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Hydrologic Modeling of the Court Creek Watershed

by
Deva K. Borah and Maitreyee Bera

Prepared for the
Illinois Department of Natural Resources

March 2000

Illinois State Water Survey
Watershed Science Section
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

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Executive Summary

Flooding, upland soil and streambank erosion, sedimentation, and contamination of drinking water from agricultural chemicals (nutrients and pesticides/herbicides) are critical environmental problems in Illinois. Upland soil erosion causes loss of fertile soil, streambank erosion causes loss of valuable riparian lands, and both contribute large quantities of sediment (soil and rock particles) in the water flowing through streams and rivers, which causes turbidity in sensitive biological resource areas and fills water supply and recreational lakes and reservoirs. Most of these physical damages occur during severe storm and flood events. Eroded soil and sediment also carry chemicals that pollute water bodies and stream/reservoir beds.

Court Creek and its 97-square-mile watershed in Knox County, Illinois, experience problems with flooding and excessive streambank erosion. Several fish kills reported in the streams of this watershed were due to agricultural pollution. Because of these problems, the Court Creek watershed was selected as one of the pilot watersheds in the Illinois multi-agency Pilot Watershed Program (PWP). The watershed is located in environmentally sensitive areas of the Illinois River basin; therefore, it is also part of the Illinois Conservation Reserve Enhancement Program (CREP).

Understanding and addressing the complex watershed processes of hydrology, soil erosion, transport of sediment and contaminants, and associated problems have been a century old challenge for scientists and engineers. Mathematical computer models simulating these processes are becoming inexpensive tools to analyze these complex processes, understand the problems, and find solutions through land-use changes and best management practices (BMPs). Effects of land-use changes and BMPs are analyzed by incorporating these into the model inputs. The models help in evaluating and selecting from alternative land-use and BMP scenarios that may help reduce damaging effects of flooding, soil and streambank erosion, sedimentation (sediment deposition), and contamination to the drinking water supplies and other valuable water resources.

A computer model of the Court Creek watershed is under development at the Illinois State Water Survey (ISWS) using the Dynamic Watershed Simulation Model (DWSM) to help achieve the restoration goals set in the Illinois PWP and CREP by directing restoration programs in the selection and placement of BMPs. The current study is part of this effort. The DWSM uses physically based governing equations to simulate propagation of flood waves, entrainment and transport of sediment, and commonly used agricultural chemicals for agricultural and rural watersheds. The model has three major components: (1) hydrology, (2) soil erosion and sediment transport, and (3) nutrient and pesticide transport. The hydrologic model of the Court Creek watershed was developed using the hydrologic component of the DWSM, which is the basic (foundation) component simulating rainfall-runoff on overland areas, and propagation of flood waves through an overland-stream-reservoir network of the watershed. A new routine was introduced into the model to allow simulation of spatially varying rainfall events associated mainly with moving storms and localized thunderstorms. The model was calibrated and verified using three rainfall-runoff events monitored by the ISWS.

The calibration and verification runs demonstrated that the model was representative of the Court Creek watershed by simulating major hydrologic processes and generating hydrographs with characteristics similar to the observed hydrographs at the monitoring stations. Therefore, model performance was promising considering watershed size, complexities of the processes being simulated, limitations of available data for model inputs, and model limitations. The model provides an inexpensive tool for preliminary investigations of the watershed for illustrating the major hydrologic processes and their dynamic interactions within the watershed, and for solving some of the associated problems using alternative land use and BMPs, evaluated through incorporating these into the model inputs.

The model was used to compare flow predictions based on spatially distributed and average rainfall inputs and no difference was found because of a fairly uniform rainfall pattern for the simulated storm. However, the routine will be useful for simulating moving storms and localized thunderstorms. A test to examine effects of different watershed subdivisions with overland and channel segments found no difference in model predictions. This was because of the dynamic routing schemes in the model where dynamic behaviors were preserved irrespective of the sizes and lengths of the divided segments. Although finer subdivision does not add accuracy to the outflows, it allows investigations of spatially distributed runoff characteristics and distinguishes these among smaller areas, which helps in prioritizing areas for proper attention and restoration.

The calibrated and verified model was used to simulate four synthetic (design) storms to analyze and understand the major dynamic processes in the watershed. Detailed summaries of results from these model runs are presented. These summary results were used to rank overland segments based on unit-width peak flows, which indicated potential flow strengths that may damage the landscape, and were based on runoff volumes that indicate potential flood-causing runoff amounts. Stream channel and reservoir segments also were ranked based on peak flows and indicate potential for damages to the streams. Maps were generated showing these runoff potentials of overland areas. These results may be useful in identifying and selecting critical overland areas and stream channels for implementation of necessary BMPs to control damaging effects of runoff water.

The model also was used to evaluate and quantify effects of the two major lakes in the watershed in reducing downstream flood flows and demonstrating model ability to evaluate detention basins. The model was run for one of the design storms with and without the lakes. The results showed significant reduction of peak flows and delaying of their occurrences immediately downstream. These effects become less pronounced further downstream.

This report presents and discusses results from the above applications of the DWSM hydrology to the Court Creek watershed along with descriptions of the

watershed, formulations of the hydrology component of the DWSM, limitations of the model and available data affecting predictions, and recommendations for future work.

Efforts are currently under way at the ISWS to add subsurface and tile flow routines to the DWSM that would improve model predictions and their correspondence with observed data. It is recommended that stream cross-sectional measurements be made at representative sections of all major streams in the Court Creek watershed and that stream flow monitoring be continued or established at least at outlets of major tributaries and upper and lower Court Creek. A minimum of four equally spaced raingage stations are recommended for recording continuous rainfall.

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Introduction

Flooding, upland soil and stream bank erosion, sedimentation, and contamination of drinking water from agricultural chemicals (nutrients and pesticides/herbicides) are critical environmental problems in Illinois (Roseboom et al., 1982a; Fitzpatrick et al., 1985, 1987; Demissie et al., 1988, 1992, 1996; Mitchell et al., 1994; Keefer et al., 1996; Goolsby et al., 1999). Upland soil erosion causes loss of fertile soil, streambank erosion causes loss of valuable riparian lands, and both contribute large quantities of sediment (soil and rock particles) to the water flowing through streams and rivers causing turbidity in sensitive biological resource areas and filling water supply and recreational lakes and reservoirs. A few examples of serious lake sedimentation in Illinois are Lake Decatur (Fitzpatrick et al., 1987), Lake Springfield (Fitzpatrick et al., 1985), and Peoria Lake (Demissie et al., 1988). Most of these physical damages occur during severe storm and flood events. Eroded soil and sediment also carry chemicals that pollute water bodies and stream/reservoir beds.

Court Creek and its watershed in Knox County, Illinois, experience problems with flooding and excessive streambank erosion (Roseboom et al., 1982a). Several fish kills, including an extensive fish kill in 1981, reported in the streams of this watershed were due to agricultural pollution. Because of these problems in this 97-square-mile watershed (Figure 1), the Court Creek watershed was selected as one of the pilot watersheds in Illinois. The watershed, located in environmentally sensitive areas of the Illinois River basin, is also part of the Illinois Conservation Reserve Enhancement Program (CREP).

The Pilot Watershed Program (PWP), established in 1998, is an interagency effort to promote coordination between government agencies and local communities, and to implement watershed science principles and good management practices on four watersheds in Illinois. Program goals are to understand watershed processes and develop land-use management tools that reduce soil and streambank erosion, improve water quality in streams and lakes, and increase the abundance of a variety of aquatic and terrestrial species. Participating agencies include: Illinois Department of Natural Resources (IDNR), Illinois Department of Agriculture (IDOA), Illinois Environmental Protection Agency (IEPA), U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Association of Illinois Soil and Water Conservation Districts (AISWCD), and Farm Service Agency (FSA). The four pilot watersheds are Court Creek, Hurricane Creek, Sugar Creek, and Big Creek located in the Spoon, Embarras, Kaskaskia, and Cache River basins, respectively. The PWP is described briefly in a document circulated jointly by the participating agencies (IDOA et al., 1998).

The CREP, a state and federal partnership program, was launched in 1998 to promote cleaner land and waters along the Illinois River (Thomas, 1998). Goals of this program are to reduce sedimentation and nutrients in the Illinois River by 20 and 10 percent, respectively; increase populations of waterfowl, shorebirds, nongame grassland birds, and threatened/endangered species by 15 percent; and increase the native fish and mussel population in the lower reaches of the Illinois River by 10 percent. The CREP is part of a much older and bigger federal program called the Conservation Reserve Program (CRP), which was designed to remove environmentally sensitive farmlands from production. The Illinois CREP expands on CRP through a partnership with the state and provides additional incentives for landowners to voluntarily enter into an agreement to extend the CRP contract. The program focuses on the Illinois River from Meredosia to Starved Rock, plus tributaries to the river, including the Spoon, Mackinaw, Vermilion, Kankakee, lower Fox, and lower Sangamon Rivers. Court Creek, a tributary to the Spoon River, is part of the program. The FSA manages the federal part of the program. The IDNR has the primary responsibility for administering the fiscal portion of the state part of the program and works with other federal and state agencies, including IDOA, IEPA, and local Soil and Water Conservation Districts, in implementing the program.

Understanding and addressing the complex processes of hydrology, soil erosion, transport of sediment and contaminants, and associated problems have been a century old challenge for scientists and engineers, especially due to the spatial and temporal variability of those processes within a watershed. Mathematical (computer) models simulating these processes are becoming inexpensive tools to analyze those complex processes, understand the problems, and find solutions through land-use changes and best management practices (BMPs). Effects of land-use changes and BMPs are analyzed by incorporating these into the model inputs. The models help in evaluating and selecting from alternative land-use and BMP scenarios, implementation of which may help reduce damaging effects of flooding, soil and streambank erosion, sedimentation (sediment deposition), and contamination to the drinking water supplies and other valuable water resources.

A dynamic watershed simulation model (DWSM) is being developed at the Illinois State Water Survey (ISWS) (Borah et al., 1998, 1999a, b) using physically based governing equations to simulate propagation of flood waves, entrainment and transport of sediment, and commonly used agricultural chemicals for agricultural and rural watersheds. The model has three major components: (1) hydrology, (2) soil erosion and sediment transport, and (3) nutrient and pesticide transport. Formulations and procedures of these components are adopted from earlier work of the first author (Borah, 1989a, b; Ashraf and Borah, 1992). Each of these model components has efficient routing schemes based on approximate analytical solutions of the physically based governing equations, and preserving the dynamic behaviors of the water, sediment, and accompanying chemical movements. The model has been tested on the 925-square-mile Upper Sangamon River basin in east central Illinois, draining into Lake Decatur, using monitored data (Borah et al., 1998, 1999a, b).

A computer model of the Court Creek watershed is under development at the ISWS using its DWSM to help achieve the restoration goals set in the Illinois PWP and CREP, i.e., to guide restoration programs in the selection and placement of BMPs. The current study is part of this effort. The hydrologic model of the watershed is developed using the hydrologic component of the DWSM, which is the basic (foundation) component simulating storm water rainfall-runoff on overland areas and propagation of flood waves through an overland-stream-reservoir network of the watershed.

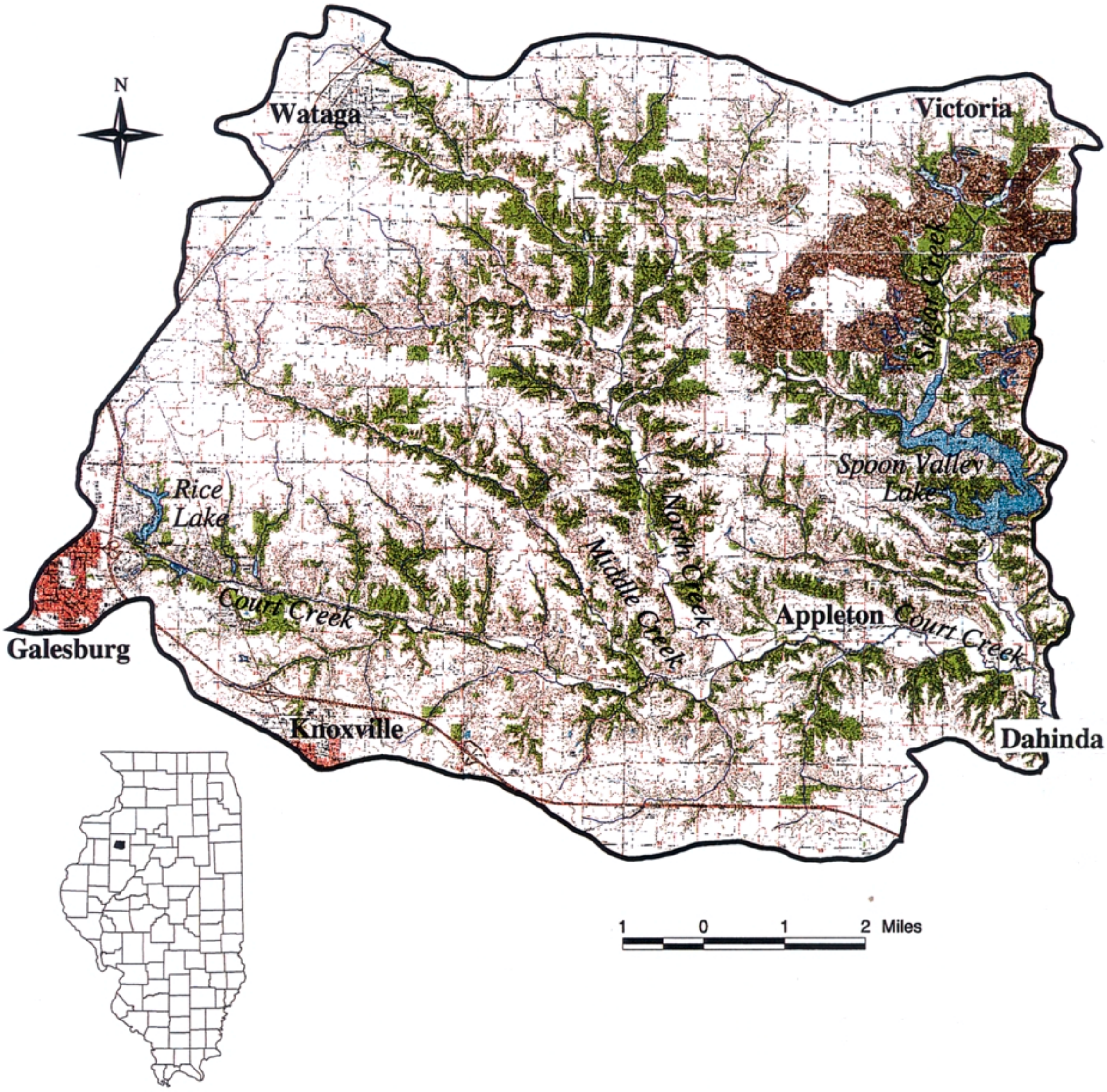

Figure 1. Location, topography, and major physical features of the Court Creek watershed

Extensive hydrologic, land-use, water quality, and biological data were collected on the Court Creek watershed by the ISWS during 1980-l988 (Roseboom et al., 1982a, b, 1986, 1990). These data were used to develop the basic model inputs. Using the rainfall-runoff data of three monitored storms, the model was calibrated and verified and then used to simulate four synthetic or design storms. The results were used to determine runoff potentials of overland, stream channel, and reservoir segments. One storm was used to evaluate impacts of the two existing lakes and demonstrate use of detention ponds as a BMP for reducing downstream flood flows that may have impacts on flood damages and streambank erosion.

This report presents and discusses results from the applications of the DWSM to the Court Creek watershed, descriptions of the watershed, formulations of the hydrology component of DWSM, limitations of the model and the available data affecting predictions, and recommendations for future work.

Acknowledgments

The authors acknowledge the financial support from IDNR to conduct this study. They sincerely appreciate the support, cooperation, and enthusiasm from Douglas Austen, head of the Watershed Management Section, Office of Resource Conservation, IDNR; David Day; and their colleagues while initiating the study as well as during the course of the study.

Partial funding was from the Illinois Council on Food and Agricultural Research (C-FAR) Water Quality Strategic Research Initiative (WQ-SRI) Program. The authors thank Mark Godsil, chairman of the Court Creek Watershed Planning Committee, and James Westervelt, coordinator of the C-FAR WQ-SRI modeling program for their interest, enthusiasm, and encouragement. The findings and recommendations in this report are not necessarily those of the funding agencies or of the Illinois State Water Survey.

The authors wish to express their sincere appreciation to Donald Roseboom of ISWS for his generous support to this study by giving the authors a comprehensive field tour of the Court Creek watershed, providing them with published reports, storm rainfall and flow data, and valuable guidance during the study.

The authors thank ISWS Chief Derek Winstanley and Watershed Science Section head Nani Bhowmik (former) and Manoutchehr Heidari (interim) for their support and permission to use ISWS resources in initiating, expanding, and completing this basic part of the Court Creek watershed modeling study. They specially thank Chief Winstanley for his critical and useful comments on the report. They also thank Kathleen Brown for her assistance in preparing the Geographic Information System maps and Renjie Xia and Susan Shaw for critically reviewing the report. Eva Kingston and Agnes Dillon edited the report, and Linda Hascall reviewed and formatted the graphics.

Court Creek Watershed and Its Investigations

The Court Creek watershed is located in Knox County, east of Galesburg, Illinois. Figure 1 shows the boundaries, topography, and major physical features of this 97-square-mile (251-square-kilometer or 62,000-acre) watershed, drawn based on U.S. Geological Survey 7.5-Minute Series Topographic Quadrangle maps. The watershed lies almost entirely within the four townships of Knox, Sparta, Copley, and Persifer. Court Creek flows along the southern boundary of the watershed for 14.5 miles before discharging into the Spoon River, a western tributary of the Illinois River, at Dahinda. Three major tributaries, Middle Creek, North Creek, and Sugar Creek, enter Court Creek from the north. Strip mining created numerous small lakes over a 3,400-acre area in the upper Sugar Creek basin. Directly below the strip-mined lands, a 512-acre Spoon Valley Lake impounds the waters of Sugar Creek for the Oak Run housing development. The only other lake in the watershed is Rice Lake, a 30-acre impoundment on the upper end of Court Creek.

Roseboom et al. (1982a, b, 1986, 1990) collected extensive hydrologic, land-use, and water quality data on the Court Creek watershed during 1980-1988. Land use in the watershed is predominately agriculture with row crop fields occurring on 49 percent of the watershed. More than 70 percent of the row crop acreage is corn. Pastures, wooded pastures, and strip-mine pastures are on 29 percent of the watershed. Animal feedlots occur on 0.3 percent of the watershed and contain the majority of the 60,000 livestock present in the watershed. Fifteen of the 93 feedlots in the watershed are total confinement sites. Urban areas in the watershed include Galesburg and a portion of Knoxville (Figure 1). The watershed has two county landfills.

Thirty-nine percent of the land in the Court Creek watershed has slopes greater than a 15 percent grade. These lands are normally in pasture, wooded pasture, strip-mine pasture, and woods. Less than 6 percent of the watershed has slopes between 6 and 15 percent. More than 50 percent of the watershed has slopes less than a 6 percent grade. Watershed areas with less than a 6 percent slope have been used for row crop agriculture and residential housing.

