Validation of a Numerical Modeling Method for Simulating Rainfall-Runoff Relations for Headwater Basins in Western King and Snohomish Counties, Washington

Water-Supply Paper 2495

Prepared in cooperation with
King County Department of Public Works, and
King County Department of Planning
and Community Development

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By R. S. Dinicola

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KING COUNTY DEPARTMENT OF PUBLIC WORKS, AND
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CONVERSION FACTORS

Multiply	by	to obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
degree Fahrenheit (°F)	°C = 5/9 x (°F-32)	degree Celsius (°C)

Validation of a Numerical Modeling Method for Simulating Rainfall-Runoff Relations for Headwater Basins in Western King and Snohomish Counties, Washington

By R. S. Dinicola

Abstract

The validity of a method to simulate pre- and post-urbanization rainfall-runoff relations for headwater basins in western King and Snohomish Counties was assessed. It was intended that additional numerical models constructed with this method, along with existing physiographic, land-use, and climate data, could help mitigate urbanization effects in drainage basins throughout the region.

This report documents an assessment of the validity of four primary components of the numerical modeling method: the conceptual model, the Hydrologic Simulation Program-FORTRAN (HSPF) program, the approach used to construct numerical models, and the 12 sets of precalibrated, or generalized, HSPF parameter values determined in a previous investigation. Numerical simulation models were first constructed for 11 drainage basins in western King County with the generalized HSPF parameters and the approach outlined in the previous study, and these initial models were run with rainfall and potential evapotranspiration data collected during the 1987-88 water years. The initial simulation results were compared to observed streamflow data, and the models were subsequently modified to determine the source of simulation errors and, hence, the validity of each of the four components of the modeling method.

Large and recurrent simulation errors were identified in the initial models, but three systematic modifications of the models corrected those errors for 10 out of 11 basins. Initially, streamflow was significantly oversimulated for most basins, the rate of decrease in summer baseflow was oversimulated for all basins, and storm runoff volumes were consistently oversimulated for about half the basins. To correct those errors, the portion of ground water contributing to streamflow in the models was decreased, the parameter values controlling the simulated ground-water discharge rate (AGWRC and KVARY) were adjusted, and simulated storm runoff from certain hillslopes was routed downslope into the ground-water system of pervious outwash deposits. After modifications were made, the composite simulation errors for all validation basins were unbiased, and the root-mean-square errors for annual runoff, storm runoff, and daily mean discharges were about 9 percent, 29 percent, and 52 percent, respectively.

The validity of the numerical modeling method for simulating rainfall-runoff relations in the study area, as modified during this investigation, was not rejected, but observed streamflow data were needed to apply the method. The conceptual model appeared to be correct, although the phenomenon of upslope runoff draining into outwash deposits was initially understated. HSPF was able to represent most hydrologic processes of

interest, except those related to complex interactions between ground water and surface water. The initial approach used for constructing numerical models was not adequate for all basins, but the systematic modifications resolved the major shortcomings. Finally, the generalized parameter values, except for those determined for AGWRC and KVARY, resulted in reasonable simulations of most components of the rainfall-runoff relations in the study area. No single values for AGWRC and KVARY were found to be generally valid across the study area.

INTRODUCTION

Planners and engineers have long sought to mitigate the effects of urbanization on runoff and streamflow in a drainage basin. These effects can result in flooding, channel expansion and encroachment, downstream sedimentation, and degradation of fisheries resources (Booth, 1989). The mitigation strategy often includes comparing pre-urbanization runoff characteristics to runoff characteristics estimated for post-development conditions. The runoff data needed to directly determine these characteristics in small drainage basins are rarely available, so a method was needed to characterize current runoff and to estimate future runoff under different land-use conditions. Dinicola (1990) determined such a method for headwater drainage basins in western King and Snohomish Counties, Wash.

The method involves using the Hydrological Simulation Program-FORTRAN (HSPF; U.S. Environmental Protection Agency, 1984) with 12 sets of pre-calibrated (or "generalized") parameter values to simulate both pre- and post-development rainfall-runoff relations for the basins. (Rainfall-runoff relations, as used in this report, are defined as that portion of the hydrologic cycle between precipitation over land areas and subsequent discharge of that water through stream channels, evapotranspiration, or recharge to regional ground-water systems.) The primary benefit of this method is that the generalized parameter values preclude the need for long-term streamflow records and parameter calibration. It was intended that numerical models representing both existing and future land-use conditions for headwater basins throughout western King and Snohomish Counties could be constructed with these generalized parameters. The models could then be driven with existing long-term climate data to produce reasonable estimates of pre- and post-development rainfall-runoff relations. The ability of such models to do that needed to be assessed.

Producing reasonable simulations of rainfall-runoff relations with numerical models is not a straightforward task. Numerical models, like those constructed with HSPF, solve mathematical equations that represent various hydrologic processes. Many of the equations include parameters that represent various physical attributes of large areas, such as interception storage capacity or infiltration capacity, that are difficult or impossible to measure directly in the field. The values for such parameters are most often determined through calibration, the process of adjusting parameter values so that simulated streamflow closely matches observed streamflow data from one or two sites within a basin. However, streamflow is a basin-integrated response of many different hydrologic processes, so the role that each individual process plays in the generation of streamflow is not always clear. Hence, it is difficult to determine if calibrated parameter values are representative of actual conditions and processes throughout a basin, even if a numerical model as a whole adequately simulates streamflow. If the actual conditions and processes are not well represented in a numerical model, then the simulation of future streamflow for changed land-use conditions may be inaccurate. In simpler terms, even though a calibrated numerical model may "work," it must work for the right reasons for it to be a valuable predictive tool.

