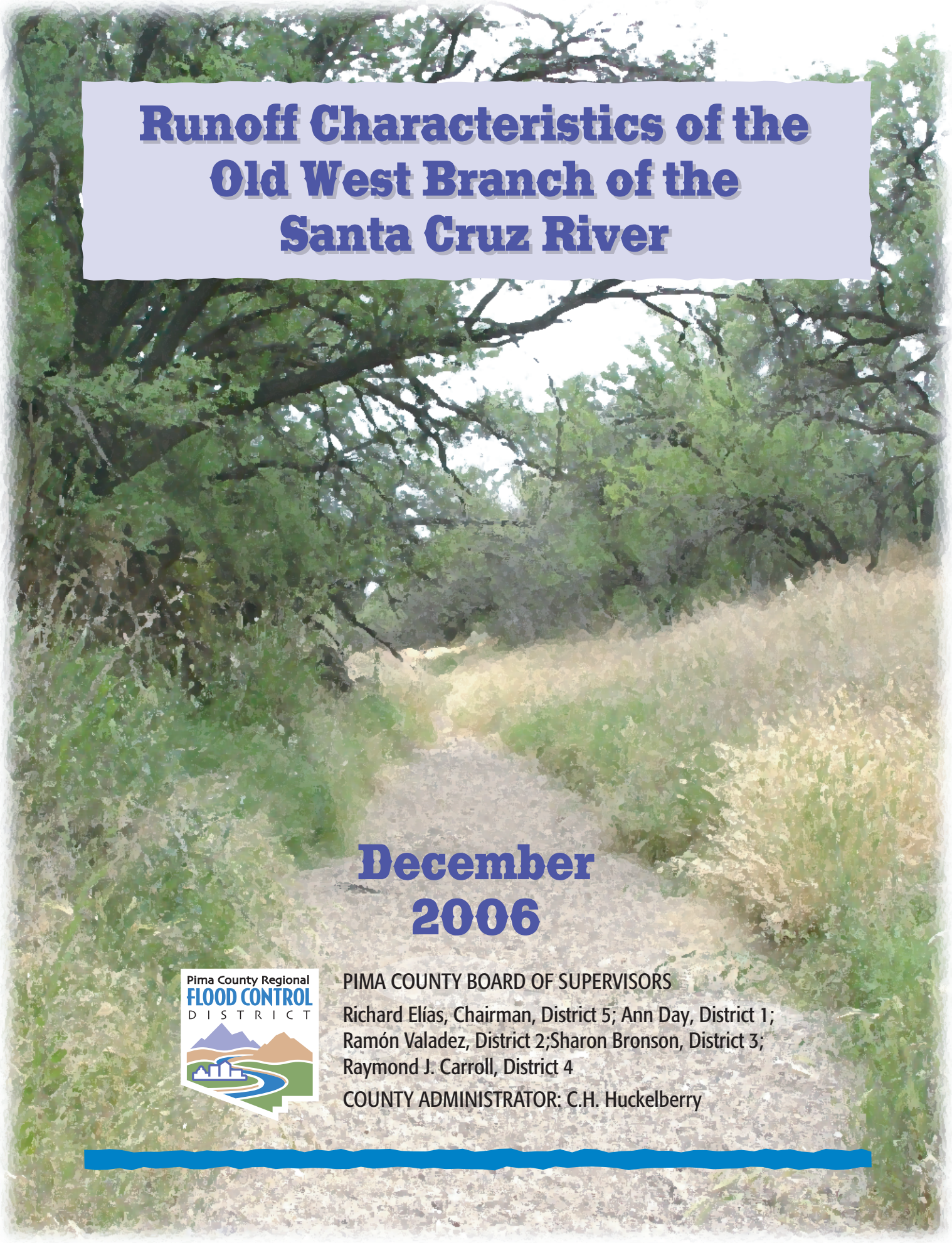
Runoff Characteristics of the Old West Branch of the Santa Cruz River



December 2006

Pima County Regional FLOOD CONTROL DISTRICT

PIMA COUNTY BOARD OF SUPERVISORS

Richard Elías, Chairman, District 5; Ann Day, District 1; Ramón Valadez, District 2;Sharon Bronson, District 3; Raymond J. Carroll, District 4

COUNTY ADMINISTRATOR: C.H. Huckelberry

Prepared by:
Evan Canfield, Ph.D., P.E.
Planning and Development Division
Pima County Regional Flood Control District

Executive Summary

The watershed of the Old West Branch of the Santa Cruz River, while disturbed, continues to retain many of the characteristics of a rural watershed. The highest density development is along Mission Road, giving the impression that the watershed is significantly developed. However, over 75 percent of the watershed is shrubland, and that most of the development that does occur tends to be low-density residential.

A GIS-based watershed hydrology assessment tool, the Automoated Geospatial Watershed Assessment with the Kineros2 model (AGWA-K2), was calibrated to simulate observed peak runoff distributions for two USGS gauging stations at the Enchanted Hills Wash and the West Branch at Valencia. Rainfall was not available, so the predicted rainfall from the NOAA 14, upper 90% rainfall was used as input data to the AGWA-K2 model. The objectives of the modeling were to determine the impact of diversion of the West Branch, and the impact of development. A separate exercise assessed whether rainfall is less at the West Branch.

The watershed above the West Branch at Valencia was diverted in 1982 by the Midvale Diversion channel, cutting off 21.9 square miles of the watershed from the Old West Branch. One of the objectives of the simulation was to determine the impact of this diversion on the hydrology of the current configuration of the Watershed called the 'Old West Branch'.

Simulations showed that runoff volume above the Midvale Diversion could deliver about 130 acre-ft of water to the Old West Branch in an average year. This could be a significant benefit to riparian vegetation growing along the West Branch. Furthermore, simulations and observation indicate that runoff from the watershed above the diversion channel tended to be less flashy and would therefore be more likely to infiltrate than discharges from the Enchanted Hills. The observed peak discharges from the West Branch at Valencia collected from 1965 to 1982 show much lower runoff peaks (in inches/hr) than those observed at the Enchanted Hills Wash on the Old. Simulated hydrographs from the West Branch at the Midvale Diversion are of longer duration, providing longer duration floods that would benefit the riparian vegetation of the Old West Branch.

Current land use platting does not indicate dramatic changes with additional development. The overall land cover of the Old West Branch continues to be shrubland, so the hydrologic modeling showed limited impact from development under current platting. The AGWA-K2 simulation showed that following the

currently-platted additional development (~150 acres), runoff from the small events would increase while runoff from the larger events would be little changed.

The AGWA-K2 values matched the observed values for the 2 to 10-year events better than the TSMS. For that reason, the AGWA-K2 simulations will be better for simulating the impact of individual events, and watershed yield under different conditions. However, the AGWA-K2 estimates for the 100 year events were greater than the estimates from TSMS, in part because AGWA-K2 was calibrated against the less-frequent events.

While some in the neighborhood believe that rainfall along the West Branch is less than in other parts of town, the observed seasonal rainfall at the West Branch does not vary greatly from what has been observed at the U of A. From 1986 to 2000, the average annual rainfall at the West Branch was 13.2 inches, while average annual rainfall at the U of A was 11.1 inches. About half the annual rainfall occurred in each season. Winter seasonal rainfall was very similar in any given year, though summer rainfall could vary substantially from the West Branch to the U of A. Therefore, rainfall does not appear to be lower in the West Branch than in other parts of Tucson.

Introduction 2
Objectives 5
Methods 5
Observed Rainfall Data 5
Daily and Seasonal Rainfall Data: 5
Rainfall Intensity: 6
The Observed Runoff Data 6
Runoff Data at Enchanted Hills: 7
Runoff Data at West Branch: 8
AGWA 9
KINEROS2 9
Modeling Approach 9
Accounting for the Diversion of the Headwaters of the West Branch: 9
Accounting for Urbanization: 11
Model Calibration and Validation 12
Accounting for Channel Characteristics 12
Calibrating KINEROS 12
Set up design storms: 12
Perform Sensitivity Analysis: 13
Perform Calibration at Enchanted Hills: 16
Calibrating KINEROS2 for the West Branch at Valencia: 17
Discussion 20
Rainfall Patterns at the West Branch 20
A Comparison of Estimated Return Period Discharges 20
Impact of Diversion Channel 22
Impact of Urbanization 24
Conclusions 25
Disclaimer 27
References 28
Appendix A - Subdivision Characteristics for Subdivisions Built Prior to 1982 30
Appendix B - Subdivision Characteristics for Subdivisions Built After 1982 31
Appendix C - Summary of Observed Peak Flow Data 32
Appendix D - The AGWA Tool 34
Appendix E – KINEROS2 Parameter File (Old West Branch - No Urbanization) 38
Appendix F – Rainfall Files 53
Appendix G – Summary of Calibrated Multipliers 55

Introduction

The Old West Branch of the Santa Cruz River contains a relict ecosystem with species that were once common in the Santa Cruz River valley, but are now rare. A recent US Army Corps of Engineers (USACE) feasibility study considered conservation and restoration efforts in the Old West Branch as part of the Paseo de las Iglesias study (USACE, 2004). The study area is approximately 5,005 acres and consists of a seven-mile reach of the Santa Cruz River and the New and Old West Branch tributary washes (Figure 1). This area is the cradle of modern day Tucson and has a lineage of continued habitation dating thousands of years before settlement of the area by the Spanish missionaries.

The West Branch of the Santa Cruz River currently extends from the southern border of the study area to the north approximately 3.5 river miles to where it joins the main stem of the Santa Cruz River, just north of Irvington Road. The portion of this channel just north of Irvington Road, the New West Branch, has been rerouted. The former channel (before it was rerouted) is called the Old West Branch and extends from just north of Irvington to just south of 22nd Street where it joins the main stem of the Santa Cruz River. The Old West Branch was once the principal western channel of the Santa Cruz River. However, entrenchment of the eastern river channel isolated the western channel, cutting off its water supply. It became known as the West Branch of the Santa Cruz River and, following construction of the flood control diversion, the Old West Branch. The study area also includes a portion of Tucson designated for redevelopment under the City of Tucson's Rio Nuevo Master Plan. That plan includes historic restoration and landscaping initiatives, which could integrate with environmental restoration measures to increase project outputs. The study area has also been designated for inclusion in Pima County's Sonoran Desert Conservation Plan (SDCP).

No federally listed threatened or endangered species were detected in the study area. The following seven species of primarily local interest were determined to occur, or have a potential to occur, within the Paseo de las Iglesias corridor: giant spotted whiptail, western yellow-billed cuckoo, burrowing owl, Abert's towhee, Bell's vireo, western red bat, and western yellow bat. Other wildlife species observed during the field investigations were also recorded. The giant spotted whiptail is designated as a US Fish and Wildlife Service (USFWS) Species of Concern, a US Forest Service (USFS) Region 3 Forester Priority Sensitive Species, and a SDCP Priority Vulnerable Species (PVS). Currently, known populations of the giant spotted whiptail have been recorded from the Santa Catalina, Santa Rita, and Baboquivari Mountains. Once common along the Santa Cruz River, the known population has been reduced to a remnant along the West Branch (Rosen 2001). Giant spotted whiptails are found in lower Sonoran (chiefly riparian areas) and upper Sonoran life zones, in mountain canyons, arroyos, and mesas in arid and semi-arid regions, entering lowland desert along stream courses. The species is found in dense shrubby vegetation, often among rocks

near permanent and intermittent streams, and in grassy areas within riparian habitats.

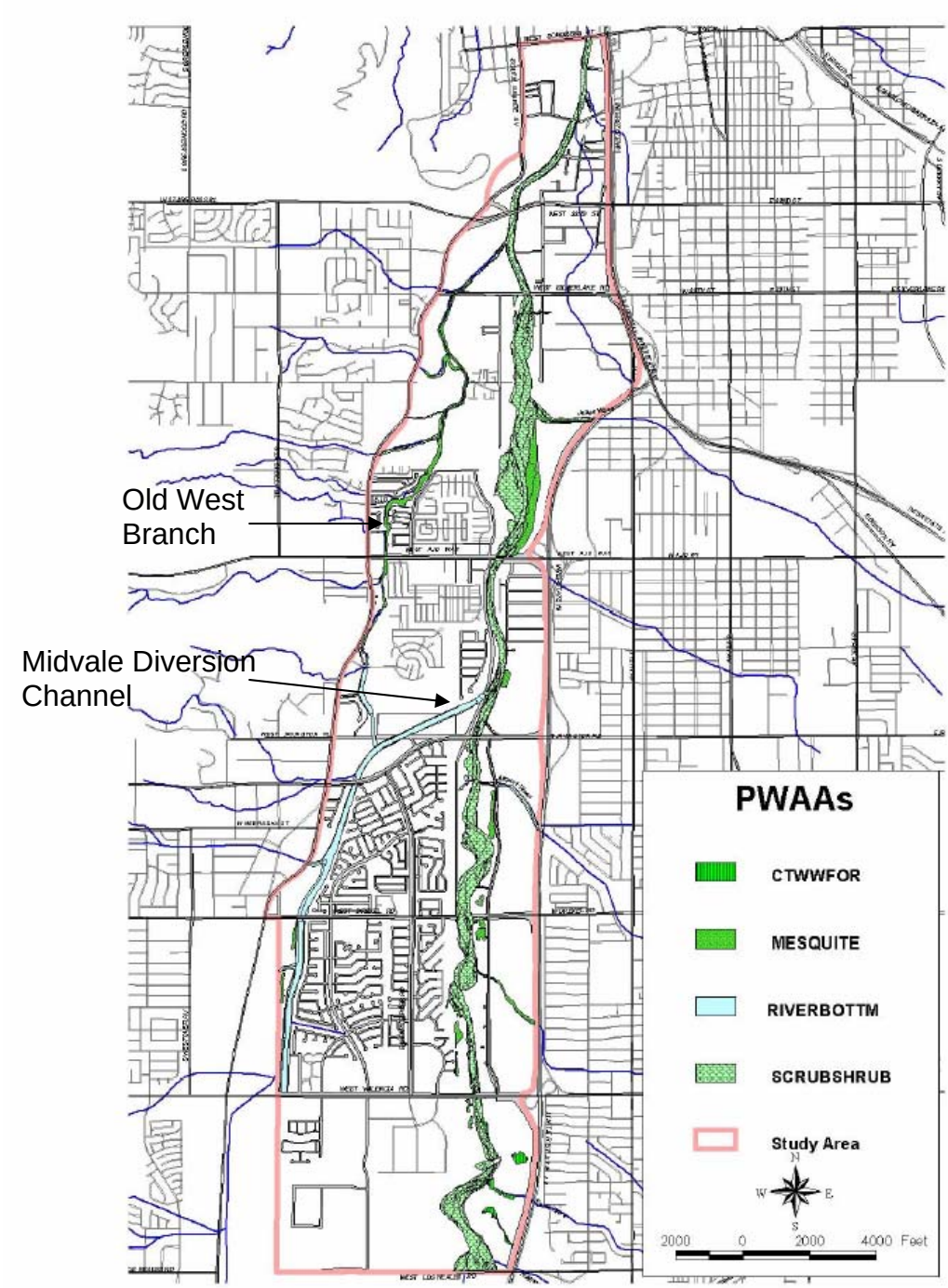


Figure 1 – Footprint of the Paseo de Las Iglesias Project showing the West Branch of the Santa Cruz

The habitat depends on the ongoing viability of the riparian areas associated with the Old West Branch, much of which is located on land owned by Pima County.

Because of the dependence of the riparian areas on the hydrology, there have been two previous studies that considered runoff and flooding (Briggs et al., 2005; Ward, 2004). In addition, the Tucson Stormwater Management Study (TSMS) estimated return period discharges for the major washes in the West Branch Watershed.

These previous studies answered some important questions about potential for overbank flows in the West Branch channel under current conditions. However, there remains a need to understand rainfall and runoff patterns on the West Branch. First, it is important to understand rainfall patterns. Rainfall can be locally variable, and some have suggested that the West Branch watershed receives less rainfall than other parts of town.

Next, the impact of the Midvale Diversion needs to be assessed. The upper 24 square miles of the original West Branch watershed were diverted back into the main stem of the Santa Cruz River at the Midvale Diversion channel in 1982. The current West Branch Watershed above the Cholla Wash has an area of about ten square miles (6,400 acres). Some have pointed to this diversion as the time when the habitat along the West Branch began to degrade, and the trees began to die.

Still others have concerns related to the potential of urbanization to alter runoff patterns, which may lead to the degradation of the riparian areas. The land cover is mostly shrubland as shown in a National Landcover Dataset map of the watershed from 1991 (Figure 2).