Roseboom et al. (1982a) reported detailed physical, soil, land-use, hydrologic, and hydraulic characteristics and data of the Court Creek watershed and its streams. Nine major bank erosion sites along Court Creek were examined, and soil composition of the banks and some chemical characteristics were analyzed. Bank erosion sites along North Creek also were identified and analyzed. Extensive monitoring stations were established to monitor rainfall (13 stations), flow (9 stations), and water quality parameters (9 primary and 7 supplemental stations). Figure 2 shows some of the stream and all the raingage stations. Data from these stations were used in the modeling study. In the first monitoring investigation of Roseboom et al. (1982a), monitoring was conducted during 1980-1982. In a separate report, Roseboom et al. (1982b) reported all the monitored data on rainfall, flow, water quality, and fish survey. The investigators reported a pesticide fish kill in the Spoon Valley Lake in 1981.

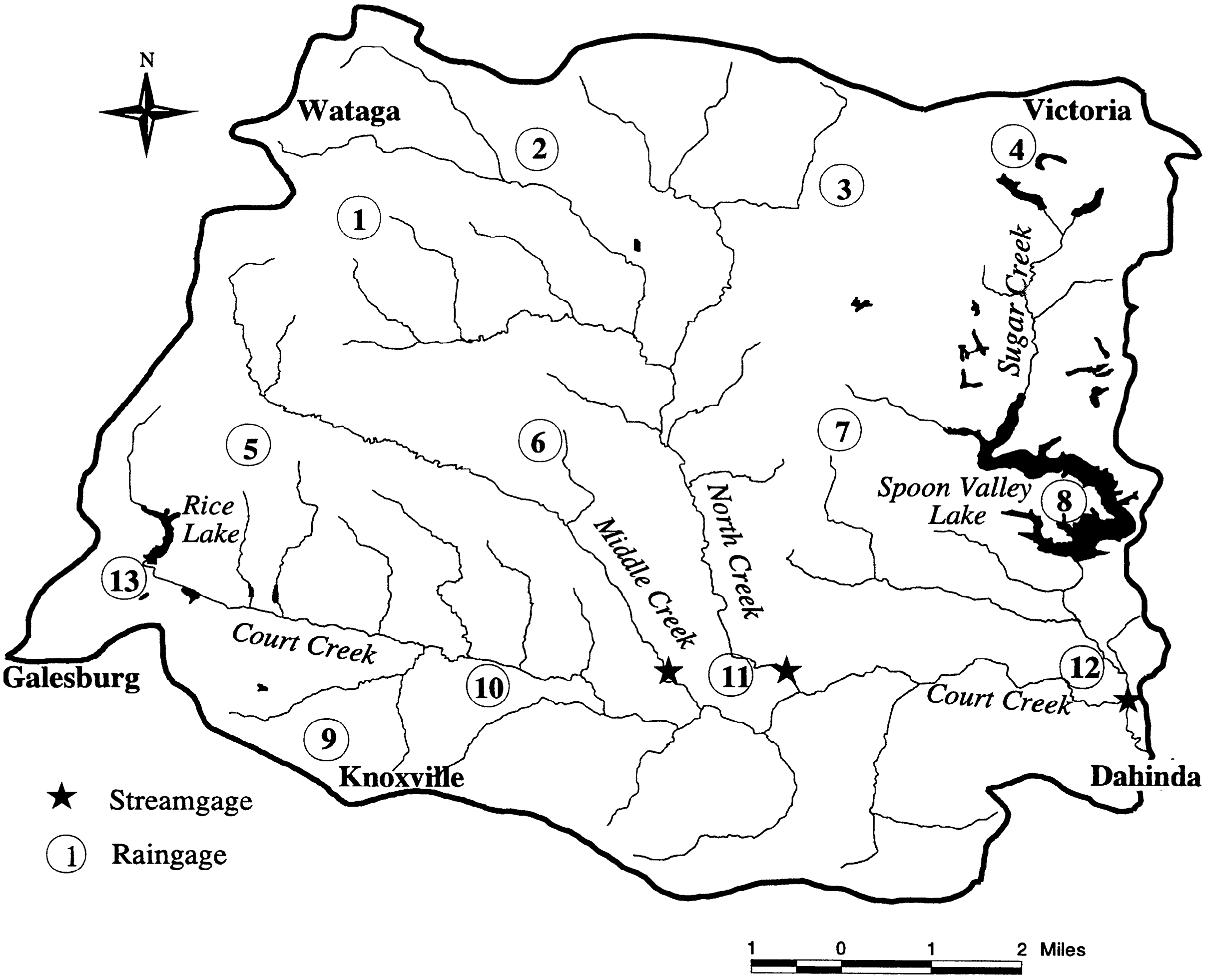

Figure 2. Major streams, reservoirs, streamgages, and raingages in the Court Creek watershed

In a subsequent investigation, Roseboom et al. (1986) studied the influences of land uses and stream modifications on water quality in the streams of the Court Creek watershed. Additional data on rainfall, flow, sediment, water quality, and streambank erosion were collected during December 1982-April 1983 storms.

Roseboom et al. (1990) conducted another monitoring study during the drought years of 1987 and 1988. Data collected during 1986 also were reported. Water quality parameters of both nutrient and pesticides were collected during baseflow and storm runoff conditions. Contributions from row crops and feedlots were investigated.

Enormous hydrologic, hydraulic, water quality, and biological (fisheries) data were collected on the Court Creek watershed. Due to its geographical location and the available data, this watershed was selected as one of the four pilot watersheds in Illinois, and played a key role in the interagency PWP and CREP, which were supported by Conservation 2000 funds. The watershed has a standing committee, the Court Creek Watershed Planning Committee (CCWPC), with high local interest.

Extensive investigations and future research planning are underway on the Court Creek and other pilot watersheds. State staff, state and university researchers, and local watershed representatives have been meeting regularly to discuss the status of watershed science, watershed assessment, future research, support, and coordination on the pilot watersheds (Austen and Hogan, 1999a, b). Emphasis was given to improved communication between landowners, agency staff, and researchers toward the common goal of restoring watersheds. These efforts have generated several research projects by university and state researchers, planning grants to the local watershed groups, active watershed planning committees, and considerable interest in watershed issues. The Court Creek modeling study presented in this report is part of these efforts.

The Hydrologic Component of DWSM

The driving force of DWSM comes from a dynamic hydrologic model in which hydrologic processes are simulated for a given rainfall event, and time and space varying flow depths and flow rates of surface runoff are computed. These processes are simulated by dividing the watershed into subwatersheds, specifically, into one-dimensional overland, channel, and reservoir flow elements or segments (Figure 3). The Court Creek watershed was divided into 78 overland, 39 channel, and 2 reservoir segments, which are identified by numbers: 1-78 (overland), 79-117 (channel), and 118-119 (reservoir). These divisions take into account the nonuniformities in topographic, soil, and land-use characteristics, which are treated as being uniform within each of the segments.

The overland segments are represented by rectangular areas with representative length, slope, width, soil, cover, and roughness. The channels are described by representative cross-sectional shape, slope, length, and roughness. The reservoirs are represented by stage-storage-discharge relations. Figure 4 shows model approximations of six overland segments (1-6) contributing to three channel segments (79-81). Areas of the overland and lengths of the channel segments are measured in the divided topographic map (Figure 3). Width (W in Figure 4) of a model overland (1) is equal to the length of the receiving channel (79). Length (L) of the model overland (1) is computed by dividing its area by the length of the receiving channel (79).

The overland segments are the primary sources of runoff (flowing water) in which rainfall turns into runoff after losses first to interception at canopies and ground covers, then to infiltration through the soil matrix and depression storage on the ground surface. The rainfall available for runoff is referred to as rainfall excess. Two overland segments contribute to one channel segment laterally from each side of the channel as shown in Figure 5. The excess rainfall is routed over the overland segments beginning at their upstream edges (ridges), in which flows are zeros, up to their downstream edges, coinciding with the receiving channel banks. Because the physical and meteorological characteristics of an overland segment are assumed uniform, routing of excess rainfall over only a unit width resulting in “flow per unit width” of the segment is required. The unit-width flow is uniform along the overland width and discharges uniformly along the channel length. Figure 5 will be discussed further along with introduction of the variables in Appendix A and the overland and channel flow routing scheme. The channels carry the receiving water downstream of the watershed and ultimately to the watershed outlet. During its journey, the runoff water may be intercepted by lakes or reservoirs, which release it again to downstream channels at reduced rates after temporary storage.

Figure 6 shows the general computational operations of the DWSM-hydrologic component in the form of a flow diagram. Rates of rainfall excess on the overland elements are computed from a given breakpoint rainfall record (rainfall recorded at different times during a storm) using two alternative algorithms. The method used in this study is the Soil Conservation Service (SCS) runoff curve number method described in

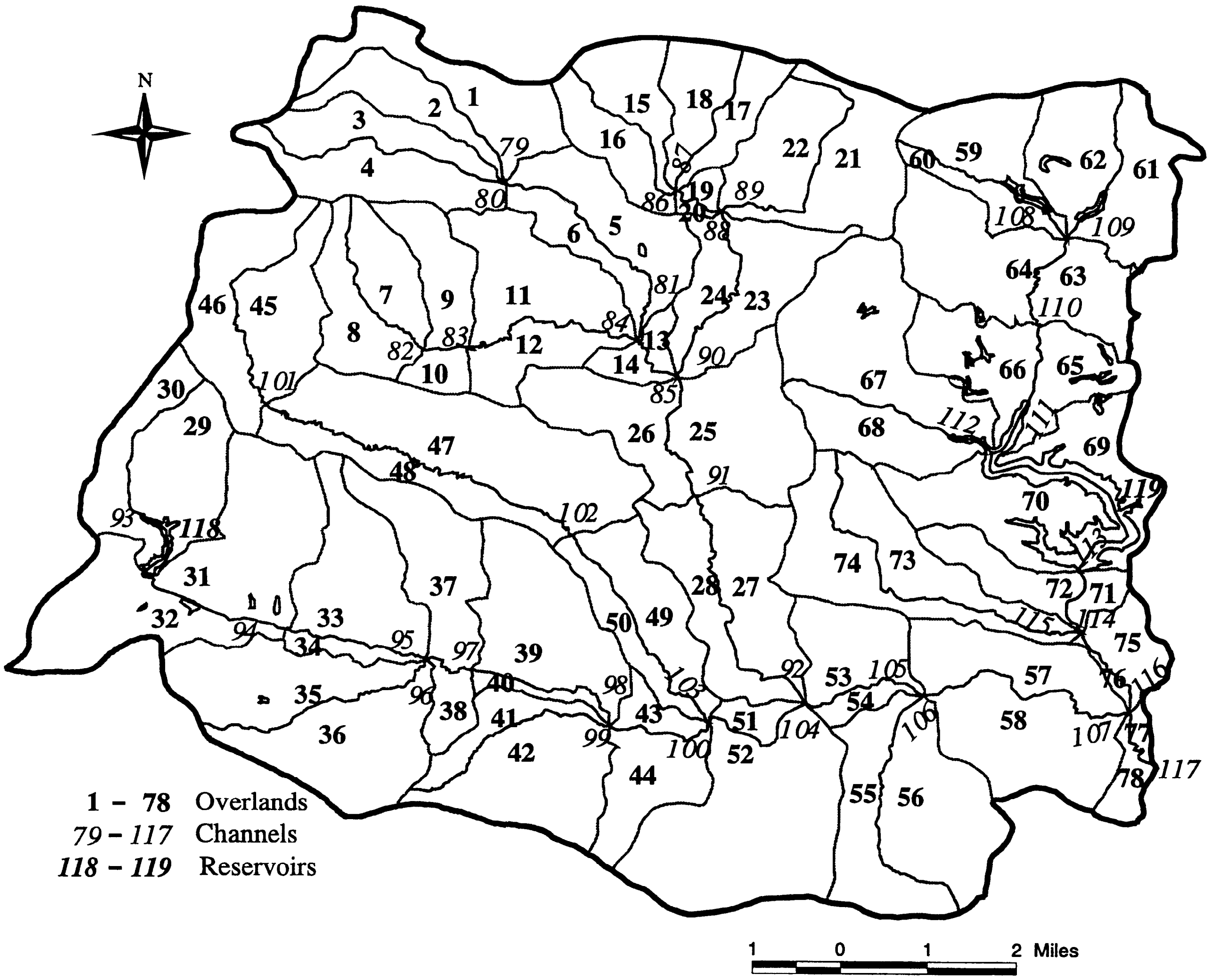

Figure 3. Numbering of model segments in the Court Creek watershed

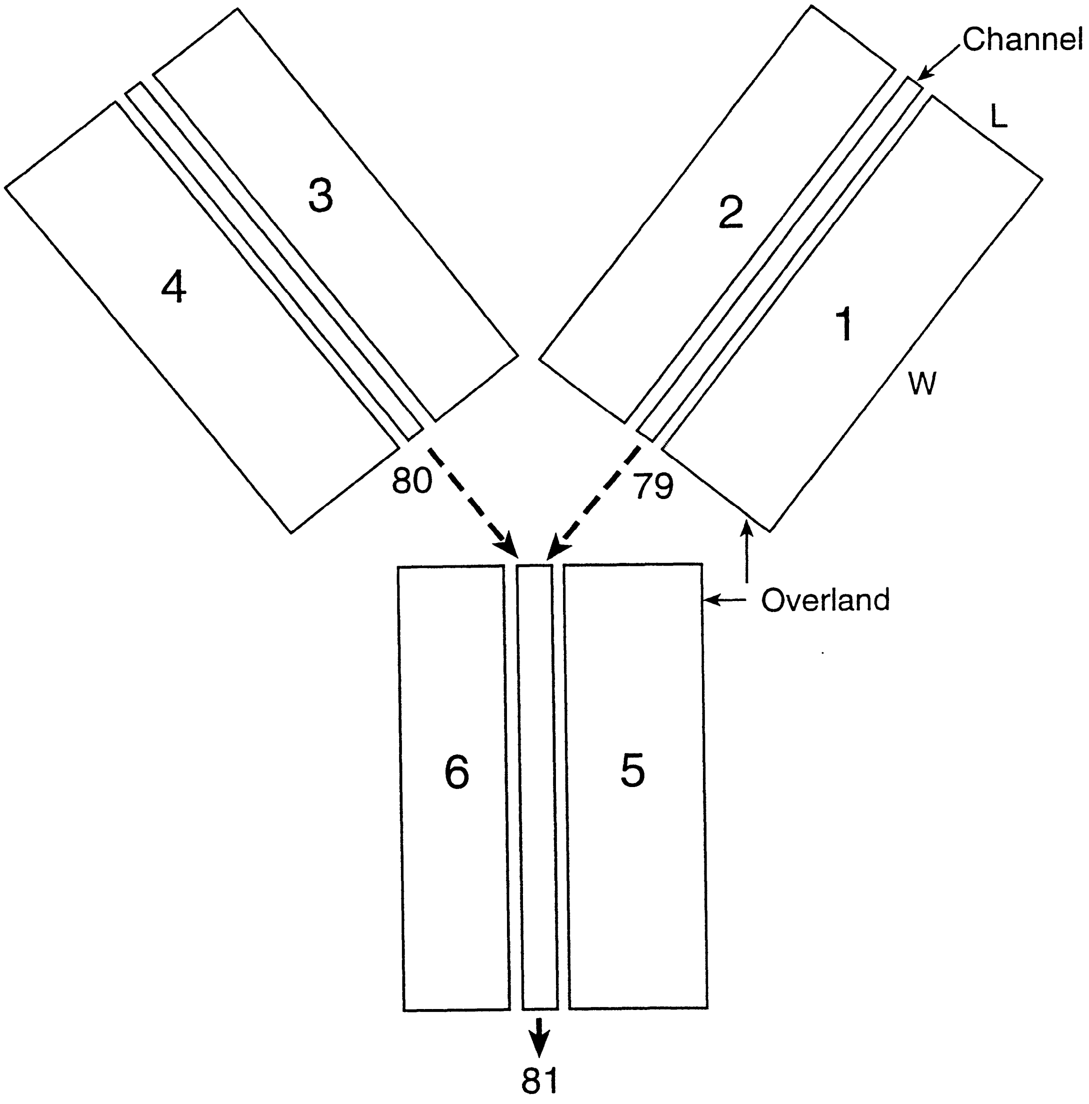

Figure 4. Dynamic Watershed Simulation Model approximations of overland and channel segments

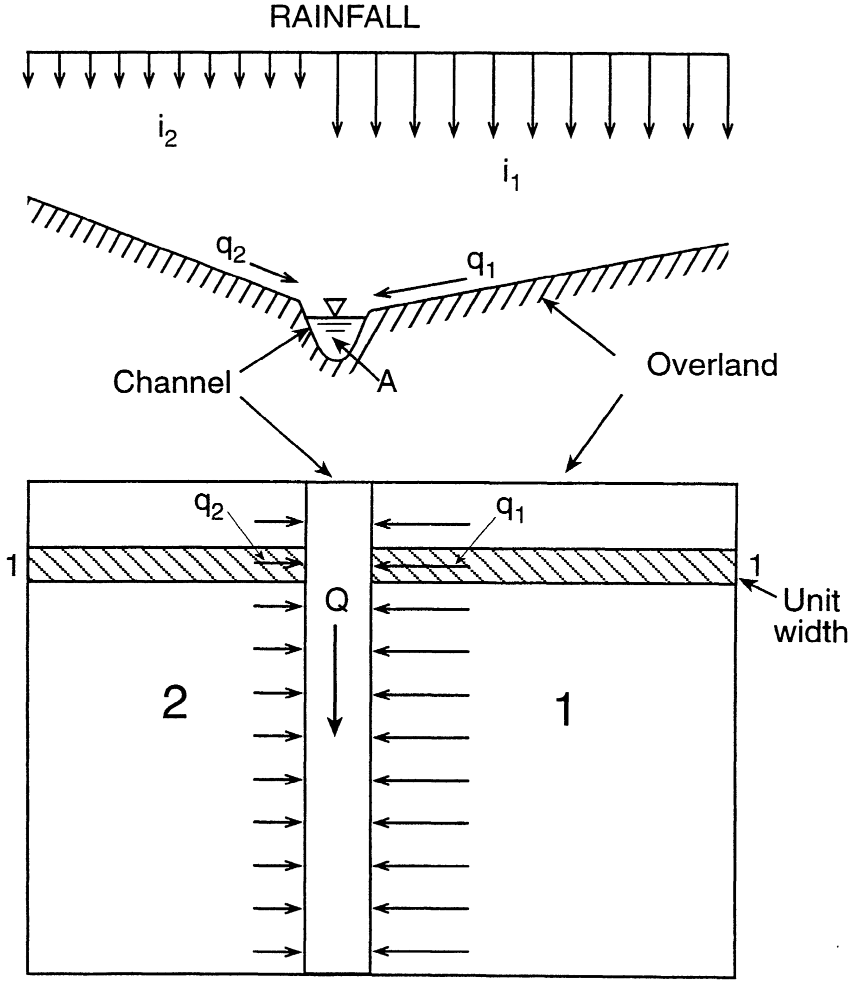

Figure 5. Dynamic Watershed Simulation Model overland and channel flow approximations