Dinicola (1990) used a generalized calibration approach to reduce the uncertainties in parameter values. As a part of that approach, a conceptual model of rainfall-runoff relations was devised for the physiographic region as a whole, and was used to guide the construction of numerical models for five drainage basins within the region. The models were constructed with the HSPF program, and certain parameters in the models were calibrated with observed data from 21 short-term stream-gage sites in the 5 drainage basins. The basins had similar soils and geologic characteristics, but different land-use and weather conditions. The key to representing both actual basin conditions and individual runoff processes was the concurrent calibration of model parameters with observed data from all 21 sites. The study, hereafter referred to as the calibration study, resulted in 12 sets of generalized HSPF parameter values, each set calibrated to simulate the distinctive hydrologic response associated with 12 generalized soil-cover-slope groups, or land-segment types, defined for the region.

These generalized parameter values, and the numerical modeling method as a whole, need to be tested in other basins throughout the region. This testing, commonly referred to as "validation" (or "verification" in some reports), is a systematic procedure for determining how well numerical simulation models can perform the tasks expected of them. In this case, those tasks are to simulate, without further parameter calibration, the pre- and post-development rainfall-runoff relations for headwater basins. Although validation studies are primarily concerned with uncertainties in calibrated parameter values, they can test the following four important assumptions inherent in the modeling procedure. The first is that the conceptual model that forms the basis of the numerical model is correct. The second assumption is that the computer program itself is adequate for quantifying the rainfall-runoff relations. The third assumption is that the approach used for constructing a numerical simulation model for a specific basin results in a model that adequately represents the significant features of the conceptual model. The final assumption is that the calibrated parameter values are truly representative of basin conditions. This investigation, which was done in cooperation with the King County Department of Public Works and the King County Department of Planning and Community Development, specifically assessed the validity of those assumptions.

Purpose and Scope

The purpose of this report is to document an assessment of the validity of a numerical modeling method for simulating rainfall-runoff relations in headwater drainage basins in western King County, Wash. The validity of four primary components of the method—the conceptual model, the HSPF program, the approach used to construct numerical models, and the generalized parameter values—were assessed by using the method to construct numerical simulation models for 11 drainage basins and then by testing the accuracy with which those models simulate streamflow. Data collection for the study began in October 1986 and was completed in September 1988.

Description of the Study Area

The study area is in the southeastern part of the Puget Sound Lowland in Washington State (fig. 1). The Puget Sound Lowland consists of a broad, rolling plain of glacial-drift (sediments deposited by a glacier or by meltwater from a glacier) that merges eastward with foothills of the Cascade Range and is cut abruptly by six major alluvial valleys. The study area was limited to the glacial-drift plain itself; the alluvial valleys along the Green, Cedar, Sammamish, Snoqualmie, Skykomish, and Snohomish Rivers were not included. Deposits laid down about 15,000 years ago during the last period of glaciation in the area cover the surface of the drift plain (Crandell and others, 1965). The drift plain is characterized by two common landform types: by rolling, hilly plains composed of glacial till (unsorted and unstratified drift deposited directly by a glacier) and by generally level bench lands composed of glacial outwash (coarse, stratified deposits removed from a glacier by meltwater streams). Numerous lakes, swamps, and peat bogs occupy depressions on the till plains, whereas the outwash bench lands are generally well drained.

All of the drainage basins selected for both the previous calibration study and this validation study are located on the glacial-drift plain. The 5 drainage basins (with 21 stream-gaging stations) used for the previous calibration study cover about 192 square miles in the 1,200-square mile area of the drift plain in western King and Snohomish Counties. These 21 gaged areas are referred to as the calibration basins in this report, and they were selected for study because they have soil, geologic, topographic, and land-use characteristics typical of the study area. The 3 groups of drainage basins (with 11 stream-gaging stations) selected for use in this validation study cover an additional 31 square miles. These 11 gaged areas are referred to as the validation basins in this report. The validation basins were selected for study because they also have physiographic and land-use characteristics typical of the study area and because the cooperating agencies for this study had an immediate need for hydrologic data in the basins.

Most soils on the drift plain have formed in the deposits of glacial till and outwash. The till layer consists of 5 to 100 feet of dense basal till (compacted till deposits laid down under the pressure of overlying ice) covered by a 3-foot-thick mantle of ablation till (loosely consolidated till deposits that settled in place as the glacial ice was removed by ablation). The till is