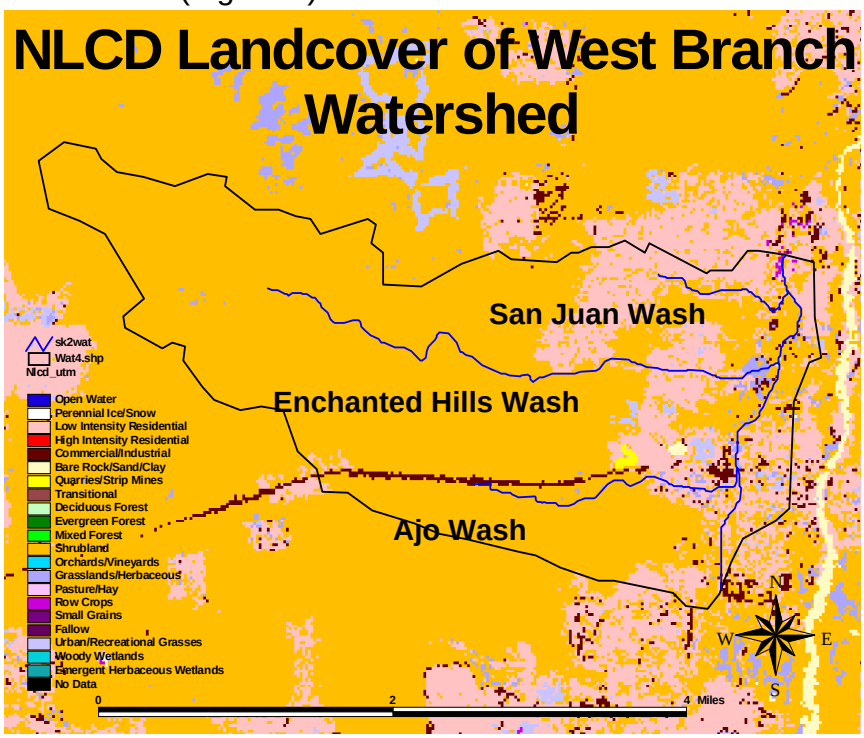


Figure 2 – National Landcover Dataset of the West Branch Watershed.

The mustard color represents shrubland. The pink is low-density development, and the rust color is commercial development. The dominance of the shrubland indicates that the majority of the West Branch Watershed is relatively undisturbed, (which is not the impression one gets traveling down Mission Road). The relict ecosystem at the West Branch Conservation Area can be attributed, at least in part, to the relatively intact watershed above the property.

Using MapGuide, the number of acres in subdivisions on the watershed was estimated at about 800 acres, which is only a fraction of the nearly 6,400 acres in the watershed. The characteristics of the subdivisions on the West Branch Watershed are summarized in the Appendices. The data is divided into subdivisions that were urbanized prior to 1982 (Appendix A) when runoff data was being collected by the USGS and the Midvale Diversion had not been installed; and those built after 1982, when no runoff data is available (Appendix B).

Objectives

In order to understand the potential for maintaining and improving habitat, we evaluated the existing hydrologic data, and calibrated a rainfall-runoff model (AGWA-K2) to address the following three objectives:

a.) to determine if rainfall conditions at the West Branch are different than the rainfall at the University of Arizona (U of A), (the longest rainfall record in Tucson),
b.) to determine whether calibrated return period discharges using the AGWA-K2 are reasonable,
c.) to determine how the diversion at Midvale in 1982 has affected runoff at Pima County property along the West Branch, and
d.) to determine how increased urbanization in the Old West Branch Watershed has the potential to affect runoff at Pima County property along the West Branch.

Methods

Observed Rainfall Data

Daily and Seasonal Rainfall Data:

Rainfall data collected at the West Branch can be compared with data from the U of A to determine whether rainfall patterns are significantly different. The data from the U of A extends back to 1895, so the mean annual and seasonal rainfall are well known for that station. There is no recording rainfall data for the West Branch Watershed that will allow rainfall intensities to be calculated. However, there are 20 years of daily rainfall data from the Dee Birch house at 2229 S. Mission Rd. near the corner of 36th Street and Mission Rd.

Rainfall Intensity:

The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 return-period rainfall events can be estimated using the NOAA interactive map found at:

http://hdsc.nws.noaa.gov/hdsc/pfds/sa/az_pfds.html

Using this map, the following intensity data was generated. The upper 90 percent confidence interval was used, because this is the rainfall currently being used in Pima County's computerized hydro program. A three-hour storm was selected because most of the peak flow events occurred during the monsoon and most monsoon events have a three-hour duration or less. As a point of comparison, the time of concentration for the Old West Branch would be about two hours for the ten-year event, but much more for the two-year event. The rainfall depths (inches) are summarized in Table 1.

Table 1 – NOAA Atlas 14 Return Period Rainfall, Upper 90 percent (Point estimate at West Branch at Enchanted Hills Wash)

	5	**10**	**15**	**30**	**60**	**120**	**3**	**6**	**12**	**24**
(years)	**min**	**min**	**min**	**min**	**min**	**min**	**hr**	**hr**	**hr**	**hr**
1	0.28	0.42	0.53	0.71	0.88	1.01	1.07	1.22	1.37	1.52
2	0.36	0.55	0.68	0.92	1.14	1.3	1.35	1.53	1.72	1.9
5	0.47	0.72	0.9	1.21	1.49	1.68	1.74	1.92	2.13	2.38
10	0.56	0.85	1.06	1.43	1.76	1.97	2.04	2.24	2.46	2.77
25	0.68	1.03	1.28	1.72	2.13	2.38	2.46	2.67	2.92	3.31
50	0.77	1.17	1.45	1.95	2.42	2.7	2.79	3.03	3.29	3.74
100	0.86	1.32	1.63	2.2	2.72	3.03	3.17	3.4	3.67	4.2

The Observed Runoff Data

From the 1960s to early 1980s, the United States Geological Survey (USGS) collected runoff data from urbanizing watersheds throughout Tucson. One of these was the Enchanted Hills at Mission Road. For the purposes of the modeling study, this data is essentially pre-development because we are interested in characterizing the impact of the additional change since the baseline data was collected. However, the watersheds were urbanizing throughout the period when data was being collected from the Enchanted Hills.

Runoff Data at Enchanted Hills:

USGS collected annual peak runoff data for the Enchanted Hills Wash at Mission Rd. (USGS Hydrologic Unit Code15050301) between 1965 and 1981 for a total of 17 observations. In four years, there was no observed flow. The peak discharge was 3,000 cfs on August 17, 1971 (Appendix C). The log of discharge is plotted against discharge as follows:

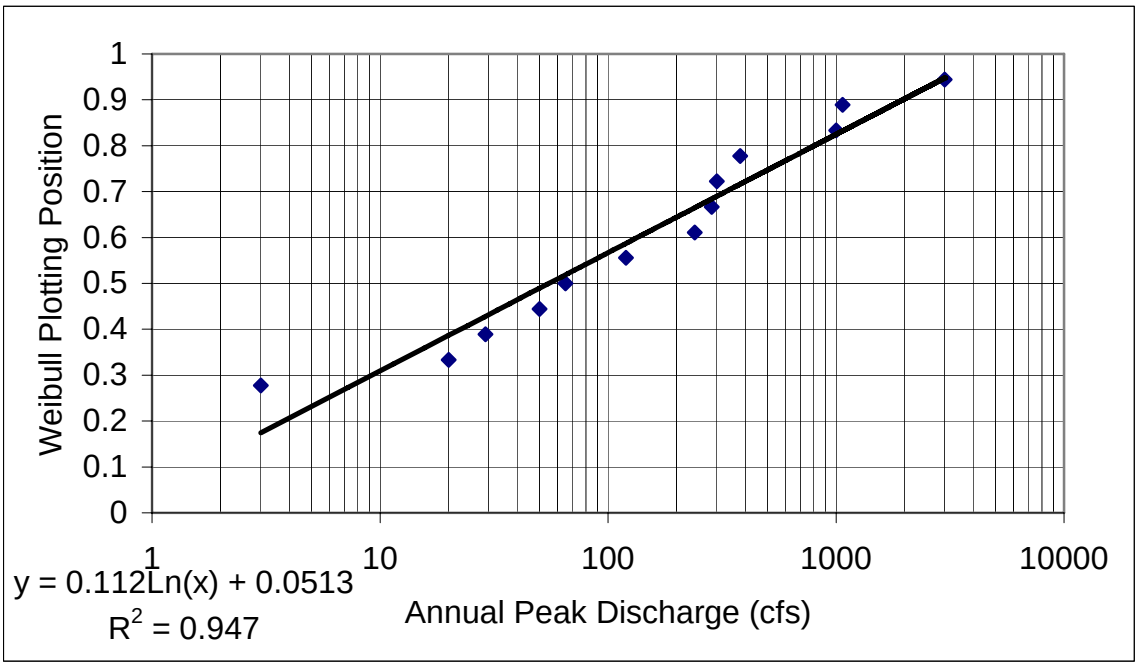


Figure 3 – Probability of Annual Exceedence at the Enchanted Hills between 1966 and 1982.

In this case, the plot can be interpreted as the probability that the annual event will be less than (i.e. 1- probability of exceedence). The data fit a log plot reasonably well. However, a Pearson Type III distribution can also be calculated. The period of record is inadequate for estimating greater than ten-year return period events. The estimated return period and discharges are summarized in Table 2.

Table 2 – Summary of Calculated Return Period Discharges for the Enchanted Hills at Mission Rd.

			Pearson			Log-Normal	
Return Period (years)	Plotting Position	Qp (cfs)	Qp (inch/hr)	Qp (mm/hr)	Qp (cfs)	Qp (inch/hr)	Qp (mm/hr)
2	0.5	40	0.02	0.50	55	0.03	0.68
5	0.8	575	0.28	7.16	800	0.39	9.98
10	0.9	1848	0.91	23.05	1954	0.96	24.36

The depth rate (i.e. inch/hr was calculated assuming a 3.2 square mile watershed, which is the contributing area calculated in the AGWA Extension to ARC View (USGS calculates 2.94 square miles).

Runoff Data at West Branch:

Peak flow data by water year is also available for the West Branch channel at Valencia. The period of record is from 1966 to 1981 (Appendix C). The Midvale Diversion was installed in 1982. The watershed above this point is 23.6 square miles, which is much larger than the Enchanted Hills watershed. Unlike Enchanted Hills, flow occurred every year that the channel was gauged. However, peak flow values are lower on both a discharge and a per unit (i.e. depth) basis.

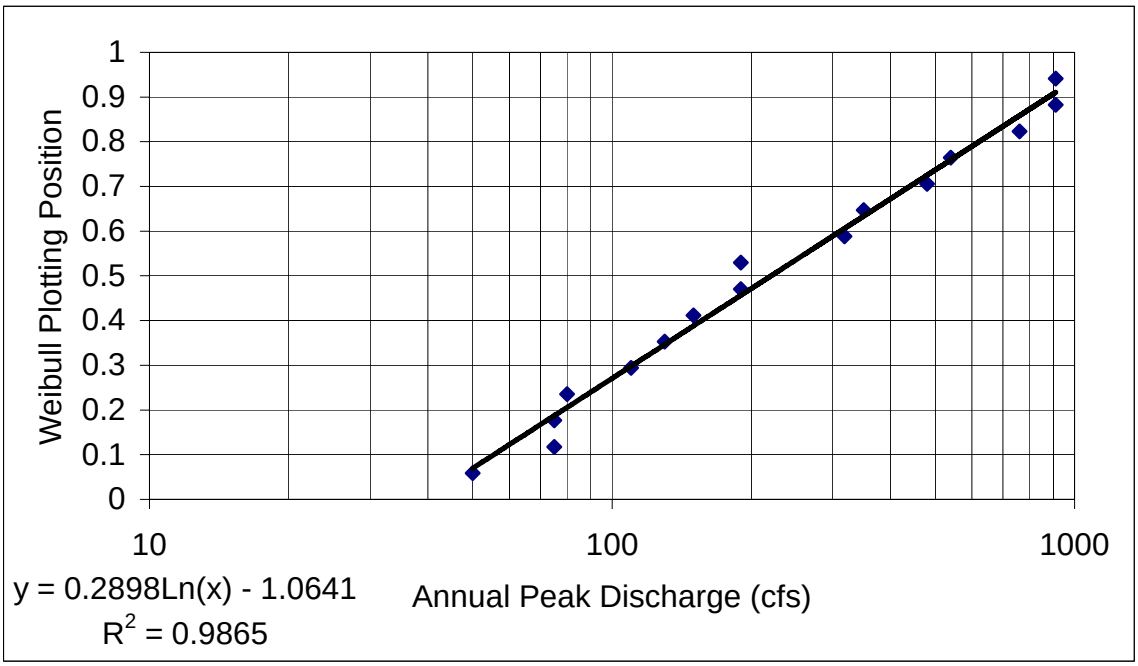


Figure 4 – Probability of Annual Exceedence at the West Branch at Valencia between 1966 and 1982

The estimated return period discharges are summarized in Table 3.

Table 3 – Summary of Calculated Return Period Discharges for the West Branch at Valencia

			Pearson			Log-Normal	
Return Period (years)	Plotting Position	Qp (cfs)	Qp (inch/hr)	Qp (mm/hr)	Qp (cfs)	Qp (inch/hr)	Qp (mm/hr)
2	0.5	217	0.015	0.37	221	0.015	0.37
5	0.8	491	0.033	0.83	622	0.041	1.05
10	0.9	759	0.050	1.28	878	0.058	1.48

AGWA

The simulations were done using the AGWA (Automated, Geospatial Watershed Assessment) hydrologic modeling tool, (http://www.tucson.ars.ag.gov/agwa/) which is an ARC View GIS extension that writes parameter files for two hydrologic models, and displays the results of the simulations graphically. The tool is described in more detail in Appendix D. In general, however, it employs a Digital Elevation Model (DEM) to describe the watershed geometry, and soil and cover characteristics to determine hydrologic model parameter values.

The two models parameterized by AGWA are the Soil and Water Assessment Tool (Arnold et al, 1994), an empirically-based continuous simulation model, and KINEROS (Smith et al 1995; Smith et al. 2000), a more process-based event model.

KINEROS2

KINEROS2 (Smith et al. 1995; Smith and Quinton 2000; http://www.tucson.ars.ag.gov/kineros) is a distributed runoff-erosion model based on Hortonian overland flow theory and, therefore, is well-suited to describing the hydrodynamics of runoff and erosion processes on southwestern watersheds, where infiltration rates are low and rainfall is infrequent but intense. Runoff is described with a one-dimensional continuity equation applicable to both overland and channel flow. Hillslopes are represented as rectangular planes draining into trapezoidal channels. Therefore, the model includes a generalized description of the infiltration and runoff processes and watershed geometry. The fact that it models the dynamics of the infiltration and runoff processes means that the model can better simulate the runoff from observed rainfall events (especially in terms of duration and shape of a hydrograph) than more empirical models.

Modeling Approach

Accounting for the Diversion of the Headwaters of the West Branch:

The entire West Branch watershed was partitioned using AGWA, including the portion that was upstream of the diversion. This allowed the impact of the diversion of the West Branch to be separated from other impacts. AGWA estimates channel geometry using regression relationships between contributing area and slope. Ideally, the area upstream prior to diversion should be used in order to more accurately estimate channel geometry prior to diverting the West Branch.

The West Branch watershed prior to the Midvale Diversion is shown in Figure 5:

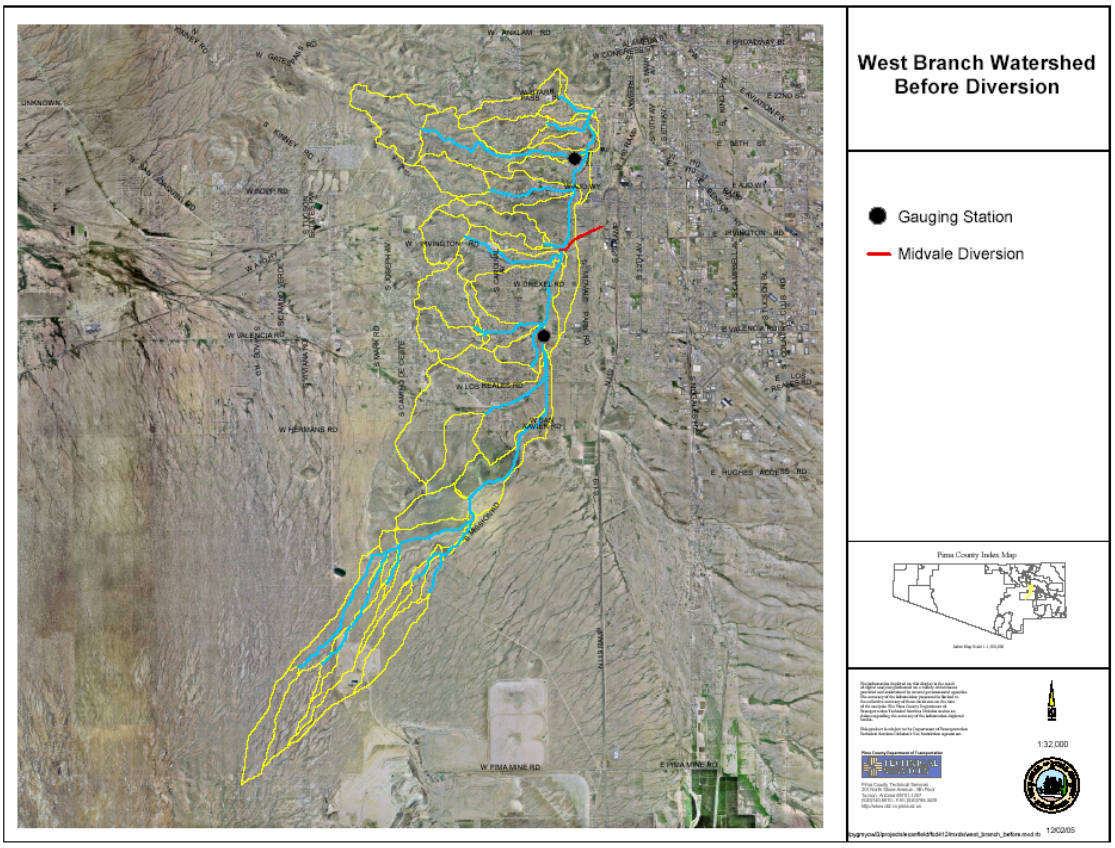


Figure 5 – The West Branch Watershed Prior to Building the Diversion

The figure shows the location of both the gauging station on the West Branch and the gauging station at the Enchanted Hills Wash. The location of the Midvale Diversion Channel is shown in red. AGWA calculated a contributing area of 47 square miles for the West Branch at Cholla Wash prior to diversion, while the area calculated for the West Branch at the Santa Cruz River is 54 square miles (Sousa pers comm. 2005). AGWA calculated a contributing area of 21.9 square miles upstream of the

gauging station at Valencia, which is in contrast to the 23.9 square miles calculated by the USGS for this station. While the watershed upstream of Valencia is certainly quite large, much of it is very flat resulting in uncertain estimates of drainage area.