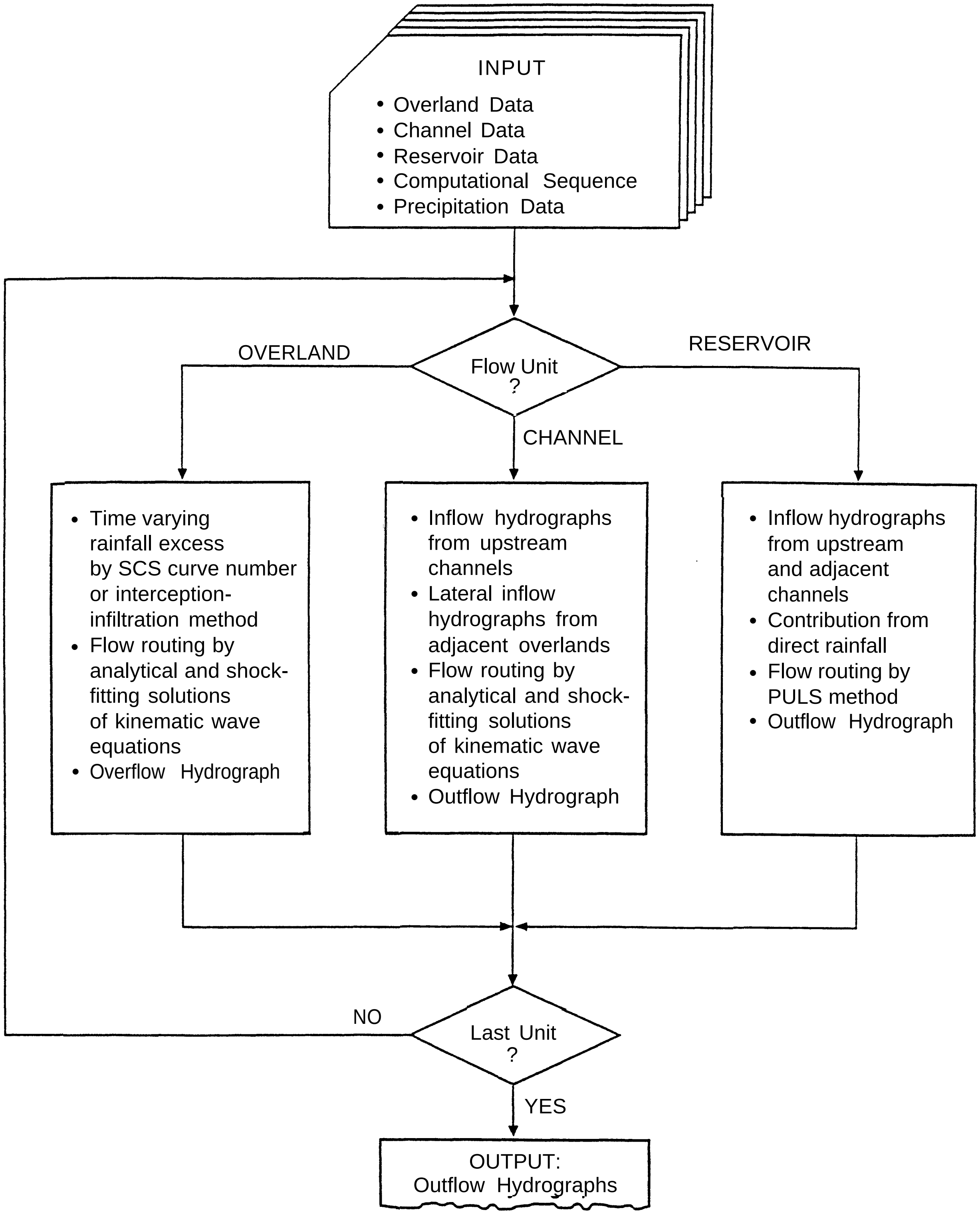

Figure 6. Flow diagram of Dynamic Watershed Simulation Model hydrologic simulation

Appendix A. The other alternative method is an interception-infiltration scheme based on Simons et al. (1975) and Smith and Parlange (1978), and presented in Borah et al. (1981, 1998, 1999a). The water reaching the channels is routed through the channel-reservoir system. The kinematic wave-based routing scheme, described in Appendix A, is used to route water over the overland and through the channel segments. The standard storage-indication method, also described in Appendix A, is used to route floodwater through reservoirs.

While routing water from upstream to downstream of the watershed, gravity flow logic is used to determine the computational sequence, starting from the uppermost overland and ending in a channel or a reservoir segment at the watershed outlet. An efficient sequencing scheme is used, in which the outflow hydrograph from a flow segment is stored until it is used as inflow while routing through the following downstream segment. Once a hydrograph is used, it is erased to make the storage space available for a hydrograph of another segment. The procedure is described in Borah et al. (1981).

A new routine is introduced into the DWSM to account for spatial rainfall distribution within a watershed. This allows simulation of a moving storm across a watershed and simulation of localized thunderstorms falling on single or multiple portions of the watershed. The procedure simply assigns different breakpoint rainfall records for each overland segment. Breakpoint rainfall records from all the raingage stations within the watershed are entered in arrays. Another array assigns a raingage to its contributing overlands, which is determined using the Thiessen Polygon method (Thiessen, 1911). All the overland segments within a polygon are assigned to the raingage corresponding to the polygon. While simulating an overland segment, the model automatically reads the breakpoint rainfall record assigned to that overland.

Special situations are dealt with individually. For simplicity, an overland area crossing polygon boundaries is assigned to the raingage station having a larger area of the overland in the corresponding polygon. For an overland covering more than one polygon or raingage, the rainfall depths are averaged and lumped into one raingage as a record from one station.

In this study, the 97-square-mile Court Creek watershed had breakpoint rainfall records at 13 raingage stations (Figure 2) evenly distributed within the watershed and provided a perfect example to test and make use of this new routine.

Modeling the Court Creek Watershed

The Court Creek watershed was divided into 78 overland, 39 channel, and 2 reservoir segments (Figure 3). These segments were identified with numbers: 1-78 (overlands), 79-117 (channels), and 118-119 (reservoirs). Areas of the overland and lengths of the channel segments were measured from Figure 3. As Figures 4 and 5 illustrate, overlands are considered as rectangular areas, and two rectangular overlands contribute laterally to one channel from each side of the channel. Width of an overland is equal to the length of the receiving channel. Lengths of overland segments were computed by dividing the overland areas by lengths of the receiving channels. Channel cross-sectional measurements made by Roseboom et al. (1982a) were used to develop relationships of wetted perimeter versus cross-sectional area (Appendix A).

Representative slopes of the overlands and the channels were determined based on the topographic maps and values given by Roseboom et al. (1982a). Representative values of Manning's roughness factor for the overlands and the channels were assumed based on land-use information given in Roseboom et al. (1982a) and recommendations in Chow (1959). Representative curve numbers for the overlands were taken from Roseboom et al. (1986) who estimated, based on soil cover complexes of the overland areas and annual average antecedent moisture (rainfall), a condition called antecedent moisture condition (AMC) II (SCS, 1972). The curve numbers and Manning's roughness factors obtained from the above sources were used as initial estimates and were adjusted during model calibration (discussed below).

Reservoirs 118 and 119 (Figure 3) are Rice Lake and Spoon Valley Lake, respectively. Stage-storage-discharge relations (tables) for these two lakes were obtained from the National Dam Safety Program Inspection Reports of the Department of the Army (1978, 1979).

Computational sequence of all the overland, channel, and reservoir segments from upstream to downstream of the watershed and a data management array were prepared using the procedure outlined in Borah et al. (1981).

Roseboom et al. (1986) recorded three storms, which occurred on December 2 and 24, 1982, and April 1, 1983. Continuous rainfall records (charts) for all the three storms at 13 stations (Figure 2) were obtained from Roseboom (personal communication, April 17, 1999). Flow records at three gaging stations near the outlets of North Creek, Middle Creek, and Court Creek (Figure 2) also were obtained from Roseboom (personal communication, June 15, 1999 and October 12, 1999). Flow records at the Court Creek or watershed outlet were available for all three storms. Flow records at the outlet of North Creek were available for the December 24, 1982, and April 1, 1983, storms. Flow records at the outlet of Middle Creek were available only for the April 1, 1983, storm. In other words, flows at all three stations were recorded during the April 1, 1983, storm. Therefore, the April 1, 1983, storm was selected to calibrate the model, and the remaining two storms were selected to verify it.

Simulation of April 1, 1983, Storm: Model Calibration

The intense rainfall for the April 1, 1983, storm began at 11:00 a.m. on that day. After raining for approximately 20 hours, rainfall ended at 7:00 a.m. the next day (April 2, 1983) at 12 stations (2-13, Figure 2). Records at station 1 were found erroneous and, therefore, were not used in the simulation. Rainfall depths varied from 2.28 inches at station 13, located at the western part of the watershed near Rice Lake, to 3.80 inches at station 3, located at the mid-northern portion of the watershed. The average depth of rainfall in the 12 stations was 2.74 inches. Breakpoint rainfall records from each of the 12 stations were assigned to overland areas according to the areas of influence given by Roseboom et al. (1982a), which was based on Thiessen Polygon method. Figure 7a shows the time-varying average rainfall intensities from these 12 stations and the predicted and observed hydrographs discussed below. Note that the predicted hydrographs were based on the distributed rainfall records at the 12 stations.

With a computational time step of 15 minutes, the hydrologic component of DWSM was run for the above rainfall event. Predicted hydrographs at the three monitored stations were compared with the monitored hydrographs. The curve numbers and the Manning’s roughness factors were slightly adjusted to improve comparisons of the hydrographs. These comparisons are shown in Figure 7a; the comparisons appear better for smaller drainage areas. The Middle Creek, which has a drainage area of 10 square miles, shows better predictions than North Creek, which has a drainage area of 30 square miles. Predictions of North Creek are better than predicted outflows at the watershed outlet on Court Creek, draining 97 square miles. The model is predicting the recession portions of the hydrographs better than the rising parts. Major discrepancies are seen in predicting the rising parts of the hydrographs. There could be many reasons for such discrepancies. In this first attempt of modeling the dynamic behaviors of hydrologic processes in the Court Creek watershed, predicting as close as shown in Figure 7a is promising considering the size of the watershed, complexities of the processes being simulated, and limitations of the available data for preparation of the model inputs.

Weaknesses of the model and lack of detailed and accurate physical data in model input are considered as the major reasons for the above discrepancies. Major weaknesses of this and many other hydrologic models are assumption of initial dry conditions in the stream channels with no subsurface flows and the model’s inability to simulate subsurface and tile flows and backwater effects. The Court Creek watershed is large and has an extensive tile drainage system; this may be a major contribution of subsurface and tile flow to the resultant hydrographs. Backwater from the Spoon River, where Court Creek empties, may have an impact on the outflows measured at the Court Creek streamgage near Dahinda (Figure 2).

Model performance depends on accuracy of the input data derived based on measurements of physical characteristics of the watershed and monitoring of the

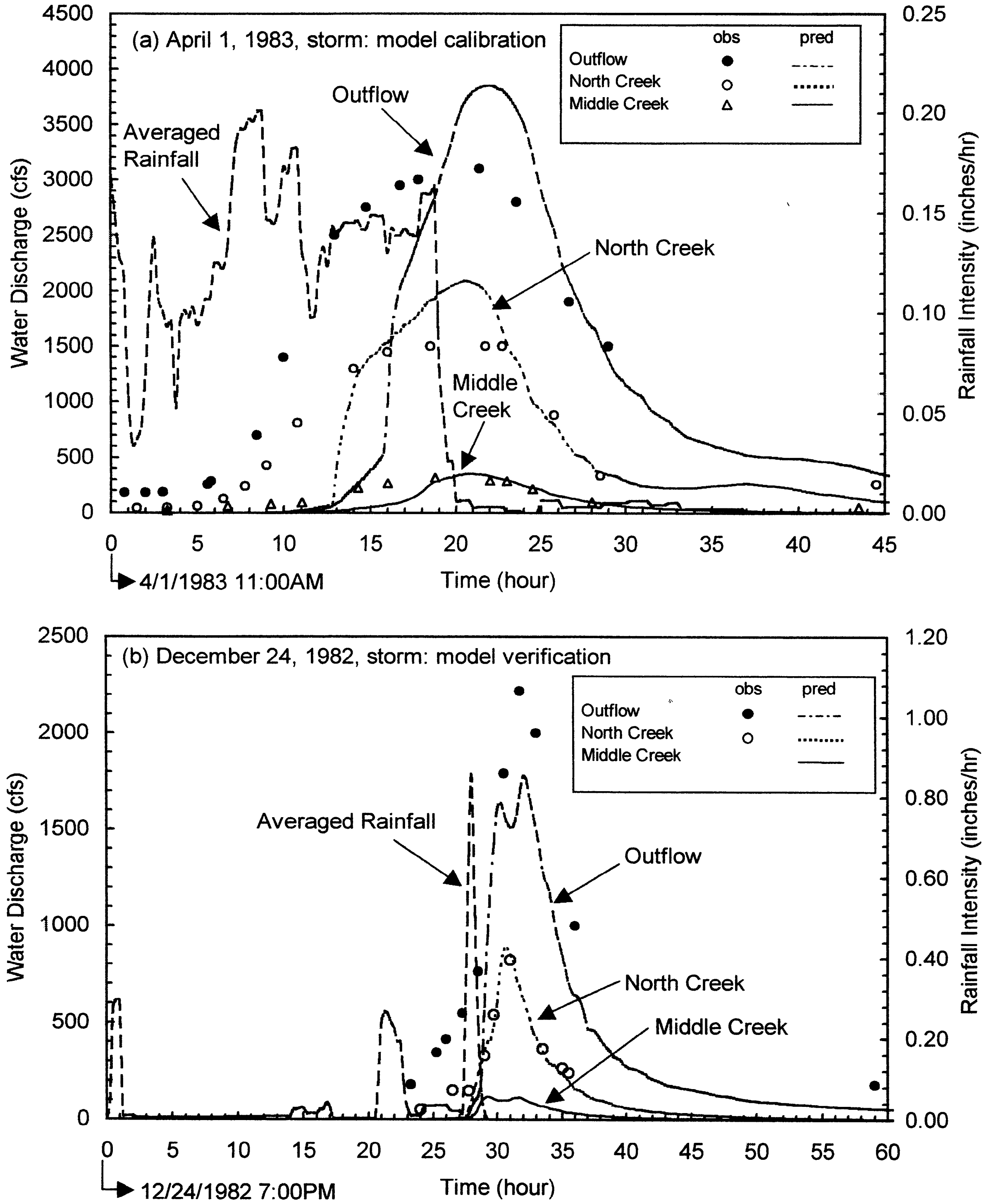

Figure 7. Comparisons of predicted and observed water discharges in the Court Creek watershed resulting from the (a) April 1, 1983, storm: model calibration and the (b) December 24, 1982, storm: model verification

hydrological and meteorological conditions of the simulated storms. The data used in this modeling study were collected and measured nearly two decades ago using older techniques for different objectives, not necessarily for modeling. For example, runoff measurements were made at discrete time intervals. Due to lack of sufficient data, many of the model inputs were approximated. An example is wetted perimeter versus cross-sectional area relationships from a few stream cross-sectional measurements. Another example is lack of dam operation records of the two lakes, especially the Spoon Valley Lake, which has a major impact on the discharges through the Court Creek gage station near the watershed outlet at Dahinda (Figure 2). In the absence of such records, the model assumes initially full lakes and no operation of the gates. Therefore, it is not surprising to see major discrepancies in model predictions and observations of the watershed outflows (Figure 7a).

In spite of the weaknesses of the model and discrepancies in its predictions, the current DWSM is simulating the major hydrologic processes and predicting the hydrographs close enough for preliminary investigations of the watershed. More stream cross-sectional data, continuous flow measurements at more upstream sections of the streams, and dam operation records of the Spoon Valley and Rice Lakes would improve calibration of the model, model parameters, and the predictions.

Simulation of December 24, 1982, Storm: Model Verification

The December 24, 1982, storm was one of the storms used to verify the model calibrated with the April 1, 1983, storm. All the input data and model parameters were kept constant with the calibrated values except the rainfall intensities; rainfall intensities for the December 24 storm were used instead. Rainfall data at all 13 stations (Figure 2) were available for this storm, and all were used in the simulations. Although this storm was considered a 29-hour storm beginning at 7:00 p.m. on December 24, 1982 (Figure 7b) and ending at 12:00 a.m. (midnight) on December 25, the intense portion of the storm was only during the last nine hours beginning at 3:00 p.m. on December 25 (20 hours later). Figure 7b shows the hyetograph of average rainfall intensities and the predicted and observed hydrographs for this storm. Rainfall during this storm was fairly uniform throughout the watershed with rainfall depths of 1.56-2.32 inches at nine stations except the western boundary where the remaining four stations recorded rainfall depths of 0.89-1.12 inches. The average rainfall depth for this storm was 1.60 inches.

Figure 7b shows the predicted hydrographs from the Middle, North, and Court Creeks. Observed flows were available only from the North and Court Creeks, which are plotted in Figure 7b to compare with the predictions. As shown in Figure 7b, the predicted hydrograph from the North Creek matched almost perfectly with the observed flows. However, discrepancies were noticed on the comparison of the predicted hydrograph at the Court Creek station (near the watershed outlet) with the observed flows. Again, lack of base flow and backwater simulations in the model and absence of the Spoon Valley Dam operation records may be the primary reasons for these discrepancies.

Simulation of December 2, 1982, Storm: Model Verification

The December 2, 1982, storm was the second storm used to verify the model. All the input data and model parameters were kept constant with the calibrated values except the rainfall intensities; rainfall intensities for the December 2 storm were used instead. Rainfall data at all 13 stations (Figure 2) were available for this storm, and all data were used in the simulations. Rainfall depths recorded at the 13 stations were fairly uniform and ranged from 2.76-4.30 inches with an average depth of 3.23 inches. This was the most intense storm among the three recorded storms; average rainfall depths for the other two storms were 2.74 and 1.60 inches, respectively, for the April 1, 1983, and December 24, 1982, storms. As shown in Figure 8a, the average rainfall intensities fluctuated frequently during the 20-hour rainfall period beginning at 1:00 a.m. on December 2, 1982; highest was 0.72 inches per hour at the beginning of the storm and from 0.4 to more than 0.5 inches per hour several times during the storm. For comparison, the April 1, 1983, storm also lasted for 20 hours, but the intensities were fairly uniform, about 0.15 inches per hour with a maximum of 0.2 inches per hour (Figure 7a). Therefore, the December 2, 1982, storm was the most intense storm among the three historical storms modeled in this study.

