CNAME     F1S
           84          KM   ROUTE INFLOW FROM RID CONCENTRATED AT F1S TO F2 (CHANNEL A)
           85          KO       0       0     0.0       0      22
           86          RS       1    FLOW     0.0     0.0
           87          RC     0.1     0.1     0.1  3225.0   0.004     0.0
           88          RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
           89          RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0
```

```
         90        KK      27
         91        KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
         92        KM    L=0.82      Lca=0.41      S=14.59      Kn=0.200      LAG=115
         93        KM    S-GRAPH TYPE=AGRICULTURE
         94        KO       0         0      0.0         1        22
         95        BA   0.2410
         96        LG    0.493     0.246     3.979     0.567     1.418
         97        UI      0.0      7.73     11.05     25.19     43.69     53.56     61.68     64.93     61.32     56.09
1                                                      HEC-1 INPUT
PAGE  3

       LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

         98        UI    48.56     42.77     30.31     23.36      21.4     13.77      11.2      9.22      7.06      6.07
         99        UI     4.39      4.39      2.56      0.97      0.97      0.97      0.97      0.97      0.97      0.97
        100        UI     0.97      0.97      0.97      0.97      0.97       0.0

        101        KK       F2     CNAME     F2-F3
        102        KM    COMBINE ROUTED HYDROGRAPH FROM F1S WITH RUNOFF FROM 27 @ F2
        103        KO        0         0       0.0         0        22
        104        HC        2

        105        KK    F2-F3     CNAME        F2
        106        KM    ROUTE HYDRPGRAPH FROM F2 TO F3 (CHANNEL A)
        107        KO        0         0       0.0         0        22
        108        RS        8      FLOW       0.0       0.0
        109        RC      0.1       0.1       0.1 5241.87    0.0057       0.0
        110        RX      0.0     250.0     500.0     750.0    1000.0    1333.3    1666.6    2000.0
        111        RY     10.0       7.5       5.0       2.5       0.0       3.3       6.6      10.0

        112        KK       29
        113        KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
        114        KM    L=1.47      Lca=0.73      S=22.92      Kn=0.200      LAG=163
        115        KM    S-GRAPH TYPE=AGRICULTURE
        116        KO        0         0       0.0         1        22
        117        BA   0.9987
        118        LG      0.5      0.25     3.977     0.548       0.0
        119        UI      0.0      22.6      22.6     40.44     67.42    122.16    127.17    170.96    171.63     189.8
        120        UI    189.8    185.58    158.17    166.76    141.69    122.98    113.44     86.27      70.6     65.75
        121        UI    56.62     40.79      36.5     28.42     27.23     20.63     20.63     15.99     12.82     12.82
        122        UI    12.82      7.09      2.82      2.82      2.82      2.82      2.82      2.82      2.82      2.82
        123        UI     2.82      2.82      2.82      2.82      2.82      2.82      2.82      2.82      2.82       0.0

        124        KK       F3     CNAME     F3-F4
        125        KM    COMBINE ROUTED HYDROGRAPH FROM F2 WITH RUNOFF FROM 29 @ F3
        126        KO        0         0       0.0         0        22
        127        HC        2

        128        KK    F3-F4     CNAME        F3
        129        KM    ROUTE HYDRPGRAPH FROM F3 TO F4 (CHANNEL A)
        130        KO        0         0       0.0         0        22
        131        RS        7      FLOW       0.0       0.0
        132        RC      0.1       0.1       0.1 5501.87    0.0058       0.0
        133        RX      0.0     250.0     500.0     750.0    1000.0    1333.3    1666.6    2000.0
        134        RY     10.0       7.5       5.0       2.5       0.0       3.3       6.6      10.0

        135        KK       41
        136        KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
        137        KM    L=1.54      Lca=0.77      S=23.99      Kn=0.200      LAG=168
        138        KM    S-GRAPH TYPE=AGRICULTURE
        139        KO        0         0       0.0         1        22
        140        BA   1.2021
        141        LG      0.5      0.25     3.965     0.474       0.0
        142        UI      0.0     26.39     26.39      45.2     74.92    131.88    154.05    177.32    206.14    221.65
        143        UI   221.65    221.65     192.1    189.15    190.62    138.53    151.39    105.43     94.19     76.42
        144        UI    81.61     52.05      44.8     39.98      32.6     29.54     24.09     24.09     16.95     14.98
        145        UI    14.98     14.98       7.5       3.3       3.3       3.3       3.3       3.3       3.3       3.3
        146        UI      3.3       3.3       3.3       3.3       3.3       3.3       3.3       3.3       3.3       3.3
1                                                      HEC-1 INPUT
PAGE  4

       LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

        147        UI      3.3       0.0

        148        KK       F4     CNAME     F4-F5B
        149        KM    COMBINE ROUTED HYDROGRAPH FROM F3 WITH RUNOFF FROM 41 @ F4
        150        KO        0         0       0.0         0        22
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151         HC       2

152         KK  F4-F5B   CNAME       F4
153         KM   ROUTE HYDRPGRAPH FROM F4 TO F5B (CHANNEL A)
154         KO       0        0      0.0       0      22
155         RS       4     FLOW      0.0     0.0
156         RC     0.1      0.1      0.1 3704.65  0.0065     0.0
157         RX     0.0    250.0    500.0   750.0  1000.0  1333.3  1666.6  2000.0
158         RY    10.0      7.5      5.0     2.5     0.0     3.3     6.6    10.0

159         KK     52B
160         KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
161         KM   L=0.71      Lca=0.32     S=32.56      Kn=0.200     LAG=85
162         KM   S-GRAPH TYPE=AGRICULTURE
163         KO       0        0      0.0       1      22
164         BA  0.4953
165         LG   0.491    0.251    4.087    0.53   0.349
166         UI     0.0    21.49    47.96  115.57  153.43   180.5  170.48  157.82  118.28   85.92
167         UI   63.75    43.62    30.66   22.85   17.91    12.2   10.93    2.69    2.69    2.69
168         UI    2.69     2.69     2.69    2.69    2.69    2.69     0.0

169         KK     F5B   CNAME F5B-F6B
170         KM   COMBINE ROUTED HYDROGRAPH FROM F4 WITH RUNOFF FROM 52B @ F5B
171         KO       0        0      0.0       0      22
172         HC       2

173         KK  F5BF6B   CNAME      F5B
174         KM   STORAGE ROUTE FROM F5B TO F6B THROUGH SPRR TRESTLE
175         KO       0        0      0.0       0      22
176         RS       1     ELEV    886.0     0.0
177         SV     0.0     0.08     0.94    6.13   37.02  122.46  262.93   479.0  749.83  749.83
178         SV  749.83   749.83   749.83  749.83  749.83  749.83  749.83  749.83  749.83  749.83
179         SE   886.0    888.0    890.0   892.0   894.0   896.0   898.0   900.0   902.0   902.0
180         SE   902.0    902.0    902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0
181         SQ     0.0     80.0    120.0   230.0  1145.0  1980.0  2670.0  2670.0  2670.0  2670.0
182         SQ  2670.0   2670.0   2670.0  2670.0  2670.0  2670.0  2670.0  2670.0  2670.0  2670.0
183         SE   886.0   887.07   888.07  889.07  890.07  891.07  892.07  892.07  892.07  892.07
184         SE  892.07   892.07   892.07  892.07  892.07  892.07  892.07  892.07  892.07  892.07

185         KK     60B
186         KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
187         KM   L=1.03      Lca=0.35     S=22.68      Kn=0.200     LAG=108
188         KM   S-GRAPH TYPE=AGRICULTURE
189         KO       0        0      0.0       1      22
190         BA  0.5744
191         LG   0.462    0.249    4.158   0.551   3.254
192         UI     0.0    19.61    30.14   73.81  110.38  144.98  164.75  164.75  142.78  142.23
193         UI  106.31    87.94     64.4   56.91    35.6   28.82   23.22   17.91   14.49   11.13
194         UI   11.13     3.84     2.45    2.45    2.45    2.45    2.45    2.45    2.45    2.45
195         UI    2.45     2.45     2.45     0.0
1                                                   HEC-1 INPUT
PAGE  5

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


196         KK     F6B
197         KM   COMBINE STORAGE HYDROGRAPH FROM F5B WITH RUNOFF FROM 60B @ F6B
198         ZW   A=RBW B=F6B C=FLOW E=15MIN F=100Y6H-EX
199         KO       0        0      0.0       0      22
200         HC       2

201         KK     52A
202         KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
203         KM   L=0.92      Lca=0.57     S=6.91      Kn=0.200     LAG=156
204         KM   S-GRAPH TYPE=AGRICULTURE
205         KO       0        0      0.0       1      22
206         BA  0.3127
207         LG   0.497     0.25    3.966   0.439   0.364
208         UI     0.0     7.39     7.39   14.03   25.52   42.85   41.09   54.59   61.74    62.1
209         UI    62.1    55.89    52.16   54.02   38.81   41.05   29.04   24.79   21.13   20.13
210         UI   13.59    11.94     9.45    8.85    6.75    6.75    4.89     4.2     4.2     4.2
211         UI    1.32     0.92     0.92    0.92    0.92    0.92    0.92    0.92    0.92    0.92
212         UI    0.92     0.92     0.92    0.92    0.92    0.92    0.92     0.0

213         KK  F5AF6A   CNAME      F5A
214         KM   STORAGE ROUTE FROM F5A TO F6A THROUGH SPRR TRESTLE
215         KO       0        0      0.0       0      22
216         RS       1     ELEV    894.0     0.0
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217    SV     0.0    0.02    0.64   12.91   61.76   61.76   61.76   61.76   61.76   61.76
218    SV   61.76   61.76   61.76   61.76   61.76   61.76   61.76   61.76   61.76   61.76
219    SE   894.0   896.0   898.0   900.0   902.0   902.0   902.0   902.0   902.0   902.0
220    SE   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0
221    SQ     0.0    58.1   112.2   146.6   174.0   198.5   218.5   237.6   255.3   271.8
222    SQ   287.4   302.2   316.3   329.7   342.7   355.2   367.2   378.9   401.2   422.3
223    SE   894.0   896.4   896.9   897.4   897.9   898.4   898.9   899.4   899.9   900.4
224    SE   900.9   901.4   901.9   902.4   902.9   903.4   903.9   904.4   905.4   906.4

225    KK     60A
226    KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
227    KM   L=1.07      Lca=0.46     S=27.51      Kn=0.200      LAG=117
228    KM   S-GRAPH TYPE=AGRICULTURE
229    KO       0       0     0.0       1      22
230    BA  0.4117
231    LG   0.493   0.249   4.045   0.541   0.795
232    UI     0.0   12.98   18.15   40.42   73.45   89.47  100.76  109.02  105.38   91.39
233    UI   88.17   72.54   53.81   42.04   38.73   24.09   20.15   16.03   12.52   11.64
234    UI    7.37    7.37    6.45    1.62    1.62    1.62    1.62    1.62    1.62    1.62
235    UI    1.62    1.62    1.62    1.62    1.62     0.0

236    KK     F6A
237    KM   COMBINE STORAGE HYDROGRAPH FROM F5A WITH RUNOFF FROM 60A @ F6A
238    ZW   A=RBW B=F6A C=FLOW E=15MIN F=100Y6H-EX
239    KO       0       0     0.0       0      22
240    HC       2
1                                   HEC-1 INPUT
PAGE  6

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


241    KK   RIDG
242    KM   ***************************************************************************
243    KM   **    SUB-WATERSHED G    *****************************************************
244    KM   ***************************************************************************
245    KM   FALSE BASIN TO SIMULATE INFLOW FROM RID
246    BA  0.0001
247    ZR  =QI A=RID RID B=13399 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID-100-06E

248    KK  G3S-G4   CNAME      G3S
249    KM   ROUTE INFLOW FROM RID CONCENTRATED AT G3S TO G4 (CHANNEL A)
250    KO       0       0     0.0       0      22
251    RS       1    FLOW     0.0     0.0
252    RC     0.1     0.1     0.1  4594.0   0.004     0.0
253    RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
254    RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

255    KK      28
256    KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
257    KM   L=1.02      Lca=0.51     S=16.68      Kn=0.200      LAG=132
258    KM   S-GRAPH TYPE=AGRICULTURE
259    KO       0       0     0.0       1      22
260    BA  0.3347
261    LG   0.497   0.249   4.178   0.467   0.543
262    UI     0.0    9.35   10.92    23.2   45.57   53.95   69.13   78.56   78.56   75.94
263    UI   65.47   68.35   49.76   47.59   34.97   27.16   26.43   17.09   14.62   11.55
264    UI    9.62    8.54    6.55    5.31    5.31    3.82    1.17    1.17    1.17    1.17
265    UI    1.17    1.17    1.17    1.17    1.17    1.17    1.17    1.17    1.17    1.17
266    UI     0.0

267    KK      G4   CNAME   G4-G5
268    KM   COMBINE ROUTED HYDROGRAPH FROM G3S WITH RUNOFF FROM 28 @ G4
269    KO       0       0     0.0       0      22
270    HC       2

271    KK   G4-G5   CNAME       G4
272    KM   ROUTE HYDRPGRAPH FROM G4 TO G5 (CHANNEL A)
273    KO       0       0     0.0       0      22
274    RS      11    FLOW     0.0     0.0
275    RC     0.1     0.1     0.1 7127.48  0.0045     0.0
276    RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
277    RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

278    KK      30
279    KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
280    KM   L=1.55      Lca=0.78     S=21.93      Kn=0.200      LAG=172
281    KM   S-GRAPH TYPE=AGRICULTURE
282    KO       0       0     0.0       1      22
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            283         BA  0.9830
            284         LG   0.444     0.25    4.028    0.469    8.734
            285         UI     0.0    21.08    21.08     34.8     57.4    101.7   123.34    132.0   163.67   177.05
            286         UI  177.05   177.05   161.31   147.54   161.39   117.56   117.82    99.14    80.48    64.92
            287         UI   61.01    54.87    38.92    34.05    28.26    26.04    20.78    19.24    18.25    11.96
            288         UI   11.96    11.96    11.96     3.63     2.63     2.63     2.63     2.63     2.63     2.63
            289         UI    2.63     2.63     2.63     2.63     2.63     2.63     2.63     2.63     2.63     2.63
1                                                     HEC-1 INPUT
PAGE  7

          LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

            290         UI    2.63     2.63      0.0

            291         KK      G5    CNAME    G5-G6
            292         KM   COMBINE ROUTED HYDROGRAPH FROM G4 WITH RUNOFF FROM 30 @ G5
            293         KO       0        0      0.0        0       22
            294         HC       2

            295         KK   G5-G6    CNAME       G5
            296         KM   ROUTE HYDRPGRAPH FROM G5 TO G6 (CHANNEL A)
            297         KO       0        0      0.0        0       22
            298         RS       8     FLOW      0.0      0.0
            299         RC     0.1      0.1      0.1  5820.25   0.0055      0.0
            300         RX     0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
            301         RY    10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