Following diversion, the West Branch watershed at Cholla Wash was calculated to be about ten square miles, with three main tributaries, San Juan Wash, Enchanted Hills Wash, and Ajo Wash. The post diversion watershed is illustrated in Figure 6.

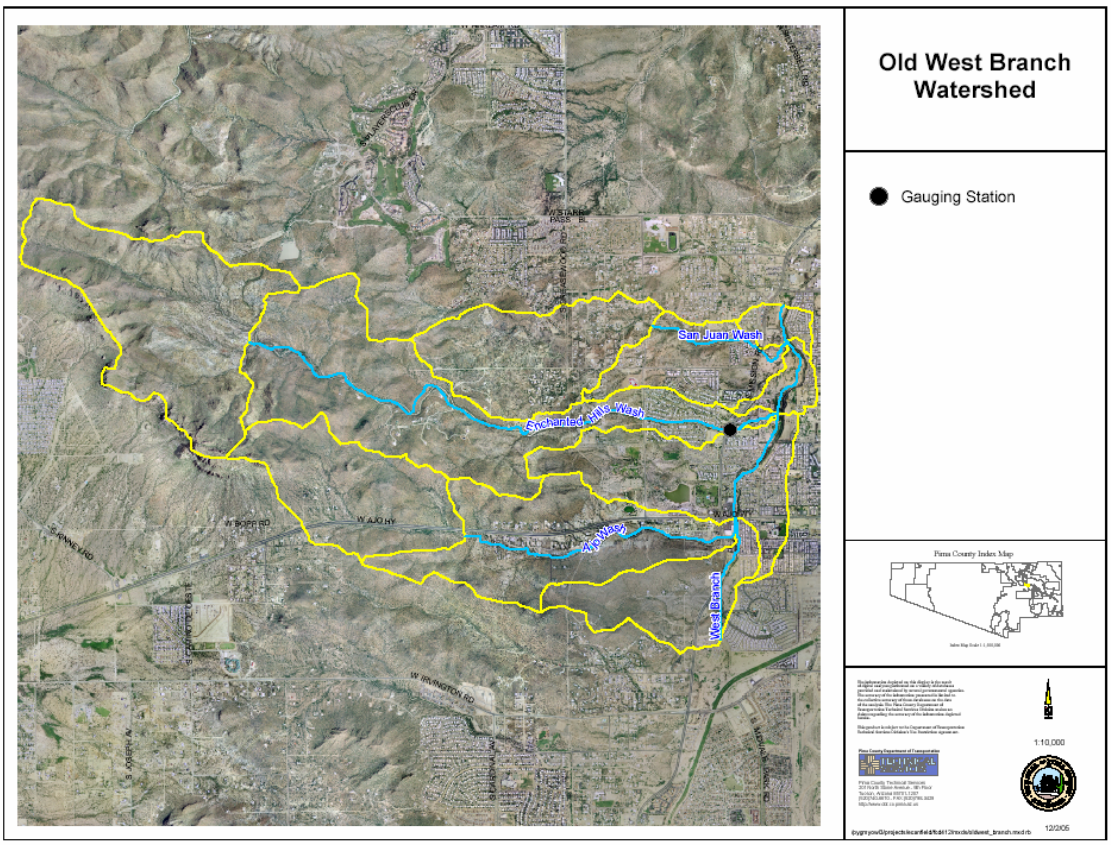


Figure 6 – The Current West Branch Watershed (i.e. old West Branch)

Accounting for Urbanization:

KINEROS was calibrated against peak runoff data that were collected by the USGS, while the Enchanted Hills was being urbanized. By the time the last peak runoff data was collected on Enchanted Hills, 650 acres had been developed. Since that time, only about 150 acres of additional development has been added, or partitioned for development.

In order to modify the model to simulate this additional development, the areas to be developed were identified. The increase in impervious area was estimated based on housing density, using values from the Pima County Hydrology Manual (PCFCD, 1979). In order to more accurately describe the spatial impact of the development, an impervious strip was added to the plane representing the hillslope to account for the increase in impervious area. The size of the strip corresponded to the area of impervious surface added in urbanization. Since the model was calibrated against the observed response of a partially urbanized watershed, the simulation should be indicative of the change from urbanization.

Model Calibration and Validation

Accounting for Channel Characteristics

AGWA estimates channel geometry using regression relationships that estimate channel width and depth as a function of contributing area and local channel slope (Miller, 1995). In general, a strong relationship exists between contributing area, channel slope and channel cross-sectional area. However, the width and depth that make up the cross-sectional area are less easy to predict based on contributing area and channel slope (e.g. Moody and Odem, 1999). Therefore, field observations can be used to account for the conditions that apply within the watershed being modeled.

Using the channel slope estimated in AGWA, a channel roughness of 0.035, and the observed peak flow and depth data, channel width can be estimated. Using this method, the width of the channel was determined to be too wide by a factor of three, so that depth was increased to be three times greater to produce the same cross-sectional area.

The channel geometry for the runoff estimate on the Old West Branch can be simulated by removing the portion of the watershed that is above the diversion channel, thus leaving the channel geometry as a function of the watershed area.

Calibrating KINEROS

KINEROS was applied for design storms with two, five and ten year return period events. A three-hour event was selected, because this was used for the TSMS study, and would be a reasonable estimate for time of concentration for the Enchanted Hills watershed. The process of implementation was as follows:

Set up design storms:

A typical Monsoon storm has a duration of three hours or less. In order to get a reasonable estimate of design storm intensities, the NOAA atlas data was used along with the SCS type II rainfall distribution. The ten

year event storm (2.04 inches or 52 mm) had cumulative rainfall depths and intensities as illustrated in Figure 7.

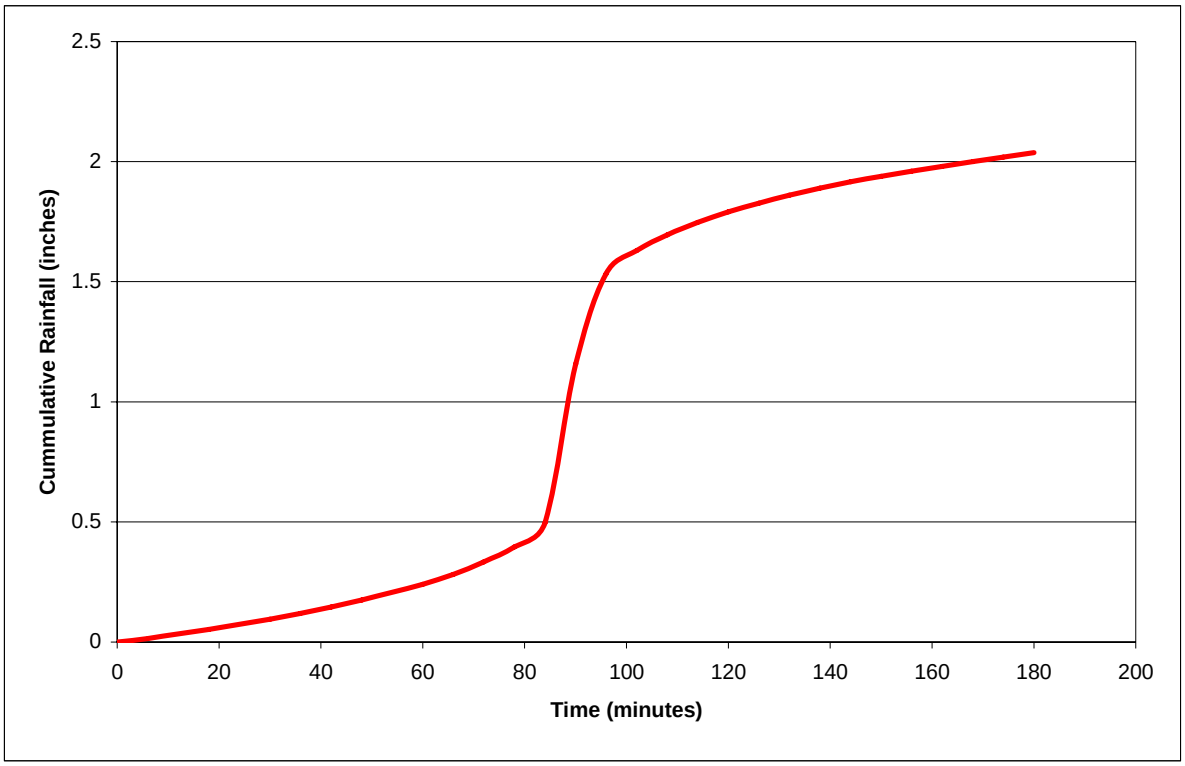


Figure 7 – 10 yr Storm

For the simulations on the West Branch prior to construction of the Midvale Diversion, no aerial reduction factor was used. However, it would have been relatively small (0.92 for 3hr storm, 24 sq mi watershed; Weather Bureau Tech Paper 40).

Perform Sensitivity Analysis:

A sensitivity analysis was performed by selecting a reasonable set of parameters for the Enchanted Hills Wash, modifying parameters from the baseline scenario and determining the degree of change caused my changing each parameter. The four parameters evaluated for sensitivity were:

- Saturated Hydraulic Conductivity (Ks)
- Coefficient of Variation of Saturated Hydraulic Conductivity (CVKs)
- Manning's Roughness for Channels (CHn)
- Manning's Roughness for Hillslopes (HSn)

The baseline scenario used the ten-year event. The baseline value for Ks was 3 x initial estimate, because the preliminary estimate indicated that the initial estimate would produce far too much runoff. Otherwise, the sensitivity analysis used the initial value.

Both calibration and sensitivity analysis used a multiplier approach. In this approach, all initial estimates are increased or decreased by multiplying the initial estimate by a factor.

The sensitivity analysis showed that Manning's roughness on hillslopes (HSn), and saturated hydraulic conductivity (Ks) were the most sensitive model parameters as indicated in Figure 8. Ks approximates a linear response with a doubling of Ks resulting in approximately a doubling of Qp. Because HSn displayed significant non-linearity, it was more sensitive than Ks when HSn was reduced, but less sensitive than HSn, when it was increased. In other words, when HSn drops, peak runoff rates increase exponentially. However, if HSn increases, peak runoff rates decrease at an exponential rate.

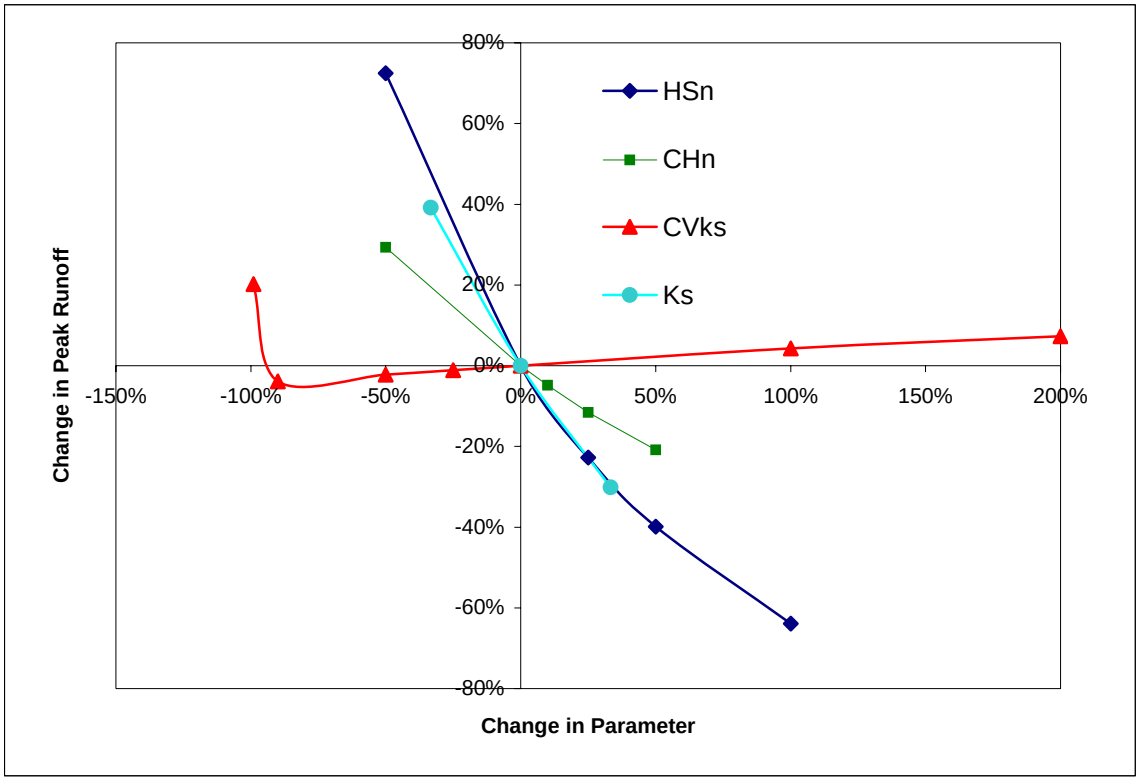


Figure 8 – Sensitivity Analysis

The results show that Manning's roughness on hillslopes is more sensitive that Manning's roughness in channels. In addition, reductions in both roughness values and Ks produce higher peak flow values. Only CVKs is

positively correlated with peak runoff, and the model is not very sensitive to CVKs.

The fact that the three most-sensitive parameters have similar slopes with peak discharge indicates that any one of them can produce similar changes in peak runoff. It also suggests that it is unlikely that a single, unique combination of parameter values will be found that reproduces the predicted peak discharge for the two, five and ten year events.

Perform Calibration at Enchanted Hills:

The model was calibrated using the SCE-UA optimization routine (Duan et al. 1993), which was used to optimize runoff parameters in KINEROS2 (Canfield et al, 2005). This version was modified to optimize the difference between observed and modeled peak, rather than the full hydrograph. The three most sensitive parameters, Chn, HSn, and Ks, were selected for optimization. The two, five and ten-year design-storm events were run using the parameter values from the AGWA look up tables.

The optimization indicated that the best results could be achieved by increasing Ks from the look up table by a factor of about 3.3. This means that the initial look-up table value averaged about 0.15 inch/hr, while the calibrated estimate was about 0.50 inch/hr. This is essentially the difference between initially estimating the infiltration rate to be similar to sandy clay loam, and determining that it is more like loam. It was also noted that decreasing the roughness in both the channel and the hillslope improved the simulations. In effect, this reduced Manning's roughness from 0.035 to 0.025 in the channel. The effect on the hillslope was to reduce the roughness from about 0.055 to 0.038. The comparison between observed and simulated runoff is summarized on Table 4.

Table 4 – Summary of Calculated Return Period Discharges and Ks Multipliers at Enchanted Hills

Event Depth (inch)	Return Period (yr)	Observed (Pearson) (inch/hr)	Observed (log Normal) (inch/hr)	Look-Up (inch/hr)	Optimized Parameter Values (inch/hr)
1.35	**2**	0.02	0.03	0.35	0.03
1.74	**5**	0.28	0.39	0.90	0.44
2.04	**10**	0.91	0.96	1.39	0.91

The results in the table can be better understood graphically as indicated in Figure 9.

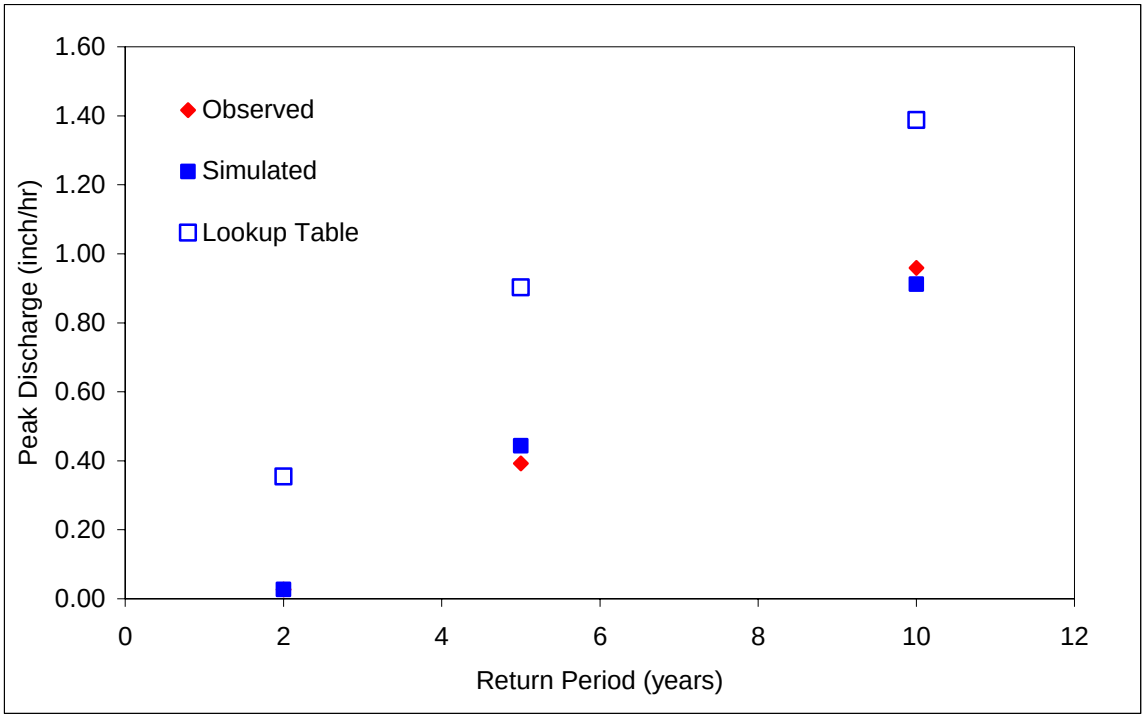


Figure 9 – Calibrated Peak Flow for Return Period Events on Enchanted Hills.