Figure 8a shows the predicted hydrographs from the Middle, North, and Court Creeks with Court Creek as outflow. Observed flows were available only from the Court Creek station (near the watershed outlet) and are plotted in Figure 8a to compare with the predictions. As shown in Figure 8a, major discrepancies were noticed during high flows. The rising and recession portions of the hydrographs matched reasonably well. The predicted peak flow is nearly 9000 cubic feet per second (cfs), and the observed flow was close to 3000 cfs, which is slightly lower than the less intense storm of April 1, 1983 (Figure 7a). For such an intense storm, extensive overbank flows and significant backwater effect from the Spoon River are expected. The current model has no capabilities to simulate these complex processes. The model assumes all the water contained inside the channels and, as a result, grossly overpredicted the peak flow. Backwater from the Spoon River could drastically slow down the flow at the Court Creek gage, significantly reducing its measured flows. This is a perfect example of complexities of the dynamic processes in a watershed and the challenges to model them.

Although the model produced mixed results in the calibration and verification runs, it demonstrated that the model was able to simulate the major hydrologic processes in the watershed, and generate reasonable hydrographs with limitations on intensities of the storms. Therefore, the model provides an inexpensive tool for preliminary investigations of the watershed, an understanding of some of the dominant hydrologic processes and their dynamic interactions within the watershed, and helps to solve some of the associated problems through evaluations of alternative land use and BMPs, accomplished by incorporating those into the model inputs.

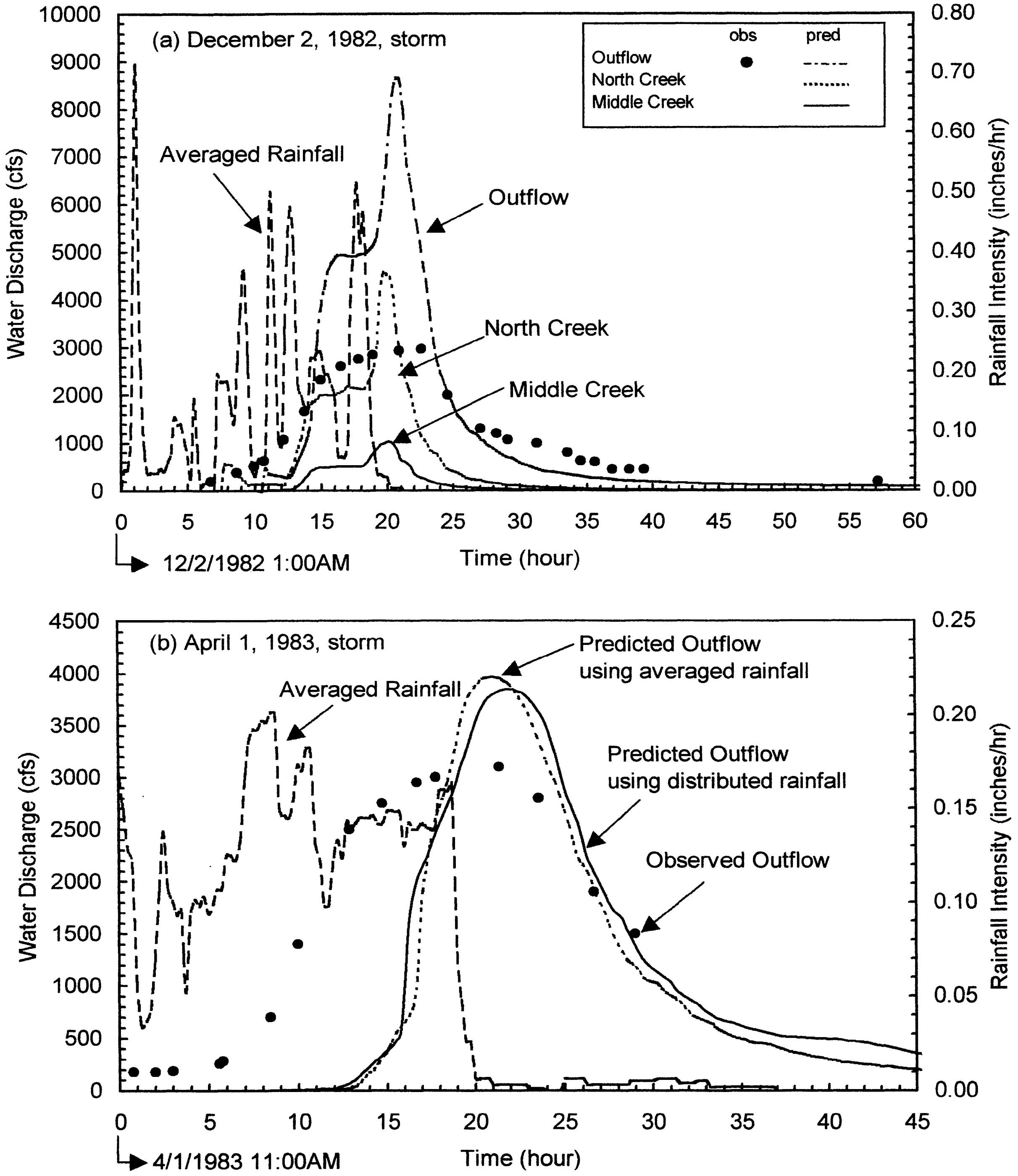

Figure 8. Comparisons of predicted and observed water discharges in the Court Creek watershed resulting from the (a) December 2, 1982, storm: model verification and the (b) April 1, 1983, storm showing effect of distributed and averaged rainfall

Effect of Spatially Distributed Rainfall Data

Better model predictions are expected with spatially distributed rainfall data as rainfall varies spatially across a watershed. The predictions for the three monitored storms (Figures 7a, 7b, and 8a) were made using spatially distributed rainfall records at the 13 raingage stations (Figure 2). It would be interesting to know the effect of using such spatially distributed rainfall records in the model as opposed to average values of the breakpoint rainfall recorded at those stations. Although all three monitored storms were fairly uniform throughout the watershed, ranges of rainfall depths during the storms April 1, 1983, December 24, 1982, and December 2, 1982, were 2.28-3.80, 1.56-2.32, and 2.76-4.30 inches, respectively. Both the first and third storms had similar rainfall ranges, which were higher than the second one. The model did not perform well for the third storm due to its high intensities; therefore, the first storm was selected for this investigation.

A test run was made for the April 1, 1983, storm, with rainfall intensities averaged from rainfall recorded at the 12 raingage stations. The resultant hydrograph at the Court Creek gage near the watershed outlet was compared with the hydrograph previously predicted using the distributed records in Figure 8b. As seen in Figure 8b, the predicted hydrographs are similar, with minor differences. These differences are not pronounced because of fairly uniform rainfall over the watershed. Except for the three northern stations, the remaining nine stations’ rainfall depths were 2.28-2.87 inches; five of them were less than 2.50 inches. With variable rainfall patterns associated with localized thunderstorms, the results from spatially distributed and averaged rainfall would be much different, and the model is capable of accounting for the spatial distributions and producing sensible results.

Simulations of Design Storms

Design (synthetic) storms provide a systematic and consistent way of analyzing and comparing flows and hydrographs at different stations under different management scenarios, and thus help understand the dynamic hydrologic processes in the watershed and evaluate BMPs. Management scenarios and BMPs are evaluated through incorporating those into the model inputs. Four design storms were selected to analyze the dynamic hydrologic processes in the Court Creek watershed; one of these also was used to evaluate the effects of the Rice and Spoon Valley Lakes on downstream flows and flooding described later. These storms were 1-year, 24-hour; 2-year, 24-hour; 2-year, 6-hour; and 10-year, 6-hour. As per Huff and Angel (1989), expected rainfall depths for these design storms in western Illinois are: 2.79, 3.45, 2.58, and 3.70 inches, respectively. Hyetographs of time-varying rainfall intensities for these synthetic storms were developed based on SCS (1972, 1986) rainfall distributions.

Using the hyetographs (rainfall intensities) and assuming uniformly distributed rainfall over the entire watershed, the model was run for each of these four synthetic storms. Detailed summaries of results from these model runs are presented in Appendix B. Tables B1, B3, B5, and B7 present some basic information (drainage areas, curve numbers, and rainfall depths) and results (rainfall excess, runoff volumes, unit-width peak flows, and width-integrated peak flows) for each overland segment (1-78, Figure 3) for each of the synthetic storms. As discussed earlier and shown in Figure 5, the unit-width peak flow is the peak flow over a unit width of an overland segment before discharging into the receiving channel. This flow is assumed uniform across the width of the overland or length of the channel. Therefore, the width-integrated peak flow is computed by multiplying the unit-width peak flow with the overland width or the channel length. Tables B2, B4, B6, and B8 list drainage areas, runoff volumes, and peak flows for each of the 39 channel (79-117) and 2 reservoir (118 and 119) segments for each synthetic storm. These results could be useful in understanding the dynamic hydrologic behavior of the watershed, in identifying critical overland areas and stream channels that produce higher runoff volumes and peak flows, and to consider necessary BMPs, such as detention basins and stream stabilization measures, in the high-risk overland areas and stream channels for minimizing damaging effects.

In addition to producing the above result summaries, the model generated hydrographs at the downstream ends of the 39 channel and 2 reservoir segments. Figure 9a shows hydrographs at the Middle, North, and Court (outlet) Creeks resulting from the 1-year, 24-hour storm and the hyetograph (rainfall intensities) of this storm based on SCS rainfall distribution. These results show the hydrographs from different subwatersheds in comparison to the outflow hydrograph from the entire watershed resulting from the same storm. The Middle Creek, North Creek, and Court Creek drain 10, 30, and 97 square miles, respectively. The peak flows and runoff volumes reflect the size of the drainage basins. Timing of the peak flow reflects the gradient and length of the flow path. The Middle and North Creeks show peak flows occurring at the same time, 14 hours and 45 minutes from the beginning of this 1-year, 24-hour storm; the peak flow at the Court Creek watershed outlet occurred at 15 hours, 30 minutes, assuming no backwater from the Spoon River. Thus the peak flow at the watershed outlet is a 45-minutes delay from the peak flows at the two tributaries for a 1-year, 24-hour storm distributed according to the SCS rainfall distribution.

Figure 9b shows hydrographs at the Court Creek outlet from the four storms, reflective of the dynamic hydrologic processes in the watershed for different rainfall events with different frequencies and durations. The rainfall distribution has a major impact on the hydrograph shape as well as the peak and timing of the peak flow. The SCS rainfall distributions used here were designed in such a way that the rainfall depth expected for a certain frequency and duration would produce the maximum peak flow if the duration was equal to the time of concentration. The time of concentration is defined as the time required by a drop of water to travel from the uppermost point of the drainage basin to its outlet. The time of concentration for the Court Creek watershed was estimated at 9-12 hours using the Kirpich (1940) and SCS (1972) empirical formulas. Location of the peak rainfall intensities within the distribution is critical (Borah, 1995). As shown in Figure 9a, the peak rainfall intensities are about 12 hours for the 24-hour distribution.,

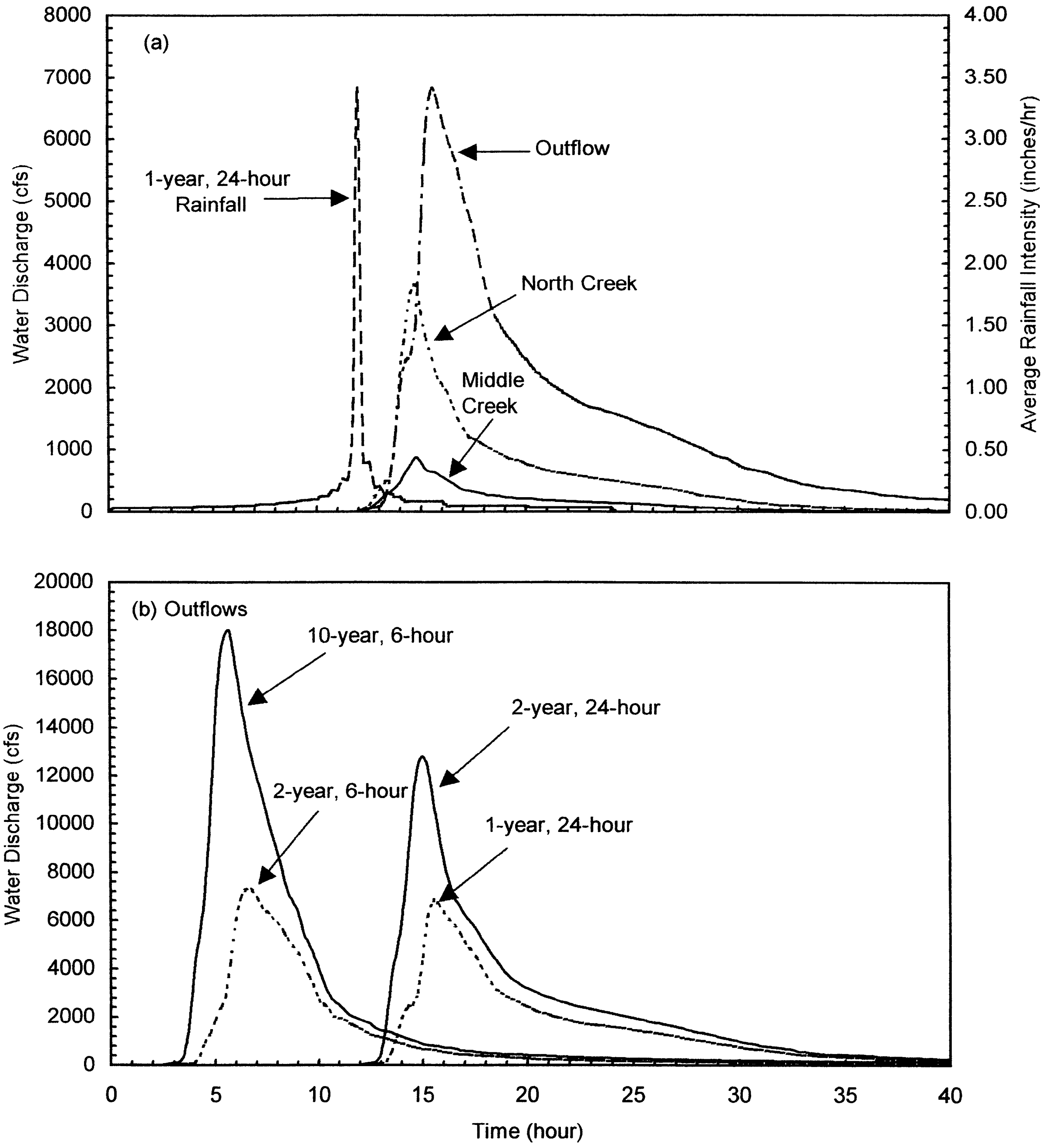

Figure 9. Comparisons of predicted water discharges in the Court Creek watershed resulting from design storms in western Illinois and Soil Conservation Service rainfall distributions: (a) Middle Creek, North Creek, and outflow from l-year, 24-hour rainfall; (b) outflows from 2-year, 6-hour; 10-year, 6-hour; l-year, 24-hour; and 2-year, 24-hour rainfall

Similarly, the peak intensities for the 6-hour distribution are about 3 hours. Therefore, the 6-hour storms produced quicker responses than the 24-hour storms (Figure 9b).

The peak flows of 10-year, 6-hour; 2-year, 6-hour; 2-year, 24-hour; and 1-year, 24-hour storms are 18,000, 7,300, 12,800, and 6,800 cfs, respectively, occurring at 5.75, 6.75, 15.00, and 15.50 hours, respectively. Rainfall depths for these storms are, respectively, 3.70, 2.58, 3.45, and 2.79 inches. Peak flows from intense storms appear to come earlier than peak flows from less intense storms. The 18,000 cfs of peak flow resulting from the 10-year, 6-hour storm passed the outlet 45 minutes earlier than the 7,300 cfs of peak flow resulting from the 2-year, 6-hour storm. Similarly, the 12,800 cfs peak flow resulting from the 2-year, 24-hour storm passed the outlet 30 minutes earlier than the 6800 cfs peak flow resulting from the 1-year, 24-hour storm.

Peak flow magnitude generally appears to be related directly to rainfall depth, which may change depending on rainfall duration. In the above example, the rainfall depths of 3.70 and 3.45 inches produced peak outflows of 18,000 and 12,800 cfs resulting, respectively, from the 10-year, 6-hour and 2-year, 24-hour storms. However, the 2.79 and 2.58 inches of rainfall produced 6,800 and 7,300 cfs of peak outflows resulting, respectively, from the 1-year, 24-hour and 2-year, 6-hour storms. These results show that the 6-hour storms produced higher peak flows than the 24-hour storms for similar rainfall depths. The 6-hour duration is closer to the estimated time of concentration of 9-12 hours in the Court Creek watershed than the 24-hour duration.

Runoff Potentials in Overland Areas, Streams, and Reservoirs

The summary results from the simulations of design storms presented in Appendix B were used to rank overland segments based on unit-width peak flows and runoff volumes. Table 1 presents ranking of overland segments based on unit-width peak flows. Unit-width peak flow (Figure 5) from an overland segment indicates potential strength of the flow that may cause damage to the landscape, such as soil erosion. Based on Table 1, Figure 10 was prepared to show the watershed and color coded high, moderate, and low runoff potentials of the overland areas. The top one-third of the overland segments in Table 1 were considered as the high runoff potential, the middle one-third were considered moderate, and the lower one-third were considered low. However, due to different duration and intensities of the design storms and different time of concentrations of the different sized overland segments, ranking of segments was not consistent among the storms. Some segments were crossing the above potential boundaries. For those undefined segments, ranking based on runoff volumes (Table 2) was used to determine their potentials (Figure 10).