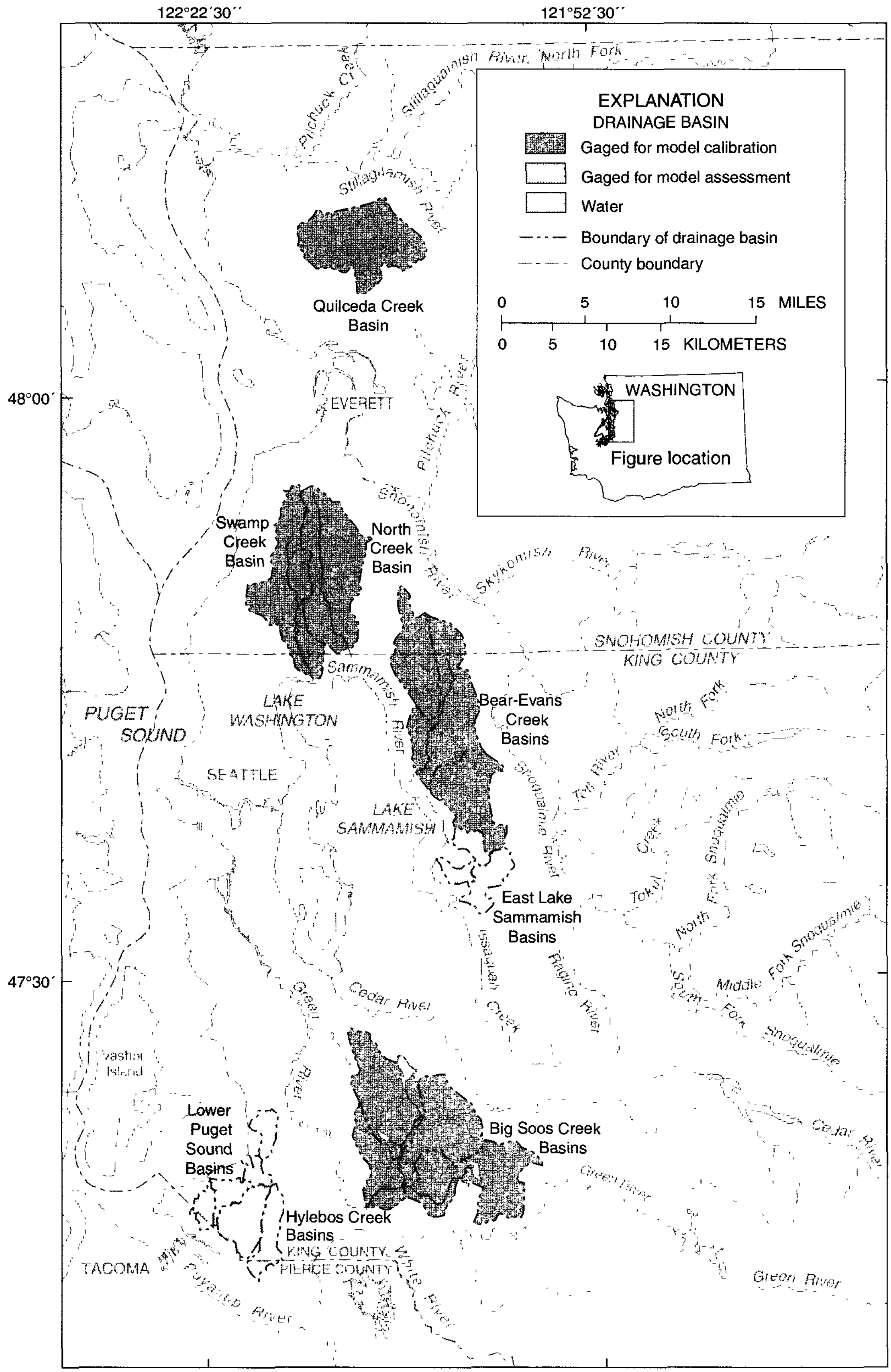

Figure 1. Location of study area and basins used for model calibration and assessment.

commonly exposed at the surface in the headwater areas of drainage basins, but it is usually buried beneath outwash deposits or has been completely eroded away in the valley bottoms. Highly permeable gravelly loam soils have formed in the loose ablation till, but the basal till remains mostly intact as an underlying layer of low permeability (locally referred to as "hardpan"). About 61 percent of the area in the calibration basins and 52 percent of the area in the validation basins is covered with soils derived from glacial till. The outwash deposits consist of unconsolidated gravel and sand and are 4 to 100 feet thick. Highly permeable gravelly loam soils, underlain by a highly permeable substratum, have formed in these deposits. About 19 percent of the area in the calibration basins, and 28 percent of the area in the validation basins is covered with soils derived from glacial outwash. Small parcels of poorly drained soils have formed in depressions on the till plains and in recently deposited alluvium in valley bottoms. About 6 percent of the area in both the calibration basins and the validation basins is covered with these poorly drained soils.

The climate of the region is of the mid-latitude, west-coast marine type, characterized by warm, dry summers and by cool, wet winters. The mean annual temperature in the region is about 51°F, and the mean monthly temperatures in January and July are about 39°F and 65°F, respectively (U.S. Department of Commerce, 1982). Mean annual precipitation ranges from about 35 to 50 inches, and most of it falls as rain (U.S. Weather Bureau, 1965). Seventy to 80 percent of the precipitation falls from October through May during long-duration, light-to moderate-intensity storms. The relatively long wet season and growing season are conducive to lush vegetation. Evergreen forests and thick undergrowth blanket much of the study region. Potential evapotranspiration (PET) in the region averages about 25 inches annually, and actual evapotranspiration (AET) averages about 18 to 20 inches. A soil-moisture deficit, where PET exceeds AET due to low volumes of available soil-water, generally occurs in July and August.

Land use in the study region is still mostly rural, although suburban and urban development is expanding. In the calibration and validation basins, respectively, forests cover 58 and 50 percent of the area, grass and shrubs cover 27 and 28 percent of the area, impervious surfaces cover 7 and 14 percent of the area, and water covers the remainder. The forests are primarily mature conifers with some deciduous trees, and the grass and shrub areas are primarily turfgrass, with a small percentage of pasture land and cleared areas. Most of the impervious surfaces are in suburban developments.