            302         KK      42
            303         KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
            304         KM   L=1.56      Lca=0.78      S=22.73      Kn=0.200      LAG=172
            305         KM   S-GRAPH TYPE=AGRICULTURE
            306         KO       0        0      0.0        1       22
            307         BA  0.7784
            308         LG   0.497     0.25    4.279    0.452    0.465
            309         UI     0.0    16.69    16.69    27.56    45.45    80.53    97.66   104.52    129.6   140.19
            310         UI  140.19   140.19   127.73   116.82   127.79    93.09    93.29     78.5    63.72     51.4
            311         UI   48.31    43.45    30.82    26.96    22.38    20.62    16.46    15.24    14.45     9.47
            312         UI    9.47     9.47     9.47     2.87     2.09     2.09     2.09     2.09     2.09     2.09
            313         UI    2.09     2.09     2.09     2.09     2.09     2.09     2.09     2.09     2.09     2.09
            314         UI    2.09     2.09      0.0

            315         KK      G6    CNAME    G6-G7
            316         KM   COMBINE ROUTED HYDROGRAPH FROM G5 WITH RUNOFF FROM 42 @ G6
            317         KO       0        0      0.0        0       22
            318         HC       2

            319         KK   G6-G7    CNAME       G6
            320         KM   ROUTE HYDRPGRAPH FROM G6 TO G7 (CHANNEL A)
            321         KO       0        0      0.0        0       22
            322         RS       4     FLOW      0.0      0.0
            323         RC     0.1      0.1      0.1  2613.05   0.0069      0.0
            324         RX     0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
            325         RY    10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

            326         KK      53
            327         KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
            328         KM   L=0.91      Lca=0.46      S=23.93      Kn=0.200      LAG=113
            329         KM   S-GRAPH TYPE=AGRICULTURE
            330         KO       0        0      0.0        1       22
            331         BA  0.3385
            332         LG     0.5     0.25    3.997    0.444      0.0
            333         UI     0.0    11.05    16.13     37.6    62.38    76.97    90.56    92.81     85.6    80.26
            334         UI   66.07    58.87    41.62    31.91    28.17    18.87    14.88    12.13    10.09     7.44
            335         UI    6.27     6.27     1.84     1.38     1.38     1.38     1.38     1.38     1.38     1.38
            336         UI    1.38     1.38     1.38     1.38      0.0
1                                                     HEC-1 INPUT
PAGE  8

          LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


            337         KK      G7    CNAME    G7-G8
            338         KM   COMBINE ROUTED HYDROGRAPH FROM G6 WITH RUNOFF FROM 53 @ G7
            339         KO       0        0      0.0        0       22
            340         HC       2

            341         KK   G7-G8    CNAME       G7
            342         KM   STORAGE ROUTE FROM G7 TO G8 THROUGH SPRR TRESTLE
            343         KO       0        0      0.0        0       22
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Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


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RS      1    ELEV   888.0     0.0
SV    0.0     0.6    4.25   26.94  108.66  257.97   449.6   449.6   449.6   449.6
SV  449.6   449.6   449.6   449.6   449.6   449.6   449.6   449.6   449.6   449.6
SE  888.0   890.0   892.0   894.0   896.0   898.0   900.0   900.0   900.0   900.0
SE  900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0
SQ    0.0   100.0   200.0   480.0  1480.0  2060.0  2520.0  2900.0  2900.0  2900.0
SQ 2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0
SE  888.0  888.07  889.07  890.07  891.07  892.07  893.07  894.07  894.07  894.07
SE 894.07  894.07  894.07  894.07  894.07  894.07  894.07  894.07  894.07  894.07

KK     61
KM  THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
KM  L=0.90     Lca=0.45     S=23.00     Kn=0.200     LAG=113
KM  S-GRAPH TYPE=AGRICULTURE
KO      0       0     0.0       1      22
BA 0.5081
LG  0.484   0.248   3.965   0.464   2.234
UI    0.0   16.58   24.21   56.43   93.62  115.52  135.92   139.3  128.47  120.46
UI  99.16   88.35   62.47    47.9   42.28   28.31   22.33   18.21   15.14   11.17
UI   9.41    9.41    2.76    2.07    2.07    2.07    2.07    2.07    2.07    2.07
UI   2.07    2.07    2.07    2.07     0.0

KK     G8
KM  COMBINE STORAGE HYDROGRAPH FROM G7 WITH RUNOFF FROM 61 @ G8
ZW  A=RBW B=G8 C=FLOW E=15MIN F=100Y6H-EX
KO      0       0     0.0       0      22
HC      2

KK  RIDH
KM  ***********************************************************************
KM  **   SUB-WATERSHED H   ************************************************
KM  ***********************************************************************
KM  FALSE BASIN TO SIMULATE INFLOW FROM RID
BA 0.0001
ZR =QI A=RID RID B=19799 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID-100-06E

KK H3S-H4   CNAME     H3S
KM  ROUTE INFLOW FROM RID CONCENTRATED AT H3S TO H4 (CHANNEL A)
KO      0       0     0.0       0      22
RS      1    FLOW     0.0     0.0
RC    0.1     0.1     0.110193.17   0.005     0.0
RX    0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
RY   10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0
                                HEC-1 INPUT
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1
PAGE 9

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LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

KK     31
KM  THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
KM  L=1.93     Lca=0.97     S=26.40     Kn=0.200     LAG=196
KM  S-GRAPH TYPE=AGRICULTURE
KO      0       0     0.0       1      22
BA 1.0788
KM  ENTELLUS CHANGED THE IA TO 1.0 INCHES
KM  ENTELLUS CHANGED THE DTHETA TO 0.19
LG    1.0    0.19   4.018   0.456   0.852
UI    0.0    20.3    20.3   26.01   42.62   75.47  110.82  116.22  130.81  156.48
UI 170.49  170.49  170.49  170.49  143.97  142.08   158.6  111.16  110.82  106.73
UI  79.11   71.61    59.1   60.85   49.19   37.72   32.79   29.13   25.07   23.42
UI  18.53   18.53   16.79   11.52   11.52   11.52   11.52    7.81    2.54    2.54
UI   2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54
UI   2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54     0.0

KK     H4   CNAME   H4-H5
KM  COMBINE ROUTED HYDROGRAPH FROM H3S WITH RUNOFF FROM 31 @ H4
KO      0       0     0.0       0      22
HC      2

KK  H4-H5   CNAME      H4
KM  ROUTE HYDRPGRAPH FROM H4 TO H5 (CHANNEL B)
KO      0       0     0.0       0      22
RS      5    FLOW     0.0     0.0
RC    0.1    0.02     0.1 5382.76  0.0059     0.0
RX    0.0  1000.0  1006.0  1010.0  1050.0  1054.0  1060.0  2060.0
RY   10.0     0.0     0.0     1.0     1.0     0.0     0.0    10.0

KK     43
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           410          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
           411          KM    L=1.92      Lca=0.96      S=20.85      Kn=0.200      LAG=204
           412          KM    S-GRAPH TYPE=AGRICULTURE
           413          KO       0        0     0.0        1       22
           414          BA   1.0022
           415          KM    ENTELLUS CHANGED THE IA TO 1.0 INCHES
           416          KM    ENTELLUS CHANGED THE DTHETA TO 0.19
           417          LG      1.0     0.19   3.958   0.425     0.66
           418          UI      0.0    18.12   18.12   20.99    38.04    57.93     94.1   108.05   107.28    138.7
           419          UI   144.35   152.18  152.18  152.18   142.03   126.81   135.44   126.81    95.11   102.81
           420          UI     87.2    69.17   61.58   52.32    54.94    42.82    33.73    29.26    26.57    22.38
           421          UI    21.91    16.54   16.54   16.54    10.58    10.28    10.28    10.28    10.28     2.91
           422          UI     2.26     2.26    2.26    2.26     2.26     2.26     2.26     2.26     2.26     2.26
           423          UI     2.26     2.26    2.26    2.26     2.26     2.26     2.26     2.26     2.26     2.26
           424          UI     2.26      0.0

           425          KK       H5    CNAME    H5-H6
           426          KM    COMBINE ROUTED HYDROGRAPH FROM H4 WITH RUNOFF FROM 43 @ H5
           427          KO       0        0     0.0        0       22
           428          HC       2
1                                                  HEC-1 INPUT
PAGE 10

          LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


           429          KK    H5-H6    CNAME       H5
           430          KM    ROUTE HYDRPGRAPH FROM H5 TO H6 (CHANNEL B)
           431          KO       0        0     0.0        0       22
           432          RS       3     FLOW     0.0      0.0
           433          RC      0.1     0.02     0.1 2887.92   0.0049      0.0
           434          RX      0.0   1000.0  1006.0  1010.0   1050.0   1054.0   1060.0   2060.0
           435          RY     10.0      0.0     0.0     1.0      1.0      0.0      0.0     10.0

           436          KK       54
           437          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
           438          KM    L=1.20      Lca=0.60      S=12.35      Kn=0.200      LAG=157
           439          KM    S-GRAPH TYPE=AGRICULTURE
           440          KO       0        0     0.0        1       22
           441          BA   0.3861
           442          KM    ENTELLUS CHANGED THE IA TO 1.0 INCHES
           443          KM    ENTELLUS CHANGED THE DTHETA TO 0.19
           444          LG      1.0     0.19     4.0   0.447      0.0
           445          UI      0.0     9.07    9.07   17.07    30.66    52.22     50.2     67.4    74.77    76.18
           446          UI    76.18    69.41   63.49   68.13    47.62    51.29    35.97     31.2    25.88    25.91
           447          UI    17.01    14.65   12.06    11.2     8.36     8.28     6.51     5.15     5.15     5.15
           448          UI     2.36     1.13    1.13    1.13     1.13     1.13     1.13     1.13     1.13     1.13
           449          UI     1.13     1.13    1.13    1.13     1.13     1.13     1.13      0.0

           450          KK       H6    CNAME    H6-H7
           451          KM    COMBINE ROUTED HYDROGRAPH FROM H5 WITH RUNOFF FROM 54 @ H6
           452          KO       0        0     0.0        0       22
           453          HC       2

           454          KK    H6-H7    CNAME       H6
           455          KM    STORAGE ROUTE FROM H6 TO H7 THROUGH SPRR TRESTLE
           456          KO       0        0     0.0        0       22
           457          RS       1     ELEV   890.0      0.0
           458          SV      0.0     0.45   30.43  148.25   336.08   336.08   336.08   336.08   336.08   336.08
           459          SV   336.08   336.08  336.08  336.08   336.08   336.08   336.08   336.08   336.08   336.08
           460          SE    890.0    892.0   894.0   896.0    898.0    898.0    898.0    898.0    898.0    898.0
           461          SE    898.0    898.0   898.0   898.0    898.0    898.0    898.0    898.0    898.0    898.0
           462          SQ      0.0    185.0   720.0  1025.0   1075.0   1150.0   1355.0   1800.0   1800.0   1800.0
           463          SQ   1800.0   1800.0  1800.0  1800.0   1800.0   1800.0   1800.0   1800.0   1800.0   1800.0
           464          SE    890.0   891.07  893.47  895.47   895.57   895.67   895.77   895.87   895.87   895.87
           465          SE   895.87   895.87  895.87  895.87   895.87   895.87   895.87   895.87   895.87   895.87

           466          KK       62
           467          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
           468          KM    L=0.98      Lca=0.49      S=21.54      Kn=0.200      LAG=122
           469          KM    S-GRAPH TYPE=AGRICULTURE
           470          KO       0        0     0.0        1       22
           471          BA   0.5717
           472          KM    ENTELLUS CHANGED THE IA TO 1.0 INCHES
           473          KM    ENTELLUS CHAGEND THE DTHETA TO 0.19
           474          LG      1.0     0.19   4.203   0.444    0.473
           475          UI      0.0    17.28   22.83   47.88    97.83   104.21   138.24   145.18   145.18   124.21
           476          UI   130.72    91.16   89.45   63.88    49.84    45.53    30.22     24.7    20.76    15.78
           477          UI    14.37     9.81    9.81    8.08     2.16     2.16     2.16     2.16     2.16     2.16
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          478         UI    2.16    2.16    2.16    2.16    2.16    2.16    2.16     0.0
1                                                   HEC-1 INPUT
PAGE 11

         LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


          479         KK      H7
          480         KM    COMBINE STORAGE HYDROGRAPH FROM H6 WITH RUNOFF FROM 62 @ H7
          481         ZW    A=RBW B=H7 C=FLOW E=15MIN F=100Y6H-EX
          482         KO       0       0     0.0       0      22
          483         HC       2

          484         KK    RIDI
          485         KM    ************************************************************************
          486         KM    **    SUB-WATERSHED I    ***************************************************
          487         KM    ************************************************************************
          488         KM    FALSE BASIN TO SIMULATE INFLOW FROM RID
          489         BA  0.0001
          490         ZR   =QI A=RID RID B=24399 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID-100-06E

          491         KK   I2S-I3   CNAME     I2S
          492         KM    ROUTE INFLOW FROM RID CONCENTRATED AT I2S TO I3 (CHANNEL A)
          493         KO       0       0     0.0       0      22
          494         RS       1    FLOW     0.0     0.0
          495         RC     0.1     0.1     0.1 8174.00   0.005     0.0
          496         RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
          497         RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

          498         KK      32
          499         KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          500         KM    L=1.84     Lca=0.92     S=24.34     Kn=0.200     LAG=192
          501         KM    S-GRAPH TYPE=AGRICULTURE
          502         KO       0       0     0.0       1      22
          503         BA  0.8959
          504         LG   0.493   0.249     4.0   0.515   1.146
          505         UI     0.0   17.21   17.21   23.11   36.91   68.18   97.57   94.68  119.26  132.99
          506         UI  144.55  144.55  144.55  139.73  120.46  127.21  121.42   90.35    99.1   77.05
          507         UI   65.71   54.78    48.6    53.0   32.85   29.42   27.69   21.26   21.26    16.6
          508         UI   15.71   15.71   10.39    9.77    9.77    9.77    8.55    2.15    2.15    2.15
          509         UI    2.15    2.15    2.15    2.15    2.15    2.15    2.15    2.15    2.15    2.15
          510         UI    2.15    2.15    2.15    2.15    2.15    2.15    2.15    2.15     0.0

          511         KK      I3   CNAME   I3-I4
          512         KM    COMBINE ROUTED HYDROGRAPH FROM I2S WITH RUNOFF FROM 32 @ I3
          513         KO       0       0     0.0       0      22
          514         HC       2

          515         KK   I3-I4   CNAME      I3
          516         KM    ROUTE HYDRPGRAPH FROM I3 TO I4 (CHANNEL B)
          517         KO       0       0     0.0       0      22
          518         RS      10    FLOW     0.0     0.0
          519         RC     0.1    0.02     0.110387.48  0.0042     0.0
          520         RX     0.0  1000.0  1006.0  1010.0  1050.0  1054.0  1060.0  2060.0
          521         RY    10.0     0.0     0.0     1.0     1.0     0.0     0.0    10.0
1                                                   HEC-1 INPUT
PAGE 12

         LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


          522         KK      44
          523         KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          524         KM    L=1.97     Lca=0.98     S=22.43     Kn=0.200     LAG=205
          525         KM    S-GRAPH TYPE=AGRICULTURE
          526         KO       0       0     0.0       1      22
          527         BA  1.0069
          528         LG   0.474    0.25   4.136   0.485   5.217
          529         UI     0.0   18.11   18.11    20.7   38.04    57.4    93.3  108.09  106.09  139.54
          530         UI  142.37  152.15  152.15  152.15   143.7   126.8  133.98  130.92    95.1  101.27
          531         UI   90.64   69.78   63.13   52.71   54.03   45.67    34.4   29.26   27.49   22.38
          532         UI   22.38   16.93   16.54   16.54   11.59   10.28   10.28   10.28   10.28     4.4
          533         UI    2.26    2.26    2.26    2.26    2.26    2.26    2.26    2.26    2.26    2.26
          534         UI    2.26    2.26    2.26    2.26    2.26    2.26    2.26    2.26    2.26    2.26
          535         UI    2.26    2.26     0.0

          536         KK      I4   CNAME   I4-I5
          537         KM    COMBINE ROUTED HYDROGRAPH FROM I3 WITH RUNOFF FROM 44 @ I4
          538         KO       0       0     0.0       0      22
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      539          HC       2

      540          KK   I4-I5   CNAME      I4
      541          KM   ROUTE HYDRPGRAPH FROM I4 TO I5 (CHANNEL A)
      542          KO       0       0     0.0       0      22
      543          RS       4    FLOW     0.0     0.0
      544          RC     0.1     0.1     0.1 2589.37  0.0035     0.0
      545          RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
      546          RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

      547          KK      55
      548          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
      549          KM   L=0.97     Lca=0.48     S=12.83     Kn=0.200     LAG=133
      550          KM   S-GRAPH TYPE=AGRICULTURE
      551          KO       0       0     0.0       1      22
      552          BA  0.2627
      553          LG     0.5    0.25   4.128   0.446     0.0
      554          UI     0.0    7.29    8.39   17.86    34.8   41.96   53.41    61.2    61.2   59.84
      555          UI    51.0   54.32   38.38   38.38   27.91   21.37   21.37   13.58   11.77     9.0
      556          UI    7.84    6.65    5.51    4.14    4.14    3.58    0.91    0.91    0.91    0.91
      557          UI    0.91    0.91    0.91    0.91    0.91    0.91    0.91    0.91    0.91    0.91
      558          UI     0.0

      559          KK      I5   CNAME   I5-I6
      560          KM   COMBINE ROUTED HYDROGRAPH FROM I4 WITH RUNOFF FROM 55 @ I5
      561          KO       0       0     0.0       0      22
      562          HC       2

      563          KK   I5-I6   CNAME      I5
      564          KM   STORAGE ROUTE FROM I5 TO I6 THROUGH SPRR TRESTLE
      565          KO       0       0     0.0       0      22
      566          RS       1    ELEV   892.0     0.0
      567          SV     0.0     0.1    25.1  124.92  273.66  273.66  273.66  273.66  273.66  273.66
      568          SV  273.66  273.66  273.66  273.66  273.66  273.66  273.66  273.66  273.66  273.66
      569          SE   892.0   894.0   896.0   898.0   900.0   900.0   900.0   900.0   900.0   900.0
      570          SE   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0
1                                                 HEC-1 INPUT
PAGE 13

     LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

      571          SQ     0.0    60.0   150.0   221.0   400.0   830.0  1134.0  1488.0  1892.0  1892.0
      572          SQ  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0
      573          SE  892.00  894.08  895.18  895.88  896.08  896.28  896.38  896.48  896.58  896.58
      574          SE  896.58  896.58  896.58  896.58  896.58  896.58  896.58  896.58  896.58  896.58

      575          KK      63
      576          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
      577          KM   L=0.95     Lca=0.47     S=20.27     Kn=0.200     LAG=120
      578          KM   S-GRAPH TYPE=AGRICULTURE
      579          KO       0       0     0.0       1      22
      580          BA  0.4994
      581          LG   0.396    0.25   4.192   0.398  20.751
      582          UI     0.0   15.35   20.75   44.48   87.02   96.69  122.47  128.92  128.92  107.43
      583          UI  111.73   82.37   73.51   54.08   44.91   35.79   25.69   20.36   16.98   14.01
      584          UI   11.04    8.71    8.71    4.64    1.92    1.92    1.92    1.92    1.92    1.92
      585          UI    1.92    1.92    1.92    1.92    1.92    1.92     0.0

      586          KK      I6
      587          KM   COMBINE STORAGE HYDROGRAPH FROM I5 WITH RUNOFF FROM 63 @ I6
      588          ZW   A=RBW B=I6 C=FLOW E=15MIN F=100Y6H-EX
      589          KO       0       0     0.0       0      22
      590          HC       2

      591          KK   RIDJ
      592          KM   ************************************************************************
      593          KM   **    SUB-WATERSHED J   ****************************************************
      594          KM   ************************************************************************
      595          KM   FALSE BASIN TO SIMULATE INFLOW FROM RID
      596          BA  0.0001
      597          ZR  =QI A=RID RID B=27599 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID-100-06E

      598          KK  J3S-J4   CNAME     J3S
      599          KM   ROUTE INFLOW FROM RID CONCENTRATED AT J3S TO J4 (CHANNEL A)
      600          KO       0       0     0.0       0      22
      601          RS       1    FLOW     0.0     0.0
      602          RC     0.1     0.1     0.1 8056.46   0.007     0.0
      603          RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
      604          RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0
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     605          KK      33
     606          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
     607          KM   L=1.84      Lca=0.92      S=29.30      Kn=0.200      LAG=185
     608          KM   S-GRAPH TYPE=AGRICULTURE
     609          KO       0        0      0.0        1       22
     610          BA  1.0024
     611          LG   0.497    0.249    3.962     0.44    0.529
     612          UI     0.0    19.98    19.98    28.99    46.91    85.21   117.85   108.17    155.0   152.26
     613          UI  167.85   167.85   167.85    149.2   139.88   152.37   115.61   108.99   103.55    77.29
     614          UI    67.9    57.35    62.19    40.17    34.82    32.28    24.96    24.68     19.1    18.24
     615          UI   18.04    11.34    11.34    11.34    11.34     7.21      2.5      2.5      2.5      2.5
     616          UI     2.5      2.5      2.5      2.5      2.5      2.5      2.5      2.5      2.5      2.5
     617          UI     2.5      2.5      2.5      2.5      2.5      2.5      0.0
1                                                 HEC-1 INPUT
PAGE 14

    LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


     618          KK      J4    CNAME    J4-J5
     619          KM   COMBINE ROUTED HYDROGRAPH FROM J3S WITH RUNOFF FROM 33 @ J4
     620          KO       0        0      0.0        0       22
     621          HC       2

     622          KK   J4-J5    CNAME       J4
     623          KM   ROUTE HYDRPGRAPH FROM J4 TO J5 (CHANNEL A)
     624          KO       0        0      0.0        0       22
     625          RS       5     FLOW      0.0      0.0
     626          RC     0.1      0.1      0.1  5307.06   0.0077      0.0
     627          RX     0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
     628          RY    10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

     629          KK     45A
     630          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
     631          KM   L=1.97      Lca=0.99      S=25.14      Kn=0.200      LAG=201
     632          KM   S-GRAPH TYPE=AGRICULTURE
     633          KO       0        0      0.0        1       22
     634          BA  1.0027
     635          LG   0.496     0.25    3.993    0.441    0.243
     636          UI     0.0     18.4     18.4    22.16    38.63    61.78    96.59   109.53   112.56   138.24
     637          UI  152.55   154.54   154.54   154.54   139.08   128.78   137.41   120.73    96.59   109.05
     638          UI   76.17    70.24    57.78    51.92    58.19    35.12     32.2    29.72    24.14    22.73
     639          UI   19.64     16.8     16.8    14.01    10.44    10.44    10.44    10.44     6.53      2.3
     640          UI     2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3
     641          UI     2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3
     642          UI     2.3

     643          KK     J5A    CNAME  J5A-5B
     644          KM   COMBINE ROUTED HYDROGRAPH FROM J4 WITH RUNOFF FROM 45A @ J5A
     645          KO       0        0      0.0        0       22
     646          HC       2

     647          KK  J5A-5B    CNAME      J5A
     648          KM   ROUTE HYDRPGRAPH FROM J5A TO J5B (CHANNEL A)
     649          KO       0        0      0.0        0       22
     650          RS       6     FLOW      0.0      0.0
     651          RC     0.1      0.1      0.1  2736.25   0.0015      0.0
     652          RX     0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
     653          RY    10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

     654          KK     45B
     655          KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
     656          KM   L=0.52      Lca=0.26      S=8.59      Kn=0.200      LAG=89
     657          KM   S-GRAPH TYPE=AGRICULTURE
     658          KO       0        0      0.0        1       22
     659          BA  0.1397
     660          LG   0.351     0.25    3.969    0.417   29.714
     661          UI     0.0     5.79     11.9    30.23     38.5    48.58    48.11    41.75    34.63     28.1
     662          UI   18.91    15.22     9.82     7.25     5.39     4.12     3.29      2.3     0.72     0.72
     663          UI    0.72     0.72     0.72     0.72     0.72     0.72     0.72      0.0
1                                                 HEC-1 INPUT
PAGE 15

    LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


     664          KK     J5B    CNAME   J5B-J6
     665          KM   COMBINE ROUTED HYDROGRAPH FROM J5A WITH RUNOFF FROM 45B @ J5B
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666        KO       0       0     0.0       0      22
667        HC       2

668        KK   J5B-J6   CNAME     J5B
669        KM   STORAGE ROUTE FROM J5B TO J6 THROUGH SPRR TRESTLE
670        KO       0       0     0.0       0      22
671        RS       1    ELEV   892.0     0.0
672        SV     0.0   20.33   91.45  223.99  223.99  223.99  223.99  223.99  223.99  223.99
673        SV  223.99  223.99  223.99  223.99  223.99  223.99  223.99  223.99  223.99  223.99
674        SE   892.0   894.0   896.0   898.0   898.0   898.0   898.0   898.0   898.0   898.0
675        SE   898.0   898.0   898.0   898.0   898.0   898.0   898.0   898.0   898.0   898.0
676        SQ     0.0   150.0   230.0   308.0   825.0  1144.0  1970.0  1970.0  1970.0  1970.0
677        SQ  1970.0  1970.0  1970.0  1970.0  1970.0  1970.0  1970.0  1970.0  1970.0  1970.0
678        SE   892.0  893.68  895.08  895.48  895.68  895.88  896.08  896.08  896.08  896.08
679        SE  896.08  896.08  896.08  896.08  896.08  896.08  896.08  896.08  896.08  896.08

680        KK      64
681        KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
682        KM   L=0.89       Lca=0.45      S=17.94      Kn=0.200      LAG=117
683        KM   S-GRAPH TYPE=AGRICULTURE
684        KO       0       0     0.0       1      22
685        BA  0.4148
686        LG   0.491   0.248   4.357   0.445   1.184
687        UI     0.0   13.07   18.28   40.72   73.99   90.13  101.51  109.82  106.16   92.07
688        UI   88.82   73.07   54.21   42.35   39.02   24.27    20.3   16.15   12.61   11.73
689        UI    7.42    7.42    6.49    1.63    1.63    1.63    1.63    1.63    1.63    1.63
690        UI    1.63    1.63    1.63    1.63    1.63     0.0

691        KK      J6
692        KM   COMBINE STORAGE HYDROGRAPH FROM J5B WITH RUNOFF FROM 64 @ J6
693        ZW   A=RBW B=J6 C=FLOW E=15MIN F=100Y6H-EX
694        KO       0       0     0.0       0      22
695        HC       2
696        ZZ
1
            SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
 LINE     (V) ROUTING         (--->) DIVERSION OR PUMP FLOW

  NO.     (.) CONNECTOR       (<---) RETURN OF DIVERTED OR PUMPED FLOW

  39        68
             V
             V
  50      E1-E2
             .
             .
  62         .           59
             .            .
             .            .
  71        E2............
             .
             .
  76         .         RIDF
             .            V
             .            V
  83         .        F1S-F2
             .            .
             .            .
  90         .            .           27
             .            .            .
             .            .            .
 101         .           F2............
             .            V
             .            V
 105         .         F2-F3
             .            .
             .            .
 112         .            .           29
             .            .            .
             .            .            .
 124         .           F3............
             .            V
             .            V
 128         .         F3-F4
             .            .
             .            .
 135         .            .           41
             .            .            .
```

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
                .                         .
148             .           F4............
                .            V
                .            V
152             .       F4-F5B
                .            .
                .            .
159             .            .          52B
                .            .            .
                .            .            .
169             .          F5B............
                .            V
                .            V
173             .       F5BF6B
                .            .
                .            .
185             .            .          60B
                .            .            .
                .            .            .
196             .          F6B............
                .            .
                .            .
201             .            .          52A
                .            .            V
                .            .            V
213             .            .       F5AF6A
                .            .            .
                .            .            .
225             .            .            .          60A
                .            .            .            .
                .            .            .            .
236             .            .          F6A............
                .            .            .
                .            .            .
241             .            .            .         RIDG
                .            .            .            V
                .            .            .            V
248             .            .            .       G3S-G4
                .            .            .            .
                .            .            .            .
255             .            .            .            .           28
                .            .            .            .            .
                .            .            .            .            .
267             .            .            .           G4............
                .            .            .            V
                .            .            .            V
271             .            .            .        G4-G5
                .            .            .            .
                .            .            .            .
278             .            .            .            .           30
                .            .            .            .            .
                .            .            .            .            .
291             .            .            .           G5............
                .            .            .            V
                .            .            .            V
295             .            .            .        G5-G6
                .            .            .            .
                .            .            .            .
302             .            .            .            .           42
                .            .            .            .            .
                .            .            .            .            .
315             .            .            .           G6............
                .            .            .            V
                .            .            .            V
319             .            .            .        G6-G7
                .            .            .            .
                .            .            .            .
326             .            .            .            .           53
                .            .            .            .            .
                .            .            .            .            .
337             .            .            .           G7............
                .            .            .            V
                .            .            .            V
341             .            .            .        G7-G8
                .            .            .            .
                .            .            .            .
353             .            .            .            .           61
                .            .            .            .            .
                .            .            .            .            .
```