Table 2 presents ranking of overland segments based on runoff volumes and indicates potential flood-causing runoff amounts. The rankings are mostly consistent among the storms because speed of the water is not a factor. Based on Table 2, Figure 11 was prepared to show the watershed and color coded high, moderate, and low potentials of runoff volumes in the overland areas. The top one-third of the overland segments in

Table 1. Ranking of Overland Segments of Court Creek Watershed Based on Unit-Width Peak Flows in Descending Order Resulting from Design Storms

	1-year, 24-hour		*2-year, 24-hour*		*2-year, 6-hour*		*10-year, 6-hour*	
Rank	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*
1	52	0.038	52	0.069	52	0.048	52	0.115
2	65	0.031	53	0.058	25	0.031	37	0.090
3	25	0.029	65	0.057	37	0.029	9	0.077
4	53	0.028	57	0.056	9	0.026	25	0.077
5	57	0.028	25	0.055	31	0.026	31	0.065
6	69	0.027	32	0.050	32	0.026	64	0.064
7	32	0.026	37	0.048	64	0.026	67	0.063
8	37	0.026	18	0.047	67	0.026	32	0.062
9	18	0.025	35	0.047	26	0.024	39	0.062
10	68	0.025	44	0.047	39	0.024	44	0.059
11	6	0.024	67	0.047	53	0.024	65	0.058
12	35	0.024	68	0.046	44	0.023	26	0.057
13	51	0.024	69	0.046	33	0.022	53	0.057
14	67	0.024	23	0.045	58	0.021	33	0.055
15	9	0.023	51	0.045	65	0.021	57	0.053
16	23	0.023	58	0.045	63	0.020	58	0.053
17	26	0.023	70	0.045	72	0.020	35	0.051
18	44	0.023	26	0.043	10	0.019	72	0.051
19	3	0.022	28	0.043	57	0.019	61	0.049
20	10	0.022	9	0.042	61	0.019	10	0.048
21	27	0.022	10	0.042	66	0.019	11	0.047
22	28	0.022	31	0.042	70	0.019	18	0.047
23	58	0.022	61	0.042	11	0.018	23	0.047
24	63	0.022	3	0.041	23	0.018	42	0.047
25	70	0.022	6	0.041	27	0.018	66	0.047
26	1	0.021	27	0.041	35	0.018	68	0.047
27	31	0.021	39	0.041	42	0.018	56	0.045
28	39	0.021	1	0.040	36	0.017	63	0.045
29	61	0.021	19	0.039	56	0.017	27	0.043
30	64	0.021	45	0.039	62	0.017	70	0.043
31	17	0.020	56	0.039	68	0.017	1	0.042
32	62	0.020	63	0.039	18	0.016	28	0.042
33	4	0.019	42	0.038	38	0.016	38	0.042
34	11	0.019	55	0.038	47	0.016	36	0.041
35	14	0.019	62	0.038	69	0.016	62	0.041
36	24	0.019	64	0.038	1	0.015	55	0.040
37	42	0.019	72	0.038	5	0.015	69	0.040
38	45	0.019	5	0.037	28	0.015	47	0.039
39	55	0.019	11	0.037	75	0.015	75	0.039
40	56	0.019	17	0.037	4	0.014	45	0.038

Table 1. (Concluded)

	1-year, 24-hour		*2-year, 24-hour*		*2-year, 6-hour*		*10-year, 6-hour*	
Rank	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*
41	72	0.019	4	0.036	8	0.014	17	0.037
42	5	0.018	14	0.036	21	0.014	21	0.037
43	12	0.018	12	0.035	55	0.014	5	0.035
44	13	0.018	13	0.035	59	0.014	8	0.035
45	19	0.018	24	0.035	3	0.013	14	0.035
46	30	0.018	30	0.035	15	0.013	30	0.035
47	33	0.018	33	0.035	16	0.013	3	0.034
48	66	0.018	38	0.035	17	0.013	4	0.034
49	75	0.018	66	0.035	22	0.013	59	0.034
50	2	0.017	15	0.033	29	0.013	12	0.033
51	36	0.017	54	0.033	6	0.012	16	0.033
52	38	0.017	73	0.033	7	0.012	29	0.033
53	54	0.017	2	0.032	12	0.012	22	0.032
54	59	0.017	16	0.032	14	0.012	15	0.031
55	73	0.017	21	0.032	30	0.012	46	0.031
56	15	0.016	36	0.032	45	0.012	73	0.030
57	16	0.016	60	0.032	46	0.012	24	0.029
58	21	0.016	75	0.032	2	0.011	2	0.028
59	60	0.016	22	0.031	19	0.011	7	0.028
60	8	0.015	59	0.031	24	0.011	19	0.028
61	22	0.015	8	0.030	49	0.011	51	0.028
62	34	0.015	47	0.030	51	0.011	13	0.027
63	47	0.015	7	0.029	73	0.011	43	0.027
64	7	0.014	43	0.028	13	0.010	49	0.027
65	40	0.014	34	0.027	60	0.010	74	0.026
66	43	0.014	50	0.027	71	0.010	6	0.025
67	71	0.014	74	0.027	74	0.010	60	0.025
68	74	0.014	78	0.027	43	0.009	71	0.025
69	78	0.014	29	0.026	54	0.009	54	0.023
70	20	0.013	46	0.026	78	0.008	41	0.022
71	29	0.013	71	0.026	34	0.007	50	0.022
72	50	0.013	49	0.025	41	0.007	78	0.022
73	46	0.012	48	0.023	48	0.007	48	0.020
74	49	0.012	40	0.022	50	0.007	34	0.017
75	41	0.011	41	0.022	20	0.006	40	0.014
76	48	0.011	20	0.018	40	0.004	20	0.012
77	76	0.009	77	0.014	76	0.004	77	0.009
78	77	0.009	76	0.013	77	0.004	76	0.008

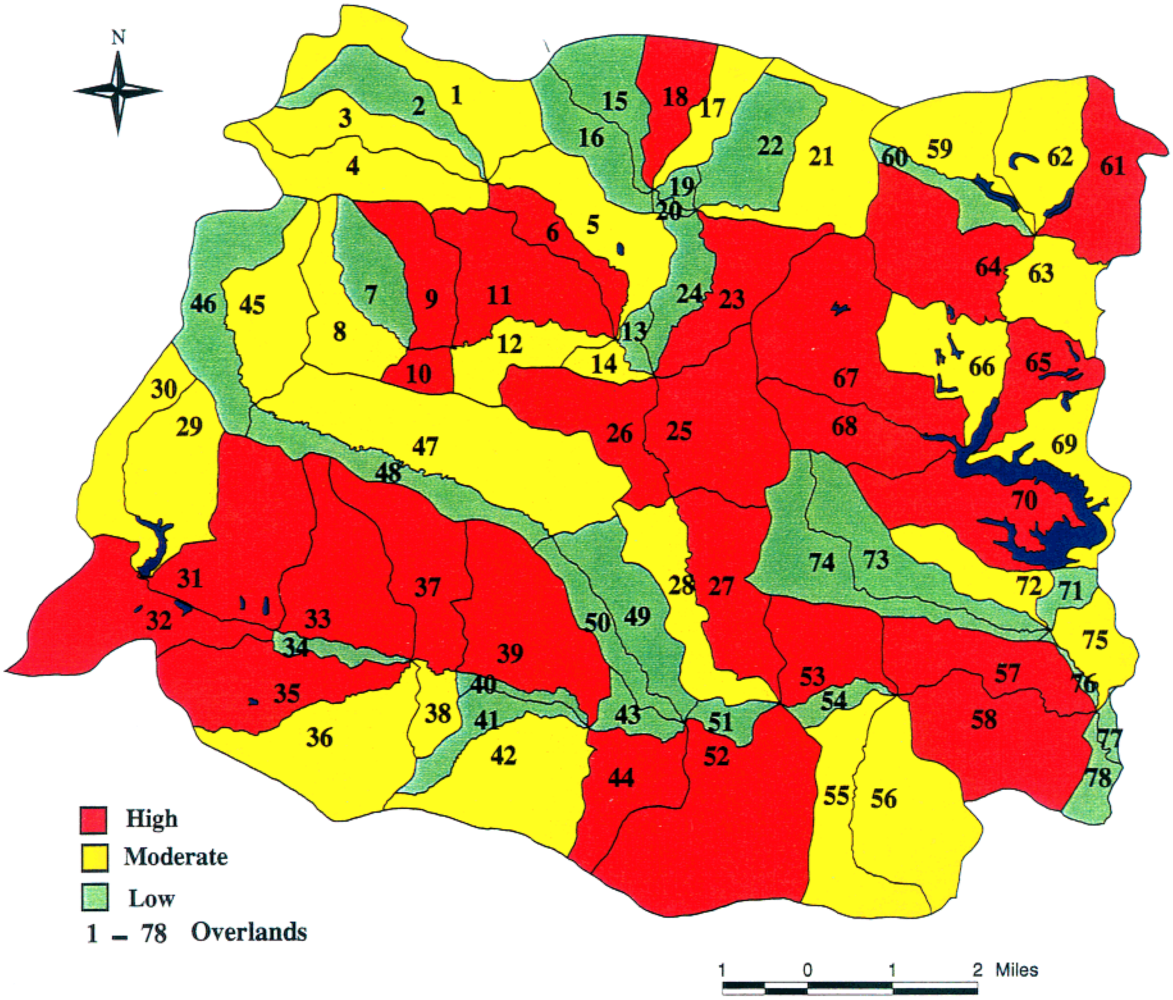

Figure 10. Runoff potentials of overland areas in Court Creek watershed based on unit-width peak flows

Table 2. Ranking of Overland Segments of Court Creek Watershed Based on Runoff Volumes in Descending Order Resulting from Design Storms

	1-year, 24-hour		*2-year, 24-hour*		*2-year, 6-hour*		*10-year, 6-hour*	
Rank	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*
1	52	191	52	287	52	163	52	326
2	47	137	47	214	47	114	47	246
3	67	129	67	196	67	110	67	223
4	25	113	25	168	25	97	25	191
5	31	105	31	160	31	88	31	183
6	58	102	39	155	58	86	39	177
7	39	101	58	154	39	85	58	176
8	56	100	56	151	56	85	56	172
9	36	97	36	149	36	82	36	170
10	64	92	64	139	64	78	64	158
11	42	90	42	139	42	76	42	158
12	32	88	32	135	70	75	32	154
13	70	87	11	130	32	74	11	148
14	27	86	70	130	27	74	33	147
15	11	86	33	129	11	73	70	147
16	33	84	27	128	33	71	27	145
17	35	81	35	125	35	69	35	142
18	1	79	1	120	1	67	1	137
19	21	79	21	119	26	67	21	136
20	26	78	37	116	21	67	37	133
21	37	76	26	116	37	64	26	132
22	55	73	55	111	55	62	55	126
23	57	69	57	105	57	59	74	119
24	74	68	74	104	74	58	57	119
25	29	67	29	103	28	57	29	118
26	5	67	5	102	5	57	5	116
27	28	67	23	100	29	57	46	114
28	23	66	61	100	23	56	23	114
29	61	66	28	100	61	56	61	114
30	4	64	46	99	4	55	28	113
31	46	63	4	98	46	53	4	111
32	22	62	73	94	68	53	73	107
33	68	62	22	93	22	52	22	106
34	73	61	68	91	73	52	66	104
35	66	60	66	91	66	51	68	103
36	62	58	62	89	62	50	62	101
37	53	57	53	87	53	49	53	99
38	69	55	45	85	69	47	45	98
39	44	55	44	85	44	47	44	96
40	45	55	69	82	45	46	69	93
41	59	53	59	81	59	45	59	92
42	8	50	49	79	8	43	49	90

Table 2. (Concluded)

	1-year, 24-hour		*2-year, 24-hour*		*2-year, 6-hour*		*10-year, 6-hour*	
Rank	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*
43	49	50	8	76	49	42	8	87
44	3	48	30	74	3	41	30	85
45	30	48	3	73	30	41	3	84
46	65	48	65	71	65	41	63	80
47	63	47	63	71	63	39	65	80
48	9	46	9	70	9	39	9	80
49	2	45	2	68	2	38	2	77
50	15	44	15	67	15	37	15	76
51	18	42	48	64	18	36	48	74
52	16	41	18	64	16	35	18	73
53	48	41	16	62	7	35	16	71
54	7	41	7	62	48	34	7	70
55	12	40	12	61	12	34	12	69
56	72	35	72	54	72	29	72	61
57	24	32	24	49	24	27	24	56
58	6	32	6	48	6	27	6	55
59	17	31	17	48	17	27	17	54
60	75	30	75	46	75	25	75	53
61	41	28	41	43	41	24	41	49
62	50	25	50	39	50	21	50	45
63	60	22	60	34	60	19	60	39
64	38	20	38	30	38	17	38	34
65	78	17	78	26	78	14	78	29
66	43	16	43	24	43	13	43	28
67	10	15	10	23	10	13	10	27
68	51	15	51	22	51	13	51	25
69	14	13	14	20	14	11	14	22
70	54	13	54	19	54	11	54	22
71	71	12	71	19	71	10	71	22
72	34	12	34	18	34	10	34	21
73	40	9	40	14	40	8	40	16
74	13	9	13	14	13	8	13	16
75	19	7	19	11	19	6	19	13
76	77	6	77	9	77	5	77	10
77	76	4	76	6	76	3	76	7
78	20	3	20	5	20	3	20	5

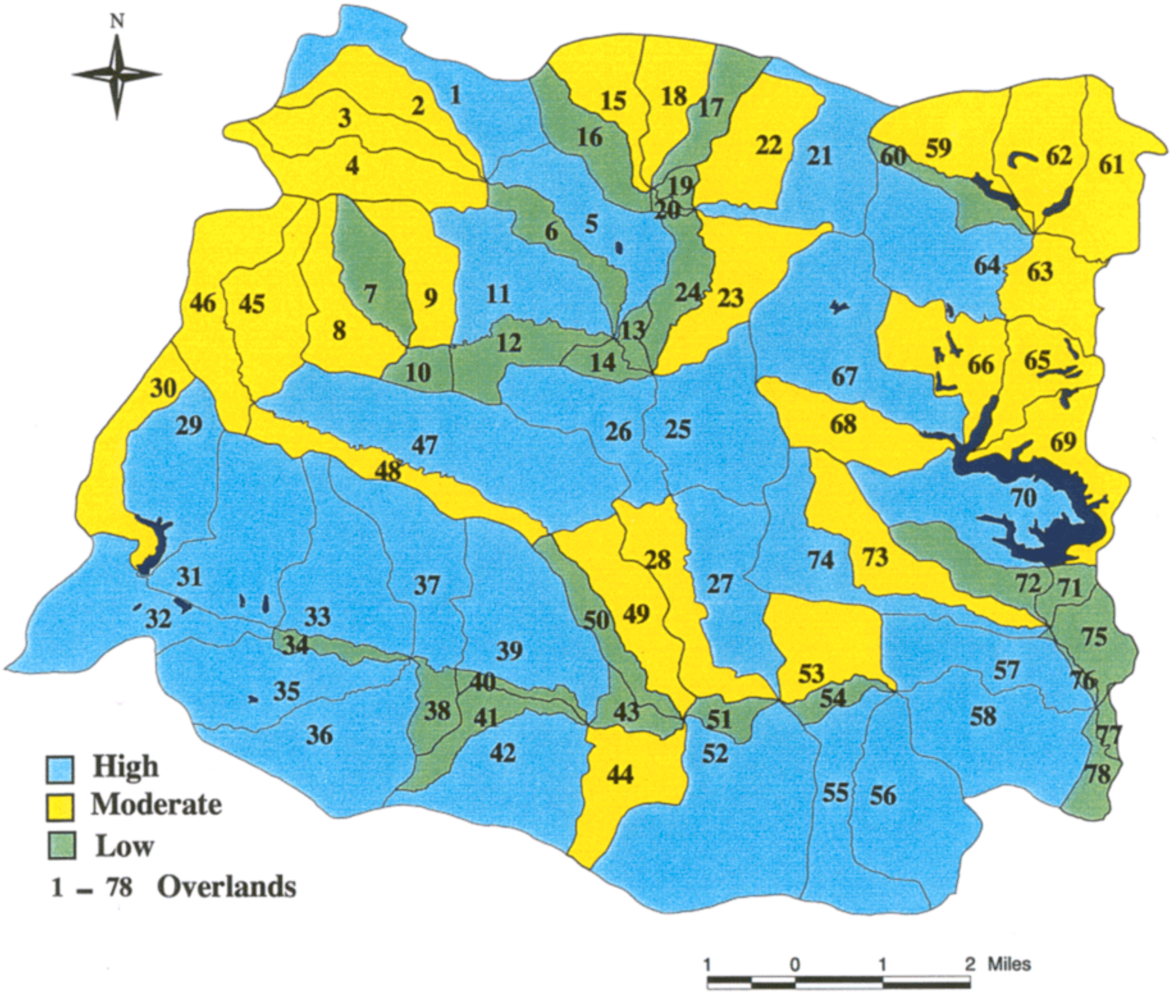

Figure 11. Runoff potentials of overland areas in Court Creek watershed based on runoff volumes

Table 2 are high potential, the middle one-third are moderate, and the lower one-third are low. For the undefined segments (16 and 48), Table 1 was used to determine their potentials for Figure 11.

Stream channel and reservoir segments also were ranked based on peak flows and are presented in Table 3. This ranking indicates streams having potentials for damages from runoff water in the form of streambank erosion or stream instability.

These model results may be useful to identify and select critical overland areas and stream channels for implementation of necessary BMPs, such as detention basins and stream stabilization measures, to control the damaging effects of runoff water. While using these results, limitations of the model and the available data must be kept in mind. These results should be considered as preliminary. The results will be improved and become more reliable when the model capabilities are improved; more data are collected; and feedback from landowners and local planning committees, who know the watershed and its problems very well, are received and incorporated.

Impacts of Detention Basins

A major goal of developing the Court Creek watershed model is to evaluate BMPs to help reduce flooding, soil and streambank erosion, and nonpoint source pollution from agricultural chemicals and minimize their negative impacts in the environment. Detention basins are commonly used BMPs. The Court Creek watershed model developed here, based on the DWSM, is capable of evaluating and quantifying the effects of detention basins in reducing downstream flood flows. In order to demonstrate this fact, the model was run for the 1-year, 24-hour design storm with and without the Rice and Spoon Valley Lakes (118 and 119 in Figure 3), and the inflow/outflow hydrographs were compared to determine their effects.

Figure 12a shows the inflow to and outflow from the 30-acre Rice Lake. The peak inflow of 378 cfs was reduced to a peak outflow of 121 cfs (68 percent reduction) while flowing out of the lake, and it was delayed by 2 hours (13.5 hours to 15.5 hours). A drastic reduction of peak flow was found in the larger 512-acre Spoon Valley Lake. Figure 12b shows the inflow and outflow hydrographs for the Spoon Valley Lake. The peak flow of 1800 cfs was reduced to an outflow of 89 cfs, with a 95 percent reduction, and it was delayed by 15 hours (14.25 to 29 hours).