Although the calibration basins and the validation basins are similar, the two groups of basins do have differences. The calibration basins range in drainage area from 1.28 to 65.8 square miles, with a median area of 14.2 square miles. The validation basins are considerably smaller, ranging in drainage area from 0.72 to 6.25 square miles, with a median area of 2.43 square miles. The pattern and areal extent of the major soil types are similar in the calibration and validation basins. Soils formed on till are predominant in 19 out of 21 calibration basins and in 9 out of 11 validation basins, but outwash soils cover a greater percentage of the validation basin area as a whole. The validation basins as a group have been more intensively urbanized than the calibration basins—the median values of impervious area are 4.3 percent and 19.8 percent, respectively—but some highly urbanized and some rural basins are included in both groups.

Acknowledgments

Personnel from the King County Department of Public Works and the King County Department of Planning and Community Development have assisted with the design, data collection, and computer modeling involved in this study. They will also have primary responsibility for application of the results. A number of citizens from the counties have allowed gage installations on their property and have recorded data for the project. Their cooperation and assistance is appreciated.

NUMERICAL MODELING METHOD

The numerical modeling method assessed in this study was originally developed by Dinicola (1990) in the calibration investigation. The complete method, including a discussion of the generalized HSPF parameter values, is described in the following section of this report entitled "Previous Investigation." The simulation models for the validation basins were constructed using the same method, except that the parameter calibration step was omitted and the generalized parameter values were used instead.

Previous Investigation

The results from the previous calibration investigation that were relevant for the validation study included a conceptual model of rainfall-runoff processes in the study area, an approach for constructing numerical simulation models with HSPF for basins throughout the study area, and 12 sets of calibrated HSPF parameter values to be used in those numerical models.

Description of the Conceptual Model

The conceptual model qualitatively describes the hydrologic processes that are most important in various physiographic settings within the study area. Because generic hydrologic simulation programs such as HSPF can be constructed and calibrated in many different ways, a conceptual model was needed to provide a consistent theoretical foundation for constructing numerical models and for calibrating parameter values. The conceptual model was devised from published information on soils, geology, topography, land use, and climate, and from results of other hydrologic investigations in humid, temperate areas, and it appeared to be well supported by the data and simulations from the calibration study.

The following 10 features are the most important components of the conceptual model. The first five features apply to undisturbed, forested areas.

- About half of the annual precipitation is lost through interception and evapotranspiration. Runoff during large storms is less affected by interception losses than is runoff during small storms. Summer and fall evapotranspiration controls the antecedent soil-moisture conditions that can affect runoff during the first few storms of the wet season.
- Horton overland flow is not an important runoff mechanism over most, if not all, undisturbed areas.
- Saturation overland flow is the predominant runoff mechanism in depressions, stream bottoms, and till-capped hilltops. This type of runoff comes quickly and frequently from depressions and stream bottoms, but it comes only during prolonged wet periods from the till-capped hilltops.
- Ground-water flow is the predominant runoff mechanism on glacial outwash deposits. Runoff rates from this mechanism are slow and attenuated. Runoff that is generated from other mechanisms and flows over or into these deposits can be rerouted and attenuated as ground-water flow.
- Interflow, often referred to as shallow-subsurface flow, is the predominant runoff mechanism on hillslopes mantled with glacial till. Interflow runoff rates are slower than overland flow rates, faster than ground-water runoff rates, and proportional to the angle of the hillslope.

The next four features apply to disturbed, nonforested areas.

- Evapotranspiration losses are still important with regards to the annual water balance, but the losses are less than those in forested areas.
- Rapid, direct overland flow is the runoff mechanism on impervious areas.
- Horton overland flow is an important runoff mechanism from disturbed, pervious areas. This is due primarily to changes in soil structure and texture from development activities and to runoff draining to these areas from nearby impervious surfaces.
- There is less surface detention and retention storage of potential runoff (unless specifically designed) relative to the storage in undisturbed, forested areas.

The final feature applies to all areas in the study basins.

- The rate at which runoff moves downstream is affected by drainage network characteristics, such as channel slope or lake volume. The rate can also be affected by infiltration of streamflow or unchannelized runoff into coarse-grained valley deposits.

The conceptual model, described in more detail in the remainder of this section, stresses the physiographic settings where certain hydrologic processes are important and the differences between undisturbed, forested areas and disturbed, nonforested areas.

In the conceptual model, rainfall enters the hydrologic system as it falls on the vegetation canopy or on the ground. Water intercepted by the canopy is stored and subsequently evaporated. In the study area, about one-fifth of the annual precipitation is lost to interception in forested areas, and a lesser quantity is lost in nonforested areas (Dunne and Leopold, 1978). Interception losses can be large enough to affect runoff during small storms, but the losses are less important during large storms. Rainfall that is not lost to interception (net rainfall) falls to the ground.

Most net rainfall on impervious ground, such as bedrock or pavement, will run off as direct overland flow; the remainder will be retained and evaporated from small depressions. Direct overland flow can contribute to streamflow within seconds or minutes of the onset of rainfall. In the study area, direct overland flow comes almost exclusively from areas covered by man-made surfaces; naturally occurring impervious land is uncommon in the region. The bulk of storm runoff from intensively developed lands in the study area is direct overland flow from impervious surfaces.