The observed peak runoff response (red) is highly non-linear with the ten-year event having a peak rate about 30-50 times greater than the two-year event. Furthermore, the fact that the calibrated KINEROS simulation (blue squares) is similar to the observed estimates is highly encouraging. However, simply selecting the parameter values from the lookup table would produce significant errors in this case (open blue squares).

Calibrating KINEROS2 for the West Branch at Valencia:

In order to determine how effective the selected calibration performed, it was useful to compare the predicted peak runoff with the observed for another station or time period. In this case, data was available for the West Branch at Valencia for the period from 1966 to 1981.

Because the estimated time of concentration was estimated to be about nine hours using the Pima County method, the 12 hour storm was used. However, during the period of record only two storms occurred outside the summer monsoon months. Therefore, while general storms typically are the storms that cause the larger events on these larger watersheds, the data did not indicate this.

The optimization indicated that the best results could be achieved with very little modification of the Ks from the look up table (about a five percent

increase). This means that the initial look-up table value averaged about 0.15 inch/hr, while the calibrated estimate was about 0.45 inch/hr. This is essentially the difference between initially estimating the infiltration rate to be similar to sandy clay loam, and determining that it is more like loam. It was also noted that increasing the roughness in both the channel and the hillslope improved the simulations. In effect, this increased Manning's roughness from 0.035 to 0.047 in the channel. The effect on the hillslope was to increase the roughness from about 0.055 to 0.078. The comparison between observed and simulated runoff is summarized on Table 5. The results are illustrated graphically in Figure 10.

Table 5 – Summary of Calculated Return Period Discharges and Predicted Peak Discharge for the West Branch at Valencia with Calibrated Parameters

Return Period (yr)	Event Depth (inch)	Observed (Pearson) (inch/hr)	Observed (log Normal) (inch/hr)	Look-Up (inch/hr)	Optimized Parameter Values (inch/hr)
2	1.72	0.014	0.015	0.021	0.005
5	2.13	0.033	0.041	0.037	0.027
10	2.46	0.050	0.058	0.153	0.057

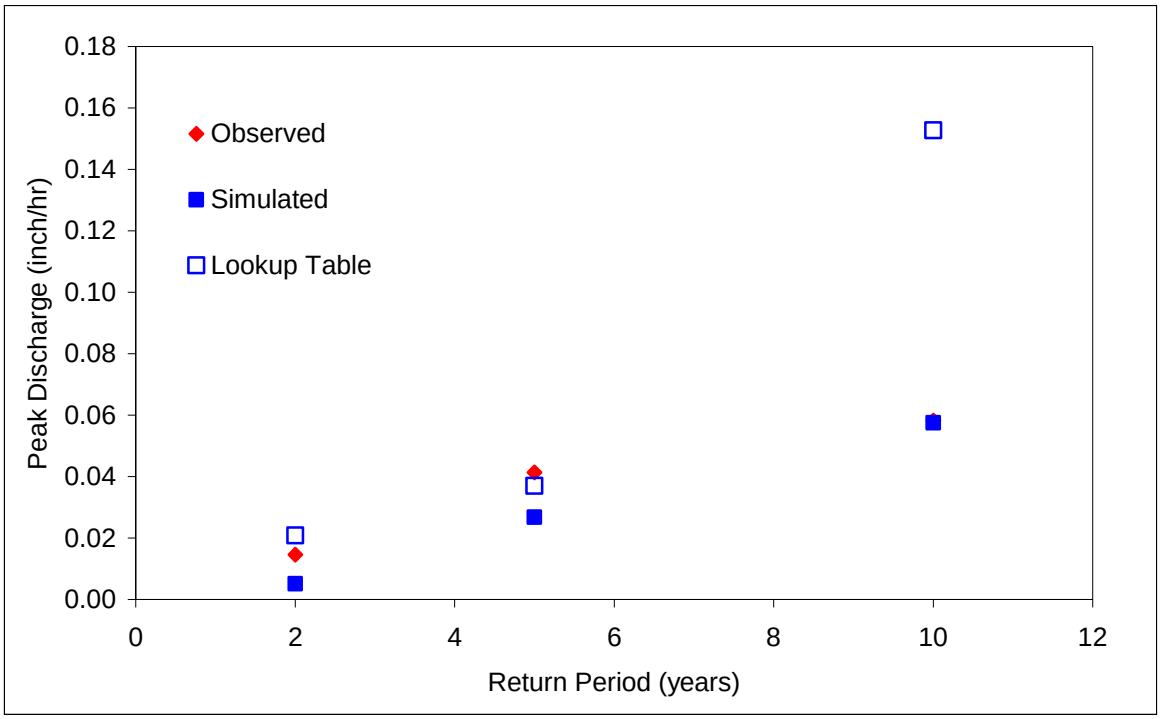


Figure 10 - Calibrated Peak Flows for Return Period Events for the West Branch at Valencia

Considering that the West Branch watershed at Valencia is much different than the Enchanted Hills Wash, the validation is good. The West Branch is a much larger watershed (21.9 square miles vs 2.94 square miles), draining a much flatter area. Furthermore, the runoff is actually a small portion of the total rainfall, so that runoff represents small differences in large numbers. The observed runoff for the ten year event is only about 0.06 inches from 2.04 inches of rainfall, and the fraction from the smaller events is even less. So results shown in the above figure suggest that the model will be a useful tool in estimating the hydrologic response.

Discussion

Rainfall Patterns at the West Branch

This data shows that the West Branch received about the same annual rainfall as the U of A (longest continuous record in Tucson), and actually received an average of two inch/yr more than the U of A (13.2 inch/yr vs 11.1 inch/yr) for the time period where both data are available. These differences are illustrated in Figure 11.

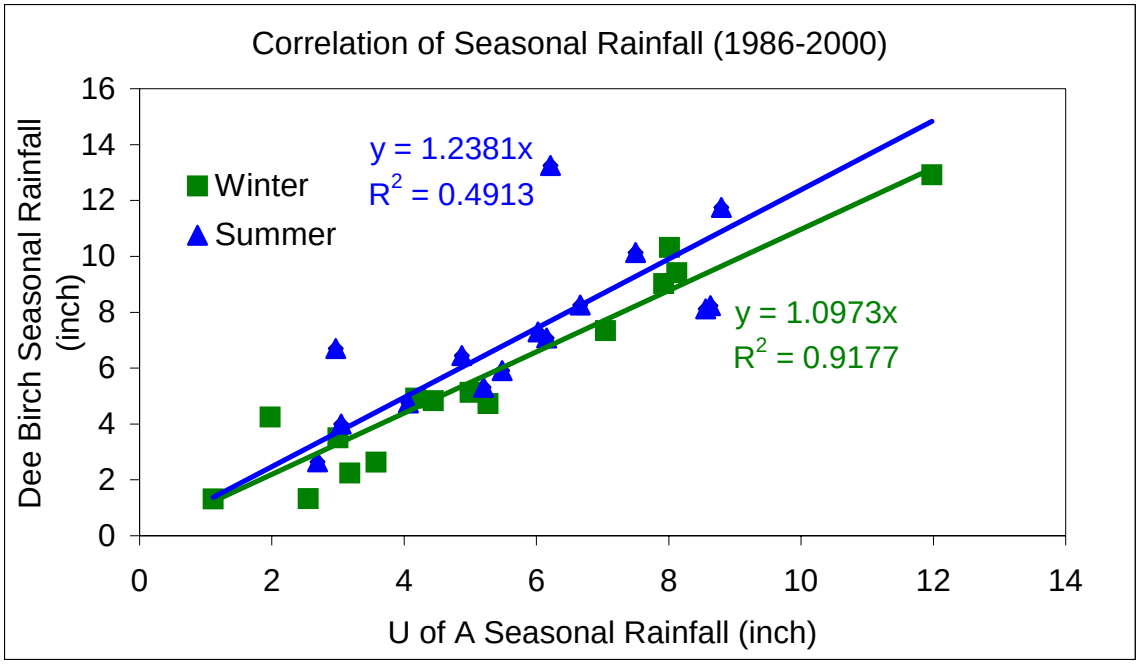


Figure 11 – Correlation of Seasonal Rainfall Between Dee Birch's House and the U of A

The data summarized in Figure 11 shows that seasonal winter rainfall at the U of A is nearly the same as that measured at Dee Birch's house on the West Branch with a slope near 1 and a correlation coefficient of 0.91. However, summer rainfall is less well correlated between the two sites as indicated by a correlation coefficient of 0.49. In addition, the data suggests that most of the increased rainfall observed at the West Branch occurs during the summer. Therefore, rainfall appears to be slightly greater at the West Branch, especially in the summer time. However, the West Branch may experience seasons when it receives less rainfall than the rain gauges at the U of A and at other parts of town.

A Comparison of Estimated Return Period Discharges

The results of the simulation compare favorably with the regional prediction tools. This is to be expected, because these tools were also calibrated against

observed data. The TSMS study (Simons and Li, 1995) estimated return period discharges for the same channels modeled in this study. Table 6 summarizes the results of the current modeling (AGWA-K2) in comparison with the TSMS study.

Table 6– TSMS and AGWA-K2 Estimated Return Period Discharges for Watersheds at the West Branch

Return Period (year)	Ajo	Ajo	Enchanted Hills	Enchanted Hills	San Juan	San Juan
	TSMS	AGWA-K2	TSMS	AGWA-K2	TSMS	AGWA-K2
2	242	254	256	55	152	86
5	689	1,133	801	904	423	420
10	1,286	1,965	1,540	1,864	757	764

The results show slightly higher discharges from AGWA-K2 for the Ajo and Enchanted Hills for the more frequent two and five year events.

The Enchanted Hills was selected as an example for illustrating the Pima County Hydrology Method (1979). Therefore, the AGWA-K2 modeling can be compared with the observed distribution of peak runoff as well as the model predictions from AGWA-K2 and two local methods, the Pima County method and TSMS. These results are summarized in Table 7.

Table 7 – Summary of Several Methods for Estimating Peak Discharge for the Enchanted Hills at Mission

Return Period (year)	Log-Normal (data set)	Pearson (data set)	Enchanted Hills	Enchanted Hills	Enchanted Hills (uncalibrated)	Enchanted Hills (calibrated)
			COT-PC	TSMS	AGWA-K2	AGWA-K2
2	55	40	286	256	797	55
5	800	575	903	801	2,039	904
10	1,954	1,848	1,423	1,540	3,149	1,864
100	NA	NA	4,064	3,968	7,611	6,146

The results show that the calibrated AGWA-K2 matches the observed data better than either of the two local methods. However, the uncalibrated AGWA-K2 has been included to illustrate that the uncalibrated process-based model is actually a very poor predictor. This observation is useful because process-based models like KINEROS are often assumed to be better predictors on ungauged watersheds. They more accurately describe the infiltration and runoff processes than empirical models. However, these more physically-based models more accurately describe the processes by including more variables than the empirical models.

There is a tendency for scientists to want to use models that more accurately describe the processes without having adequate data to parameterize these processes. The inability of a model to describe a process can be considered to be model error. The inability to properly select model inputs can be considered to be a parameterization error. A generalized illustration of the error associated with distortion of the processes relative to the error associated with parameterization is illustrated in Figure 12. A good model is one that can describe the processes without including too much uncertainty in the input values. No model will be without some error in prediction.

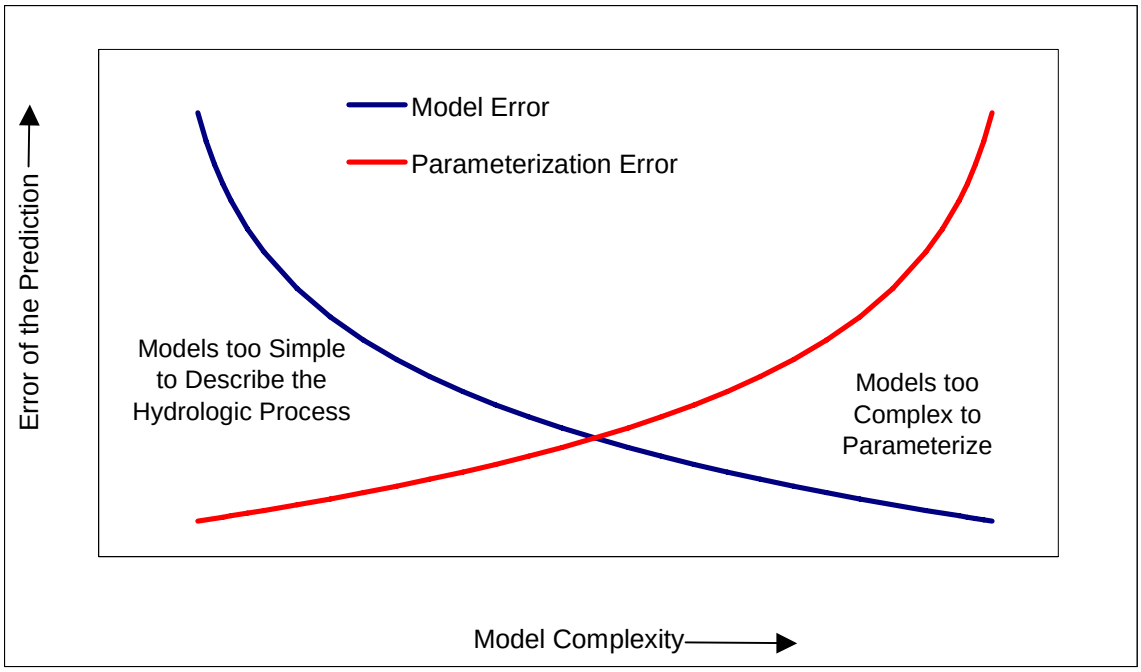


Figure 12 – Schematic Representation of the Error Associated with a Hydrologic Model, Parameterization Error and Model Complexity

When adequate input data is available to parameterize a process-based model, it can be expected to simulate the hydrologic processes better. Such input data include soil moisture, net capillary drive (which was estimated as a function of saturated hydraulic conductivity in this exercise) and aerially-distributed breakpoint rainfall data. However, when it is difficult to estimate these model inputs, the prediction may not be able to benefit from the capability of the physically-based model to better describe the processes. In fact, poor parameterization can increase the error of the model estimate.

Impact of Diversion Channel

In order to determine the relative impact of the diversion channel, a full year of rainfall was run through the calibrated model to determine how much water would be delivered to the West Branch in a normal year, a year with the lowest ten percent rainfall and a year in the upper ten percent rainfall.

Easily obtainable rainfall breakpoint data is not available from the West Branch itself, so breakpoint precipitation data was downloaded from the Santa Rita Experimental Range watersheds operated by the USDA Agricultural Research Service. (http://www.tucson.ars.ag.gov/website/SantaRita/viewer.htm).

Mean annual rainfall at Santa Rita 4 is 13.8 inch/yr which is slightly more than the 13.2 inch/yr observed at the West Branch. The total annual volume of water exiting the West Branch at Valencia, in acre-ft, was the basis of comparison.

Table 8 – Summary of Rainfall Characteristics and Simulated Annual Water Yield

Year	Total (in)	Wet Days	Rank (rainfall)	Weibull Plotting Position	Annual Water Yield Predicted by AGWA-K2(acre-ft)
1975	6.81	23	1	0.03	
1995	7.90	52	2	0.06	
1976	9.48	44	3	0.10	0.35
1980	9.51	50	4	0.13	
1989	9.92	32	5	0.16	
1996	10.00	47	6	0.19	
1997	10.59	64	7	0.23	
1986	11.03	63	8	0.26	
2003	11.42	58	9	0.29	
2002	11.71	47	10	0.32	
1985	11.94	65	11	0.35	
2004	12.14	51	12	0.39	
1979	12.59	46	13	0.42	
1982	12.65	59	14	0.45	
1981	12.96	55	15	0.48	
1991	13.03	56	16	0.52	
1988	13.32	58	17	0.55	131
2001	13.37	77	18	0.58	
1977	13.38	56	19	0.61	
1987	14.42	66	20	0.65	
1999	14.90	50	21	0.68	
1998	15.03	53	22	0.71	
1994	16.19	63	23	0.74	
2000	16.86	62	24	0.77	
1993	17.00	64	25	0.81	
1992	17.50	61	26	0.84	
1984	18.49	64	27	0.87	
1978	20.27	73	28	0.90	
1990	20.29	69	29	0.94	387
1983	23.08	68	30	0.97	

The results show that using the calibrated model in an average year (e.g. 1988), 130 acre-feet of water are delivered by the West Branch, which is approximately enough to irrigate 100 acres of Mesquite trees. In a good year (e.g. 1990), up to three times more water would be delivered and in a bad year (1976), virtually no water would be delivered from the West Branch.