The impact of these lakes at the watershed outlet is interesting. Figure 12c shows outflow hydrographs at the Court Creek watershed outlet with and without the Spoon Valley Lake. The Spoon Valley Lake reduced the peak outflow from 8400 cfs to 6800 cfs, a 19 percent reduction. There is no change in timing of the peak flows, both at 15.50 hours. Therefore, the effect of the Spoon Valley Lake is reduced considerably at the watershed outlet, 19 percent peak flow reduction, in comparison to the 95 percent

Table 3. Ranking of Stream and Reservoir Segments of Court Creek Watershed Based on Peak Flows in Descending Order Resulting from Design Storms

	1-year, 24-hour		*2-year, 24-hour*		*2-year, 6-hour*		*10-year, 6-hour*	
Rank	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*	*Overland #*	*Unit-Width peak flow (cfs/ft)*
1	117	6802	117	12823	117	7291	117	17983
2	107	6544	107	12352	107	6951	107	17097
3	105	6300	105	12064	105	6464	105	15932
4	92	3654	92	6922	92	3492	92	8194
5	91	3611	91	6634	91	3215	91	7881
6	104	2767	104	5533	104	3051	104	7876
7	85	1985	85	3760	113	1853	100	4612
8	113	1798	113	3374	100	1784	113	4437
9	100	1670	100	3226	85	1754	85	4218
10	81	1340	98	2632	98	1438	98	3680
11	98	1307	81	2514	97	1211	97	3088
12	90	1195	111	2272	111	1095	111	2669
13	111	1177	90	2230	81	1054	90	2635
14	97	1085	97	2204	90	1042	81	2621
15	110	942	110	1783	103	889	103	2358
16	103	880	103	1739	110	826	110	2049
17	102	796	102	1571	102	760	102	2014
18	84	789	84	1527	95	733	95	1792
19	116	727	88	1504	84	699	84	1734
20	88	717	116	1290	116	607	88	1520
21	95	662	106	1273	94	525	116	1474
22	106	589	95	1233	88	516	106	1346
23	80	576	96	1082	106	506	94	1263
24	112	574	112	1036	112	487	96	1227
25	115	564	115	1023	96	458	112	1150
26	79	544	79	1011	115	408	115	1103
27	96	539	80	985	79	400	79	1066
28	94	491	94	907	80	382	80	946
29	89	427	101	890	89	371	101	922
30	83	426	83	829	83	364	89	919
31	87	415	109	809	109	359	83	917
32	109	413	89	801	101	325	109	907
33	101	403	87	769	99	321	99	817
34	93	378	93	739	93	303	93	801
35	86	356	99	708	82	284	87	776
36	99	342	86	696	86	278	82	708
37	82	334	82	651	87	270	86	686
38	108	287	108	632	108	225	108	590
39	118	121	114	235	118	138	118	360
40	114	118	118	204	114	126	114	304
41	119	88	119	161	119	78	119	214

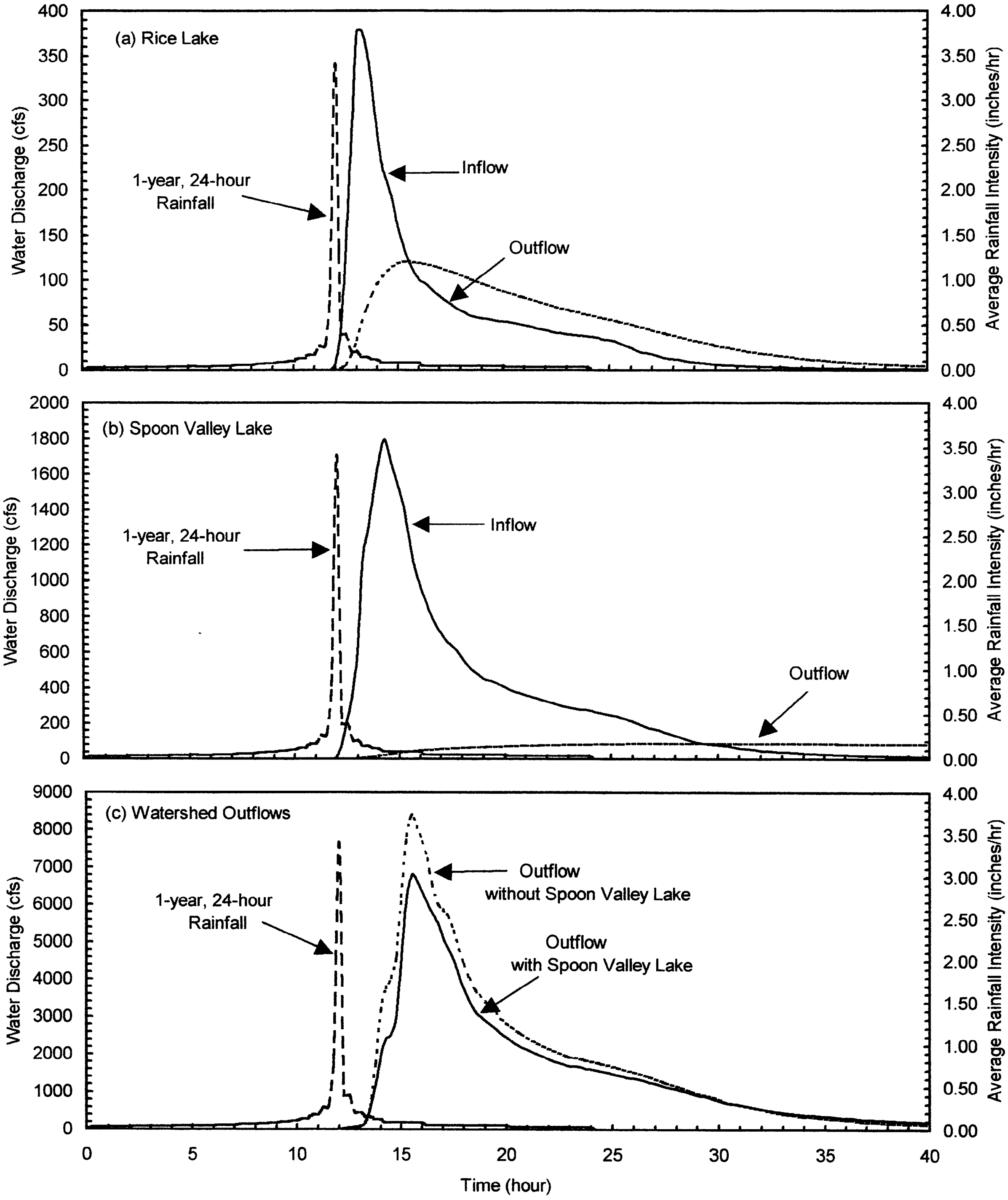

Figure 12. Comparisons of water discharges in Court Creek watershed resulting from a l-year, 24-hour rainfall in western Illinois and Soil Conservation Service rainfall distribution showing impact of lakes: (a) inflows to and outflows from Rice Lake, (b) inflows to and outflows from Spoon Valley Lake, and (c) watershed outflows with and without Spoon Valley Lake

reduction immediately downstream of the lake. Impact of the smaller (30-acre) Rice Lake on the Court Creek watershed outlet, located nearly 14 miles downstream of the lake, is expected to be negligible.

Effect of Different Watershed Subdivisions

The model runs were made based on division of the Court Creek watershed into 78 overland, 39 channel, and 2 reservoir segments (Figure 3). This division helps in investigating runoff characteristics in each of the segments and discerns one from the other based on runoff volume and peak flow or unit-width peak flow. If a project requires finer resolution, the watershed could be divided into more overland and channel segments with smaller areas and lengths, which will require more data processing. However, if the project does not require as many spatially distributed runoff characteristics, only the outflows from the watershed and each of the tributaries, it would be efficient to use coarser division with less overland and channel segments and minimize time and effort in data processing. The question is, how accurate would the model results be? To answer this question, a coarser division of the Court Creek watershed (Figure 13) is used to run the DWSM-hydrology. In this division, the watershed was divided into 24 overland (1-24), 12 channel (25-36), and one reservoir (37) segments. Model parameters for these coarse segments were derived by averaging parameters of the fine segments (Figure 3) within each of the coarse segments.

The model was run for the April 1, 1983, storm using both subdivisions, respective parameters, and average rainfall intensities derived from rainfall records over the 12 raingage stations discussed earlier. Predicted outflow hydrographs from both the coarse and fine divisions are shown in Figure 14 along with the observed outflows and average rainfall intensities used in the model runs. Hydrographs from both the subdivisions are almost the same (Figure 14). Such a match is due to the consistencies of the parameters. Parameters of the coarse divisions are averages of the respective fine divisions, and the dynamic routing scheme of the model preserving the dynamic behaviors of the water flow irrespective of the segment size and length. Therefore, finer divisions do not necessarily add accuracy to the outflows of larger drainage areas. However, finer divisions allow investigations of spatial distribution of runoff characteristics (volume and peak flow) and distinguish these characteristics among smaller areas within the watershed. Such results are important to identify problem areas, prioritize them, and find solutions.

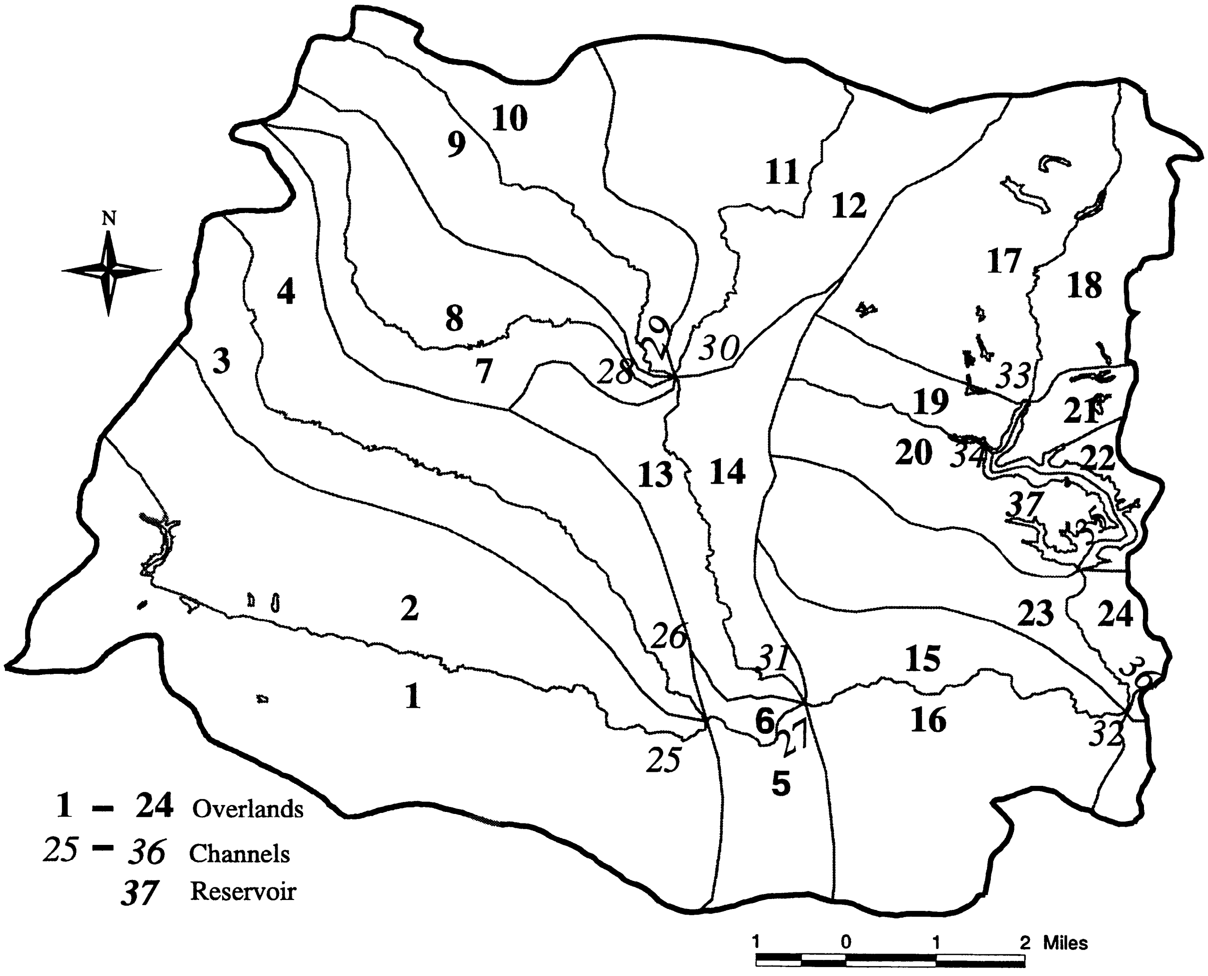

Figure 13. Coarse model divisions of the Court Creek watershed

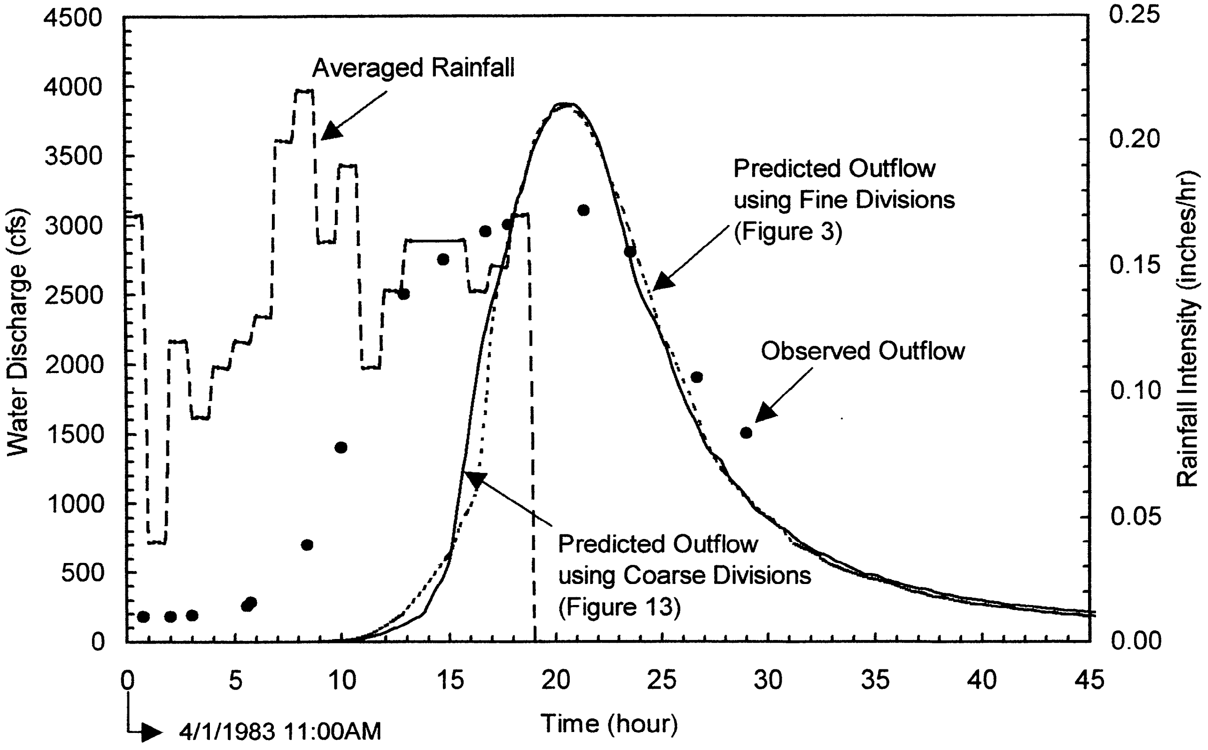

Figure 14. Comparisons of predicted and observed outflows from the Court Creek watershed for the April 1, 1983, storm showing effect of fine and coarse divisions of the watershed

Conclusions

A hydrologic model of the Court Creek watershed was developed using the hydrologic component of the DWSM to simulate storm water rainfall-runoff on overland areas and propagation of flood waves through the overland-stream-reservoir network of the watershed. A new routine was introduced into the model to allow simulation of spatially distributed rainfall events, which is especially useful for moving storms and localized thunderstorms. The model was calibrated and verified using three rainfall-runoff events monitored by the ISWS. The calibration and verification produced mixed results.

The Court Creek watershed is large and has a tile drainage system; this may cause a significant amount of subsurface and tile flow to the resultant hydrographs at the monitoring stations. Intense storms cause over bank channel flows and change the dynamics of flood propagation and flows through the monitoring stations. In addition, backwater from the Spoon River, where Court Creek empties, may have an impact on the Court Creek flows measured at the watershed outlet. The model's inability to simulate subsurface, tile, over bank channel flow, and backwater effects are some of the reasons for discrepancies in the calibration and verification runs.

Model results depend on accuracy of the input data derived from measurements of the physical characteristics of the watershed and monitored hydrological and meteorological data. Data used in this modeling study were based on limited data measured and monitored nearly two decades ago for different objectives, not necessarily for modeling; therefore, approximations were made in many of the model inputs. More stream cross-sectional measurements, up-to-date land-use information, dam operation records of the two major lakes, and more flow monitoring in the upstream sections of the streams would improve calibration and verification of the model as well as accurately represent the watershed.

In spite of its mixed performance, the model demonstrated that it was able to represent the watershed in simulating its major hydrologic processes and generating hydrographs that have similar characteristics as the observed hydrographs at the monitoring stations, with limitations on intensities of the storms. Therefore, in this first attempt of modeling the dynamic behaviors of hydrologic processes in the Court Creek watershed, the model performance is promising considering the size of the watershed, complexities of the processes being simulated, limitations of available data for the model inputs, and limitations of the model. This model provides an inexpensive tool to conduct preliminary investigations of the watershed, understand the major hydrologic processes and their dynamic interactions within the watershed, and help solve some of the associated problems using alternative land use and BMPs, evaluated through incorporating these into the model inputs.

The model was used to compare model predictions of water discharges based on spatially distributed rainfall inputs and average rainfall input. No differences were found because of a fairly uniform rainfall pattern for the monitored storm simulated. However, the routine will be useful for simulating moving storms and localized thunderstorms. A test was made to examine effects of different subdivisions. No differences in model predictions were found because of the dynamic routing schemes in the model for which dynamic behaviors were preserved irrespective of the size and length of the segments. Although finer subdivision does not add accuracy to the outflows, it allows investigations of spatially distributed runoff characteristics and distinguishes these among smaller areas to help prioritize the areas for proper attention.

The calibrated and verified model was used to simulate four synthetic (design) storms to analyze and understand the major dynamic processes in the watershed. Detailed summaries of results from these model runs are presented. These summary results were used to rank overland segments based on unit-width peak flows (indicating potential flow strengths that may damage the landscape) and runoff volumes (indicating potential flood-causing runoff amounts). Stream channel and reservoir segments also were ranked based on peak flows (indicating potentials for damages to the streams). Maps were generated to show runoff potentials of overland areas. These results may be useful to identify, prioritize, and select critical overland areas and stream channels for the implementation of necessary BMPs to control damaging effects of runoff water.

The model also was used to evaluate and quantify effects of Rice Lake and Spoon Valley Lake, in reducing downstream flood flows and to demonstrate the model’s ability to evaluate detention basins. The model was run for one of the design storms with and without the lakes. The results showed significant reduction (68-95 percent) of peak flows and delayed their occurrence (up to 15 hours) immediately downstream. The effects were reduced further downstream.

Limitations of the model and the available data must be kept in mind. These results should be considered preliminary. As the model capabilities are improved, more data are collected, and feedback from the landowner and local planning committees are received and incorporated, the results will be improved and become more reliable. Partnership with the Court Creek Watershed Planning Committee, which knows the characteristics, problems, and behaviors of the watershed on a daily basis, is extremely important to reflect on the assumptions in model formulations and data preparation.

Efforts are currently under way at the ISWS to add subsurface and tile flow routines to the DWSM. It is recommended that stream cross-sectional measurements be made at representative sections of all the major streams in the Court Creek watershed. Stream flow monitoring needs to be continued or established at least at the outlets of major tributaries, including Middle Creek, North Creek, Sugar Creek, and upper Court Creek upstream of its confluence with the Middle Creek. Monitoring definitely needs to be continued on Court Creek at the watershed outlet. The last station needs to be far away from the influence of backwater from the Spoon River. It is recommended for continuous rainfall records that a minimum of four raingage stations be spaced equally in this approximately square-sized watershed. Approximate locations of these raingages could be upstream of North Creek, upstream of Sugar Creek, upstream of Court Creek, and downstream of Court Creek.

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Appendix A.