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
364            .           .           .         G8............
               .           .           .           .
               .           .           .           .
369            .           .           .           .       RIDH
               .           .           .           .           V
               .           .           .           .           V
376            .           .           .           .     H3S-H4
               .           .           .           .           .
               .           .           .           .           .
383            .           .           .           .           .          31
               .           .           .           .           .           .
               .           .           .           .           .           .
398            .           .           .           .         H4............
               .           .           .           .           V
               .           .           .           .           V
402            .           .           .           .      H4-H5
               .           .           .           .           .
               .           .           .           .           .
409            .           .           .           .           .          43
               .           .           .           .           .           .
               .           .           .           .           .           .
425            .           .           .           .         H5............
               .           .           .           .           V
               .           .           .           .           V
429            .           .           .           .      H5-H6
               .           .           .           .           .
               .           .           .           .           .
436            .           .           .           .           .          54
               .           .           .           .           .           .
               .           .           .           .           .           .
450            .           .           .           .         H6............
               .           .           .           .           V
               .           .           .           .           V
454            .           .           .           .      H6-H7
               .           .           .           .           .
               .           .           .           .           .
466            .           .           .           .           .          62
               .           .           .           .           .           .
               .           .           .           .           .           .
479            .           .           .           .         H7............
               .           .           .           .           .
               .           .           .           .           .
484            .           .           .           .           .       RIDI
               .           .           .           .           .           V
               .           .           .           .           .           V
491            .           .           .           .           .     I2S-I3
               .           .           .           .           .           .
               .           .           .           .           .           .
498            .           .           .           .           .           .          32
               .           .           .           .           .           .           .
               .           .           .           .           .           .           .
511            .           .           .           .           .         I3............
               .           .           .           .           .           V
               .           .           .           .           .           V
515            .           .           .           .           .      I3-I4
               .           .           .           .           .           .
               .           .           .           .           .           .
522            .           .           .           .           .           .          44
               .           .           .           .           .           .           .
               .           .           .           .           .           .           .
536            .           .           .           .           .         I4............
               .           .           .           .           .           V
               .           .           .           .           .           V
540            .           .           .           .           .      I4-I5
               .           .           .           .           .           .
               .           .           .           .           .           .
547            .           .           .           .           .           .          55
               .           .           .           .           .           .           .
               .           .           .           .           .           .           .
559            .           .           .           .           .         I5............
               .           .           .           .           .           V
               .           .           .           .           .           V
563            .           .           .           .           .      I5-I6
               .           .           .           .           .           .
               .           .           .           .           .           .
575            .           .           .           .           .           .          63
               .           .           .           .           .           .           .
               .           .           .           .           .           .           .
586            .           .           .           .           .         I6............
```

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
              .         .         .         .         .         .
              .         .         .         .         .         .
 591          .         .         .         .         .         .     RIDJ
              .         .         .         .         .         .        V
              .         .         .         .         .         .        V
 598          .         .         .         .         .         .    J3S-J4
              .         .         .         .         .         .        .
              .         .         .         .         .         .        .
 605          .         .         .         .         .         .        .          33
              .         .         .         .         .         .        .           .
              .         .         .         .         .         .        .           .
 618          .         .         .         .         .         .       J4............
              .         .         .         .         .         .        V
              .         .         .         .         .         .        V
 622          .         .         .         .         .         .     J4-J5
              .         .         .         .         .         .        .
              .         .         .         .         .         .        .
 629          .         .         .         .         .         .        .         45A
              .         .         .         .         .         .        .           .
              .         .         .         .         .         .        .           .
 643          .         .         .         .         .         .      J5A............
              .         .         .         .         .         .        V
              .         .         .         .         .         .        V
 647          .         .         .         .         .         .    J5A-5B
              .         .         .         .         .         .        .
              .         .         .         .         .         .        .
 654          .         .         .         .         .         .        .         45B
              .         .         .         .         .         .        .           .
              .         .         .         .         .         .        .           .
 664          .         .         .         .         .         .      J5B............
              .         .         .         .         .         .        V
              .         .         .         .         .         .        V
 668          .         .         .         .         .         .    J5B-J6
              .         .         .         .         .         .        .
              .         .         .         .         .         .        .
 680          .         .         .         .         .         .        .          64
              .         .         .         .         .         .        .           .
              .         .         .         .         .         .        .           .
 691          .         .         .         .         .         .       J6............
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

TIME OF MAX STAGE	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE
+	HYDROGRAPH AT	68	694.	4.50	64.	16.	5.	0.41	
+	ROUTED TO	E1-E2	453.	4.75	62.	16.	5.	0.41	
+	HYDROGRAPH AT	59	203.	4.75	41.	10.	3.	0.25	
+	2 COMBINED AT	E2	625.	4.75	99.	25.	8.	0.66	
+	HYDROGRAPH AT	RIDF	298.	6.25	182.	46.	15.	0.00	
+	ROUTED TO	F1S-F2	238.	7.75	167.	46.	15.	0.00	
+	HYDROGRAPH AT	27	84.	5.75	33.	8.	3.	0.24	
+	2 COMBINED AT	F2	263.	7.50	186.	54.	18.	0.24	
+	ROUTED TO	F2-F3	255.	8.50	182.	54.	18.	0.24	

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)

+	HYDROGRAPH AT	29	213.	6.50	114.	30.	10.	1.00
+	2 COMBINED AT	F3	338.	8.00	253.	82.	27.	1.24
+	ROUTED TO	F3-F4	326.	9.25	249.	82.	27.	1.24
+	HYDROGRAPH AT	41	264.	6.50	144.	39.	13.	1.20
+	2 COMBINED AT	F4	379.	9.00	317.	112.	37.	2.44
+	ROUTED TO	F4-F5B	367.	9.50	314.	112.	37.	2.44
+	HYDROGRAPH AT	52B	233.	5.25	69.	17.	6.	0.50
+	2 COMBINED AT	F5B	362.	9.75	313.	123.	41.	2.94
+	ROUTED TO	F5BF6B	361.	9.75	312.	122.	41.	2.94
+	HYDROGRAPH AT	60B	213.	5.50	80.	20.	7.	0.57
+	2 COMBINED AT	F6B	356.	9.75	335.	134.	45.	3.51
+	HYDROGRAPH AT	52A	88.	6.25	45.	12.	4.	0.31
+	ROUTED TO	F5AF6A	88.	6.25	45.	12.	4.	0.31
+	HYDROGRAPH AT	60A	141.	5.75	56.	14.	5.	0.41
+	2 COMBINED AT	F6A	210.	6.00	96.	25.	8.	0.72
+	HYDROGRAPH AT	RIDG	637.	6.25	202.	50.	17.	0.00
+	ROUTED TO	G3S-G4	371.	7.25	187.	50.	17.	0.00
+	HYDROGRAPH AT	28	107.	5.75	48.	12.	4.	0.33
+	2 COMBINED AT	G4	435.	7.25	227.	63.	21.	0.33
+	ROUTED TO	G4-G5	400.	8.75	219.	63.	21.	0.33
+	HYDROGRAPH AT	30	249.	6.50	140.	38.	13.	0.98
+	2 COMBINED AT	G5	483.	8.50	308.	97.	33.	1.32
+	ROUTED TO	G5-G6	460.	10.00	303.	97.	33.	1.32
+	HYDROGRAPH AT	42	181.	6.50	100.	27.	9.	0.78
+	2 COMBINED AT	G6	476.	9.75	343.	117.	39.	2.10
+	ROUTED TO	G6-G7	470.	10.25	341.	117.	39.	2.10

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)

	HYDROGRAPH AT							
+		53	129.	5.75	50.	13.	4.	0.34
	2 COMBINED AT							
+		G7	469.	10.25	348.	126.	42.	2.43
	ROUTED TO							
+		G7-G8	469.	10.25	345.	126.	42.	2.43
	HYDROGRAPH AT							
+		61	196.	5.75	77.	19.	6.	0.51
	2 COMBINED AT							
+		G8	467.	10.25	363.	139.	47.	2.94
	HYDROGRAPH AT							
+		RIDH	427.	6.50	189.	47.	16.	0.00
	ROUTED TO							
+		H3S-H4	186.	8.50	137.	47.	16.	0.00
	HYDROGRAPH AT							
+		31	173.	6.75	106.	30.	10.	1.08
	2 COMBINED AT							
+		H4	337.	8.00	229.	76.	26.	1.08
	ROUTED TO							
+		H4-H5	314.	8.75	222.	76.	26.	1.08
	HYDROGRAPH AT							
+		43	161.	7.00	102.	29.	10.	1.00
	2 COMBINED AT							
+		H5	403.	8.25	279.	97.	33.	2.08
	ROUTED TO							
+		H5-H6	393.	8.75	278.	97.	33.	2.08
	HYDROGRAPH AT							
+		54	90.	6.50	47.	12.	4.	0.39
	2 COMBINED AT							
+		H6	406.	8.75	290.	104.	35.	2.47
	ROUTED TO							
+		H6-H7	397.	9.00	290.	104.	35.	2.47
	HYDROGRAPH AT							
+		62	167.	6.00	70.	18.	6.	0.57
	2 COMBINED AT							
+		H7	400.	8.75	307.	113.	38.	3.04
	HYDROGRAPH AT							
+		RIDI	373.	6.00	23.	6.	2.	0.00
	ROUTED TO							
+		I2S-I3	56.	6.75	10.	2.	1.	0.00
	HYDROGRAPH AT							
+		32	176.	6.75	106.	29.	10.	0.90
	2 COMBINED AT							
+		I3	231.	6.75	116.	32.	11.	0.90
	ROUTED TO							
+		I3-I4	181.	9.00	104.	32.	11.	0.90
	HYDROGRAPH AT							
+		44	198.	7.00	126.	36.	12.	1.01
	2 COMBINED AT							
+		I4	260.	9.00	177.	61.	20.	1.90
	ROUTED TO							
+		I4-I5	245.	9.50	175.	61.	20.	1.90
	HYDROGRAPH AT							

Pilot Study Area Modeled w/100-Year 6-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)

+		55	85.	6.00	38.	10.	3.	0.26
	2 COMBINED AT							
+		I5	243.	9.50	188.	67.	22.	2.17
	ROUTED TO							
+		I5-I6	220.	9.75	171.	67.	22.	2.17
	HYDROGRAPH AT							
+		63	228.	5.75	97.	25.	8.	0.50
	2 COMBINED AT							
+		I6	250.	5.75	206.	87.	29.	2.66
	HYDROGRAPH AT							
+		RIDJ	237.	6.00	64.	16.	5.	0.00
	ROUTED TO							
+		J3S-J4	82.	7.25	51.	16.	5.	0.00
	HYDROGRAPH AT							
+		33	216.	6.75	127.	35.	12.	1.00
	2 COMBINED AT							
+		J4	292.	7.00	175.	51.	17.	1.00
	ROUTED TO							
+		J4-J5	273.	8.00	170.	51.	17.	1.00
	HYDROGRAPH AT							
+		45A	197.	7.00	123.	34.	11.	1.00
	2 COMBINED AT							
+		J5A	406.	8.00	258.	78.	26.	2.01
	ROUTED TO							
+		J5A-5B	393.	8.75	254.	78.	26.	2.01
	HYDROGRAPH AT							
+		45B	90.	5.25	30.	8.	3.	0.14
	2 COMBINED AT							
+		J5B	393.	8.75	257.	84.	28.	2.14
	ROUTED TO							
+		J5B-J6	222.	10.75	204.	84.	28.	2.14
	HYDROGRAPH AT							
+		64	152.	5.75	61.	16.	5.	0.41
	2 COMBINED AT							
+		J6	222.	10.75	207.	95.	32.	2.56

```
*** NORMAL END OF HEC-1 ***


    -----DSS---ZCLOSE Unit:  71,    File: C:\temp\a1.dss
             Pointer Utilization:  1.44
             Number of Records:   2108
             File Size:  11285.5  Kbytes
             Percent Inactive:   0.0
```

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
1*****************************************
***************************************
 *                                       *                                                                                     *
*
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                                                     *    U.S. ARMY CORPS
OF ENGINEERS      *
 *              JUN   1998               *                                                                                     *    HYDROLOGIC
ENGINEERING CENTER    *
 *             VERSION 4.1               *                                                                                     *          609 SECOND
STREET          *
 *                                       *                                                                                     *       DAVIS,
CALIFORNIA 95616       *
 *  RUN DATE    06JAN05  TIME  14:38:29  *                                                                                     *          (916)
756-1104             *
 *                                       *                                                                                     *
*
 *****************************************
***************************************


                                                      X     X  XXXXXXX   XXXXX          X
                                                      X     X  X        X     X        XX
                                                      X     X  X        X               X
                                                      XXXXXXX  XXXX     X       XXXXX   X
                                                      X     X  X        X               X
                                                      X     X  X        X     X         X
                                                      X     X  XXXXXXX   XXXXX         XXX


            THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND
HEC1KW.

            THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE
INPUT STRUCTURE.
            THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77
VERSION
            NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE
FREQUENCY,
            DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
            KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


1                                                  HEC-1 INPUT
PAGE  1

           LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

             1           ID   Buckeye/Sun Valley ADMS - November 2004
             2           ID   PBS&J - Modelers: Jacob Lesue & Wen Chen
             3           ID   100-year 24-hour
             4           ID   Existing Conditions
             5           ID   Area 1 - RID to BIC (West)
             6           ID   Rainfall Loss Method - Green & Ampt
             7           ID   Unit Hydrograph Method - FCDMC S-Graph
             8           ID   Channel Routing Method - Normal Depth
             9           ID   Land Use - FCDMC GIS Data: mag_landuse (2000)
            10           ID   Soil Data - USDA SCS Soil Survey (1972 & 1981)
            11           ID   Units - L(mi)   Lca(mi)   S(ft/mi)   LAG(min)
                         *DIAGRAM
            12           IT      15 02JAN94       0     400
            13           IO       3
            14           IN      15 02JAN94       0
            15           JD     4.1    0.01
                         * 24-hour distribution
            16           PC     0.0   0.002   0.005   0.008   0.011   0.014   0.017    0.02   0.023   0.026
            17           PC   0.029   0.032   0.035   0.038   0.041   0.044   0.048   0.052   0.056    0.06
            18           PC   0.064   0.068   0.072   0.076    0.08   0.085    0.09   0.095     0.1   0.105
            19           PC    0.11   0.115    0.12   0.126   0.133    0.14   0.147   0.155   0.163   0.172
            20           PC   0.181   0.191   0.203   0.218   0.236   0.257   0.283   0.387   0.663   0.707
            21           PC   0.735   0.758   0.776   0.791   0.804   0.815   0.825   0.834   0.842   0.849
            22           PC   0.856   0.863   0.869   0.875   0.881   0.887   0.893   0.898   0.903   0.908
            23           PC   0.913   0.918   0.922   0.926    0.93   0.934   0.938   0.942   0.946    0.95
            24           PC   0.953   0.956   0.959   0.962   0.965   0.968   0.971   0.974   0.977    0.98
            25           PC   0.983   0.986   0.989   0.992   0.995   0.998     1.0
            26           IN      15 02JAN94       0
            27           JD   3.895    10.0
```