A more simplistic regression model used to predict water yield at regional detention basins (Tetra-tech, 2001) calculates a similar quantity of water for an average year (177 acre-ft) and a good year (358 acre-ft). The fact that the calibrated model and regression models produce similar estimates of yield indicates that the calibrated model is realistic. However, the calibrated model allows for other effects to be studied (e.g. water yield from individual events, the impact of different rainfall patterns on water yield).

The calibrated model indicates only minimal reduction in flood peak attributed to the cutoff of the diversion. The watershed upstream of the Midvale diversion tends to be flatter and more pervious than the channels draining out of the Enchanted Hills. Even though the watershed above the West Branch is quite large (21.9 square miles), there was less runoff coming off of it during the time the USGS collected peak flow data on the West Branch at Valencia. For example, runoff depth for the ten-year three-hr event (2.04 inch) is only about a 0.05 inch for the West Branch at Valencia Rd, in comparison to about a 0.34 inch at Enchanted Hills.

The hydrographs upstream of the Midvale Diversion are longer in duration and shorter in peak, and would therefore be more likely to infiltrate. AGWA-K2 is able to simulate the transmission losses (i.e. water infiltrated into the channel bed) as a hydrograph moves through a watershed. For this reason, the model is indicating that the water entering the current West Branch (blue line) augments the hydrograph peak to a very small degree. A great portion of the water entering the West Branch at the point of truncation does not exit at Cholla Wash, but is infiltrated along the way.

Impact of Urbanization

The impact of urbanization on the current West Branch is to increase the volumes of runoff coming off the developed areas. In general, this has a greater impact on the small events. Impermeable areas produce runoff from even small events, which otherwise would infiltrate. The discharges under calibrated conditions (i.e. 1982), and following the planned urbanization are summarized in Table 9.

Table 9 – Summary of Discharges for the West Branch at Cholla Wash Under Calibrated Conditions and Under Urbanization

Return Period (year)	Peak Flow (cfs)		Flow Volume (cubic ft)	
	Calibrated Conditions	**Urbanized**	**Calibrated Conditions**	**Urbanized**
2	88	171	226,186	385,143
5	2,066	2,090	3,213,720	3,447,026
10	4,486	4,502	6,517,014	6,777,655
100	15,874	15,855	20,969,127	21,289,576

Conclusions

- The watershed of the Old West Branch of the Santa Cruz River, while disturbed, continues to retain many of the characteristics of a rural watershed. The highest density development is along Mission Road, giving the impression that the watershed is significantly developed. However, the land use map (Figure 2), shows that over 75 percent of the watershed is shrubland, and that most of the development that does occur tends to be low-density residential (17 percent).

- A GIS-based watershed hydrology assessment tool, the Automoated Geospatial Watershed Assessment with the Kineros2 model (AGWA-K2), can be calibrated to simulate observed peak runoff distributions for two USGS gauging stations at the Enchanted Hills Wash and the West Branch at Valencia. Rainfall was not available, so the predicted rainfall from the NOAA 14, upper 90% rainfall was used as input data to the AGWA-K2 model.

- While some in the neighborhood believe that rainfall along the West Branch is less than in other parts of town, the observed seasonal rainfall at the West Branch does not vary greatly from what has been observed at the U of A. From 1986 to 2000, the average annual rainfall at the West Branch was 13.2 inches, while average annual rainfall at the U of A was

11.1 inches. About half the annual rainfall occurred in each season. Winter seasonal rainfall was very similar in any given year, though summer rainfall could vary substantially from the West Branch to the U of A. Therefore, rainfall does not appear to be lower in the West Branch than in other parts of Tucson.

- The AGWA-K2 values matched the observed values for the 2 to 10-year events better than the TSMS. For that reason, the AGWA-K2 simulations will be better for simulating the impact of individual events, and watershed yield under different conditions. However, the AGWA-K2 estimates for the 100 year events were greater than the estimates from TSMS, in part because AGWA-K2 was calibrated against the less-frequent events.

- Simulations showed that runoff volume above the Midvale Diversion could deliver about 130 acre-ft of water to the Old West Branch in an average year. This could be a significant benefit to riparian vegetation growing along the West Branch. Furthermore, simulations and observation indicate that runoff from the watershed above the diversion channel tended to be less flashy and would therefore be more likely to infiltrate than discharges from the Enchanted Hills. The observed peak discharges from the West Branch at Valencia collected from 1965 to 1982 show much lower runoff peaks (in inches/hr) than those observed at the Enchanted Hills Wash on the Old. Simulated hydrographs from the West Branch at the Midvale Diversion are of longer duration, providing longer duration floods that would benefit the riparian vegetation of the Old West Branch.

- Current land use platting does not indicate dramatic changes with additional development. The overall land cover of the Old West Branch continues to be shrubland, so the hydrologic modeling showed limited impact from development under current platting. The AGWA-K2 simulation showed that following the currently-platted additional development (~150 acres), runoff from the small events would increase while runoff from the larger events would be little changed.

Disclaimer

The results of these simulations appear to match the observed peak flows over the period of observation. The assumptions are similar to those made by others in assessing the impact of urbanization. Because runoff data is only available for 17 years, the estimate of the peak flows for the 100-year event is done by extrapolating hydrologic response beyond the limits of the supporting data. Therefore, readers should recognize that this estimate carries significant uncertainty.

Additional modeling would better account for the fact that rainfall is not uniform across the watershed. Better survey of cross-sections should better represent the actual conditions. However, like most models, KINEROS2 is limited by the fact that only the most dominant hydrologic processes can be modeled, and these are represented in a somewhat simplistic manner. Furthermore, if a more complicated model were used, it would suffer from the need to parameterize the additional processes. In most cases, the additional error introduced by the parameterization of these additional processes would introduce more error into the estimate than the representation of the processes in KINEROS2.

References

Arnold, J.G., Williams, J.R., Srinivasan, R., King, K.W., and Griggs, R.H. 1994. *SWAT: Soil Water Assessment Tool*. U. S. Department of Agriculture, Agricultural Research Service, Grassland, Soil and Water Research Laboratory, Temple, TX.

Briggs, M., Magirl C., and Quinn, M. 2005. Bringing back the West Branch of the Santa Cruz River: Summary of the West Branch's Hydrology, Channel Morphology, and Bottomland Vegetation Characteristics. Report to Arizona Open Land Trust.

Canfield, H.E. and Goodrich, D.C. 2005. The impact of parameter lumping and geometric simplification in modeling runoff and erosion in the shrublands of southeast Arizona

Chin, A and Gregory, K.J. 2001. Urbanization and adjustments of ephemeral stream channels. Annals of the Association of American Geographers 91:595-608

Goodrich, D.C., J.M. Faures, D.A. Woolhiser, L.J. Lane, and S. Sorooshian. 1995. Measurement and analysis of small-scale convective storm rainfall variability. Journal of Hydrology 173:283-308.

Knighton, D. 1998. Fluvial forms and processes. Oxford University Press, 383 p.

Miller, Scott N, 1995. An Analysis of Channel Morphology at Walnut Gulch Linking Field Research with GIS Applications. Masters Thesis, School of Renewable Natural Resources, University of Arizona. Available from UMI Dissertation Services. 169 pp.

Moody, T.O. and Oodem, W. Regional Relationships For Bankfull Discharge in Natural Channels of Central and Southern Arizona. 1999 Northern Arizona College of Engineering and Technology. 23pp.

Mosely M.P. and McKerchar, A.I. 1992. Streamflow *in:* Handbook of Hydrology, Maidment, D.R. (Editor). McGraw Hill, New York. pp. 8.1-8.39.

Pima County Flood Control District. 1979. *Hydrology Manual for Engineering Design and Flood Plain Management Within Pima County*. 137 pp.
Ponce, V.M. 1989. *Engineering Hydrology – Principles and Practices*. Prentice Hall, Englewood Cliffs, NJ. 640 pp.

Rosen, P. 2001.
Simons, Li and Associates. 1995. Existing-conditions Hydrologic Modeling for the Tucson Stormwater Management Study, Phase II, Stormwater Master Plan.

Smith, R.E., D.C. Goodrich, D.A. Woolhiser, and C.L. Unkrich, 1995. KINEROS – A Kinematic Runoff and Erosion Model. Chapter 20: Computer Models of Watershed Hydrology, V.J. Singh (Editor). Water Resources Publications, pp. 697-632.

Smith, R.E. and J.N. Quinton, 2000. Dynamics and Scale in Simulating Erosion by Water. *In:* Soil Erosion: Application of Physically Based Models, J. Schmidt (Editor). Springer-Verlag, Berlin, Germany, pp.283-294.

Tetra-Tech. 2001. Summary Report: Water Yield Analysis for the Ajo Way Stormwater Detention Facility (Yield calculated using equations 5, 6, 7 & 8.)

United States Department of Commerce, Weather Bureau. 1961. Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours, and Return Periods from 1 to 100 Years. Technical Paper 40. Washington D.C.

Ward, D. 2004. West Branch of the Santa Cruz River stream profile Silverlake Road to 900 feet south of the 44th Street alignment. Pima County report, Tucson, Arizona. 18p.

Appendix A - Subdivision Characteristics for Subdivisions Built Prior to 1982

Subdivisions Built Before 1982	Plan Approval Date	# Lots	Area (Acres)	Avg. Lot Size (Acres)
Hiram Banks Acres	1938	1	85.3	85.30
Casas Oestes	1947	13	36.1	2.77
Pitiquito Terrace	1963	16	4.8	0.30
Plain View Heights Addition	1949	26	9.3	0.36
Hiram Banks Annex Resub.	1974	30	8.2	0.27
Probasco Addition #2	1949	32	11.1	0.35
Kennedy Park #2	1980	99	12.2	0.12
Kennedy Park Estates	1970	100	24.2	0.24
Kenndey Park Townhouses	1972	125	17.1	0.14
Probasco Addition	1933	147	35.7	0.24
Casitas Del Sol	1971	NA	226.0	NA
Plaza Del Sol	1972	NA	88.0	NA
San Xavier Addition	1950	NA	7.8	NA
Freedom Homes 2	1954	NA	10.2	NA
Freedom Homes 1	1950	NA	11.2	NA
N. of Ajo - No subdivision			64.5	
	total		651.4	

Appendix B - Subdivision Characteristics for Subdivisions Built After 1982

Subdivisions Built After 1982	Date	# Lots	Area (Acres)	Avg. Lot Size (Acres)
Sol Estates	2000	11	2.3	0.21
Hiram Banks Court	2001	11	2.3	0.21
36th & Mission Apts	1985	1	19.4	19.40
Mission Harbor	2002	25	6.8	0.27
Mission Manor Apts.	1986	1	11.7	11.66
Kennedy Park Hills	1996	100	19.2	0.19
36th & Mission	Not Const	207	88.2	0.43
Parkview Center	1984	1	7.5	7.50
	total		157.4	

Appendix C – Summary of Observed Peak Flow Data

Enchanted Hills at Mission (also known as Big Wash at Tucson)

Pima County, Arizona
Hydrologic Unit Code 15050301
Latitude 32°11'10", Longitude 111°00'07" NAD27
Drainage area 2.94 square miles
Contributing drainage area 2.75
square miles
Gage datum 2,410. feet above sea level NGVD29

Water Year	Date	Rank	Peak Discharge (cfs)	Stage (ft)
1965	7/10/1965	15	1000	
1966	8/12/1966	11	240	4.27
1967	7/17/1967	8	50	3.39
1968	8/10/1968	9	65	3.47
1969	1969	1	0	
1970	7/19/1970	16	1070	6.6
1971	8/17/1971	17	3000	11.41
1972	7/16/1972	12	285	4.79
1973	July, 1973*	13	300	4.23
1974	1974	2	0	
1975	1975	3	0	
1976	9/25/1976	10	120	3.79
1977	1977	4	0	
1978	10/6/1977	14	380	4.63
1979	8/12/1979	6	20	3.1
1980	9/7/1980	5	3	
1981	9/18/1981	7	29	3.18

* Estimate

Return Period (years)	Plotting Position	Qp (cfs)	Pearson Qp (m3/s)	Qp (mm/hr)	Qp (cfs)	Log-Normal Qp (m3/s)	Qp (mm/hr)
2	0.5	40.4	1.1	0.5	54.9	1.6	0.7
5	0.8	574.6	16.3	7.2	800.2	22.7	10.0
10	0.9	1848.5	52.4	23.0	1954.1	55.4	24.4

West Branch at Valencia

Pima County, Arizona
Hydrologic Unit Code 15050301
Latitude 32°08'00", Longitude 111°00'30" NAD27
Drainage area 23.60 square miles
Gage datum 2,475. feet above sea level NGVD29

Water Year	**Date**	**Rank**	**Peak Discharge (cfs)**	**Stage (ft)**
1966	8/19/1966	2	75	3.1
1967	7/17/1967	6	130	2.93
1968	8/10/1968	12	480	6.54
1969	8/8/1969	10	318	3.13
1970	7/19/1970	3	75	2.44
1971	8/17/1971	13	540	4.67
1972	7/16/1972	8	190	2.06
1973	8/23/1973	4	80	2.2
1974	6/25/1974	5	110	2
1975	9/9/1975	9	190	3
1976	9/25/1976	15	910	6.91
1977	9/9/1977	11	350	6.09
1978	10/6/1977	16	910	7.61
1979	12/18/1978	1	50	3.43
1980	9/25/1980	7	150	4.34
1981	7/29/1981	14	760	8.02

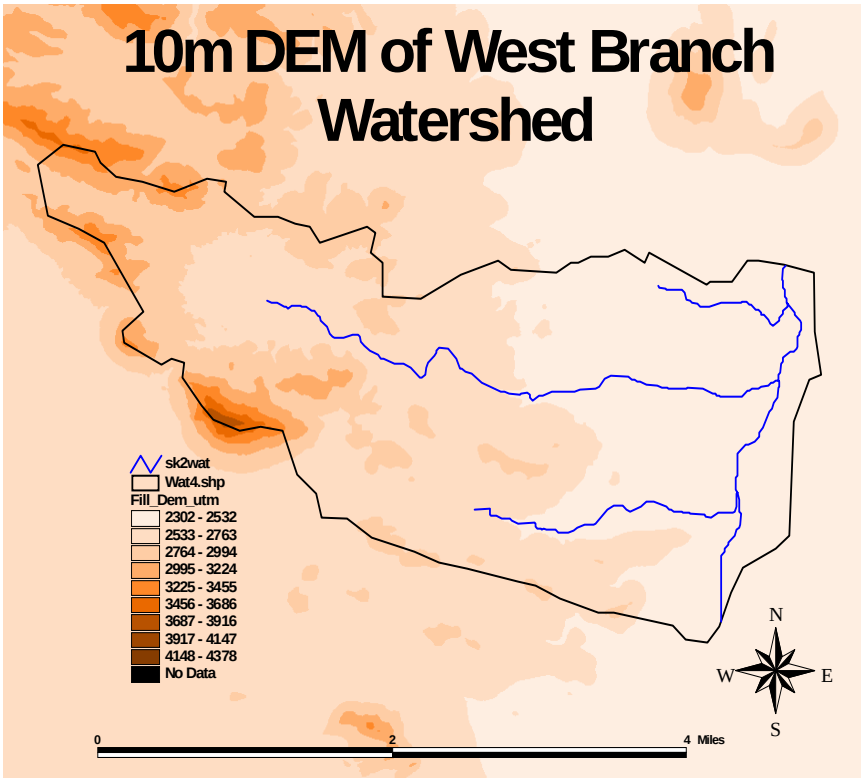
		Pearson			Log-Normal		
Return Period (years)	Plotting Position	Qp (cfs)	Qp (m3/s)	Qp (mm/hr)	Qp (cfs)	Qp (m3/s)	Qp (mm/hr)
2	0.5	217	6.1	0.37	221	6.3	0.37
5	0.8	491	13.9	0.83	622	17.6	1.05
10	0.9	759	21.5	1.28	878	24.9	1.48

Appendix D - The AGWA Tool

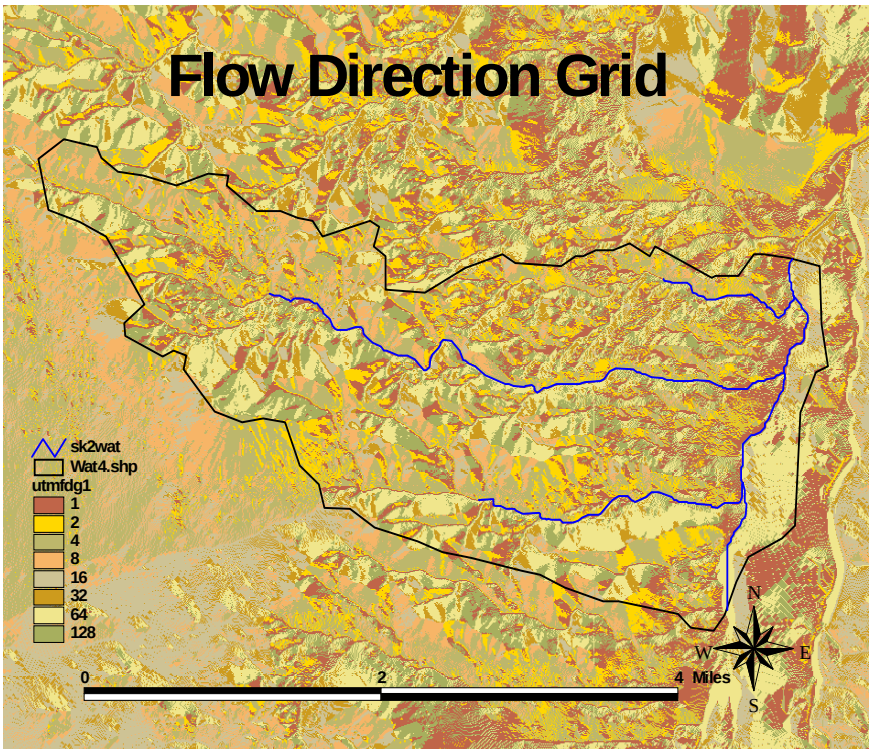
The AGWA hydrologic modeling tool is an extension to ARC View GIS (http://www.tucson.ars.ag.gov/AGWA/). It contains two models, SWAT (the Soil and Water Assessment Tool), which is an empirical model employing Curve Number, rational formula, MUSLE technology; and KINEROS, a more process-based event model that describes dynamic infiltration, kinematic wave routing and process-based sediment transport. Both models are part of the EPA's BASINS models for large-scale assessment of environmental impacts and TMDLs.