Most net rainfall on pervious ground will either run off as Horton or saturation overland flow or it will infiltrate into the ground; the remainder will, again, be retained and evaporated from small surface depressions. If the rainfall rate exceeds the infiltration capacity of the upper soil layer, the soil surface will become saturated and Horton overland flow will be generated (Dunne and Leopold, 1978). If the rainfall rate does not exceed the infiltration capacity, but the soil becomes saturated at the surface due to a rising water table, saturation overland flow will be generated (Dunne and Leopold, 1978). Finally, if the rainfall rate does not exceed the infiltration capacity and a rising water table does not saturate the surface, the water will infiltrate into the ground.

A distinction between the types of overland flow is made because they are generated in distinctly different physiographic settings. Direct overland flow from impervious surfaces has been discussed. Horton overland flow is generated in areas where the uppermost soil layer is fine textured, poorly structured, or compacted. Saturation overland flow is generated in areas where a shallow, impeding soil or subsoil layer or where the relative topographic position of a site is such that the water table can rise to the ground surface. Regardless of the type, all overland flow can quickly contribute to streamflow.

In the study area, Horton overland flow is not important in undisturbed areas, but it can be important in disturbed areas. In undisturbed areas, rainfall rates are usually lower than soil infiltration capacities. For example, the 2-year recurrence interval, 1-hour rainfall intensity that falls on the study area is about 0.4 inches per hour, and the 100-year, 1-hour intensity is about 1.0 inch per hour (U.S. Department of Commerce, 1973). These rates are well below the saturated hydraulic conductivities of 2 to 6 inches per hour that are attributed to the undisturbed soils that cover most of the study area (U.S. Department of Agriculture, 1973; 1983). Saturated hydraulic conductivity could be considered the minimum infiltration rate expected of these soils (Snider and Miller, 1985). In disturbed areas, however, clearing and grading operations associated with land development compact soils; landscaping operations commonly apply fine-grained topsoils in lawns, parks, and golf courses; and deep-rooted trees are sometimes replaced with shallow-rooted vegetation. These activities can reduce the infiltration capacities of soils to levels less than rainfall rates. Additionally, runoff from impervious surfaces may drain to pervious parcels within developed areas, such as roof drainage onto a lawn, which is analogous to increasing the rainfall rate relative to the soil infiltration capacity.

In the study area, saturation overland flow is important in both undisturbed and disturbed areas in two distinct physiographic settings: near stream bottoms and depressions and in flat areas underlain by low-permeability materials. The first setting includes the larger topographic depressions and drainage courses where rising water tables are fed by direct infiltration and by substantial quantities of subsurface drainage from surrounding hillslopes. These areas can generate overland flow regularly during the wet season, and some may even remain saturated throughout the year. The second setting includes mildly undulating hilltop areas underlain by glacial till. Here, the shallow, impeding substratum limits percolation of soil water and the gentle slopes limit lateral subsurface drainage of soil water, so the soil water can accumulate and raise the water table to the surface. A single storm will not likely saturate these areas because the soils can store about 12 inches of water before saturation, but a series of storms can saturate these areas by completely filling this storage. Saturation overland flow can move quickly, but the local topography in undisturbed areas does not always allow surface drainage to stream channels. Although saturation overland flow may be generated in both undisturbed and disturbed areas, the flow from disturbed areas will more quickly reach the drainage network because grading has often been done to encourage rapid drainage of overland flow.

The net rainfall that does not run off as any type of overland flow will infiltrate the ground, and some will be held as soil moisture and evaporated or transpired by vegetation. In the study area, evapotranspiration losses from forested areas are expected to be higher than those losses from disturbed areas covered with more shallow-rooted vegetation. Evapotranspiration losses, including interception losses, may account for up to half of the annual precipitation in forested areas, and less in nonforested areas. The losses are not particularly important during individual storms, but summer and fall evapotranspiration does indirectly affect runoff from the first few winter storms by its control of antecedent soil moisture.

Infiltrated water that is not held as soil moisture will drain downslope as interflow (shallow-subsurface flow) if the rainfall rate exceeds the percolation capacity of a subsurface soil layer or underlying material. Water that accumulates at the upper boundary of the impeding layer will, if on a hillslope, drain downslope through the soil until a break in the slope, a topographic convergence, or an incised channel forces the flow to exfiltrate to the surface. This interflow can contribute large volumes of storm runoff to streams at variable rates, usually on the order of hours to days, and it has been shown that steeper slopes lead to shorter lag times between upslope infiltration and interflow discharge. The discharge rate of interflow is almost always slower than any type of overland flow, even on the steepest slopes.

In the study area, interflow is an important source of runoff from hillslopes in both undisturbed and disturbed areas where shallow, highly permeable soils are underlain by compact basal till. The basal till in the study area has a saturated hydraulic conductivity less than 0.06 inch per hour, and is covered by 30-inch-deep soils having saturated hydraulic conductivities of at least 2.0 inches per hour (U.S. Department of Agriculture, 1973; 1983), conditions that highly favor the generation of interflow.

Infiltrated water will percolate downward and recharge the ground-water system if the rainfall rate is less than the infiltration and percolation capacity of all soil layers and the underlying parent material. This recharge may eventually contribute to streamflow as ground-water discharge, but streamflow response to recharge lags by days or months. In the study area, ground-water flow is an important source of streamflow in both undisturbed and disturbed areas underlain by glacial outwash deposits. The saturated conductivity of these deposits is high, so infiltration and percolation capacities are also high. The recharge may flow through local or intermediate ground-water systems (Toth, 1963) and contribute to stream baseflow (considered active ground water), or it may flow through regional ground-water systems (considered inactive ground water with regards to most headwater drainage basins). Generalizations regarding these ground-water systems for the study area are difficult.