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
                        * 24-hour distribution
          28            PC     0.0   0.002   0.005   0.008   0.011   0.014   0.017    0.02   0.023   0.026
          29            PC   0.029   0.032   0.035   0.038   0.041   0.044   0.048   0.052   0.056    0.06
          30            PC   0.064   0.068   0.072   0.076    0.08   0.085    0.09   0.095     0.1   0.105
          31            PC    0.11   0.115    0.12   0.126   0.133    0.14   0.147   0.155   0.163   0.172
          32            PC   0.181   0.191   0.203   0.218   0.236   0.257   0.283   0.387   0.663   0.707
          33            PC   0.735   0.758   0.776   0.791   0.804   0.815   0.825   0.834   0.842   0.849
          34            PC   0.856   0.863   0.869   0.875   0.881   0.887   0.893   0.898   0.903   0.908
          35            PC   0.913   0.918   0.922   0.926    0.93   0.934   0.938   0.942   0.946    0.95
          36            PC   0.953   0.956   0.959   0.962   0.965   0.968   0.971   0.974   0.977    0.98
          37            PC   0.983   0.986   0.989   0.992   0.995   0.998     1.0
          38            IN      15 02JAN94       0
          39            JD   3.764    20.0
                        * 24-hour distribution
          40            PC     0.0   0.002   0.005   0.008   0.011   0.014   0.017    0.02   0.023   0.026
          41            PC   0.029   0.032   0.035   0.038   0.041   0.044   0.048   0.052   0.056    0.06
          42            PC   0.064   0.068   0.072   0.076    0.08   0.085    0.09   0.095     0.1   0.105
          43            PC    0.11   0.115    0.12   0.126   0.133    0.14   0.147   0.155   0.163   0.172
          44            PC   0.181   0.191   0.203   0.218   0.236   0.257   0.283   0.387   0.663   0.707
          45            PC   0.735   0.758   0.776   0.791   0.804   0.815   0.825   0.834   0.842   0.849
          46            PC   0.856   0.863   0.869   0.875   0.881   0.887   0.893   0.898   0.903   0.908
          47            PC   0.913   0.918   0.922   0.926    0.93   0.934   0.938   0.942   0.946    0.95
          48            PC   0.953   0.956   0.959   0.962   0.965   0.968   0.971   0.974   0.977    0.98
          49            PC   0.983   0.986   0.989   0.992   0.995   0.998     1.0
1                                                        HEC-1 INPUT
PAGE  2

        LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


          50            KK      68
          51            KM   ***************************************************************************
          52            KM   **    SUB-WATERSHED E    ****************************************************
          53            KM   ***************************************************************************
          54            KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          55            KM   L=0.96      Lca=0.33      S=45.58      Kn=0.050      LAG=22
          56            KM   S-GRAPH TYPE=DESERT RANGELAND
          57            KO       0       0     0.0       1      22
          58            BA  0.4130
          59            LG   0.374   0.334   4.366   0.374     0.0
          60            UI     0.0  257.36  526.31   199.5   61.33   15.58     0.0

          61            KK   E1-E2   CNAME      E1
          62            KM   STORAGE ROUTE FROM E1 TO E2 THROUGH SPRR TRESTLE
          63            KO       0       0     0.0       0      22
          64            RS       1    ELEV   871.0     0.0
          65            SV     0.0    1.39    5.84   13.36   41.09   96.81  182.04   292.0  426.27  581.71
          66            SV  756.67  957.16  1179.1  1179.1  1179.1  1179.1  1179.1  1179.1  1179.1  1179.1
          67            SE   872.0   874.0   876.0   878.0   880.0   882.0   884.0   886.0   888.0   890.0
          68            SE   892.0   894.0   896.0   896.0   896.0   896.0   896.0   896.0   896.0   896.0
          69            SQ     0.0   100.0   240.0   360.0   480.0   600.0  1020.0  2000.0  2760.0  2760.0
          70            SQ  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0  2760.0
          71            SE  873.07  874.07  875.07  876.07  877.07  878.07  879.07  880.07  881.07  881.07
          72            SE  881.07  881.07  881.07  881.07  881.07  881.07  881.07  881.07  881.07  881.07

          73            KK      59
          74            KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          75            KM   L=0.50      Lca=0.17      S=49.34      Kn=0.200      LAG=53
          76            KM   S-GRAPH TYPE=AGRICULTURE
          77            KO       0       0     0.0       1      22
          78            BA  0.2519
          79            LG    0.46    0.23   4.174   0.497   8.088
          80            UI     0.0    22.5   84.15  139.94  135.77  109.93   62.24   38.79   21.52    13.5
          81            UI    9.12    2.19    2.19    2.19    2.19    2.19     0.0

          82            KK      E2
          83            KM   COMBINE STORAGE HYDROGRAPH FROM E1 WITH RUNOFF FROM 59 @ E2
          84            ZW   A=RBW B=E2 C=FLOW E=15MIN F=100Y24H-EX
          85            KO       0       0     0.0       0      22
          86            HC       2

          87            KK   RIDF
          88            KM   ***************************************************************************
          89            KM   **    SUB-WATERSHED F    ****************************************************
          90            KM   ***************************************************************************
          91            KM   FALSE BASIN TO SIMULATE INFLOW FROM RID
          92            BA  0.0001
          93            ZR  =QI A=RID RID B=8199 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID100-24E
1                                                        HEC-1 INPUT
PAGE  3
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Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


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LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                KK  F1S-F2   CNAME     F1S
                KM   ROUTE INFLOW FROM RID CONCENTRATED AT F1S TO F2 (CHANNEL A)
                KO       0       0     0.0       0      22
                RS       1    FLOW     0.0     0.0
                RC     0.1     0.1     0.1  3225.0   0.004     0.0
                RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
                RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

                KK      27
                KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
                KM   L=0.82      Lca=0.41      S=14.59      Kn=0.200      LAG=115
                KM   S-GRAPH TYPE=AGRICULTURE
                KO       0       0     0.0       1      22
                BA  0.2410
                LG   0.493   0.246   3.979   0.567   1.418
                UI     0.0    7.73   11.05   25.19   43.69   53.56   61.68   64.93   61.32   56.09
                UI   48.56   42.77   30.31   23.36    21.4   13.77    11.2    9.22    7.06    6.07
                UI    4.39    4.39    2.56    0.97    0.97    0.97    0.97    0.97    0.97    0.97
                UI    0.97    0.97    0.97    0.97    0.97     0.0

                KK      F2   CNAME   F2-F3
                KM   COMBINE ROUTED HYDROGRAPH FROM F1S WITH RUNOFF FROM 27 @ F2
                KO       0       0     0.0       0      22
                HC       2

                KK   F2-F3   CNAME      F2
                KM   ROUTE HYDRPGRAPH FROM F2 TO F3 (CHANNEL A)
                KO       0       0     0.0       0      22
                RS       8    FLOW     0.0     0.0
                RC     0.1     0.1     0.1 5241.87  0.0057     0.0
                RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
                RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

                KK      29
                KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
                KM   L=1.47      Lca=0.73      S=22.92      Kn=0.200      LAG=163
                KM   S-GRAPH TYPE=AGRICULTURE
                KO       0       0     0.0       1      22
                BA  0.9987
                LG     0.5    0.25   3.977   0.548     0.0
                UI     0.0    22.6    22.6   40.44   67.42  122.16  127.17  170.96  171.63   189.8
                UI   189.8  185.58  158.17  166.76  141.69  122.98  113.44   86.27    70.6   65.75
                UI   56.62   40.79    36.5   28.42   27.23   20.63   20.63   15.99   12.82   12.82
                UI   12.82    7.09    2.82    2.82    2.82    2.82    2.82    2.82    2.82    2.82
                UI    2.82    2.82    2.82    2.82    2.82    2.82    2.82    2.82    2.82     0.0

                KK      F3   CNAME   F3-F4
                KM   COMBINE ROUTED HYDROGRAPH FROM F2 WITH RUNOFF FROM 29 @ F3
                KO       0       0     0.0       0      22
                HC       2
1                                                HEC-1 INPUT
PAGE  4

LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                KK   F3-F4   CNAME      F3
                KM   ROUTE HYDRPGRAPH FROM F3 TO F4 (CHANNEL A)
                KO       0       0     0.0       0      22
                RS       7    FLOW     0.0     0.0
                RC     0.1     0.1     0.1 5501.87  0.0058     0.0
                RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
                RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

                KK      41
                KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
                KM   L=1.54      Lca=0.77      S=23.99      Kn=0.200      LAG=168
                KM   S-GRAPH TYPE=AGRICULTURE
                KO       0       0     0.0       1      22
                BA  1.2021
                LG     0.5    0.25   3.965   0.474     0.0
                UI     0.0   26.39   26.39    45.2   74.92  131.88  154.05  177.32  206.14  221.65
                UI  221.65  221.65   192.1  189.15  190.62  138.53  151.39  105.43   94.19   76.42
                UI   81.61   52.05    44.8   39.98    32.6   29.54   24.09   24.09   16.95   14.98
                UI   14.98   14.98     7.5     3.3     3.3     3.3     3.3     3.3     3.3     3.3
                UI     3.3     3.3     3.3     3.3     3.3     3.3     3.3     3.3     3.3     3.3
                UI     3.3     0.0
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Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
159          KK     F4    CNAME  F4-F5B
160          KM    COMBINE ROUTED HYDROGRAPH FROM F3 WITH RUNOFF FROM 41 @ F4
161          KO      0       0     0.0       0       22
162          HC      2

163          KK  F4-F5B   CNAME      F4
164          KM    ROUTE HYDRPGRAPH FROM F4 TO F5B (CHANNEL A)
165          KO      0       0     0.0       0       22
166          RS      4    FLOW     0.0     0.0
167          RC    0.1     0.1     0.1 3704.65  0.0065     0.0
168          RX    0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
169          RY   10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

170          KK    52B
171          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
172          KM    L=0.71     Lca=0.32     S=32.56     Kn=0.200     LAG=85
173          KM    S-GRAPH TYPE=AGRICULTURE
174          KO      0       0     0.0       1       22
175          BA  0.4953
176          LG  0.491   0.251   4.087    0.53   0.349
177          UI    0.0   21.49   47.96  115.57  153.43   180.5  170.48  157.82  118.28   85.92
178          UI  63.75   43.62   30.66   22.85   17.91    12.2   10.93    2.69    2.69    2.69
179          UI   2.69    2.69    2.69    2.69    2.69    2.69     0.0

180          KK    F5B    CNAME F5B-F6B
181          KM    COMBINE ROUTED HYDROGRAPH FROM F4 WITH RUNOFF FROM 52B @ F5B
182          KO      0       0     0.0       0       22
183          HC      2
1                                          HEC-1 INPUT
PAGE  5

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


184          KK  F5BF6B   CNAME     F5B
185          KM    STORAGE ROUTE FROM F5B TO F6B THROUGH SPRR TRESTLE
186          KO      0       0     0.0       0       22
187          RS      1    ELEV   886.0     0.0
188          SV    0.0    0.08    0.94    6.13   37.02  122.46  262.93   479.0  749.83  749.83
189          SV 749.83  749.83  749.83  749.83  749.83  749.83  749.83  749.83  749.83  749.83
190          SE  886.0   888.0   890.0   892.0   894.0   896.0   898.0   900.0   902.0   902.0
191          SE  902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0
192          SQ    0.0    80.0   120.0   230.0  1145.0  1980.0  2670.0  2670.0  2670.0  2670.0
193          SQ 2670.0  2670.0  2670.0  2670.0  2670.0  2670.0  2670.0  2670.0  2670.0  2670.0
194          SE  886.0  887.07  888.07  889.07  890.07  891.07  892.07  892.07  892.07  892.07
195          SE 892.07  892.07  892.07  892.07  892.07  892.07  892.07  892.07  892.07  892.07

196          KK    60B
197          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
198          KM    L=1.03     Lca=0.35     S=22.68     Kn=0.200     LAG=108
199          KM    S-GRAPH TYPE=AGRICULTURE
200          KO      0       0     0.0       1       22
201          BA  0.5744
202          LG  0.462   0.249   4.158   0.551   3.254
203          UI    0.0   19.61   30.14   73.81  110.38  144.98  164.75  164.75  142.78  142.23
204          UI 106.31   87.94    64.4   56.91    35.6   28.82   23.22   17.91   14.49   11.13
205          UI  11.13    3.84    2.45    2.45    2.45    2.45    2.45    2.45    2.45    2.45
206          UI   2.45    2.45    2.45     0.0

207          KK    F6B
208          KM    COMBINE STORAGE HYDROGRAPH FROM F5B WITH RUNOFF FROM 60B @ F6B
209          ZW    A=RBW B=F6B C=FLOW E=15MIN F=100Y24H-EX
210          KO      0       0     0.0       0       22
211          HC      2

212          KK    52A
213          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
214          KM    L=0.92     Lca=0.57     S=6.91     Kn=0.200     LAG=156
215          KM    S-GRAPH TYPE=AGRICULTURE
216          KO      0       0     0.0       1       22
217          BA  0.3127
218          LG  0.497    0.25   3.966   0.439   0.364
219          UI    0.0    7.39    7.39   14.03   25.52   42.85   41.09   54.59   61.74    62.1
220          UI   62.1   55.89   52.16   54.02   38.81   41.05   29.04   24.79   21.13   20.13
221          UI  13.59   11.94    9.45    8.85    6.75    6.75    4.89     4.2     4.2     4.2
222          UI   1.32    0.92    0.92    0.92    0.92    0.92    0.92    0.92    0.92    0.92
223          UI   0.92    0.92    0.92    0.92    0.92    0.92    0.92     0.0

224          KK  F5AF6A   CNAME     F5A
225          KM    STORAGE ROUTE FROM F5A TO F6A THROUGH SPRR TRESTLE
226          KO      0       0     0.0       0       22
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Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


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 227          RS      1    ELEV   894.0     0.0
 228          SV    0.0    0.02    0.64   12.91   61.76   61.76   61.76   61.76   61.76   61.76
 229          SV  61.76   61.76   61.76   61.76   61.76   61.76   61.76   61.76   61.76   61.76
 230          SE  894.0   896.0   898.0   900.0   902.0   902.0   902.0   902.0   902.0   902.0
 231          SE  902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0   902.0
 232          SQ    0.0    58.1   112.2   146.6   174.0   198.5   218.5   237.6   255.3   271.8
 233          SQ  287.4   302.2   316.3   329.7   342.7   355.2   367.2   378.9   401.2   422.3
1                                     HEC-1 INPUT
PAGE  6

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 234          SE  894.0   896.4   896.9   897.4   897.9   898.4   898.9   899.4   899.9   900.4
 235          SE  900.9   901.4   901.9   902.4   902.9   903.4   903.9   904.4   905.4   906.4

 236          KK    60A
 237          KM  THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
 238          KM  L=1.07     Lca=0.46     S=27.51      Kn=0.200      LAG=117
 239          KM  S-GRAPH TYPE=AGRICULTURE
 240          KO      0       0     0.0       1      22
 241          BA 0.4117
 242          LG  0.493   0.249   4.045   0.541   0.795
 243          UI    0.0   12.98   18.15   40.42   73.45   89.47  100.76  109.02  105.38   91.39
 244          UI  88.17   72.54   53.81   42.04   38.73   24.09   20.15   16.03   12.52   11.64
 245          UI   7.37    7.37    6.45    1.62    1.62    1.62    1.62    1.62    1.62    1.62
 246          UI   1.62    1.62    1.62    1.62    1.62     0.0

 247          KK    F6A
 248          KM  COMBINE STORAGE HYDROGRAPH FROM F5A WITH RUNOFF FROM 60A @ F6A
 249          ZW  A=RBW B=F6A C=FLOW E=15MIN F=100Y24H-EX
 250          KO      0       0     0.0       0      22
 251          HC      2