The GIS Processes:

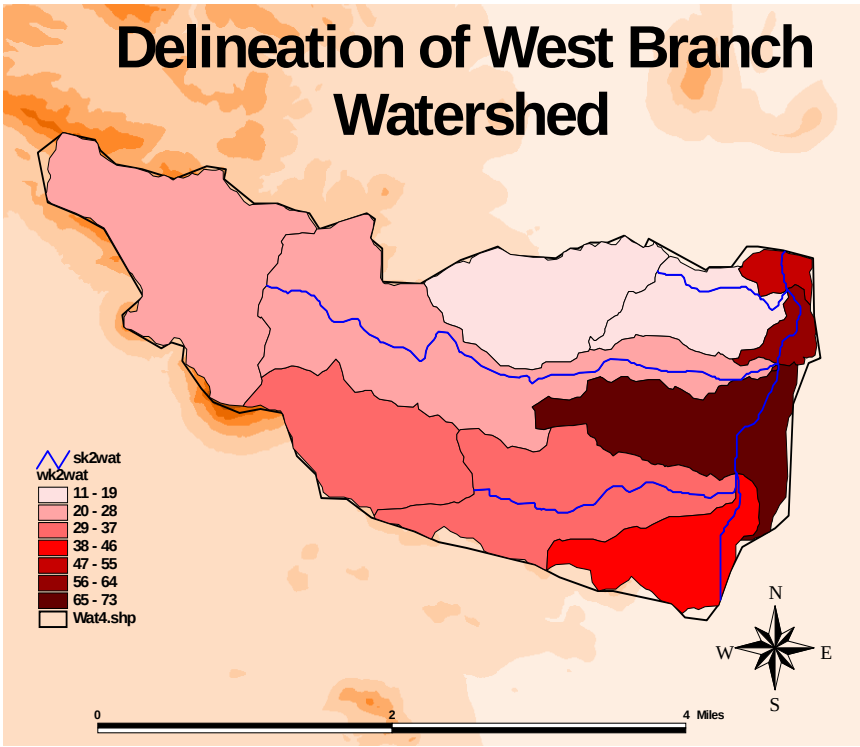
A. ***Use a DEM:*** Begin with a10m DEM as a basis for describing the watershed topography and delineating the watershed.



B. ***Determine Flow Directions and Flow Accumulation:*** Determine the direction of flow in each of the eight possible directions from a grid cell, and then determine the contributing area draining to each grid cell. Ultimately, all the flow will drain through the grid point at the watershed outlet.

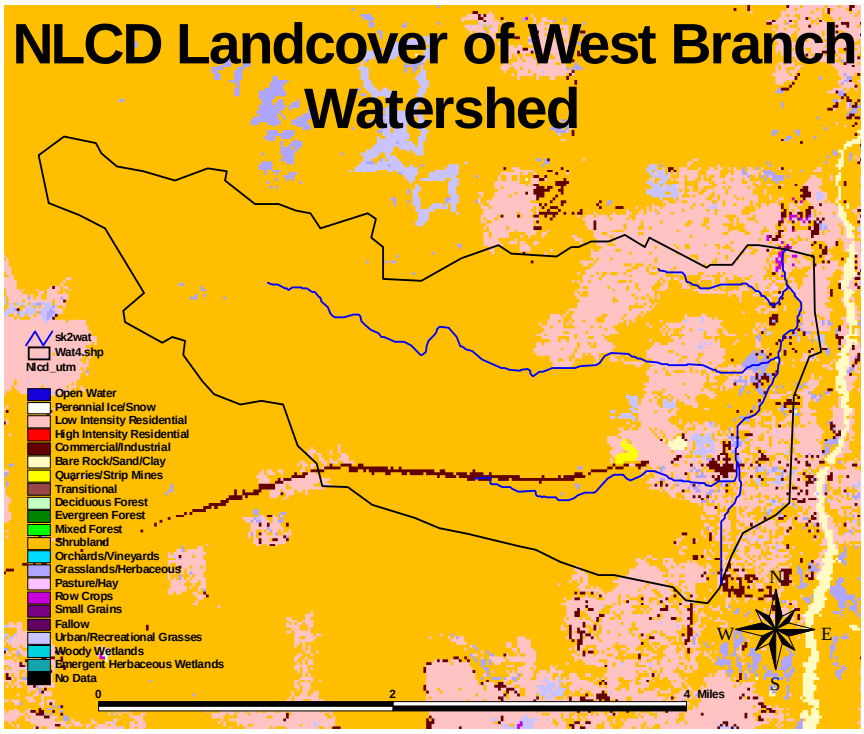


C. ***Delineate Watershed:*** Delineate the watershed and subwatersheds after estimating a suitable subwatershed size. Channel geometry is estimated using contributing area- channel cross-sectional area relationships (e.g. like Moody and Odem,1999)

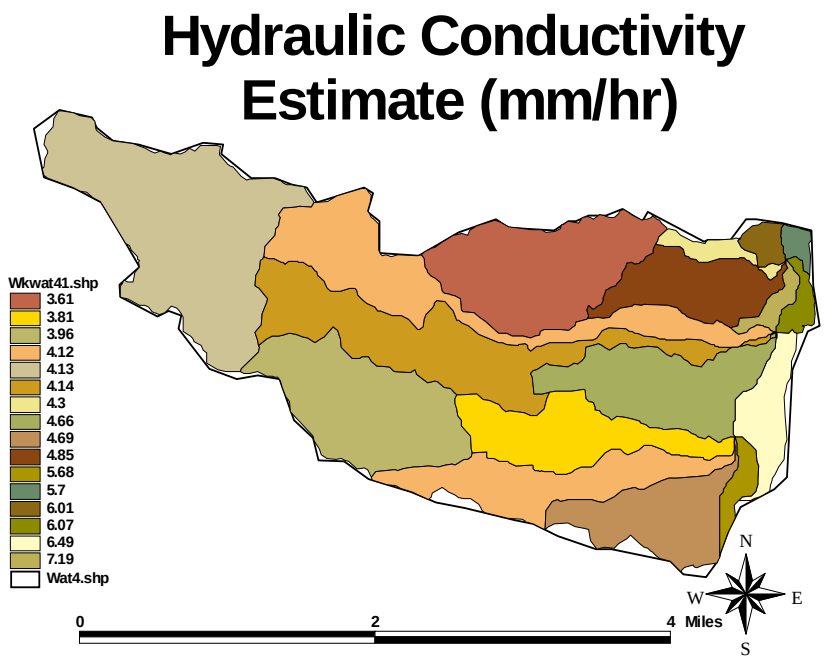


Even though watershed processes themselves are highly complex, runoff models can be significantly simplified and still produce results similar to the more complex representation (Canfield and Goodrich, in press).

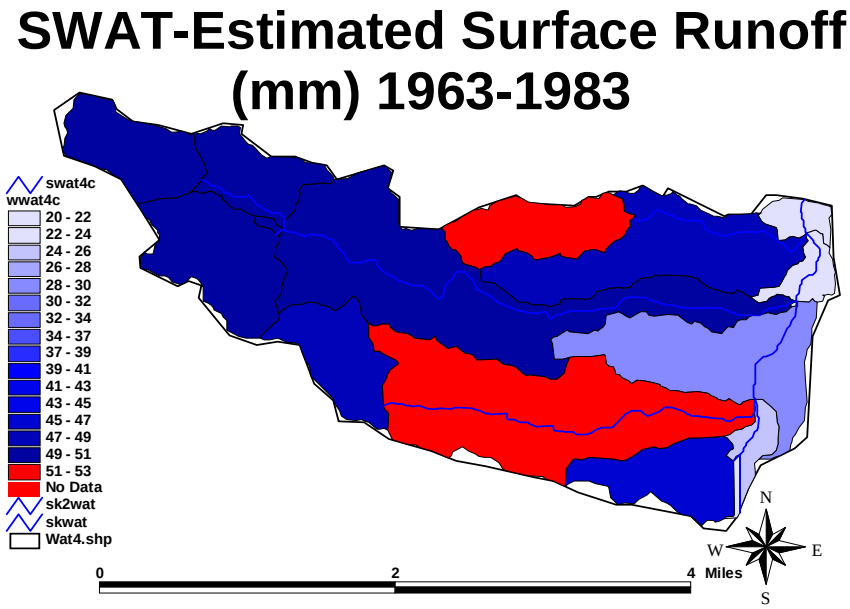
D. ***Use Landscape Properties to Estimate Parameter Values***: Overlay a land cover grid and soils map on the subwatershed, and estimate hydrologic model parameter values using look up tables that relate soils and landcover to hydrologic parameters.

E. 

F. ***Parameterize Subwatersheds:*** Attribute parameter values to each subwatershed.



View Results Run Simulation and view results graphically or through the output files.