Finally, in the conceptual model, streamflow at a particular location is not always a simple summation of all of the runoff generated from upstream parcels. For example, the shape, slope, and roughness of channels, as well as the presence of lakes, ponds, and wetlands all affect the rate at which runoff moves downstream. Some runoff may not flow out of a basin for days or months after it was generated. In the study area, such attenuation is most important in drainage basins with many lakes and wetlands. The attenuation may be less in developed areas, due to some floodplain and channel modifications, but man-made detention ponds and modified lake outlets are often used to mitigate such changes. Runoff may also be attenuated by channel infiltration into unsaturated, coarse-grained deposits or by downslope infiltration of unchannelized runoff into those same deposits. In the study area, this attenuation is important in basins where till-mantled hillslopes are surrounded by extensive deposits of glacial outwash.

Description of the HSPF Program

The conceptual model provided the theoretical foundation for constructing numerical simulation models for the calibration basins. HSPF provided the computational framework for constructing the numerical models. The following is a description of the water quantity components of the HSPF program, with emphasis on how the program was applied for this investigation.

The HSPF program was used for this study because it can realistically simulate the important hydrologic components identified in the conceptual model and because it is a public domain program available for use on many different computer systems. The latter reason was important because HSPF is an integral component of the numerical modeling method, and it was intended that the method be used by various planners and engineers. The HSPF program is documented in the HSPF Users Manual (U.S. Environmental Protection Agency, 1984). Viessman and others (1977) also give an excellent description of the Stanford Watershed Model IV, a recent predecessor of the HSPF program that employs most of the same algorithms.

HSPF is a deterministic, continuous-simulation type program. Deterministic models always produce a given set of results from a given set of input data and boundary conditions. In contrast, stochastic or probabilistic models have a random component in their results. Continuous simulation programs simulate and update processes during each user-specified time step over the entire time span of a simulation. In contrast, event-based programs only simulate processes during selected storm periods.

HSPF represents a drainage basin with land segments and reaches. Land segments represent both the pervious and impervious land areas, and reaches represent the various components of the surface-water drainage network. Land segments and reaches are connected with a network routine in HSPF to represent the geometry of a drainage basin as a whole.

HSPF uses a mass balance approach, or water budget, to account for all inflows to both land segments and reaches as either outflow or change in storage. Inflows are (1) observed precipitation, or (2) overland flow, interflow, ground-water flow, or streamflow from other land segments or reaches. Outflows are (1) evapotranspiration, (2) overland flow, interflow, ground-water flow, or streamflow directed to other land segments or reaches, or (3) recharge to regional ground-water systems (inactive ground water). Changes in storage can be in any of the numerous defined storage components of the water budget, such as soil moisture, ground water, or a lake. HSPF requires records of precipitation and estimates of potential evapotranspiration (PET) to drive the water budget computations. Because the program uses PET data, rather than temperature data, energy balance computations are not needed to simulate evapotranspiration processes.

Land Segments in HSPF

A land segment in HSPF is a parcel of land having distinctive and relatively uniform meteorologic, physical (soil, cover, and slope), and hydrologic characteristics. HSPF represents the hydrologic characteristics of both pervious and impervious land segments by "process-related" parameters in the water-budget formulations. The process-related parameters represent properties relevant to the movement or storage of water through or within land segments (table 1): the interception capacity of vegetation; the retention or detention capacity of the ground surface; the soil-moisture storage capacity; the soil-infiltration rate; the evapotranspiration rate of soil and ground water; and the rates at which overland flow, interflow, and ground-water flow are delivered from a land segment to the drainage network. Few of the process-related parameters can be measured directly, so their values are first estimated from available physiographic data, from the results of previous studies, and from ideas outlined in the conceptual model, and the values are then refined through calibration. Dinicola (1990) used the term "process-related" parameters to denote those parameters that generally require calibration. Following are descriptions of the HSPF water-budget formulations for impervious and pervious land segments.

Precipitation falling on impervious land segments is allocated to surface retention or to overland flow (fig. 2a). The retention storage capacity (defined by the parameter RETSC) represents the maximum quantity of water that can be retained. Retained water evaporates at the potential rate. When the retention storage capacity is met, the overflow is briefly held in detention storage and then allocated to overland flow. The length (LSUR), roughness (NSUR), and slope (SLSUR) of the overland flow plane all control the outflow rate of overland flow. The user may allocate runoff draining from another land segment or reach to retention inflow or outflow in an impervious land segment.

Precipitation falling on pervious land segments is initially allocated to interception storage or to the soil surface (fig. 2b). The interception storage capacity (CEPSC) represents the maximum quantity of water that can be stored as interception. Intercepted water is evaporated at the potential rate. When the interception storage capacity is met, the overflow is allocated to the ground.

Water allocated to the ground is further allocated to direct infiltration or to potential runoff. In general, direct infiltration results from low rainfall rates, low soil-moisture storage, and high INFILT values. Potential runoff results from high rainfall rates, high soil-moisture storage, and low INFILT values. The allocation is controlled by the process-related parameters (INFILT), (INFILD), (INFEXP), and (LZSN). Some water allocated to potential runoff may later infiltrate as delayed infiltration, as discussed later in this section of the report.