 252          KK  RIDG
 253          KM  ****************************************************************************
 254          KM  **   SUB-WATERSHED G   *******************************************************
 255          KM  ****************************************************************************
 256          KM  FALSE BASIN TO SIMULATE INFLOW FROM RID
 257          BA 0.0001
 258          ZR =QI A=RID RID B=13399 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID100-24E

 259          KK G3S-G4   CNAME     G3S
 260          KM  ROUTE INFLOW FROM RID CONCENTRATED AT G3S TO G4 (CHANNEL A)
 261          KO      0       0     0.0       0      22
 262          RS      1    FLOW     0.0     0.0
 263          RC    0.1     0.1     0.1  4594.0   0.004     0.0
 264          RX    0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
 265          RY   10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

 266          KK     28
 267          KM  THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
 268          KM  L=1.02     Lca=0.51     S=16.68      Kn=0.200      LAG=132
 269          KM  S-GRAPH TYPE=AGRICULTURE
 270          KO      0       0     0.0       1      22
 271          BA 0.3347
 272          LG  0.497   0.249   4.178   0.467   0.543
 273          UI    0.0    9.35   10.92    23.2   45.57   53.95   69.13   78.56   78.56   75.94
 274          UI  65.47   68.35   49.76   47.59   34.97   27.16   26.43   17.09   14.62   11.55
 275          UI   9.62    8.54    6.55    5.31    5.31    3.82    1.17    1.17    1.17    1.17
 276          UI   1.17    1.17    1.17    1.17    1.17    1.17    1.17    1.17    1.17    1.17
 277          UI    0.0
1                                     HEC-1 INPUT
PAGE  7

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 278          KK     G4   CNAME   G4-G5
 279          KM  COMBINE ROUTED HYDROGRAPH FROM G3S WITH RUNOFF FROM 28 @ G4
 280          KO      0       0     0.0       0      22
 281          HC      2

 282          KK  G4-G5   CNAME      G4
 283          KM  ROUTE HYDRPGRAPH FROM G4 TO G5 (CHANNEL A)
 284          KO      0       0     0.0       0      22
 285          RS     11    FLOW     0.0     0.0
 286          RC    0.1     0.1     0.1 7127.48  0.0045     0.0
 287          RX    0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
 288          RY   10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

 289          KK     30
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Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


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290     KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
291     KM   L=1.55     Lca=0.78     S=21.93     Kn=0.200     LAG=172
292     KM   S-GRAPH TYPE=AGRICULTURE
293     KO        0        0      0.0        1       22
294     BA   0.9830
295     LG    0.444     0.25    4.028    0.469    8.734
296     UI      0.0    21.08    21.08     34.8     57.4    101.7   123.34    132.0   163.67   177.05
297     UI   177.05   177.05   161.31   147.54   161.39   117.56   117.82    99.14    80.48    64.92
298     UI    61.01    54.87    38.92    34.05    28.26    26.04    20.78    19.24    18.25    11.96
299     UI    11.96    11.96    11.96     3.63     2.63     2.63     2.63     2.63     2.63     2.63
300     UI     2.63     2.63     2.63     2.63     2.63     2.63     2.63     2.63     2.63     2.63
301     UI     2.63     2.63      0.0

302     KK       G5    CNAME    G5-G6
303     KM   COMBINE ROUTED HYDROGRAPH FROM G4 WITH RUNOFF FROM 30 @ G5
304     KO        0        0      0.0        0       22
305     HC        2

306     KK    G5-G6    CNAME       G5
307     KM   ROUTE HYDRPGRAPH FROM G5 TO G6 (CHANNEL A)
308     KO        0        0      0.0        0       22
309     RS        8     FLOW      0.0      0.0
310     RC      0.1      0.1      0.1  5820.25   0.0055      0.0
311     RX      0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
312     RY     10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

313     KK       42
314     KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
315     KM   L=1.56     Lca=0.78     S=22.73     Kn=0.200     LAG=172
316     KM   S-GRAPH TYPE=AGRICULTURE
317     KO        0        0      0.0        1       22
318     BA   0.7784
319     LG    0.497     0.25    4.279    0.452    0.465
320     UI      0.0    16.69    16.69    27.56    45.45    80.53    97.66   104.52    129.6   140.19
321     UI   140.19   140.19   127.73   116.82   127.79    93.09    93.29     78.5    63.72     51.4
322     UI    48.31    43.45    30.82    26.96    22.38    20.62    16.46    15.24    14.45     9.47
323     UI     9.47     9.47     9.47     2.87     2.09     2.09     2.09     2.09     2.09     2.09
324     UI     2.09     2.09     2.09     2.09     2.09     2.09     2.09     2.09     2.09     2.09
325     UI     2.09     2.09      0.0
1                                        HEC-1 INPUT
PAGE  8

LINE    ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


326     KK       G6    CNAME    G6-G7
327     KM   COMBINE ROUTED HYDROGRAPH FROM G5 WITH RUNOFF FROM 42 @ G6
328     KO        0        0      0.0        0       22
329     HC        2

330     KK    G6-G7    CNAME       G6
331     KM   ROUTE HYDRPGRAPH FROM G6 TO G7 (CHANNEL A)
332     KO        0        0      0.0        0       22
333     RS        4     FLOW      0.0      0.0
334     RC      0.1      0.1      0.1  2613.05   0.0069      0.0
335     RX      0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
336     RY     10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

337     KK       53
338     KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
339     KM   L=0.91     Lca=0.46     S=23.93     Kn=0.200     LAG=113
340     KM   S-GRAPH TYPE=AGRICULTURE
341     KO        0        0      0.0        1       22
342     BA   0.3385
343     LG      0.5     0.25    3.997    0.444      0.0
344     UI      0.0    11.05    16.13     37.6    62.38    76.97    90.56    92.81     85.6    80.26
345     UI    66.07    58.87    41.62    31.91    28.17    18.87    14.88    12.13    10.09     7.44
346     UI     6.27     6.27     1.84     1.38     1.38     1.38     1.38     1.38     1.38     1.38
347     UI     1.38     1.38     1.38     1.38      0.0

348     KK       G7    CNAME    G7-G8
349     KM   COMBINE ROUTED HYDROGRAPH FROM G6 WITH RUNOFF FROM 53 @ G7
350     KO        0        0      0.0        0       22
351     HC        2

352     KK    G7-G8    CNAME       G7
353     KM   STORAGE ROUTE FROM G7 TO G8 THROUGH SPRR TRESTLE
354     KO        0        0      0.0        0       22
355     RS        1     ELEV    888.0      0.0
356     SV      0.0      0.6     4.25    26.94   108.66   257.97    449.6    449.6    449.6    449.6
357     SV    449.6    449.6    449.6    449.6    449.6    449.6    449.6    449.6    449.6    449.6
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358   SE   888.0   890.0   892.0   894.0   896.0   898.0   900.0   900.0   900.0   900.0
359   SE   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0
360   SQ     0.0   100.0   200.0   480.0  1480.0  2060.0  2520.0  2900.0  2900.0  2900.0
361   SQ  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0  2900.0
362   SE   888.0  888.07  889.07  890.07  891.07  892.07  893.07  894.07  894.07  894.07
363   SE  894.07  894.07  894.07  894.07  894.07  894.07  894.07  894.07  894.07  894.07

364   KK      61
365   KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
366   KM   L=0.90      Lca=0.45     S=23.00      Kn=0.200      LAG=113
367   KM   S-GRAPH TYPE=AGRICULTURE
368   KO       0       0     0.0       1      22
369   BA  0.5081
370   LG   0.484   0.248   3.965   0.464   2.234
371   UI     0.0   16.58   24.21   56.43   93.62  115.52  135.92   139.3  128.47  120.46
372   UI   99.16   88.35   62.47    47.9   42.28   28.31   22.33   18.21   15.14   11.17
373   UI    9.41    9.41    2.76    2.07    2.07    2.07    2.07    2.07    2.07    2.07
374   UI    2.07    2.07    2.07    2.07     0.0
1                                         HEC-1 INPUT
PAGE  9

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


375   KK      G8
376   KM   COMBINE STORAGE HYDROGRAPH FROM G7 WITH RUNOFF FROM 61 @ G8
377   ZW   A=RBW B=G8 C=FLOW E=15MIN F=100Y24H-EX
378   KO       0       0     0.0       0      22
379   HC       2

380   KK   RIDH
381   KM   ***********************************************************************
382   KM   **   SUB-WATERSHED H    *********************************************
383   KM   ***********************************************************************
384   KM   FALSE BASIN TO SIMULATE INFLOW FROM RID
385   BA  0.0001
386   ZR  =QI A=RID RID B=19799 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID100-24E

387   KK  H3S-H4   CNAME     H3S
388   KM   ROUTE INFLOW FROM RID CONCENTRATED AT H3S TO H4 (CHANNEL A)
389   KO       0       0     0.0       0      22
390   RS       1    FLOW     0.0     0.0
391   RC     0.1     0.1     0.110193.17   0.005     0.0
392   RX     0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
393   RY    10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

394   KK      31
395   KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
396   KM   L=1.93      Lca=0.97     S=26.40      Kn=0.200      LAG=196
397   KM   S-GRAPH TYPE=AGRICULTURE
398   KO       0       0     0.0       1      22
399   BA  1.0788
400   KM   ENTELLUS CHANGED THE IA TO 1.0 INCHES
401   KM   ENTELLUS CHANGED THE DTHETA TO 0.19
402   LG     1.0    0.19   4.018   0.456   0.852
403   UI     0.0    20.3    20.3   26.01   42.62   75.47  110.82  116.22  130.81  156.48
404   UI  170.49  170.49  170.49  170.49  143.97  142.08   158.6  111.16  110.82  106.73
405   UI   79.11   71.61    59.1   60.85   49.19   37.72   32.79   29.13   25.07   23.42
406   UI   18.53   18.53   16.79   11.52   11.52   11.52   11.52    7.81    2.54    2.54
407   UI    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54
408   UI    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54    2.54     0.0

409   KK      H4   CNAME   H4-H5
410   KM   COMBINE ROUTED HYDROGRAPH FROM H3S WITH RUNOFF FROM 31 @ H4
411   KO       0       0     0.0       0      22
412   HC       2

413   KK   H4-H5   CNAME      H4
414   KM   ROUTE HYDRPGRAPH FROM H4 TO H5 (CHANNEL B)
415   KO       0       0     0.0       0      22
416   RS       5    FLOW     0.0     0.0
417   RC     0.1    0.02     0.1 5382.76  0.0059     0.0
418   RX     0.0  1000.0  1006.0  1010.0  1050.0  1054.0  1060.0  2060.0
419   RY    10.0     0.0     0.0     1.0     1.0     0.0     0.0    10.0
1                                         HEC-1 INPUT
PAGE 10

LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


420   KK      43
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421      KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
422      KM   L=1.92     Lca=0.96     S=20.85     Kn=0.200     LAG=204
423      KM   S-GRAPH TYPE=AGRICULTURE
424      KO      0        0      0.0        1       22
425      BA  1.0022
426      KM   ENTELLUS CHANGED THE IA TO 1.0 INCHES
427      KM   ENTELLUS CHANGED THE DTHETA TO 0.19
428      LG     1.0     0.19    3.958    0.425     0.66
429      UI     0.0    18.12    18.12    20.99    38.04    57.93     94.1   108.05   107.28    138.7
430      UI  144.35   152.18   152.18   152.18   142.03   126.81   135.44   126.81    95.11   102.81
431      UI    87.2    69.17    61.58    52.32    54.94    42.82    33.73    29.26    26.57    22.38
432      UI   21.91    16.54    16.54    16.54    10.58    10.28    10.28    10.28    10.28     2.91
433      UI    2.26     2.26     2.26     2.26     2.26     2.26     2.26     2.26     2.26     2.26
434      UI    2.26     2.26     2.26     2.26     2.26     2.26     2.26     2.26     2.26     2.26
435      UI    2.26      0.0

436      KK      H5    CNAME    H5-H6
437      KM   COMBINE ROUTED HYDROGRAPH FROM H4 WITH RUNOFF FROM 43 @ H5
438      KO      0        0      0.0        0       22
439      HC      2

440      KK   H5-H6    CNAME       H5
441      KM   ROUTE HYDRPGRAPH FROM H5 TO H6 (CHANNEL B)
442      KO      0        0      0.0        0       22
443      RS      3     FLOW      0.0      0.0
444      RC     0.1     0.02      0.1  2887.92   0.0049      0.0
445      RX     0.0   1000.0   1006.0   1010.0   1050.0   1054.0   1060.0   2060.0
446      RY    10.0      0.0      0.0      1.0      1.0      0.0      0.0     10.0

447      KK      54
448      KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
449      KM   L=1.20     Lca=0.60     S=12.35     Kn=0.200     LAG=157
450      KM   S-GRAPH TYPE=AGRICULTURE
451      KO      0        0      0.0        1       22
452      BA  0.3861
453      KM   ENTELLUS CHANGED THE IA TO 1.0 INCHES
454      KM   ENTELLUS CHANGED THE DTHETA TO 0.19
455      LG     1.0     0.19      4.0    0.447      0.0
456      UI     0.0     9.07     9.07    17.07    30.66    52.22     50.2     67.4    74.77    76.18
457      UI   76.18    69.41    63.49    68.13    47.62    51.29    35.97     31.2    25.88    25.91
458      UI   17.01    14.65    12.06     11.2     8.36     8.28     6.51     5.15     5.15     5.15
459      UI    2.36     1.13     1.13     1.13     1.13     1.13     1.13     1.13     1.13     1.13
460      UI    1.13     1.13     1.13     1.13     1.13     1.13     1.13      0.0

461      KK      H6    CNAME    H6-H7
462      KM   COMBINE ROUTED HYDROGRAPH FROM H5 WITH RUNOFF FROM 54 @ H6
463      KO      0        0      0.0        0       22
464      HC      2
1                                          HEC-1 INPUT
PAGE 11

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


465      KK   H6-H7    CNAME       H6
466      KM   STORAGE ROUTE FROM H6 TO H7 THROUGH SPRR TRESTLE
467      KO      0        0      0.0        0       22
468      RS      1     ELEV    890.0      0.0
469      SV     0.0     0.45    30.43   148.25   336.08   336.08   336.08   336.08   336.08   336.08
470      SV  336.08   336.08   336.08   336.08   336.08   336.08   336.08   336.08   336.08   336.08
471      SE   890.0    892.0    894.0    896.0    898.0    898.0    898.0    898.0    898.0    898.0
472      SE   898.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0
473      SQ     0.0    185.0    720.0   1025.0   1075.0   1150.0   1355.0   1800.0   1800.0   1800.0
474      SQ  1800.0   1800.0   1800.0   1800.0   1800.0   1800.0   1800.0   1800.0   1800.0   1800.0
475      SE   890.0   891.07   893.47   895.47   895.57   895.67   895.77   895.87   895.87   895.87
476      SE  895.87   895.87   895.87   895.87   895.87   895.87   895.87   895.87   895.87   895.87