Appendix E – KINEROS2 Parameter File (Old West Branch - No Urbanization)

```
! File Info
!   Watershed:           wwbws2
!   LandCover:           Nlcd_utm
!   Soils:               Az_utm.shp
!   Number of Channels:  31
!   Number of Planes:    78
!   Contrib Source Area: 531 Acres
!   DEM Grid Size:       2 m
!   Total Drainage Area: 22641 Acres (9163 ha)
!   AGWA Version:        ta b
!   Creation date/time:  09/26/2005 10:09
! End of File Info

BEGIN GLOBAL
  CLEN = 10, UNITS = METRIC,
  DIAMS = 0.25,0.033, 0.004 ! mm
  DENSITY = 2.65,2.65, 2.65 ! g/cc,
  TEMP = 33 !deg C,
  NELE = 109,
END GLOBAL,

BEGIN PLANE
  ID = 71, LEN = 674.7, AREA = 2789397.7,
  SL = 0.106, MAN = 0.083, X = 495596.7, Y = 3556381.8
  CV = 0.47, PRINT = 1
  KS = 3.51, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33,
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87
  INTER = 1.95, CANOPY = 0.2593, PAVE = 0.36,
END PLANE

BEGIN PLANE
  ID = 72, LEN = 67.0, AREA = 44425.1,
  SL = 0.014, MAN = 0.114, X = 496597.1, Y = 3555207.8
  CV = 0.47, PRINT = 1
  KS = 3.02, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33,
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87
  INTER = 1.11, CANOPY = 0.2492, PAVE = 0.47,
END PLANE

BEGIN PLANE
  ID = 73, LEN = 75.0, AREA = 47477.7,
  SL = 0.023, MAN = 0.141, X = 496648.1, Y = 3555345.8
  CV = 0.47, PRINT = 1
  KS = 2.56, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33,
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87
  INTER = 0.30, CANOPY = 0.249, PAVE = 0.58,
END PLANE

BEGIN CHANNEL
  ID = 74, PRINT = 1,
  LAT =  72 73
  UP =  71
  LEN = 487.63, SLOPE = 0.0094, X = 496711.577, Y = 3555207.465,
  WIDTH = 3.3, 4.2,  DEPTH = 1.44, 1.44,
  MAN = 0.035, SS1 = 5.00, SS2 = 5.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 81, LEN = 515.1, AREA = 2217366.2
  SL = 0.084, MAN = 0.075, X = 495503.6, Y = 3555073.8,
  CV = 0.47, PRINT = 1
  KS = 3.49, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33,
```

```
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87
  INTER = 1.98, CANOPY = 0.2508, PAVE = 0.36,
END PLANE

BEGIN PLANE
  ID = 82, LEN = 35.0, AREA = 20491.0,
  SL = 0.009, MAN = 0.099, X = 496749.5, Y = 3555095.8
  CV = 0.47, PRINT = 1
  KS = 3.03, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33,
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87
  INTER = 1.31, CANOPY = 0.2467, PAVE = 0.46,
END PLANE

BEGIN PLANE
  ID = 83, LEN = 105.0, AREA = 52999.2
  SL = 0.032, MAN = 0.051, X = 496880.1, Y = 3554949.8,
  CV = 0.47, PRINT = 1,
  KS = 3.09, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87,
  INTER = 1.83, CANOPY = 0.2434, PAVE = 0.45
END PLANE

BEGIN CHANNEL
  ID = 84, PRINT = 1,
  LAT =  82 83
  UP =  81
  LEN = 192.97, SLOPE = 0.0063, X = 496860.773, Y = 3555078.257,
  WIDTH = 3.0, 3.9,  DEPTH = 1.38, 1.41,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101,
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00,
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 172, LEN = 244.9, AREA = 753536.0,
  SL = 0.023, MAN = 0.096, X = 497604.3, Y = 3554990.3
  CV = 1.16, PRINT = 1
  KS = 12.11, G = 186.42, DIST = 0.29, POR = 0.461, ROCK = 0.21,
  FR = 0.50,0.28,0.23, SPLASH = 106.20, COH = 0.006, SMAX = 0.90
  INTER = 1.21, CANOPY = 0.2559, PAVE = 0.36,
END PLANE

BEGIN PLANE
  ID = 173, LEN = 284.9, AREA = 916292.4,
  SL = 0.038, MAN = 0.119, X = 496929.7, Y = 3555741.3,
  CV = 0.59, PRINT = 1,
  KS = 4.41, G = 254.49, DIST = 0.22, POR = 0.468, ROCK = 0.31
  FR = 0.37,0.3,0.33, SPLASH = 122.09, COH = 0.008, SMAX = 0.87,
  INTER = 0.90, CANOPY = 0.2487, PAVE = 0.48
END PLANE

BEGIN CHANNEL
  ID = 174, PRINT = 1,
  LAT =  172 173
  UP =  74 84
  LEN = 2072.72, SLOPE = 0.0082, X = 497892.436, Y = 3555300.782,
  WIDTH = 4.1, 5.7,  DEPTH = 1.59, 1.65,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00,
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 121, LEN = 309.1, AREA = 2277965.7,
  SL = 0.033, MAN = 0.039, X = 492400.1, Y = 3543932.5
  CV = 1.68, PRINT = 1
  KS = 23.97, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
```

```
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.00, CANOPY = 0.1762, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 122, LEN = 130.1, AREA = 256003.9,
  SL = 0.040, MAN = 0.044, X = 494750.7, Y = 3547303.3
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.72, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 123, LEN = 186.7, AREA = 535477.0,
  SL = 0.022, MAN = 0.046, X = 494424.7, Y = 3546475.5
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.78, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN CHANNEL,
  ID = 124, PRINT = 1,
  LAT =  122 123
  UP =  121
  LEN = 1629.51, SLOPE = 0.0129, X = 494859.808, Y = 3547312.475,
  WIDTH = 3.1, 4.3,  DEPTH = 1.41, 1.47,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 141, LEN = 388.0, AREA = 2160362.3
  SL = 0.028, MAN = 0.044, X = 493594.0, Y = 3544724.5,
  CV = 1.68, PRINT = 1,
  KS = 24.56, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.30, CANOPY = 0.1994, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 142, LEN = 25.0, AREA = 31047.6,
  SL = 0.015, MAN = 0.055, X = 495209.8, Y = 3547168.8
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 3.00, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 143, LEN = 172.5, AREA = 458215.6,
  SL = 0.018, MAN = 0.049, X = 494938.9, Y = 3546881.3,
  CV = 1.68, PRINT = 1,
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92,
  INTER = 2.86, CANOPY = 0.25, PAVE = 0.00
END PLANE

BEGIN CHANNEL
  ID = 144, PRINT = 1,
  LAT =  142 143
  UP =  141
  LEN = 1496.44, SLOPE = 0.0147, X = 495117.029, Y = 3547063.581,
  WIDTH = 3.0, 4.1,  DEPTH = 1.38, 1.44,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00,
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 202, LEN = 59.5, AREA = 81509.2,
  SL = 0.014, MAN = 0.042, X = 495916.0, Y = 3548058.0
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.68, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 203, LEN = 105.0, AREA = 128159.9,
  SL = 0.039, MAN = 0.053, X = 495794.2, Y = 3548093.8
  CV = 1.68, PRINT = 1,
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92,
  INTER = 2.95, CANOPY = 0.25, PAVE = 0.00
END PLANE

BEGIN CHANNEL
  ID = 204, PRINT = 1,
  LAT =  202 203
  UP =  124 144
  LEN = 1605.74, SLOPE = 0.0116, X = 495982.157, Y = 3548152.011,
  WIDTH = 4.3, 5.4,  DEPTH = 1.62, 1.62,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 151, LEN = 473.1, AREA = 2405950.5,
  SL = 0.034, MAN = 0.055, X = 490277.3, Y = 3542433.0
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.99, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 152, LEN = 144.9, AREA = 396322.5,
  SL = 0.026, MAN = 0.038, X = 492270.4, Y = 3545478.8
  CV = 1.68, PRINT = 1
  KS = 23.80, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 1.93, CANOPY = 0.1693, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 153, LEN = 196.7, AREA = 802464.6,
  SL = 0.028, MAN = 0.051, X = 492148.7, Y = 3545010.8
  CV = 1.68, PRINT = 1
  KS = 25.59, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.80, CANOPY = 0.2385, PAVE = 0.00,
END PLANE

BEGIN CHANNEL,
  ID = 154, PRINT = 1
  LAT =  152 153
  UP =  151
  LEN = 4707.94, SLOPE = 0.0220, X = 492609.082, Y = 3545708.572,
  WIDTH = 3.1, 4.5,  DEPTH = 1.41, 1.5,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 161, LEN = 394.9, AREA = 2148719.5
  SL = 0.034, MAN = 0.054, X = 489353.1, Y = 3541811.5,
  CV = 1.68, PRINT = 1,
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.98, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 162, LEN = 214.9, AREA = 1339001.3,
  SL = 0.031, MAN = 0.055, X = 491672.3, Y = 3545548.8
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.99, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 163, LEN = 253.2, AREA = 1560009.4,
  SL = 0.028, MAN = 0.054, X = 492141.1, Y = 3545708.5
  CV = 1.68, PRINT = 1,
  KS = 25.84, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92,
  INTER = 2.95, CANOPY = 0.2477, PAVE = 0.00
END PLANE

BEGIN CHANNEL
  ID = 164, PRINT = 1,
  LAT =  162 163
  UP =  161
  LEN = 5466.31, SLOPE = 0.0221, X = 492014.025, Y = 3545791.858,
  WIDTH = 3.0, 5.1,  DEPTH = 1.38, 1.59,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 192, LEN = 161.2, AREA = 337008.9,
  SL = 0.020, MAN = 0.052, X = 493540.8, Y = 3547310.0
  CV = 1.68, PRINT = 1
  KS = 24.74, G = 125.68, DIST = 0.36, POR = 0.454, ROCK = 0.16,
  FR = 0.62,0.25,0.13, SPLASH = 92.39, COH = 0.005, SMAX = 0.91
  INTER = 2.93, CANOPY = 0.25, PAVE = 0.01,
END PLANE

BEGIN PLANE
  ID = 193, LEN = 279.4, AREA = 374409.6,
  SL = 0.173, MAN = 0.055, X = 493535.9, Y = 3548128.3
  CV = 1.68, PRINT = 1
  KS = 8.00, G = 147.88, DIST = 0.38, POR = 0.445, ROCK = 0.63
  FR = 0.64,0.21,0.15, SPLASH = 102.96, COH = 0.006, SMAX = 0.90,
  INTER = 3.00, CANOPY = 0.25, PAVE = 0.19
END PLANE

BEGIN CHANNEL
  ID = 194, PRINT = 1,
  LAT =  192 193
  UP =  154 164
  LEN = 559.56, SLOPE = 0.0087, X = 493683.201, Y = 3547859.337,
  WIDTH = 4.9, 6.3,  DEPTH = 1.71, 1.74,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL ,

BEGIN PLANE
  ID = 131, LEN = 332.2, AREA = 2148748.4,
  SL = 0.029, MAN = 0.040, X = 492071.0, Y = 3544292.8
  CV = 1.68, PRINT = 1
  KS = 23.97, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.02, CANOPY = 0.1764, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 132, LEN = 45.0, AREA = 58515.9,
  SL = 0.019, MAN = 0.043, X = 493636.2, Y = 3547109.8
  CV = 1.68, PRINT = 1
  KS = 25.12, G = 125.17, DIST = 0.36, POR = 0.455, ROCK = 0.15,
  FR = 0.62,0.25,0.13, SPLASH = 92.14, COH = 0.005, SMAX = 0.91
  INTER = 2.71, CANOPY = 0.25, PAVE = 0.01,
END PLANE

BEGIN PLANE
  ID = 133, LEN = 97.0, AREA = 186289.1,
  SL = 0.021, MAN = 0.048, X = 493628.7, Y = 3546821.5
  CV = 1.68, PRINT = 1
  KS = 25.70, G = 124.41, DIST = 0.36, POR = 0.455, ROCK = 0.13,
  FR = 0.62,0.25,0.13, SPLASH = 91.78, COH = 0.005, SMAX = 0.91
  INTER = 2.82, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN CHANNEL,
  ID = 134, PRINT = 1
  LAT =  132 133,
  UP =  131
  LEN = 1450.43, SLOPE = 0.0162, X = 493799.016, Y = 3547283.053,
  WIDTH = 3.0, 3.9,  DEPTH = 1.38, 1.41,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 182, LEN = 244.9, AREA = 957690.8
  SL = 0.120, MAN = 0.055, X = 494915.0, Y = 3548495.0,
  CV = 1.68, PRINT = 1,
  KS = 14.54, G = 139.21, DIST = 0.37, POR = 0.449, ROCK = 0.45
  FR = 0.63,0.23,0.14, SPLASH = 98.83, COH = 0.006, SMAX = 0.90,
  INTER = 3.00, CANOPY = 0.25, PAVE = 0.12,
END PLANE

BEGIN PLANE
  ID = 183, LEN = 454.8, AREA = 2427001.6,
  SL = 0.032, MAN = 0.049, X = 494339.7, Y = 3547250.8
  CV = 1.68, PRINT = 1
  KS = 24.68, G = 125.68, DIST = 0.36, POR = 0.454, ROCK = 0.16,
  FR = 0.62,0.25,0.13, SPLASH = 92.39, COH = 0.005, SMAX = 0.91
  INTER = 2.84, CANOPY = 0.2477, PAVE = 0.01,
END PLANE

BEGIN CHANNEL,
  ID = 184, PRINT = 1
  LAT =  182 183,
  UP =  194 134,
  LEN = 2740.32, SLOPE = 0.0102, X = 495108.820, Y = 3548369.138,
  WIDTH = 5.5, 7.5,  DEPTH = 1.8, 1.86,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 312, LEN = 101.2, AREA = 50186.8
  SL = 0.071, MAN = 0.050, X = 496311.3, Y = 3548959.5,
  CV = 1.68, PRINT = 1,
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92,
  INTER = 2.87, CANOPY = 0.25, PAVE = 0.00
END PLANE

BEGIN PLANE
  ID = 313, LEN = 59.5, AREA = 63303.0,
  SL = 0.010, MAN = 0.050, X = 496389.0, Y = 3548792.5
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.87, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN CHANNEL,
  ID = 314, PRINT = 1
  LAT =  312 313,
  UP =  184 204,
  LEN = 900.07, SLOPE = 0.0105, X = 496304.594, Y = 3549110.284
  WIDTH = 6.7, 8.4,  DEPTH = 1.95, 1.98,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 111, LEN = 527.6, AREA = 2173028.4
  SL = 0.277, MAN = 0.055, X = 495102.7, Y = 3549200.8,
  CV = 1.68, PRINT = 1,
  KS = 8.96, G = 146.60, DIST = 0.38, POR = 0.445, ROCK = 0.61
  FR = 0.63,0.22,0.15, SPLASH = 102.35, COH = 0.006, SMAX = 0.90,
  INTER = 3.00, CANOPY = 0.25, PAVE = 0.18
END PLANE

BEGIN PLANE
  ID = 112, LEN = 15.0, AREA = 12233.9,
  SL = 0.017, MAN = 0.052, X = 496282.9, Y = 3549295.3
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.93, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 113, LEN = 31.2, AREA = 34393.5,
  SL = 0.291, MAN = 0.055, X = 496001.2, Y = 3549689.8
  CV = 1.68, PRINT = 1
  KS = 7.42, G = 148.65, DIST = 0.38, POR = 0.444, ROCK = 0.65,
  FR = 0.64,0.21,0.15, SPLASH = 103.33, COH = 0.006, SMAX = 0.90
  INTER = 3.00, CANOPY = 0.25, PAVE = 0.19
END PLANE

BEGIN CHANNEL
  ID = 114, PRINT = 1,
  LAT =  112 113
  UP =  111
  LEN = 63.55, SLOPE = 0.0096, X = 496289.248, Y = 3549539.253,
  WIDTH = 3.0, 3.8,  DEPTH = 1.38, 1.38,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 302, LEN = 459.4, AREA = 1931741.3,
  SL = 0.278, MAN = 0.055, X = 497009.2, Y = 3550635.0
  CV = 1.68, PRINT = 1
  KS = 13.66, G = 140.23, DIST = 0.37, POR = 0.448, ROCK = 0.47,
  FR = 0.63,0.23,0.14, SPLASH = 99.32, COH = 0.006, SMAX = 0.90
  INTER = 2.90, CANOPY = 0.25, PAVE = 0.14,
END PLANE

BEGIN PLANE
  ID = 303, LEN = 402.8, AREA = 1965020.3,
  SL = 0.018, MAN = 0.056, X = 497784.3, Y = 3550924.3
  CV = 1.68, PRINT = 1
  KS = 24.14, G = 125.68, DIST = 0.36, POR = 0.454, ROCK = 0.16,
  FR = 0.62,0.25,0.13, SPLASH = 92.39, COH = 0.005, SMAX = 0.91
  INTER = 2.78, CANOPY = 0.2497, PAVE = 0.03,
END PLANE

BEGIN CHANNEL
  ID = 304, PRINT = 1,
  LAT =  302 303
  UP =  114 314
  LEN = 6397.98, SLOPE = 0.0076, X = 498063.065, Y = 3551728.949,
  WIDTH = 7.0, 9.2,  DEPTH = 2.01, 2.04,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 101, LEN = 544.2, AREA = 2592016.2,
  SL = 0.167, MAN = 0.061, X = 495871.8, Y = 3551189.8
  CV = 1.68, PRINT = 1
  KS = 21.93, G = 128.49, DIST = 0.36, POR = 0.453, ROCK = 0.22,
  FR = 0.62,0.25,0.13, SPLASH = 93.72, COH = 0.005, SMAX = 0.91
  INTER = 2.77, CANOPY = 0.2474, PAVE = 0.06,
END PLANE

BEGIN PLANE
  ID = 102, LEN = 657.3, AREA = 3177744.5,
  SL = 0.078, MAN = 0.066, X = 497640.8, Y = 3552072.3
  CV = 1.68, PRINT = 1
  KS = 23.38, G = 124.92, DIST = 0.36, POR = 0.455, ROCK = 0.14,
  FR = 0.62,0.25,0.13, SPLASH = 92.02, COH = 0.005, SMAX = 0.91
  INTER = 2.36, CANOPY = 0.2497, PAVE = 0.09,
END PLANE

BEGIN PLANE
  ID = 103, LEN = 809.2, AREA = 7273856.0
  SL = 0.068, MAN = 0.078, X = 495644.2, Y = 3552413.0,
  CV = 1.48, PRINT = 1,
  KS = 19.54, G = 144.89, DIST = 0.33, POR = 0.452, ROCK = 0.16
  FR = 0.58,0.26,0.16, SPLASH = 95.94, COH = 0.005, SMAX = 0.90,
  INTER = 2.17, CANOPY = 0.2595, PAVE = 0.16
END PLANE

BEGIN CHANNEL
  ID = 104, PRINT = 1,
  LAT =  102 103
  UP =  101
  LEN = 3298.95, SLOPE = 0.0035, X = 498248.636, Y = 3553017.081,
  WIDTH = 3.2, 7.1,  DEPTH = 1.44, 1.83,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00,
  WOOL = Yes,
  CV = 0.00, KSAT = 210, G = 101,
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00,
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 292, LEN = 49.5, AREA = 52909.5,
  SL = 0.004, MAN = 0.055, X = 498864.0, Y = 3554678.0
  CV = 1.68, PRINT = 1
  KS = 25.59, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.83, CANOPY = 0.25, PAVE = 0.01,
END PLANE

BEGIN PLANE
  ID = 293, LEN = 87.0, AREA = 81351.1
  SL = 0.008, MAN = 0.054, X = 498789.3, Y = 3554242.8,
  CV = 1.68, PRINT = 1,
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92,
  INTER = 2.97, CANOPY = 0.25, PAVE = 0.00
END PLANE

BEGIN CHANNEL
  ID = 294, PRINT = 1,
  LAT =  292 293
  UP =  104 304
  LEN = 1045.43, SLOPE = 0.0050, X = 498793.946, Y = 3554843.878,
  WIDTH = 8.5, 10.6,  DEPTH = 2.16, 2.16,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes,
  CV = 0.00, KSAT = 210, G = 101,
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00,
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 91, LEN = 537.9, AREA = 2304896.4,
  SL = 0.023, MAN = 0.116, X = 497041.3, Y = 3553957.5
  CV = 1.15, PRINT = 1
  KS = 11.38, G = 187.87, DIST = 0.29, POR = 0.461, ROCK = 0.21,
  FR = 0.49,0.28,0.23, SPLASH = 106.54, COH = 0.006, SMAX = 0.89
  INTER = 0.89, CANOPY = 0.2573, PAVE = 0.40,
END PLANE

BEGIN PLANE
  ID = 92, LEN = 147.0, AREA = 334248.1,
  SL = 0.006, MAN = 0.052, X = 498646.6, Y = 3554586.8
  CV = 1.68, PRINT = 1
  KS = 25.59, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.77, CANOPY = 0.25, PAVE = 0.01,
END PLANE

BEGIN PLANE
  ID = 93, LEN = 436.3, AREA = 1074428.3,
  SL = 0.016, MAN = 0.096, X = 498007.0, Y = 3554523.0
  CV = 1.64, PRINT = 1
  KS = 18.34, G = 128.49, DIST = 0.36, POR = 0.455, ROCK = 0.13,
  FR = 0.60,0.26,0.14, SPLASH = 92.67, COH = 0.005, SMAX = 0.91
  INTER = 1.26, CANOPY = 0.2643, PAVE = 0.29,
END PLANE

BEGIN CHANNEL
  ID = 94, PRINT = 1,
  LAT =  92 93
  UP =  91
  LEN = 1662.07, SLOPE = 0.0046, X = 498498.382, Y = 3554707.036,
  WIDTH = 3.1, 4.6,  DEPTH = 1.41, 1.5,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
```

```
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 282, LEN = 17.1, AREA = 7100.4
  SL = 0.010, MAN = 0.049, X = 498742.5, Y = 3555379.8
  CV = 1.68, PRINT = 1
  KS = 25.90, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.86, CANOPY = 0.25, PAVE = 0.00,
END PLANE

BEGIN PLANE
  ID = 283, LEN = 35.0, AREA = 36511.9,
  SL = 0.008, MAN = 0.056, X = 498854.3, Y = 3555042.5
  CV = 1.68, PRINT = 1
  KS = 25.59, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 2.86, CANOPY = 0.25, PAVE = 0.01,
END PLANE

BEGIN CHANNEL
  ID = 284, PRINT = 1,
  LAT =  282 283
  UP =  294 94
  LEN = 78.07, SLOPE = 0.0078, X = 498838.249, Y = 3555391.386,
  WIDTH = 8.7, 10.9,  DEPTH = 2.19, 2.19,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 272, LEN = 244.9, AREA = 994927.9
  SL = 0.008, MAN = 0.087, X = 499159.3, Y = 3555792.5,
  CV = 1.68, PRINT = 1
  KS = 22.54, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 1.80, CANOPY = 0.2883, PAVE = 0.16,
END PLANE

BEGIN PLANE
  ID = 273, LEN = 958.9, AREA = 4328710.6,
  SL = 0.029, MAN = 0.105, X = 497927.9, Y = 3556449.5
  CV = 1.11, PRINT = 1
  KS = 12.05, G = 192.22, DIST = 0.29, POR = 0.462, ROCK = 0.22,
  FR = 0.48,0.28,0.24, SPLASH = 107.55, COH = 0.006, SMAX = 0.89
  INTER = 1.29, CANOPY = 0.2661, PAVE = 0.33,
END PLANE

BEGIN CHANNEL,
  ID = 274, PRINT = 1,
  LAT =  272 273
  UP =  284 174
  LEN = 2547.36, SLOPE = 0.0037, X = 499004.597, Y = 3556574.473,
  WIDTH = 9.2, 11.9,  DEPTH = 2.25, 2.28,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 61, LEN = 694.7, AREA = 2163451.3
  SL = 0.161, MAN = 0.061, X = 495486.8, Y = 3558405.3,
  CV = 0.57, PRINT = 1,
  KS = 5.74, G = 257.39, DIST = 0.22, POR = 0.468, ROCK = 0.31,
```

```
  FR = 0.36,0.3,0.34, SPLASH = 122.77, COH = 0.008, SMAX = 0.87
  INTER = 2.83, CANOPY = 0.25, PAVE = 0.20,
END PLANE

BEGIN PLANE
  ID = 62, LEN = 284.9, AREA = 1060455.6,
  SL = 0.082, MAN = 0.082, X = 497624.1, Y = 3558012.8
  CV = 0.57, PRINT = 1
  KS = 5.23, G = 257.39, DIST = 0.22, POR = 0.468, ROCK = 0.31,
  FR = 0.36,0.3,0.34, SPLASH = 122.77, COH = 0.008, SMAX = 0.87
  INTER = 2.12, CANOPY = 0.2646, PAVE = 0.30,
END PLANE

BEGIN PLANE
  ID = 63, LEN = 512.8, AREA = 1880293.0,
  SL = 0.145, MAN = 0.090, X = 496927.8, Y = 3557577.3,
  CV = 0.53, PRINT = 1,
  KS = 4.23, G = 261.73, DIST = 0.21, POR = 0.468, ROCK = 0.32
  FR = 0.35,0.3,0.35, SPLASH = 123.78, COH = 0.008, SMAX = 0.87,
  INTER = 1.68, CANOPY = 0.2535, PAVE = 0.38
END PLANE

BEGIN CHANNEL
  ID = 64, PRINT = 1,
  LAT =  62 63
  UP =  61
  LEN = 3851.65, SLOPE = 0.0102, X = 497692.913, Y = 3557545.542,
  WIDTH = 3.0, 5.1,  DEPTH = 1.38, 1.59,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00,
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 262, LEN = 95.0, AREA = 77470.2,
  SL = 0.012, MAN = 0.092, X = 499528.4, Y = 3557629.0
  CV = 1.68, PRINT = 1
  KS = 21.86, G = 124.15, DIST = 0.36, POR = 0.455, ROCK = 0.12,
  FR = 0.62,0.25,0.13, SPLASH = 91.66, COH = 0.005, SMAX = 0.92
  INTER = 1.86, CANOPY = 0.25, PAVE = 0.16,
END PLANE

BEGIN PLANE
  ID = 263, LEN = 283.2, AREA = 839811.0,
  SL = 0.084, MAN = 0.082, X = 498031.3, Y = 3558114.8
  CV = 0.54, PRINT = 1,
  KS = 4.54, G = 261.97, DIST = 0.21, POR = 0.473, ROCK = 0.32
  FR = 0.35,0.3,0.34, SPLASH = 125.37, COH = 0.008, SMAX = 0.88,
  INTER = 2.01, CANOPY = 0.246, PAVE = 0.33
END PLANE

BEGIN CHANNEL
  ID = 264, PRINT = 1,
  LAT =  262 263
  UP =  64 274
  LEN = 366.31, SLOPE = 0.0102, X = 499484.253, Y = 3557882.949,
  WIDTH = 9.8, 12.3,  DEPTH = 2.31, 2.31,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050,
END CHANNEL ,

BEGIN PLANE
  ID = 51, LEN = 394.9, AREA = 2340539.0,
  SL = 0.174, MAN = 0.067, X = 497304.2, Y = 3558913.5
  CV = 0.48, PRINT = 1
  KS = 4.08, G = 267.52, DIST = 0.20, POR = 0.469, ROCK = 0.33,
```

```
  FR = 0.34,0.3,0.35, SPLASH = 125.14, COH = 0.008, SMAX = 0.87
  INTER = 2.59, CANOPY = 0.2497, PAVE = 0.26,
END PLANE

BEGIN PLANE
  ID = 52, LEN = 85.0, AREA = 62562.2,
  SL = 0.017, MAN = 0.119, X = 499000.3, Y = 3558220.3
  CV = 0.51, PRINT = 1
  KS = 3.34, G = 255.04, DIST = 0.21, POR = 0.467, ROCK = 0.33,
  FR = 0.36,0.3,0.34, SPLASH = 126.28, COH = 0.008, SMAX = 0.87
  INTER = 0.84, CANOPY = 0.2483, PAVE = 0.49,
END PLANE

BEGIN PLANE
  ID = 53, LEN = 65.0, AREA = 67815.8,
  SL = 0.016, MAN = 0.100, X = 498971.4, Y = 3558034.0
  CV = 0.53, PRINT = 1
  KS = 3.93, G = 253.37, DIST = 0.22, POR = 0.467, ROCK = 0.33,
  FR = 0.36,0.3,0.34, SPLASH = 125.44, COH = 0.008, SMAX = 0.87
  INTER = 1.33, CANOPY = 0.2476, PAVE = 0.43,
END PLANE

BEGIN CHANNEL,
  ID = 54, PRINT = 1
  LAT =  52 53
  UP =  51
  LEN = 735.13, SLOPE = 0.0091, X = 499180.190, Y = 3558053.268,
  WIDTH = 3.1, 4.0,  DEPTH = 1.41, 1.41,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 252, LEN = 593.8, AREA = 1859539.3
  SL = 0.127, MAN = 0.080, X = 499096.7, Y = 3559013.5,
  CV = 0.53, PRINT = 1,
  KS = 4.62, G = 224.38, DIST = 0.23, POR = 0.457, ROCK = 0.35
  FR = 0.39,0.3,0.3, SPLASH = 129.32, COH = 0.008, SMAX = 0.87
  INTER = 2.03, CANOPY = 0.246, PAVE = 0.27,
END PLANE

BEGIN PLANE
  ID = 253, LEN = 324.9, AREA = 1929329.9,
  SL = 0.006, MAN = 0.097, X = 499710.2, Y = 3557289.5
  CV = 1.49, PRINT = 1
  KS = 17.52, G = 128.15, DIST = 0.35, POR = 0.454, ROCK = 0.18,
  FR = 0.60,0.26,0.14, SPLASH = 100.71, COH = 0.006, SMAX = 0.91
  INTER = 1.38, CANOPY = 0.2651, PAVE = 0.24,
END PLANE

BEGIN CHANNEL,
  ID = 254, PRINT = 1
  LAT =  252 253,
  UP =  54 264
  LEN = 2255.58, SLOPE = 0.0038, X = 499727.901, Y = 3559088.646,
  WIDTH = 10.0, 12.7,  DEPTH = 2.34, 2.34,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 41, LEN = 560.7, AREA = 2149820.8
  SL = 0.263, MAN = 0.055, X = 495874.8, Y = 3560455.8,
  CV = 0.47, PRINT = 1,
  KS = 4.01, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33
```

```
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87,
  INTER = 2.88, CANOPY = 0.2491, PAVE = 0.23,
END PLANE

BEGIN PLANE
  ID = 42, LEN = 374.6, AREA = 1359272.5,
  SL = 0.145, MAN = 0.065, X = 498120.7, Y = 3560157.0
  CV = 0.48, PRINT = 1
  KS = 4.00, G = 260.39, DIST = 0.21, POR = 0.467, ROCK = 0.34,
  FR = 0.35,0.31,0.35, SPLASH = 126.63, COH = 0.008, SMAX = 0.87
  INTER = 2.37, CANOPY = 0.2556, PAVE = 0.28,
END PLANE

BEGIN PLANE
  ID = 43, LEN = 332.2, AREA = 1459914.4,
  SL = 0.199, MAN = 0.061, X = 497831.2, Y = 3559653.8
  CV = 0.48, PRINT = 1
  KS = 3.81, G = 262.84, DIST = 0.21, POR = 0.468, ROCK = 0.33
  FR = 0.35,0.31,0.35, SPLASH = 126.30, COH = 0.008, SMAX = 0.87,
  INTER = 2.41, CANOPY = 0.2445, PAVE = 0.30
END PLANE

BEGIN CHANNEL
  ID = 44, PRINT = 1,
  LAT =  42 43
  UP =  41
  LEN = 3399.95, SLOPE = 0.0131, X = 498504.958, Y = 3559979.775,
  WIDTH = 3.0, 5.1,  DEPTH = 1.38, 1.59,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL ,

BEGIN PLANE
  ID = 242, LEN = 275.2, AREA = 561747.2,
  SL = 0.006, MAN = 0.084, X = 500231.2, Y = 3560333.5
  CV = 0.62, PRINT = 1
  KS = 6.23, G = 146.38, DIST = 0.30, POR = 0.447, ROCK = 0.42,
  FR = 0.49,0.31,0.21, SPLASH = 141.96, COH = 0.009, SMAX = 0.91
  INTER = 1.70, CANOPY = 0.2882, PAVE = 0.19,
END PLANE

BEGIN PLANE
  ID = 243, LEN = 404.9, AREA = 1587913.0,
  SL = 0.053, MAN = 0.081, X = 499100.3, Y = 3560672.5
  CV = 0.52, PRINT = 1
  KS = 4.70, G = 228.52, DIST = 0.24, POR = 0.462, ROCK = 0.36,
  FR = 0.39,0.31,0.31, SPLASH = 130.92, COH = 0.008, SMAX = 0.88,
  INTER = 2.00, CANOPY = 0.2873, PAVE = 0.26
END PLANE

BEGIN CHANNEL
  ID = 244, PRINT = 1,
  LAT =  242 243
  UP =  44 254
  LEN = 1321.36, SLOPE = 0.0039, X = 500108.590, Y = 3560665.158,
  WIDTH = 10.4, 13.2,  DEPTH = 2.37, 2.4,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 31, LEN = 775.5, AREA = 3764011.8,
  SL = 0.284, MAN = 0.055, X = 493877.8, Y = 3562328.3
  CV = 0.47, PRINT = 1
  KS = 4.13, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33,
```

```
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87
  INTER = 3.00, CANOPY = 0.25, PAVE = 0.20,
END PLANE

BEGIN PLANE
  ID = 32, LEN = 427.0, AREA = 2016255.5,
  SL = 0.164, MAN = 0.067, X = 496736.1, Y = 3561795.3
  CV = 0.48, PRINT = 1
  KS = 4.13, G = 260.39, DIST = 0.21, POR = 0.467, ROCK = 0.34,
  FR = 0.35,0.31,0.35, SPLASH = 126.63, COH = 0.008, SMAX = 0.87
  INTER = 2.62, CANOPY = 0.25, PAVE = 0.24,
END PLANE

BEGIN PLANE
  ID = 33, LEN = 356.3, AREA = 2477624.4,
  SL = 0.212, MAN = 0.064, X = 496664.4, Y = 3561155.5
  CV = 0.48, PRINT = 1
  KS = 4.07, G = 265.29, DIST = 0.21, POR = 0.468, ROCK = 0.33,
  FR = 0.34,0.31,0.35, SPLASH = 125.97, COH = 0.008, SMAX = 0.87
  INTER = 2.74, CANOPY = 0.25, PAVE = 0.23,
END PLANE

BEGIN CHANNEL,
  ID = 34, PRINT = 1
  LAT =  32 33,
  UP =  31,
  LEN = 6510.20, SLOPE = 0.0136, X = 497340.039, Y = 3561131.580,
  WIDTH = 3.7, 6.1,  DEPTH = 1.5, 1.71,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 232, LEN = 143.6, AREA = 178804.1
  SL = 0.020, MAN = 0.093, X = 500586.2, Y = 3561550.5,
  CV = 0.62, PRINT = 1,
  KS = 5.97, G = 146.38, DIST = 0.30, POR = 0.447, ROCK = 0.42
  FR = 0.49,0.31,0.21, SPLASH = 141.96, COH = 0.009, SMAX = 0.91,
  INTER = 1.53, CANOPY = 0.257, PAVE = 0.20
END PLANE

BEGIN PLANE
  ID = 233, LEN = 304.9, AREA = 777362.3,
  SL = 0.027, MAN = 0.078, X = 499900.0, Y = 3561625.8
  CV = 0.59, PRINT = 1
  KS = 5.94, G = 175.80, DIST = 0.28, POR = 0.452, ROCK = 0.40,
  FR = 0.45,0.31,0.24, SPLASH = 138.00, COH = 0.009, SMAX = 0.90
  INTER = 2.14, CANOPY = 0.2675, PAVE = 0.17,
END PLANE

BEGIN CHANNEL,
  ID = 234, PRINT = 1
  LAT =  232 233,
  UP =  34 244,
  LEN = 1274.35, SLOPE = 0.0036, X = 500607.214, Y = 3561753.208
  WIDTH =  10.9, 13.7,  DEPTH = 2.43, 2.43,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 21, LEN = 571.0, AREA = 2157195.8
  SL = 0.080, MAN = 0.083, X = 497772.3, Y = 3561894.0,
  CV = 0.47, PRINT = 1,
  KS = 3.64, G = 268.97, DIST = 0.20, POR = 0.469, ROCK = 0.33
```

```
  FR = 0.34,0.3,0.36, SPLASH = 125.47, COH = 0.008, SMAX = 0.87,
  INTER = 2.13, CANOPY = 0.25, PAVE = 0.32
END PLANE

BEGIN PLANE
  ID = 22, LEN = 166.0, AREA = 307580.2,
  SL = 0.050, MAN = 0.137, X = 499761.4, Y = 3562158.8
  CV = 0.56, PRINT = 1
  KS = 4.01, G = 194.19, DIST = 0.26, POR = 0.456, ROCK = 0.39,
  FR = 0.43,0.31,0.27, SPLASH = 135.53, COH = 0.009, SMAX = 0.89
  INTER = 0.48, CANOPY = 0.2573, PAVE = 0.43,
END PLANE

BEGIN PLANE
  ID = 23, LEN = 194.9, AREA = 495495.5,
  SL = 0.036, MAN = 0.122, X = 499147.5, Y = 3561837.3
  CV = 0.50, PRINT = 1
  KS = 3.38, G = 248.13, DIST = 0.22, POR = 0.465, ROCK = 0.34,
  FR = 0.36,0.31,0.33, SPLASH = 128.28, COH = 0.008, SMAX = 0.88
  INTER = 0.97, CANOPY = 0.25, PAVE = 0.45
END PLANE

BEGIN CHANNEL
  ID = 24, PRINT = 1,
  LAT =  22 23
  UP =  21
  LEN = 1778.95, SLOPE = 0.0098, X = 499790.586, Y = 3562023.787,
  WIDTH = 3.0, 4.2,  DEPTH = 1.38, 1.47,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL

BEGIN PLANE
  ID = 222, LEN = 111.2, AREA = 125138.1,
  SL = 0.037, MAN = 0.120, X = 500147.8, Y = 3562402.5
  CV = 0.62, PRINT = 1
  KS = 4.86, G = 146.38, DIST = 0.30, POR = 0.447, ROCK = 0.42,
  FR = 0.49,0.31,0.21, SPLASH = 141.96, COH = 0.009, SMAX = 0.91
  INTER = 0.68, CANOPY = 0.2506, PAVE = 0.34,
END PLANE

BEGIN PLANE
  ID = 223, LEN = 157.0, AREA = 146202.0,
  SL = 0.009, MAN = 0.114, X = 500588.2, Y = 3562189.3
  CV = 0.62, PRINT = 1
  KS = 5.56, G = 146.38, DIST = 0.30, POR = 0.447, ROCK = 0.42,
  FR = 0.49,0.31,0.21, SPLASH = 141.96, COH = 0.009, SMAX = 0.91
  INTER = 0.90, CANOPY = 0.2942, PAVE = 0.28,
END PLANE

BEGIN CHANNEL
  ID = 224, PRINT = 3, FILE = loop.dat
  LAT =  222 223
  UP =  24 234
  LEN = 288.91, SLOPE = 0.0063, X = 500437.149, Y = 3562440.778,
  WIDTH = 11.1, 13.9,  DEPTH = 2.43, 2.43,
  MAN = 0.035, SS1 = 2.00, SS2 = 2.00
  WOOL = Yes
  CV = 0.00, KSAT = 210, G = 101
  DIST = 0.5450, POR = 0.4400, ROCK = 0.00
  FR = 0.9000,0.05,0.05, SP = 63.00, COH = 0.0050
END CHANNEL
```