Hydrology Formulations Used in the Dynamic Watershed Simulation Model

Rainfall Excess by SCS Runoff Curve Number

The Soil Conservation Service or SCS (1972) runoff curve number method is the simpler of the two alternative methods used to compute rainfall excess. In this method, estimation of only one parameter, the curve number, for each overland is required. Rainfall excess is computed using the following relations:

$$Q_r = \frac{(P - 0.2S_r)^2}{P + 0.8S_r} \tag{1}$$

$$S_r = \frac{25400}{CN} - 254 \tag{2}$$

in which, Q_r = direct runoff or rainfall excess (millimeters or mm), P = accumulated rainfall (mm), and CN = curve number representing runoff potential of a surface (values 2-100). Curve number for each overland is estimated based on its soil type, land use, management practices, and antecedent moisture conditions. Accumulated rainfall excess at each breakpoint time interval is computed using these two equations, estimated CN, and the accumulated rainfall at the breakpoint. Increments of rainfall excess during the breakpoint time intervals are computed by subtracting each accumulated rainfall excess from its successive value. Rainfall intensities are computed by dividing the rainfall excess increments by the corresponding time intervals.

Water Routing through Overland and Channel

The water routing algorithm for both overland and channel flow elements is based on the kinematic wave approximations (Lighthill and Whitham, 1955) of the Saint-Venant or shallow water wave equations governing unsteady free surface flow. The governing equations are:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q \tag{3}$$

$$Q = \alpha A^m \tag{4}$$

in which A = flow cross-sectional area, Q = flow rate of water discharge, q = rate of lateral inflow per unit length, t = time, x = downslope position, α = kinematic wave parameter, and m = kinematic wave exponent. These equations were written for a channel, and Figure 5 shows the physical interpretations of A, Q, and q. These equations also are used for overlands simply by substituting A, Q, and q with flow depth, rate of water discharge per unit width, and rate of rainfall excess, respectively. This substitution is possible because of routing over a unit width of overland as shown in Figure 5 and discussed earlier. The kinematic wave parameter α and the exponent m are assumed independent of time and piecewise uniform in space (constant within each flow element), and are expressed as:

$$\alpha = \frac{S^{1/2}}{na^{2/3}} \tag{5}$$

$$m = (5-2b)/3 \tag{6}$$

$$P = a\,A^{b} \tag{7}$$

in which S = longitudinal bed slope of the flow element, n = Manning's roughness coefficient, P = wetted perimeter of the flow element, and a and b = coefficient and exponent, respectively, in wetted perimeter versus flow area relation. For the unit width of overland, a = 1.0 and b = 0.0. For a channel, a and b are estimated from cross-sectional measurements. The lateral inflow q is assumed piecewise uniform in space and piecewise constant in time (constant over a time interval).

Equations 3 and 4 were solved analytically by the method of characteristics, and the solutions were expressed in the following discretized form (Borah et al., 1980):

$$A_{i,j} = A_{i-1,j-1} + q_j \Delta t_j \tag{8}$$

$$Q_{i,j} = Q_{i-1,j-1} + q_j \Delta x_i \tag{9}$$

in which i = subscript representing a discrete point along the x-axis, j = subscript representing a discrete point along the t-axis, Δt_j = time increment, and Δx_i = space increment, as shown in Figure Al. Figure Al illustrates the water-routing algorithm. A constant computational time interval is chosen. The initial flow condition is assumed uniform within the flow elements. Routing is carried out by tracing characteristics and shock paths, starting with the characteristic C_0, in the x-t domain. A characteristic is traced starting from the t-axis (x=0) and continued until it intersects the downstream end of the flow element by using the above analytical solution (Equations 8 and 9) and Equation 4. Equation 8 is used to compute $A_{i,j}$ and Equation 4 to compute $Q_{i,j}$. Equation 9 is used to solve for Δx_i which is added to x_{i-1} to compute a new coordinate (x_i,t_j) of the characteristic. When there is no lateral inflow ($q_j = 0$), the flow values A and Q remain unchanged along the characteristic, and the space increment is computed as $\Delta x_i = \alpha m A^{m-1} \Delta t_j$.

Because the initial flow condition is assumed uniform, all the characteristics emanating from the x-axis (t=0) are parallel to C_0 and the outflow conditions at times t_1, t_2, t_3, . . . are equal to those computed at the points 1, 2, 3, . . . on C_0 (Figure A1). After the initial characteristic C_0, the characteristics are traced one from each time interval emanating from the mid points. Before tracing a characteristic, it is necessary to check a shock-forming condition in which two characteristics meet and the solution fails. The condition is:

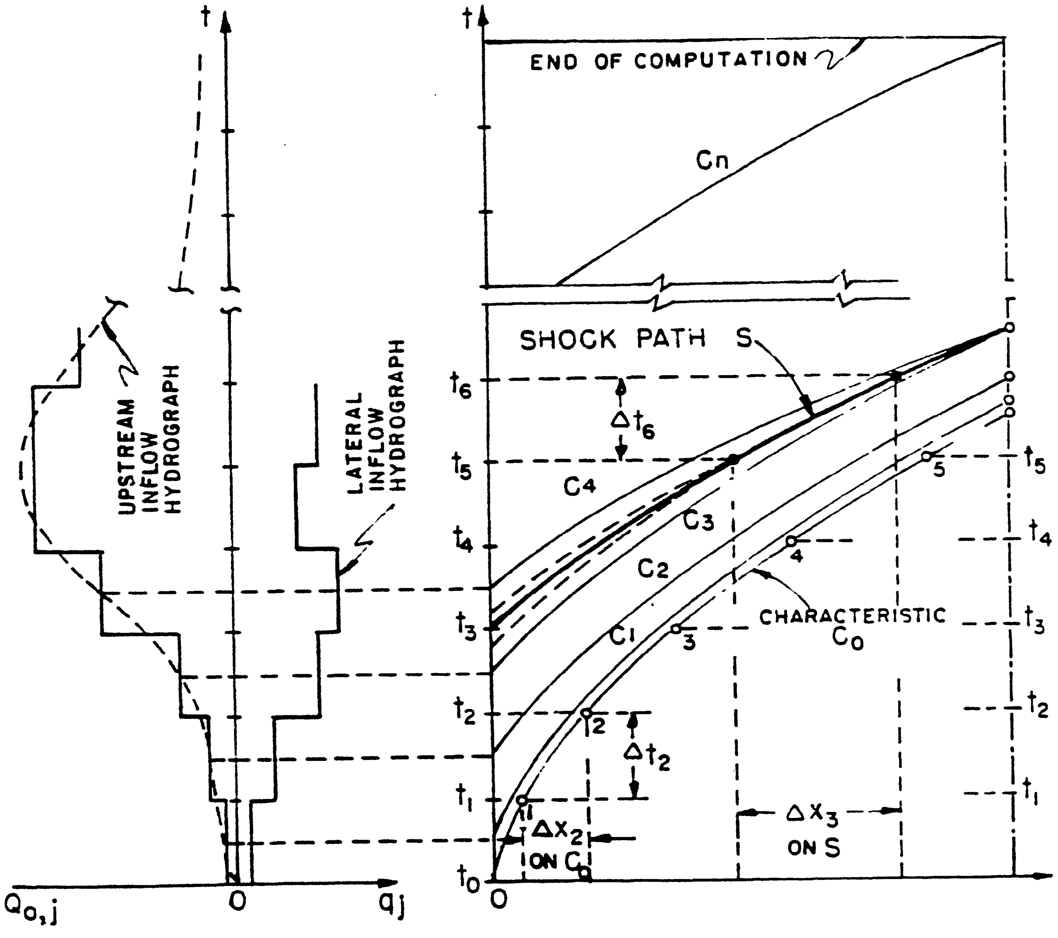

Figure A1. Tracing characteristics and shock paths in kinematic wave routing (after Borah et al., 1980)

$$A_{0,j} - A_{0,j\text{-}1} \rangle \frac{1}{2}(q_j + q_{j\text{-}1})\Delta t \tag{10}$$

If this condition is satisfied, a shock wave (discontinuous water surface or abrupt flow depth) is introduced at time $t_{j\text{-}1}$. The shock wave is a discontinuity in which the initial flow values ahead and behind the shock are $A_{0,j\text{-}1}{}^{a} = A_{0,j\text{-}1}$ and $A_{0,j\text{-}1}{}^{b} = A_{0,j}$, respectively. The superscripts a and b indicate conditions ahead and behind the shock. The shock path is traced by updating the flow values ahead and behind the shock at the end of each time interval using Equations 8 and 4, and computing the corresponding space increment using the following expression given by Borah et al. (1980):

$$\Delta x_i = \alpha \frac{(A_{i,j}{}^{b})^{m+1} - (A_{i,j}{}^{a})^{m+1} - (A_{i\text{-}1,j\text{-}1}{}^{b})^{m+1} + (A_{i\text{-}1,j\text{-}1}{}^{a})^{m+1}}{(m+1)(A_{i\text{-}1,j\text{-}1}{}^{b} - A_{i\text{-}1,j\text{-}1}{}^{a})q_j} \tag{11}$$

Similar to the characteristics, the procedure of tracing shock path continues until the shock intersects the downstream boundary. A single outflow value at the arriving time interval is computed by averaging the flow depths or flow areas ahead and behind the shock and converting this to flow using Equation 4. When $q_j=0$, the flow values ahead and behind the shock remain unchanged and the space increment is computed as $\Delta x_i=\Delta t_j(Q^b-Q^a)/(A^b-A^a)$.

Introduction of the shock wave and routing it with the above procedure is called the "approximate shock-fitting solution" (Borah et al., 1980). Equations 4, 8, and 9 constitute the analytical solution, and Equations 4, 8, and 11 constitute the approximate shock-fitting solution.

The discharges existing on all the characteristics and shock paths at the time of arrival at the downstream boundary define an outflow distribution. Flow values at intermediate time intervals are computed by linear interpolation. Flow values are averaged when characteristics and/or shock paths arrive downstream during the same time interval.

Advantages of this water routing scheme, based on the analytical and approximate shock-fitting solutions of the kinematic wave equations over finite difference numerical solutions, were demonstrated in Borah et al. (1980).

Water Routing through a Reservoir

Water routing through a reservoir is performed using the storage-indication method (Soil Conservation Service, 1972). The method assumes a level water surface within the reservoir, invariable storage-discharge relation, and steady-state flow during small time intervals. The method is based on the continuity equation, and may be expressed in the following discretized form:

$$\frac{2S_{t+\Delta t}}{\Delta t} + O_{t+\Delta t} = (I_t + I_{t+\Delta t}) + \left(\frac{2S_t}{\Delta t} - O_t\right) \qquad (12)$$

in which S = reservoir storage, O = outflow rate, I = inflow rate, t = time, and Δt = time interval. Initially, the depth of water (or elevation of the water surface) in the reservoir and the outflow from the reservoir are known. The inflow hydrograph is known or estimated. Therefore, the terms in the right-hand side of Equation 12 also are known. The outflows, and thus the outflow hydrograph, are computed by repeatedly using Equation 12 and the storage-discharge relation for the reservoir.

Appendix B.

Model Results for Design Storms

Table B1. Predicted Runoff Volumes and Peak Flows in Overland Segments of Court Creek Watershed Resulting from the 1-year, 24-hour Storm in Western Illinois with SCS Rainfall Distribution

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
1	1087	1.7	76	2.79	0.88	79	0.021	374
2	613	1.0	76	2.79	0.88	45	0.017	303
3	663	1.1	76	2.79	0.88	48	0.022	375
4	883	1.4	76	2.79	0.88	64	0.019	322
5	922	1.5	76	2.79	0.88	67	0.018	279
6	436	0.7	76	2.79	0.88	32	0.024	376
7	559	0.9	76	2.79	0.88	41	0.014	167
8	689	1.1	76	2.79	0.88	50	0.015	181
9	632	1.0	76	2.79	0.88	46	0.023	60
10	211	0.3	76	2.79	0.88	15	0.022	59
11	1176	1.9	76	2.79	0.88	86	0.019	262
12	547	0.9	76	2.79	0.88	40	0.018	244
13	125	0.2	76	2.79	0.88	9	0.018	73
14	177	0.3	76	2.79	0.88	13	0.019	77
15	601	1.0	76	2.79	0.88	44	0.016	181
16	564	0.9	76	2.79	0.88	41	0.016	186
17	429	0.7	76	2.79	0.88	31	0.020	202
18	578	0.9	76	2.79	0.88	42	0.025	252
19	101	0.2	76	2.79	0.88	7	0.018	67
20	42	0.1	76	2.79	0.88	3	0.013	46
21	1077	1.7	76	2.79	0.88	79	0.016	278
22	843	1.3	76	2.79	0.88	62	0.015	261
23	904	1.4	76	2.79	0.88	66	0.023	299
24	443	0.7	76	2.79	0.88	32	0.019	244
25	1385	2.2	78	2.79	0.98	113	0.029	263
26	956	1.5	78	2.79	0.98	78	0.023	209
27	1053	1.7	78	2.79	0.98	86	0.022	391
28	819	1.3	78	2.79	0.98	67	0.022	398
29	980	1.6	75	2.79	0.83	67	0.013	203
30	703	1.1	75	2.79	0.83	48	0.018	283
31	1519	2.4	75	2.79	0.83	105	0.021	204
32	1281	2.0	75	2.79	0.83	88	0.026	246
33	1224	2.0	75	2.79	0.83	84	0.018	166
34	174	0.3	75	2.79	0.83	12	0.015	136
35	1181	1.9	75	2.79	0.83	81	0.024	382
36	1409	2.3	75	2.79	0.83	97	0.017	267
37	1102	1.8	75	2.79	0.83	76	0.026	98
38	285	0.5	75	2.79	0.83	20	0.017	66
39	1466	2.3	75	2.79	0.83	101	0.021	218
40	137	0.2	75	2.79	0.83	9	0.014	146
41	406	0.6	75	2.79	0.83	28	0.011	164
42	1314	2.1	75	2.79	0.83	90	0.019	273

Table B1. (Concluded)

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
43	232	0.4	75	2.79	0.83	16	0.014	99
44	801	1.3	75	2.79	0.83	55	0.023	163
45	895	1.4	73	2.79	0.73	55	0.019	321
46	1041	1.7	73	2.79	0.73	63	0.012	210
47	2241	3.6	73	2.79	0.73	137	0.015	377
48	675	1.1	73	2.79	0.73	41	0.011	278
49	824	1.3	73	2.79	0.73	50	0.012	185
50	413	0.7	73	2.79	0.73	25	0.013	195
51	193	0.3	77	2.79	0.93	15	0.024	195
52	2472	4.0	77	2.79	0.93	191	0.038	305
53	787	1.3	76	2.79	0.88	57	0.028	230
54	175	0.3	76	2.79	0.88	13	0.017	137
55	999	1.6	76	2.79	0.88	73	0.019	334
56	1367	2.2	76	2.79	0.88	100	0.019	339
57	945	1.5	76	2.79	0.88	69	0.028	438
58	1394	2.2	76	2.79	0.88	102	0.022	344
59	728	1.2	76	2.79	0.88	53	0.017	208
60	308	0.5	76	2.79	0.88	22	0.016	200
61	901	1.4	76	2.79	0.88	66	0.021	233
62	800	1.3	76	2.79	0.88	58	0.020	224
63	637	1.0	76	2.79	0.88	47	0.022	158
64	1257	2.0	76	2.79	0.88	92	0.021	151
65	583	0.9	78	2.79	0.98	48	0.031	280
66	824	1.3	76	2.79	0.88	60	0.018	164
67	1769	2.8	76	2.79	0.88	129	0.024	346
68	752	1.2	78	2.79	0.98	62	0.025	360
69	676	1.1	78	2.79	0.98	55	0.027	408
70	1068	1.7	78	2.79	0.98	87	0.022	340
71	179	0.3	75	2.79	0.83	12	0.014	64
72	507	0.8	75	2.79	0.83	35	0.019	87
73	886	1.4	75	2.79	0.83	61	0.017	408
74	990	1.6	75	2.79	0.83	68	0.014	334
75	438	0.7	75	2.79	0.83	30	0.018	115
76	56	0.1	75	2.79	0.83	4	0.009	58
77	82	0.1	75	2.79	0.83	6	0.009	86
78	243	0.4	75	2.79	0.83	17	0.014	129

Table B2. Predicted Runoff Volumes and Peak Flows in Stream and Reservoir Segments of Court Creek Watershed Resulting from the 1-year, 24-hour Storm in Western Illinois with SCS Rainfall Distribution

Stream #	*Drainage area (acres)*	*Drainage area (mi^2)*	*Runoff volume (ac-ft)*	*Peak flow (cfs)*
79	1700	3	133	544
80	1546	2	120	576
81	4605	7	351	1340
82	1249	2	95	334
83	2092	3	157	426
84	3814	6	284	789
85	8721	14	672	1985
86	1165	2	88	356
87	1007	2	77	415
88	2315	4	178	717
89	1920	3	144	427
90	5582	9	424	1195
91	16644	27	1268	3611
92	18515	30	1415	3654
93	1683	3	119	378
94	4483	7	316	491
95	5881	9	414	662
96	2591	4	181	539
97	9859	16	695	1085
98	11462	18	808	1307
99	1720	3	121	342
100	14216	23	995	1670
101	1936	3	120	403
102	4852	8	301	796
103	6089	10	376	880
104	22969	37	1570	2767
105	42447	68	3055	6300
106	2366	4	176	589
107	47153	75	3414	6544
108	1037	2	79	287
109	1701	3	126	413
110	4631	7	345	942
111	6039	10	456	1177
112	2521	4	198	574
113	10304	16	796	1798
114	10990	18	779	118
115	1876	3	134	564
116	13359	21	945	727
117	60837	97	4394	6802
118	1683	3	119	121
119	10304	16	732	88

Table B3. Predicted Runoff Volumes and Peak Flows in Overland Segments of Court Creek Watershed Resulting from the 2-year, 24-hour Storm in Western Illinois with SCS Rainfall Distribution