Water allocated to infiltration is stored as soil moisture in the lower zone storage, or it recharges ground water. When the lower zone storage is dry (less than LZSN), most infiltrated water is allocated to the lower zone, and when the lower zone storage is wet (greater than LZSN), most infiltrated water is allocated to ground water. The maximum quantity of storage available in the lower zone is two and one-half times

Table 1. Process-related parameters in the HSPF program with definitions and descriptions

Parameter	Definition and description
AGWETP	Active ground-water evapotranspiration (ET) index; represents the fraction of available PET that can be met from active ground-water storage, (active ground-water storage is the portion of ground water that can discharge to the surface). It represents ET by plants that have roots in the saturated zone.
AGWRC	Active ground-water recession coefficient; governs the rate at which active ground water is discharged from a land segment over time. When there is no inflow to the active ground-water storage, it is equal to the ratio of the rate of discharge 'today' to the rate of discharge 'yesterday'.
BASETP	Baseflow evapotranspiration index; represents the fraction of available PET that can be met from discharged active ground water. It represents ET from riparian vegetation.
CEPSC	Interception storage capacity; represents the maximum amount of intercepted precipitation that can be stored on vegetation.
DEEPFR	Deep fraction of ground-water index; represents the fraction of ground-water inflow that will enter the deep (inactive) ground-water system and, thus, be lost from the basin of interest.
INFEXP	Infiltration equation exponent; it is the exponent in the infiltration equation that governs the rate of decrease of infiltration with increasing soil-moisture in the lower zone.
INFILD	Infiltration difference; it is the ratio of the maximum to the mean infiltration rate within a land-segment. It is used to represent the amount of variation in soil properties within a land-segment type.
INFILT	Infiltration index; governs the partitioning of water incident on the soil surface into either potential direct runoff (including interflow and overland flow), or lower-zone soil-moisture.
INTFW	Interflow index; governs the partitioning of potential direct runoff into either interflow (shallow-subsurface flow), overland flow, or upper-zone soil moisture storage.
IRC	Interflow recession coeffient; governs the rate at which interflow is discharged from a land-segment over time.
KVARY	"K" variation; governs, in combination with AGWRC, the rate at which active ground-water is discharged from a land segment over time. It affects this discharge when there is inflow to active ground-water storage.
LSUR	Length of the surface overland-flow plane; represents the average length of the overland flow plane for a land segment.
LZETP	Lower-zone evapotranspiration; represents the depth and density of plant roots in the lower soil zone and, thus, governs transpiration from that zone.
LZSN	Lower-zone storage - nominal; represents the soil-moisture storage ability of the lower soil zone.
NSUR	"N" value of the surface overland-flow plane; represents the average Manning's roughness coeffient of the overland flow plane for a land segment.
RETSC	Retention storage capacity; represents the maximum amount of water that can be retained on impervious land segments.
SLSUR	Slope of the surface overland-flow plane; represents the average slope of the overland flow plane for a land segment.
UZSN	Upper-zone storage - nominal; represents the storage ability in depressions and surface layers of a pervious land segment.