477      KK      62
478      KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
479      KM   L=0.98     Lca=0.49     S=21.54     Kn=0.200     LAG=122
480      KM   S-GRAPH TYPE=AGRICULTURE
481      KO      0        0      0.0        1       22
482      BA  0.5717
483      KM   ENTELLUS CHANGED THE IA TO 1.0 INCHES
484      KM   ENTELLUS CHANGED THE DTHETA TO 0.19
485      LG     1.0     0.19    4.203    0.444    0.473
486      UI     0.0    17.28    22.83    47.88    97.83   104.21   138.24   145.18   145.18   124.21
487      UI  130.72    91.16    89.45    63.88    49.84    45.53    30.22     24.7    20.76    15.78
488      UI   14.37     9.81     9.81     8.08     2.16     2.16     2.16     2.16     2.16     2.16
489      UI    2.16     2.16     2.16     2.16     2.16     2.16     2.16      0.0
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KK      H7
KM   COMBINE STORAGE HYDROGRAPH FROM H6 WITH RUNOFF FROM 62 @ H7
ZW   A=RBW B=H7 C=FLOW E=15MIN F=100Y24H-EX
KO      0         0       0.0         0        22
HC      2

KK   RIDI
KM   **************************************************************************
KM   **    SUB-WATERSHED I    ****************************************************
KM   **************************************************************************
KM   FALSE BASIN TO SIMULATE INFLOW FROM RID
BA  0.0001
ZR  =QI A=RID RID B=24399 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID100-24E

KK  I2S-I3    CNAME      I2S
KM   ROUTE INFLOW FROM RID CONCENTRATED AT I2S TO I3 (CHANNEL A)
KO      0         0       0.0         0        22
RS      1      FLOW       0.0       0.0
RC    0.1       0.1       0.1 8174.00     0.005       0.0
RX    0.0     250.0     500.0     750.0    1000.0    1333.3    1666.6    2000.0
RY   10.0       7.5       5.0       2.5       0.0       3.3       6.6      10.0
                                         HEC-1 INPUT
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LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

KK      32
KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
KM   L=1.84       Lca=0.92       S=24.34       Kn=0.200       LAG=192
KM   S-GRAPH TYPE=AGRICULTURE
KO      0         0       0.0         1        22
BA  0.8959
LG   0.493     0.249       4.0     0.515     1.146
UI     0.0     17.21     17.21     23.11     36.91     68.18     97.57     94.68    119.26    132.99
UI  144.55    144.55    144.55    139.73    120.46    127.21    121.42     90.35      99.1     77.05
UI   65.71     54.78      48.6      53.0     32.85     29.42     27.69     21.26     21.26      16.6
UI   15.71     15.71     10.39      9.77      9.77      9.77      8.55      2.15      2.15      2.15
UI    2.15      2.15      2.15      2.15      2.15      2.15      2.15      2.15      2.15      2.15
UI    2.15      2.15      2.15      2.15      2.15      2.15      2.15      2.15       0.0

KK      I3    CNAME    I3-I4
KM   COMBINE ROUTED HYDROGRAPH FROM I2S WITH RUNOFF FROM 32 @ I3
KO      0         0       0.0         0        22
HC      2

KK   I3-I4    CNAME       I3
KM   ROUTE HYDRPGRAPH FROM I3 TO I4 (CHANNEL B)
KO      0         0       0.0         0        22
RS     10      FLOW       0.0       0.0
RC    0.1      0.02       0.110387.48    0.0042       0.0
RX    0.0    1000.0    1006.0    1010.0    1050.0    1054.0    1060.0    2060.0
RY   10.0       0.0       0.0       1.0       1.0       0.0       0.0      10.0

KK      44
KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
KM   L=1.97       Lca=0.98       S=22.43       Kn=0.200       LAG=205
KM   S-GRAPH TYPE=AGRICULTURE
KO      0         0       0.0         1        22
BA  1.0069
LG   0.474      0.25     4.136     0.485     5.217
UI     0.0     18.11     18.11      20.7     38.04      57.4      93.3    108.09    106.09    139.54
UI  142.37    152.15    152.15    152.15     143.7     126.8    133.98    130.92      95.1    101.27
UI   90.64     69.78     63.13     52.71     54.03     45.67      34.4     29.26     27.49     22.38
UI   22.38     16.93     16.54     16.54     11.59     10.28     10.28     10.28     10.28       4.4
UI    2.26      2.26      2.26      2.26      2.26      2.26      2.26      2.26      2.26      2.26
UI    2.26      2.26      2.26      2.26      2.26      2.26      2.26      2.26      2.26      2.26
UI    2.26      2.26       0.0

KK      I4    CNAME    I4-I5
KM   COMBINE ROUTED HYDROGRAPH FROM I3 WITH RUNOFF FROM 44 @ I4
KO      0         0       0.0         0        22
HC      2

KK   I4-I5    CNAME       I4
KM   ROUTE HYDRPGRAPH FROM I4 TO I5 (CHANNEL A)
KO      0         0       0.0         0        22
RS      4      FLOW       0.0       0.0
RC    0.1       0.1       0.1 2589.37    0.0035       0.0
RX    0.0     250.0     500.0     750.0    1000.0    1333.3    1666.6    2000.0
RY   10.0       7.5       5.0       2.5       0.0       3.3       6.6      10.0
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Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


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1                                                        HEC-1 INPUT
PAGE 13

         LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


          558          KK      55
          559          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          560          KM    L=0.97      Lca=0.48     S=12.83      Kn=0.200       LAG=133
          561          KM    S-GRAPH TYPE=AGRICULTURE
          562          KO       0       0     0.0       1      22
          563          BA   0.2627
          564          LG      0.5    0.25   4.128   0.446     0.0
          565          UI      0.0    7.29    8.39   17.86    34.8   41.96   53.41    61.2    61.2   59.84
          566          UI     51.0   54.32   38.38   38.38   27.91   21.37   21.37   13.58   11.77     9.0
          567          UI     7.84    6.65    5.51    4.14    4.14    3.58    0.91    0.91    0.91    0.91
          568          UI     0.91    0.91    0.91    0.91    0.91    0.91    0.91    0.91    0.91    0.91
          569          UI      0.0

          570          KK       I5   CNAME   I5-I6
          571          KM    COMBINE ROUTED HYDROGRAPH FROM I4 WITH RUNOFF FROM 55 @ I5
          572          KO       0       0     0.0       0      22
          573          HC       2

          574          KK    I5-I6   CNAME      I5
          575          KM    STORAGE ROUTE FROM I5 TO I6 THROUGH SPRR TRESTLE
          576          KO       0       0     0.0       0      22
          577          RS       1    ELEV   892.0     0.0
          578          SV      0.0     0.1    25.1  124.92  273.66  273.66  273.66  273.66  273.66  273.66
          579          SV   273.66  273.66  273.66  273.66  273.66  273.66  273.66  273.66  273.66  273.66
          580          SE    892.0   894.0   896.0   898.0   900.0   900.0   900.0   900.0   900.0   900.0
          581          SE    900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0   900.0
          582          SQ      0.0    60.0   150.0   221.0   400.0   830.0  1134.0  1488.0  1892.0  1892.0
          583          SQ   1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0  1892.0
          584          SE   892.00  894.08  895.18  895.88  896.08  896.28  896.38  896.48  896.58  896.58
          585          SE   896.58  896.58  896.58  896.58  896.58  896.58  896.58  896.58  896.58  896.58

          586          KK      63
          587          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          588          KM    L=0.95      Lca=0.47     S=20.27      Kn=0.200       LAG=120
          589          KM    S-GRAPH TYPE=AGRICULTURE
          590          KO       0       0     0.0       1      22
          591          BA   0.4994
          592          LG    0.396    0.25   4.192   0.398  20.751
          593          UI      0.0   15.35   20.75   44.48   87.02   96.69  122.47  128.92  128.92  107.43
          594          UI   111.73   82.37   73.51   54.08   44.91   35.79   25.69   20.36   16.98   14.01
          595          UI    11.04    8.71    8.71    4.64    1.92    1.92    1.92    1.92    1.92    1.92
          596          UI     1.92    1.92    1.92    1.92    1.92    1.92     0.0

          597          KK       I6
          598          KM    COMBINE STORAGE HYDROGRAPH FROM I5 WITH RUNOFF FROM 63 @ I6
          599          ZW    A=RBW B=I6 C=FLOW E=15MIN F=100Y24H-EX
          600          KO       0       0     0.0       0      22
          601          HC       2
1                                                        HEC-1 INPUT
PAGE 14

         LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


          602          KK    RIDJ
          603          KM    *************************************************************************
          604          KM    **   SUB-WATERSHED J   ****************************************************
          605          KM    *************************************************************************
          606          KM    FALSE BASIN TO SIMULATE INFLOW FROM RID
          607          BA   0.0001
          608          ZR   =QI A=RID RID B=27599 LAT STRUCT C=FLOW-WEIR D=02JAN1994 E=15MIN F=RID100-24E

          609          KK   J3S-J4   CNAME     J3S
          610          KM    ROUTE INFLOW FROM RID CONCENTRATED AT J3S TO J4 (CHANNEL A)
          611          KO       0       0     0.0       0      22
          612          RS       1    FLOW     0.0     0.0
          613          RC      0.1     0.1     0.1 8056.46   0.007     0.0
          614          RX      0.0   250.0   500.0   750.0  1000.0  1333.3  1666.6  2000.0
          615          RY     10.0     7.5     5.0     2.5     0.0     3.3     6.6    10.0

          616          KK      33
          617          KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
          618          KM    L=1.84      Lca=0.92     S=29.30      Kn=0.200       LAG=185
          619          KM    S-GRAPH TYPE=AGRICULTURE
          620          KO       0       0     0.0       1      22
```

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
621         BA  1.0024
622         LG   0.497    0.249    3.962     0.44    0.529
623         UI     0.0    19.98    19.98    28.99    46.91    85.21   117.85   108.17    155.0   152.26
624         UI  167.85   167.85   167.85    149.2   139.88   152.37   115.61   108.99   103.55    77.29
625         UI    67.9    57.35    62.19    40.17    34.82    32.28    24.96    24.68     19.1    18.24
626         UI   18.04    11.34    11.34    11.34    11.34     7.21      2.5      2.5      2.5      2.5
627         UI     2.5      2.5      2.5      2.5      2.5      2.5      2.5      2.5      2.5      2.5
628         UI     2.5      2.5      2.5      2.5      2.5      2.5      0.0

629         KK      J4    CNAME    J4-J5
630         KM    COMBINE ROUTED HYDROGRAPH FROM J3S WITH RUNOFF FROM 33 @ J4
631         KO       0        0      0.0        0       22
632         HC       2

633         KK   J4-J5    CNAME       J4
634         KM    ROUTE HYDRPGRAPH FROM J4 TO J5 (CHANNEL A)
635         KO       0        0      0.0        0       22
636         RS       5     FLOW      0.0      0.0
637         RC     0.1      0.1      0.1  5307.06   0.0077      0.0
638         RX     0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
639         RY    10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

640         KK     45A
641         KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
642         KM    L=1.97       Lca=0.99       S=25.14       Kn=0.200       LAG=201
643         KM    S-GRAPH TYPE=AGRICULTURE
644         KO       0        0      0.0        1       22
645         BA  1.0027
646         LG   0.496     0.25    3.993    0.441    0.243
647         UI     0.0     18.4     18.4    22.16    38.63    61.78    96.59   109.53   112.56   138.24
648         UI  152.55   154.54   154.54   154.54   139.08   128.78   137.41   120.73    96.59   109.05
649         UI   76.17    70.24    57.78    51.92    58.19    35.12     32.2    29.72    24.14    22.73
650         UI   19.64     16.8     16.8    14.01    10.44    10.44    10.44    10.44     6.53      2.3
1
PAGE 15                                          HEC-1 INPUT

LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

651         UI     2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3
652         UI     2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3      2.3
653         UI     2.3

654         KK     J5A    CNAME   J5A-5B
655         KM    COMBINE ROUTED HYDROGRAPH FROM J4 WITH RUNOFF FROM 45A @ J5A
656         KO       0        0      0.0        0       22
657         HC       2

658         KK  J5A-5B    CNAME      J5A
659         KM    ROUTE HYDRPGRAPH FROM J5A TO J5B (CHANNEL A)
660         KO       0        0      0.0        0       22
661         RS       6     FLOW      0.0      0.0
662         RC     0.1      0.1      0.1  2736.25   0.0015      0.0
663         RX     0.0    250.0    500.0    750.0   1000.0   1333.3   1666.6   2000.0
664         RY    10.0      7.5      5.0      2.5      0.0      3.3      6.6     10.0

665         KK     45B
666         KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
667         KM    L=0.52       Lca=0.26       S=8.59       Kn=0.200       LAG=89
668         KM    S-GRAPH TYPE=AGRICULTURE
669         KO       0        0      0.0        1       22
670         BA  0.1397
671         LG   0.351     0.25    3.969    0.417   29.714
672         UI     0.0     5.79     11.9    30.23     38.5    48.58    48.11    41.75    34.63     28.1
673         UI   18.91    15.22     9.82     7.25     5.39     4.12     3.29      2.3     0.72     0.72
674         UI    0.72     0.72     0.72     0.72     0.72     0.72     0.72      0.0

675         KK     J5B    CNAME   J5B-J6
676         KM    COMBINE ROUTED HYDROGRAPH FROM J5A WITH RUNOFF FROM 45B @ J5B
677         KO       0        0      0.0        0       22
678         HC       2

679         KK  J5B-J6    CNAME      J5B
680         KM    STORAGE ROUTE FROM J5B TO J6 THROUGH SPRR TRESTLE
681         KO       0        0      0.0        0       22
682         RS       1     ELEV    892.0      0.0
683         SV     0.0    20.33    91.45   223.99   223.99   223.99   223.99   223.99   223.99   223.99
684         SV  223.99   223.99   223.99   223.99   223.99   223.99   223.99   223.99   223.99   223.99
685         SE   892.0    894.0    896.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0
686         SE   898.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0    898.0
687         SQ     0.0    150.0    230.0    308.0    825.0   1144.0   1970.0   1970.0   1970.0   1970.0
688         SQ  1970.0   1970.0   1970.0   1970.0   1970.0   1970.0   1970.0   1970.0   1970.0   1970.0
```

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
           689            SE   892.0  893.68  895.08  895.48  895.68  895.88  896.08  896.08  896.08  896.08
           690            SE  896.08  896.08  896.08  896.08  896.08  896.08  896.08  896.08  896.08  896.08

           691            KK      64
           692            KM    THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
           693            KM    L=0.89     Lca=0.45     S=17.94     Kn=0.200     LAG=117
           694            KM    S-GRAPH TYPE=AGRICULTURE
           695            KO       0       0     0.0       1      22
           696            BA  0.4148
           697            LG   0.491   0.248   4.357   0.445   1.184
           698            UI     0.0   13.07   18.28   40.72   73.99   90.13  101.51  109.82  106.16   92.07
           699            UI   88.82   73.07   54.21   42.35   39.02   24.27    20.3   16.15   12.61   11.73
1                                                          HEC-1 INPUT
PAGE 16