Appendix F – Rainfall Files

```
BEGIN 2yr

    N = 31
    s = 0.10

   TIME    DEPTH
!  (min)   (mm)
     0     0.0
     6     0.3
    12     0.7
    18     1.1
    24     1.6
    30     2.0
    36     2.5
    42     3.1
    48     3.7
    54     4.4
    60     5.1
    66     6.0
    72     7.1
    78     8.4
    84    10.5
    90    24.7
    96    32.6
   102    34.7
   108    36.1
   114    37.2
   120    38.1
   126    38.9
   132    39.6
   138    40.2
   144    40.8
   150    41.3
   156    41.7
   162    42.2
   168    42.6
   174    43.0
   180    43.4

END
```

```
BEGIN 5yr

    N = 31
    s = 0.10

   TIME    DEPTH
!  (min)   (mm)
     0     0.0
     6     0.3
    12     0.7
    18     1.1
    24     1.6
    30     2.0
    36     2.5
    42     3.1
    48     3.7
    54     4.4
    60     5.1
    66     6.0
    72     7.1
    78     8.4
    84    10.5
    90    24.7
    96    32.6
   102    34.7
   108    36.1
   114    37.2
   120    38.1
   126    38.9
   132    39.6
   138    40.2
   144    40.8
   150    41.3
   156    41.7
   162    42.2
   168    42.6
   174    43.0
   180    43.4

END
```

BEGIN 10yr

N = 31
s = 0.10

!	TIME (min)	DEPTH (mm)
	0	0.0
	6	0.4
	12	0.8
	18	1.3
	24	1.8
	30	2.4
	36	3.0
	42	3.6
	48	4.3
	54	5.1
	60	6.0
	66	7.0
	72	8.3
	78	9.9
	84	12.3
	90	28.8
	96	38.2
	102	40.6
	108	42.2
	114	43.5
	120	44.6
	126	45.5
	132	46.3
	138	47.1
	144	47.7
	150	48.3
	156	48.8
	162	49.3
	168	49.8
	174	50.3
	180	50.7

END

Appendix G – Summary of Calibrated Multipliers

Enchanted Hills at Mission

3.226 Multiplier for Ks
0.712 Multiplier for Channel Roughness
0.675 Multiplier for Hillslope Roughness
1.022 Multiplier for Coefficient of Variation of Ks (CVKs)
(Essentially a partial area response parameter)
0.683 Multiplier for net Capillary drive
(in this case a function of Ks)

West Branch at Valencia

1.049 Multiplier for Ks
1.266 Multiplier for Channel Roughness
1.347 Multiplier for Hillslope Roughness
1.047 Multiplier for Coefficient of Variation of Ks (CVKs)
(Essentially a partial area response parameter)
0.985 Multiplier for net Capillary drive
(in this case a function of Ks)