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
1	1087	1.7	76	3.45	1.33	120	0.040	724
2	613	1.0	76	3.45	1.33	68	0.032	575
3	663	1.1	76	3.45	1.33	73	0.041	697
4	883	1.4	76	3.45	1.33	98	0.036	610
5	922	1.5	76	3.45	1.33	102	0.037	574
6	436	0.7	76	3.45	1.33	48	0.041	635
7	559	0.9	76	3.45	1.33	62	0.029	344
8	689	1.1	76	3.45	1.33	76	0.030	358
9	632	1.0	76	3.45	1.33	70	0.042	112
10	211	0.3	76	3.45	1.33	23	0.042	111
11	1176	1.9	76	3.45	1.33	130	0.037	518
12	547	0.9	76	3.45	1.33	61	0.035	481
13	125	0.2	76	3.45	1.33	14	0.035	142
14	177	0.3	76	3.45	1.33	20	0.036	145
15	601	1.0	76	3.45	1.33	67	0.033	374
16	564	0.9	76	3.45	1.33	62	0.032	364
17	429	0.7	76	3.45	1.33	48	0.037	380
18	578	0.9	76	3.45	1.33	64	0.047	478
19	101	0.2	76	3.45	1.33	11	0.039	141
20	42	0.1	76	3.45	1.33	5	0.018	67
21	1077	1.7	76	3.45	1.33	119	0.032	551
22	843	1.3	76	3.45	1.33	93	0.031	536
23	904	1.4	76	3.45	1.33	100	0.045	584
24	443	0.7	76	3.45	1.33	49	0.035	452
25	1385	2.2	78	3.45	1.46	168	0.055	500
26	956	1.5	78	3.45	1.46	116	0.043	386
27	1053	1.7	78	3.45	1.46	128	0.041	735
28	819	1.3	78	3.45	1.46	100	0.043	762
29	980	1.6	75	3.45	1.27	103	0.026	408
30	703	1.1	75	3.45	1.27	74	0.035	544
31	1519	2.4	75	3.45	1.27	160	0.042	403
32	1281	2.0	75	3.45	1.27	135	0.050	481
33	1224	2.0	75	3.45	1.27	129	0.035	323
34	174	0.3	75	3.45	1.27	18	0.027	244
35	1181	1.9	75	3.45	1.27	125	0.047	746
36	1409	2.3	75	3.45	1.27	149	0.032	518
37	1102	1.8	75	3.45	1.27	116	0.048	183
38	285	0.5	75	3.45	1.27	30	0.035	135
39	1466	2.3	75	3.45	1.27	155	0.041	424
40	137	0.2	75	3.45	1.27	14	0.022	225
41	406	0.6	75	3.45	1.27	43	0.022	327
42	1314	2.1	75	3.45	1.27	139	0.038	550

Table B3. (Concluded)

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
43	232	0.4	75	3.45	1.27	24	0.028	199
44	801	1.3	75	3.45	1.27	85	0.047	331
45	895	1.4	73	3.45	1.15	85	0.039	665
46	1041	1.7	73	3.45	1.15	99	0.026	443
47	2241	3.6	73	3.45	1.15	214	0.030	747
48	675	1.1	73	3.45	1.15	64	0.023	571
49	824	1.3	73	3.45	1.15	79	0.025	369
50	413	0.7	73	3.45	1.15	39	0.027	412
51	193	0.3	77	3.45	1.39	22	0.045	362
52	2472	4.0	77	3.45	1.39	287	0.069	563
53	787	1.3	76	3.45	1.33	87	0.058	473
54	175	0.3	76	3.45	1.33	19	0.033	265
55	999	1.6	76	3.45	1.33	111	0.038	674
56	1367	2.2	76	3.45	1.33	151	0.039	688
57	945	1.5	76	3.45	1.33	105	0.056	871
58	1394	2.2	76	3.45	1.33	154	0.045	698
59	728	1.2	76	3.45	1.33	81	0.031	390
60	308	0.5	76	3.45	1.33	34	0.032	394
61	901	1.4	76	3.45	1.33	100	0.042	463
62	800	1.3	76	3.45	1.33	89	0.038	417
63	637	1.0	76	3.45	1.33	71	0.039	283
64	1257	2.0	76	3.45	1.33	139	0.038	282
65	583	0.9	78	3.45	1.46	71	0.057	509
66	824	1.3	76	3.45	1.33	91	0.035	309
67	1769	2.8	76	3.45	1.33	196	0.047	663
68	752	1.2	78	3.45	1.46	91	0.046	654
69	676	1.1	78	3.45	1.46	82	0.046	710
70	1068	1.7	78	3.45	1.46	130	0.045	683
71	179	0.3	75	3.45	1.27	19	0.026	123
72	507	0.8	75	3.45	1.27	54	0.038	177
73	886	1.4	75	3.45	1.27	94	0.033	792
74	990	1.6	75	3.45	1.27	104	0.027	646
75	438	0.7	75	3.45	1.27	46	0.032	211
76	56	0.1	75	3.45	1.27	6	0.013	87
77	82	0.1	75	3.45	1.27	9	0.014	131
78	243	0.4	75	3.45	1.27	26	0.027	257

Table B4. Predicted Runoff Volumes and Peak Flows in Stream and Reservoir Segments of Court Creek Watershed Resulting from the 2-year, 24-hour Storm in Western Illinois with SCS Rainfall Distribution

Stream #	*Drainage area (acres)*	*Drainage area (mi^2)*	*Runoff volume (ac-ft)*	*Peak flow (cfs)*
79	1700	3	197	1011
80	1546	2	183	985
81	4605	7	541	2514
82	1249	2	146	651
83	2092	3	240	829
84	3814	6	443	1527
85	8721	14	1019	3760
86	1165	2	138	696
87	1007	2	123	769
88	2315	4	283	1504
89	1920	3	223	801
90	5582	9	654	2230
91	16644	27	1969	6634
92	18515	30	2189	6922
93	1683	3	185	739
94	4483	7	485	907
95	5881	9	632	1233
96	2591	4	285	1082
97	9859	16	1074	2204
98	11462	18	1254	2632
99	1720	3	191	708
100	14216	23	1544	3226
101	1936	3	195	890
102	4852	8	474	1571
103	6089	10	594	1739
104	22969	37	2459	5533
105	42447	68	4827	12064
106	2366	4	279	1273
107	47153	75	5331	12352
108	1037	2	126	632
109	1701	3	194	809
110	4631	7	526	1783
111	6039	10	689	2272
112	2521	4	300	1036
113	10304	16	1193	3374
114	10990	18	1176	235
115	1876	3	204	1023
116	13359	21	1421	1290
117	60837	97	6741	12823
118	1683	3	185	204
119	10304	16	1102	161

Table B5. Predicted Runoff Volumes and Peak Flows in Overland Segments of Court Creek Watershed Resulting from the 2-year, 6-hour Storm in Western Illinois with SCS Rainfall Distribution

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
1	1087	1.7	76	2.58	0.74	67	0.015	278
2	613	1.0	76	2.58	0.74	38	0.011	201
3	663	1.1	76	2.58	0.74	41	0.013	217
4	883	1.4	76	2.58	0.74	55	0.014	248
5	922	1.5	76	2.58	0.74	57	0.015	236
6	436	0.7	76	2.58	0.74	27	0.012	181
7	559	0.9	76	2.58	0.74	35	0.012	137
8	689	1.1	76	2.58	0.74	43	0.014	166
9	632	1.0	76	2.58	0.74	39	0.026	69
10	211	0.3	76	2.58	0.74	13	0.019	51
11	1176	1.9	76	2.58	0.74	73	0.018	254
12	547	0.9	76	2.58	0.74	34	0.012	160
13	125	0.2	76	2.58	0.74	8	0.010	42
14	177	0.3	76	2.58	0.74	11	0.012	50
15	601	1.0	76	2.58	0.74	37	0.013	148
16	564	0.9	76	2.58	0.74	35	0.013	147
17	429	0.7	76	2.58	0.74	27	0.013	136
18	578	0.9	76	2.58	0.74	36	0.016	164
19	101	0.2	76	2.58	0.74	6	0.011	39
20	42	0.1	76	2.58	0.74	3	0.006	21
21	1077	1.7	76	2.58	0.74	67	0.014	249
22	843	1.3	76	2.58	0.74	52	0.013	219
23	904	1.4	76	2.58	0.74	56	0.018	236
24	443	0.7	76	2.58	0.74	27	0.011	143
25	1385	2.2	78	2.58	0.84	97	0.031	283
26	956	1.5	78	2.58	0.84	67	0.024	220
27	1053	1.7	78	2.58	0.84	74	0.018	314
28	819	1.3	78	2.58	0.84	57	0.015	268
29	980	1.6	75	2.58	0.70	57	0.013	198
30	703	1.1	75	2.58	0.70	41	0.012	185
31	1519	2.4	75	2.58	0.70	88	0.026	246
32	1281	2.0	75	2.58	0.70	74	0.026	250
33	1224	2.0	75	2.58	0.70	71	0.022	199
34	174	0.3	75	2.58	0.70	10	0.007	66
35	1181	1.9	75	2.58	0.70	69	0.018	288
36	1409	2.3	75	2.58	0.70	82	0.017	274
37	1102	1.8	75	2.58	0.70	64	0.029	110
38	285	0.5	75	2.58	0.70	17	0.016	61
39	1466	2.3	75	2.58	0.70	85	0.024	248
40	137	0.2	75	2.58	0.70	8	0.004	45
41	406	0.6	75	2.58	0.70	24	0.007	109
42	1314	2.1	75	2.58	0.70	76	0.018	266

Table B5. (Concluded)

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
43	232	0.4	75	2.58	0.70	13	0.009	64
44	801	1.3	75	2.58	0.70	47	0.023	160
45	895	1.4	73	2.58	0.61	46	0.012	208
46	1041	1.7	73	2.58	0.61	53	0.012	195
47	2241	3.6	73	2.58	0.61	114	0.016	386
48	675	1.1	73	2.58	0.61	34	0.007	167
49	824	1.3	73	2.58	0.61	42	0.011	160
50	413	0.7	73	2.58	0.61	21	0.007	111
51	193	0.3	77	2.58	0.79	13	0.011	90
52	2472	4.0	77	2.58	0.79	163	0.048	392
53	787	1.3	76	2.58	0.74	49	0.024	191
54	175	0.3	76	2.58	0.74	11	0.009	70
55	999	1.6	76	2.58	0.74	62	0.014	257
56	1367	2.2	76	2.58	0.74	85	0.017	311
57	945	1.5	76	2.58	0.74	59	0.019	296
58	1394	2.2	76	2.58	0.74	86	0.021	317
59	728	1.2	76	2.58	0.74	45	0.014	175
60	308	0.5	76	2.58	0.74	19	0.010	119
61	901	1.4	76	2.58	0.74	56	0.019	208
62	800	1.3	76	2.58	0.74	50	0.017	191
63	637	1.0	76	2.58	0.74	39	0.020	148
64	1257	2.0	76	2.58	0.74	78	0.026	190
65	583	0.9	78	2.58	0.84	41	0.021	186
66	824	1.3	76	2.58	0.74	51	0.019	172
67	1769	2.8	76	2.58	0.74	110	0.026	366
68	752	1.2	78	2.58	0.84	53	0.017	239
69	676	1.1	78	2.58	0.84	47	0.016	244
70	1068	1.7	78	2.58	0.84	75	0.019	289
71	179	0.3	75	2.58	0.70	10	0.010	46
72	507	0.8	75	2.58	0.70	29	0.020	93
73	886	1.4	75	2.58	0.70	52	0.011	254
74	990	1.6	75	2.58	0.70	58	0.010	246
75	438	0.7	75	2.58	0.70	25	0.015	97
76	56	0.1	75	2.58	0.70	3	0.004	26
77	82	0.1	75	2.58	0.70	5	0.004	39
78	243	0.4	75	2.58	0.70	14	0.008	76

Table B6. Predicted Runoff Volumes and Peak Flows in Stream and Reservoir Segments of Court Creek Watershed Resulting from the 2-year, 6-hour Storm in Western Illinois with SCS Rainfall Distribution

Stream #	*Drainage area (acres)*	*Drainage area (mi^2)*	*Runoff volum (ac-ft)*	*Peak flow (cfs)*
79	1700	3	109	400
80	1546	2	97	382
81	4605	7	290	1054
82	1249	2	79	284
83	2092	3	131	364
84	3814	6	239	699
85	8721	14	558	1754
86	1165	2	73	278
87	1007	2	63	270
88	2315	4	144	516
89	1920	3	120	371
90	5582	9	351	1042
91	16644	27	1063	3215
92	18515	30	1187	3492
93	1683	3	99	303
94	4483	7	264	525
95	5881	9	346	733
96	2591	4	152	458
97	9859	16	583	1211
98	11462	18	672	1438
99	1720	3	101	321
100	14216	23	831	1784
101	1936	3	100	325
102	4852	8	249	760
103	6089	10	313	889
104	22969	37	1311	3051
105	42447	68	2568	6464
106	2366	4	148	506
107	47153	75	2879	6951
108	1037	2	66	225
109	1701	3	107	359
110	4631	7	290	826
111	6039	10	386	1095
112	2521	4	164	487
113	10304	16	674	1853
114	10990	18	665	126
115	1876	3	112	408
116	13359	21	803	607
117	60837	97	3683	7291
118	1683	3	99	138
119	10304	16	626	78

Table B7. Predicted Runoff Volumes and Peak Flows in Overland Segments of Court Creek Watershed Resulting from the 10-year, 6-hour Storm in Western Illinois with SCS Rainfall Distribution

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
1	1087	1.7	76	3.70	1.51	137	0.042	759
2	613	1.0	76	3.70	1.51	77	0.028	509
3	663	1.1	76	3.70	1.51	84	0.034	578
4	883	1.4	76	3.70	1.51	111	0.034	583
5	922	1.5	76	3.70	1.51	116	0.035	547
6	436	0.7	76	3.70	1.51	55	0.025	396
7	559	0.9	76	3.70	1.51	70	0.028	330
8	689	1.1	76	3.70	1.51	87	0.035	418
9	632	1.0	76	3.70	1.51	80	0.077	204
10	211	0.3	76	3.70	1.51	27	0.048	129
11	1176	1.9	76	3.70	1.51	148	0.047	649
12	547	0.9	76	3.70	1.51	69	0.033	464
13	125	0.2	76	3.70	1.51	16	0.027	111
14	177	0.3	76	3.70	1.51	22	0.035	145
15	601	1.0	76	3.70	1.51	76	0.031	356
16	564	0.9	76	3.70	1.51	71	0.033	382
17	429	0.7	76	3.70	1.51	54	0.037	375
18	578	0.9	76	3.70	1.51	73	0.047	475
19	101	0.2	76	3.70	1.51	13	0.028	102
20	42	0.1	76	3.70	1.51	5	0.012	43
21	1077	1.7	76	3.70	1.51	136	0.037	647
22	843	1.3	76	3.70	1.51	106	0.032	564
23	904	1.4	76	3.70	1.51	114	0.047	612
24	443	0.7	76	3.70	1.51	56	0.029	381
25	1385	2.2	78	3.70	1.65	191	0.077	698
26	956	1.5	78	3.70	1.65	132	0.057	513
27	1053	1.7	78	3.70	1.65	145	0.043	773
28	819	1.3	78	3.70	1.65	113	0.042	750
29	980	1.6	75	3.70	1.45	118	0.033	514
30	703	1.1	75	3.70	1.45	85	0.035	547
31	1519	2.4	75	3.70	1.45	183	0.065	626
32	1281	2.0	75	3.70	1.45	154	0.062	593
33	1224	2.0	75	3.70	1.45	147	0.055	506
34	174	0.3	75	3.70	1.45	21	0.017	152
35	1181	1.9	75	3.70	1.45	142	0.051	810
36	1409	2.3	75	3.70	1.45	170	0.041	649
37	1102	1.8	75	3.70	1.45	133	0.090	341
38	285	0.5	75	3.70	1.45	34	0.042	160
39	1466	2.3	75	3.70	1.45	177	0.062	643
40	137	0.2	75	3.70	1.45	16	0.014	143
41	406	0.6	75	3.70	1.45	49	0.022	321
42	1314	2.1	75	3.70	1.45	158	0.047	690

Table B7. (Concluded)

Overland #	*Overland area (acres)*	*Overland area (mi^2)*	*Curve number*	*Rainfall (in)*	*Rainfall excess (in)*	*Runoff volume (ac-ft)*	*Unit-Width peak flow (cfs/ft)*	*Width Integrated peak flow (cfs)*
43	232	0.4	75	3.70	1.45	28	0.027	189
44	801	1.3	75	3.70	1.45	96	0.059	415
45	895	1.4	73	3.70	1.32	98	0.038	642
46	1041	1.7	73	3.70	1.32	114	0.031	529
47	2241	3.6	73	3.70	1.32	246	0.039	958
48	675	1.1	73	3.70	1.32	74	0.020	493
49	824	1.3	73	3.70	1.32	90	0.027	410
50	413	0.7	73	3.70	1.32	45	0.022	324
51	193	0.3	77	3.70	1.58	25	0.028	231
52	2472	4.0	77	3.70	1.58	326	0.115	937
53	787	1.3	76	3.70	1.51	99	0.057	460
54	175	0.3	76	3.70	1.51	22	0.023	187
55	999	1.6	76	3.70	1.51	126	0.040	704
56	1367	2.2	76	3.70	1.51	172	0.045	806
57	945	1.5	76	3.70	1.51	119	0.053	819
58	1394	2.2	76	3.70	1.51	176	0.053	820
59	728	1.2	76	3.70	1.51	92	0.034	420
60	308	0.5	76	3.70	1.51	39	0.025	311
61	901	1.4	76	3.70	1.51	114	0.049	542
62	800	1.3	76	3.70	1.51	101	0.041	456
63	637	1.0	76	3.70	1.51	80	0.045	332
64	1257	2.0	76	3.70	1.51	158	0.064	467
65	583	0.9	78	3.70	1.65	80	0.058	517
66	824	1.3	76	3.70	1.51	104	0.047	418
67	1769	2.8	76	3.70	1.51	223	0.063	888
68	752	1.2	78	3.70	1.65	103	0.047	666
69	676	1.1	78	3.70	1.65	93	0.040	618
70	1068	1.7	78	3.70	1.65	147	0.043	666
71	179	0.3	75	3.70	1.45	22	0.025	116
72	507	0.8	75	3.70	1.45	61	0.051	240
73	886	1.4	75	3.70	1.45	107	0.030	702
74	990	1.6	75	3.70	1.45	119	0.026	621
75	438	0.7	75	3.70	1.45	53	0.039	257
76	56	0.1	75	3.70	1.45	7	0.008	55
77	82	0.1	75	3.70	1.45	10	0.009	83
78	243	0.4	75	3.70	1.45	29	0.022	207

Table B8. Predicted Runoff Volumes and Peak Flows in Stream and Reservoir Segments of Court Creek Watershed Resulting from the 10-year, 6-hour Storm in Western Illinois with SCS Rainfall Distribution

Stream #	*Drainage area (acres)*	*Drainage area (mi^2)*	*Runoff volume (ac-ft)*	*Peak flow (cfs)*
79	1700	3	223	1066
80	1546	2	197	946
81	4605	7	583	2621
82	1249	2	160	708
83	2092	3	269	917
84	3814	6	493	1734
85	8721	14	1107	4218
86	1165	2	149	686
87	1007	2	136	776
88	2315	4	309	1520
89	1920	3	246	919
90	5582	9	719	2635
91	16644	27	2166	7881
92	18515	30	2433	8194
93	1683	3	205	801
94	4483	7	546	1263
95	5881	9	721	1792
96	2591	4	321	1227
97	9859	16	1235	3088
98	11462	18	1431	3680
99	1720	3	212	817
100	14216	23	1746	4612
101	1936	3	219	922
102	4852	8	536	2014
103	6089	10	679	2358
104	22969	37	2790	7876
105	42447	68	5449	15932
106	2366	4	310	1346
107	47153	75	5968	17097
108	1037	2	137	590
109	1701	3	215	907
110	4631	7	589	2049
111	6039	10	770	2669
112	2521	4	334	1150
113	10304	16	1338	4437
114	10990	18	1333	304
115	1876	3	227	1103
116	13359	21	1605	1474
117	60837	97	7422	17983
118	1683	3	205	360
119	10304	16	1253	214

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