          LINE            ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           700            UI    7.42    7.42    6.49    1.63    1.63    1.63    1.63    1.63    1.63    1.63
           701            UI    1.63    1.63    1.63    1.63    1.63     0.0

           702            KK      J6
           703            KM    COMBINE STORAGE HYDROGRAPH FROM J5B WITH RUNOFF FROM 64 @ J6
           704            ZW    A=RBW B=J6 C=FLOW E=15MIN F=100Y24H-EX
           705            KO       0       0     0.0       0      22
           706            HC       2
           707            ZZ
1
               SCHEMATIC DIAGRAM OF STREAM NETWORK

 INPUT
  LINE       (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.        (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   50          68
               V
               V
   61        E1-E2
               .
               .
   73          .          59
               .           .
               .           .
   82          E2...........
               .
               .
   87          .       RIDF
               .           V
               .           V
   94          .      F1S-F2
               .           .
               .           .
  101          .           .          27
               .           .           .
               .           .           .
  112          .          F2...........
               .           V
               .           V
  116          .       F2-F3
               .           .
               .           .
  123          .           .          29
               .           .           .
               .           .           .
  135          .          F3...........
               .           V
               .           V
  139          .       F3-F4
               .           .
               .           .
  146          .           .          41
               .           .           .
               .           .           .
  159          .          F4...........
               .           V
               .           V
  163          .      F4-F5B
               .           .
               .           .
  170          .           .         52B
               .           .           .
               .           .           .
```

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
180            .         F5B............
               .           V
               .           V
184            .      F5BF6B
               .           .
               .           .
196            .           .         60B
               .           .           .
               .           .           .
207            .         F6B............
               .           .
               .           .
212            .           .         52A
               .           .           V
               .           .           V
224            .           .      F5AF6A
               .           .           .
               .           .           .
236            .           .           .         60A
               .           .           .           .
               .           .           .           .
247            .           .         F6A............
               .           .           .
               .           .           .
252            .           .           .       RIDG
               .           .           .           V
               .           .           .           V
259            .           .           .      G3S-G4
               .           .           .           .
               .           .           .           .
266            .           .           .           .          28
               .           .           .           .           .
               .           .           .           .           .
278            .           .           .          G4............
               .           .           .           V
               .           .           .           V
282            .           .           .       G4-G5
               .           .           .           .
               .           .           .           .
289            .           .           .           .          30
               .           .           .           .           .
               .           .           .           .           .
302            .           .           .          G5............
               .           .           .           V
               .           .           .           V
306            .           .           .       G5-G6
               .           .           .           .
               .           .           .           .
313            .           .           .           .          42
               .           .           .           .           .
               .           .           .           .           .
326            .           .           .          G6............
               .           .           .           V
               .           .           .           V
330            .           .           .       G6-G7
               .           .           .           .
               .           .           .           .
337            .           .           .           .          53
               .           .           .           .           .
               .           .           .           .           .
348            .           .           .          G7............
               .           .           .           V
               .           .           .           V
352            .           .           .       G7-G8
               .           .           .           .
               .           .           .           .
364            .           .           .           .          61
               .           .           .           .           .
               .           .           .           .           .
375            .           .           .          G8............
               .           .           .           .
               .           .           .           .
380            .           .           .           .       RIDH
               .           .           .           .           V
               .           .           .           .           V
387            .           .           .           .      H3S-H4
               .           .           .           .           .
               .           .           .           .           .
394            .           .           .           .           .          31
               .           .           .           .           .           .
               .           .           .           .           .           .
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Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)


```
409           .           .           .           .          H4............
              .           .           .           .           V
              .           .           .           .           V
413           .           .           .           .       H4-H5
              .           .           .           .           .
              .           .           .           .           .
420           .           .           .           .           .          43
              .           .           .           .           .           .
              .           .           .           .           .           .
436           .           .           .           .          H5............
              .           .           .           .           V
              .           .           .           .           V
440           .           .           .           .       H5-H6
              .           .           .           .           .
              .           .           .           .           .
447           .           .           .           .           .          54
              .           .           .           .           .           .
              .           .           .           .           .           .
461           .           .           .           .          H6............
              .           .           .           .           V
              .           .           .           .           V
465           .           .           .           .       H6-H7
              .           .           .           .           .
              .           .           .           .           .
477           .           .           .           .           .          62
              .           .           .           .           .           .
              .           .           .           .           .           .
490           .           .           .           .          H7............
              .           .           .           .           .
              .           .           .           .           .
495           .           .           .           .           .       RIDI
              .           .           .           .           .           V
              .           .           .           .           .           V
502           .           .           .           .           .      I2S-I3
              .           .           .           .           .           .
              .           .           .           .           .           .
509           .           .           .           .           .           .          32
              .           .           .           .           .           .           .
              .           .           .           .           .           .           .
522           .           .           .           .           .          I3............
              .           .           .           .           .           V
              .           .           .           .           .           V
526           .           .           .           .           .       I3-I4
              .           .           .           .           .           .
              .           .           .           .           .           .
533           .           .           .           .           .           .          44
              .           .           .           .           .           .           .
              .           .           .           .           .           .           .
547           .           .           .           .           .          I4............
              .           .           .           .           .           V
              .           .           .           .           .           V
551           .           .           .           .           .       I4-I5
              .           .           .           .           .           .
              .           .           .           .           .           .
558           .           .           .           .           .           .          55
              .           .           .           .           .           .           .
              .           .           .           .           .           .           .
570           .           .           .           .           .          I5............
              .           .           .           .           .           V
              .           .           .           .           .           V
574           .           .           .           .           .       I5-I6
              .           .           .           .           .           .
              .           .           .           .           .           .
586           .           .           .           .           .           .          63
              .           .           .           .           .           .           .
              .           .           .           .           .           .           .
597           .           .           .           .           .          I6............
              .           .           .           .           .           .
              .           .           .           .           .           .
602           .           .           .           .           .           .       RIDJ
              .           .           .           .           .           .           V
              .           .           .           .           .           .           V
609           .           .           .           .           .           .      J3S-J4
              .           .           .           .           .           .           .
              .           .           .           .           .           .           .
616           .           .           .           .           .           .           .          33
              .           .           .           .           .           .           .           .
              .           .           .           .           .           .           .           .
629           .           .           .           .           .           .          J4............
              .           .           .           .           .           .           V
              .           .           .           .           .           .           V
```

```
 633     .    .    .    .    .    .    J4-J5
         .    .    .    .    .    .      .
         .    .    .    .    .    .      .
 640     .    .    .    .    .    .      .          45A
         .    .    .    .    .    .      .            .
         .    .    .    .    .    .      .            .
 654     .    .    .    .    .    .     J5A............
         .    .    .    .    .    .      V
         .    .    .    .    .    .      V
 658     .    .    .    .    .    .    J5A-5B
         .    .    .    .    .    .      .
         .    .    .    .    .    .      .
 665     .    .    .    .    .    .      .          45B
         .    .    .    .    .    .      .            .
         .    .    .    .    .    .      .            .
 675     .    .    .    .    .    .     J5B............
         .    .    .    .    .    .      V
         .    .    .    .    .    .      V
 679     .    .    .    .    .    .    J5B-J6
         .    .    .    .    .    .      .
         .    .    .    .    .    .      .
 691     .    .    .    .    .    .      .           64
         .    .    .    .    .    .      .            .
         .    .    .    .    .    .      .            .
 702     .    .    .    .    .    .      J6...........
```

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	68	499.	12.50	46.	12.	4.	0.41		
+	ROUTED TO	E1-E2	343.	12.50	45.	11.	4.	0.41		
+	HYDROGRAPH AT	59	150.	12.75	31.	8.	3.	0.25		
+	2 COMBINED AT	E2	489.	12.75	76.	20.	7.	0.66		
+	HYDROGRAPH AT	RIDF	264.	15.50	194.	51.	17.	0.00		
+	ROUTED TO	F1S-F2	232.	16.75	178.	51.	17.	0.00		
+	HYDROGRAPH AT	27	62.	13.75	25.	6.	2.	0.24		
+	2 COMBINED AT	F2	238.	16.75	185.	58.	19.	0.24		
+	ROUTED TO	F2-F3	233.	18.00	182.	58.	19.	0.24		
+	HYDROGRAPH AT	29	176.	14.25	94.	25.	8.	1.00		
+	2 COMBINED AT	F3	257.	18.00	220.	82.	27.	1.24		
+	ROUTED TO	F3-F4	254.	18.75	218.	82.	27.	1.24		
+	HYDROGRAPH AT	41	220.	14.25	120.	32.	11.	1.20		
+	2 COMBINED AT	F4	346.	15.50	279.	114.	38.	2.44		
	ROUTED TO									

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)

+		F4-F5B	327.	16.25	277.	114.	38.	2.44
+	HYDROGRAPH AT	52B	171.	13.25	51.	13.	4.	0.50
+	2 COMBINED AT	F5B	335.	16.00	280.	126.	42.	2.94
+	ROUTED TO	F5BF6B	336.	16.00	280.	126.	42.	2.94
+	HYDROGRAPH AT	60B	160.	13.50	60.	16.	5.	0.57
+	2 COMBINED AT	F6B	358.	16.00	311.	141.	47.	3.51
+	HYDROGRAPH AT	52A	65.	14.25	34.	9.	3.	0.31
+	ROUTED TO	F5AF6A	56.	14.25	34.	9.	3.	0.31
+	HYDROGRAPH AT	60A	104.	13.75	42.	11.	4.	0.41
+	2 COMBINED AT	F6A	160.	14.00	75.	19.	6.	0.72
+	HYDROGRAPH AT	RIDG	367.	15.50	159.	40.	13.	0.00
+	ROUTED TO	G3S-G4	249.	16.75	144.	40.	13.	0.00
+	HYDROGRAPH AT	28	80.	13.75	36.	9.	3.	0.33
+	2 COMBINED AT	G4	263.	16.50	162.	49.	16.	0.33
+	ROUTED TO	G4-G5	247.	18.25	158.	49.	16.	0.33
+	HYDROGRAPH AT	30	200.	14.50	115.	33.	11.	0.98
+	2 COMBINED AT	G5	281.	18.25	216.	81.	27.	1.32
+	ROUTED TO	G5-G6	268.	19.50	213.	81.	27.	1.32
+	HYDROGRAPH AT	42	142.	14.50	79.	21.	7.	0.78
+	2 COMBINED AT	G6	295.	15.50	249.	102.	34.	2.10
+	ROUTED TO	G6-G7	281.	16.25	248.	102.	34.	2.10
+	HYDROGRAPH AT	53	95.	13.75	37.	9.	3.	0.34
+	2 COMBINED AT	G7	295.	16.00	253.	111.	37.	2.43
+	ROUTED TO	G7-G8	294.	16.00	253.	111.	37.	2.43
+	HYDROGRAPH AT	61	144.	13.75	57.	15.	5.	0.51
+	2 COMBINED AT	G8	317.	16.00	272.	125.	42.	2.94
+	HYDROGRAPH AT	RIDH	388.	14.50	164.	41.	14.	0.00
	ROUTED TO							

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)

+		H3S-H4	160.	16.50	118.	41.	14.	0.00
	HYDROGRAPH AT							
+		31	153.	15.00	94.	26.	9.	1.08
	2 COMBINED AT							
+		H4	293.	16.00	197.	67.	23.	1.08
	ROUTED TO							
+		H4-H5	271.	16.75	191.	66.	23.	1.08
	HYDROGRAPH AT							
+		43	140.	15.00	89.	25.	8.	1.00
	2 COMBINED AT							
+		H5	373.	16.25	258.	91.	31.	2.08
	ROUTED TO							
+		H5-H6	364.	16.75	256.	91.	31.	2.08
	HYDROGRAPH AT							
+		54	69.	14.25	36.	9.	3.	0.39
	2 COMBINED AT							
+		H6	385.	16.75	276.	99.	34.	2.47
	ROUTED TO							
+		H6-H7	382.	16.75	275.	99.	34.	2.47
	HYDROGRAPH AT							
+		62	130.	13.75	54.	14.	5.	0.57
	2 COMBINED AT							
+		H7	398.	16.50	306.	113.	38.	3.04
	HYDROGRAPH AT							
+		RIDI	434.	13.75	27.	7.	2.	0.00
	ROUTED TO							
+		I2S-I3	60.	14.25	7.	2.	1.	0.00
	HYDROGRAPH AT							
+		32	141.	14.75	86.	24.	8.	0.90
	2 COMBINED AT							
+		I3	192.	14.25	93.	26.	9.	0.90
	ROUTED TO							
+		I3-I4	130.	17.00	83.	26.	9.	0.90
	HYDROGRAPH AT							
+		44	162.	15.00	104.	31.	10.	1.01
	2 COMBINED AT							
+		I4	223.	17.00	157.	56.	19.	1.90
	ROUTED TO							
+		I4-I5	206.	17.75	155.	56.	19.	1.90
	HYDROGRAPH AT							
+		55	63.	13.75	28.	7.	2.	0.26
	2 COMBINED AT							
+		I5	210.	17.50	169.	63.	21.	2.17
	ROUTED TO							
+		I5-I6	180.	18.50	154.	63.	21.	2.17
	HYDROGRAPH AT							
+		63	170.	13.75	76.	23.	8.	0.50
	2 COMBINED AT							
+		I6	227.	14.00	191.	84.	28.	2.66
	HYDROGRAPH AT							
+		RIDJ	209.	14.00	44.	11.	4.	0.00
	ROUTED TO							
+		J3S-J4	61.	15.25	35.	11.	4.	0.00
	HYDROGRAPH AT							

Pilot Study Area Modeled w/100-Year 24-Hour Storm

(From: 2004 Buckeye Sun Valley ADMS, and modified with proposed changes to the District methodology)

+		33	174.	14.75	102.	28.	9.	1.00
	2 COMBINED AT							
+		J4	233.	14.75	136.	39.	13.	1.00
	ROUTED TO							
+		J4-J5	217.	16.00	131.	39.	13.	1.00
	HYDROGRAPH AT							
+		45A	159.	15.00	99.	28.	9.	1.00
	2 COMBINED AT							
+		J5A	353.	16.00	220.	67.	22.	2.01
	ROUTED TO							
+		J5A-5B	340.	16.75	217.	66.	22.	2.01
	HYDROGRAPH AT							
+		45B	67.	13.25	24.	7.	2.	0.14
	2 COMBINED AT							
+		J5B	344.	16.75	223.	73.	25.	2.14
	ROUTED TO							
+		J5B-J6	203.	18.75	189.	73.	25.	2.14
	HYDROGRAPH AT							
+		64	113.	13.75	46.	12.	4.	0.41
	2 COMBINED AT							
+		J6	204.	18.75	193.	84.	28.	2.56

```
*** NORMAL END OF HEC-1 ***


     -----DSS---ZCLOSE Unit:  71,    File: C:\temp\b1.dss
                 Pointer Utilization:  1.48
                 Number of Records:    2108
                 File Size:  11289.6  Kbytes
                 Percent Inactive:    0.0
```