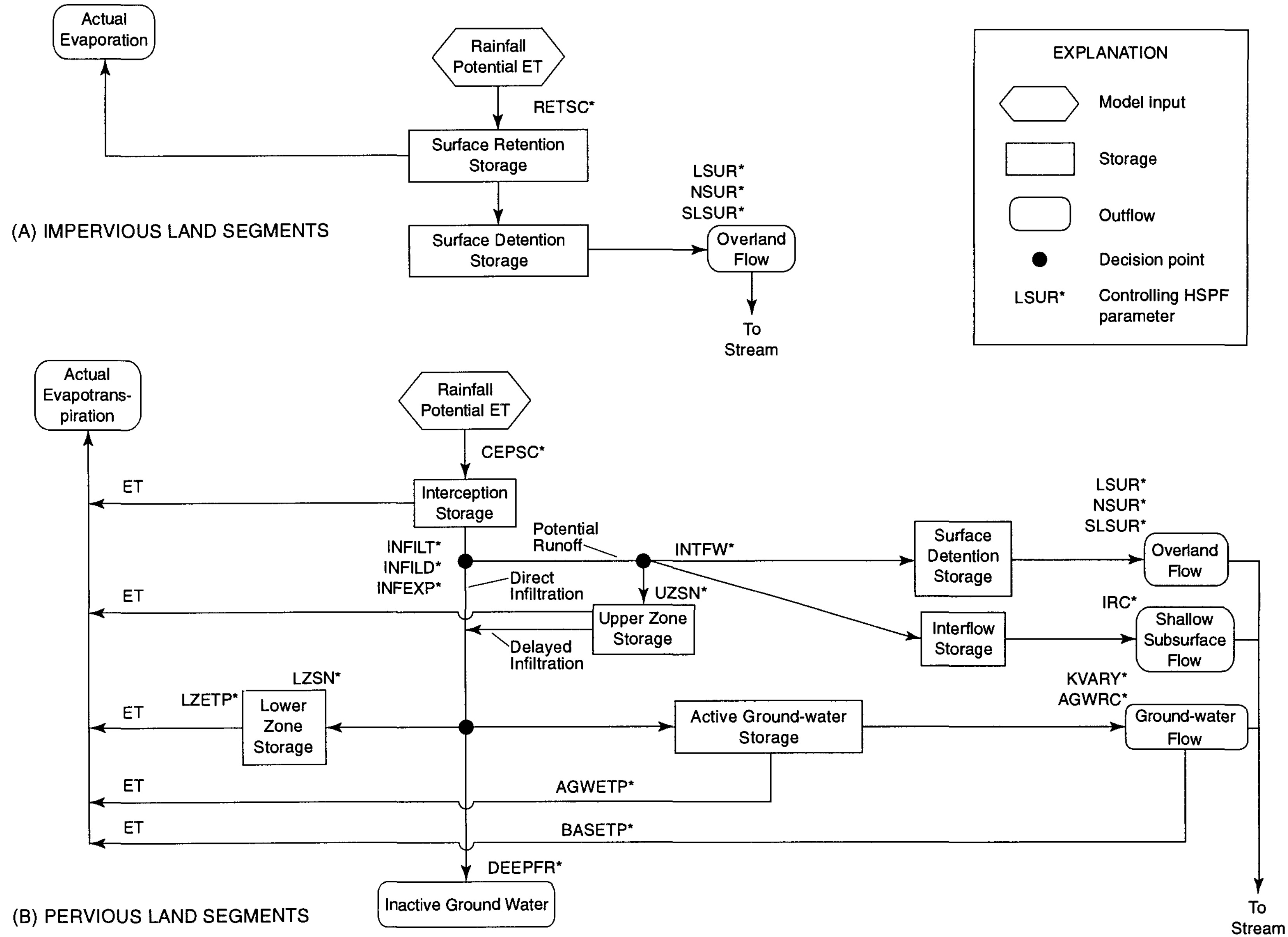

Figure 2. Hydrological Simulation Program–FORTRAN flowcharts for (A) impervious and (B) pervious land segments.

the value of lower zone nominal storage (LZSN). Water allocated to the lower zone either is evapotranspired or remains in storage. The actual evapotranspiration rate is controlled by the potential rate, the lower zone storage, and the parameter (LZETP). Water allocated to ground water either is lost from the system as inactive ground-water system or goes to active ground-water storage, as controlled by the (DEEPFR) parameter. Active ground water in storage may be evapotranspired if the value of the parameter (AGWETP) is greater than zero, or it will be allocated as ground-water outflow. The rate of ground-water outflow is controlled by an empirical equation using the parameters (AGWRC) and (KVARY). Some active ground-water outflow may also be lost to evapotranspiration if the value of the parameter (BASETP) is greater than zero, a feature designed to simulate water use by a narrow strip of riparian vegetation.

Potential runoff is initially allocated to interflow storage, to upper soil-zone storage, or to surface detention storage. First, a portion of potential runoff is allocated, as determined by the parameter (INTFW), to interflow storage. All water in interflow storage eventually drains as interflow outflow. The interflow outflow rate is an empirical function of inflow rate, current storage, and the parameter (IRC). Next, a portion of the remaining potential runoff is allocated to upper soil-zone storage, as controlled by the parameter (UZSN). Water stored in the upper zone is evaporated at nearly the potential rate, or it infiltrates to the lower zone as delayed infiltration. Delayed infiltration is controlled by the parameter (INFILT) and the quantity of water stored in the upper and lower soil zones. In general, if the upper zone is wetter than the lower zone, delayed infiltration will occur. Finally, as the upper zone storage fills, the remaining potential runoff is allocated to surface detention storage for eventual outflow as overland flow. The length (LSUR), roughness (NSUR), and slope (SLSUR) of the overland flow plane all control the overland flow rate.

An approximate simulation method for saturation overland flow was devised for this investigation because HSPF does not explicitly simulate (1) a water table rising to the land surface, (2) the combination of high infiltration rates and low percolation rates in the same soil, and (3) saturation of the lower soil zone resulting from slow drainage of interflow. The method involved a somewhat atypical manipulation of the parameter (INFEXP). In a typical application, the value of (INFEXP) is set equal to two, and the exponential decrease in infiltration capacity with increasing soil follows that described by the Philip equation (Philip, 1954). In the atypical application, a higher value of (INFEXP) was assigned to decrease infiltration capacity at a faster rate. After proper calibration of (INFEXP), simulated infiltration was unlimited when soils were somewhat dry, and it quickly decreased to near zero when soils were wet. In such an application, the lower soil-zone storage is used as a surrogate for the height of the water table.

Reaches in HSPF

A reach in HSPF is defined as a segment of a surface-water drainage network that has relatively uniform hydraulic properties. HSPF represents the hydraulic characteristics of a given reach of stream channel, ditch, pipe, lake, wetland, or any other conveyance feature in "flow tables," which define the discharge from the downstream end of a reach as a function of the volume in the reach. These tables can generally be derived using various theoretical flow equations in combination with some measurable reach characteristics, such as cross-section, roughness, slope, and length. Flow tables were defined as "fixed" parameters by Dinicola (1990) because they are based on known or measurable information and they should not require calibration. However, they sometimes did require calibration in this investigation.

A water budget for a reach is calculated by first adding the inflows from land segment runoff, upstream reach discharge, and precipitation to the storage of a reach. The water in storage is then evaporated at the potential rate, routed downstream, or infiltrated into the channel. The hydraulic routing routine used for all reaches is a storage-routing algorithm that uses the storage-volume relation defined in the FTABLE. A given reach can have up to five separate outflows, each outflow computed by a separate volume-discharge relation. Channel infiltration is simulated by directing one of these outflows to the underlying ground-water system.

Drainage Basin Geometry in HSPF

HSPF represents drainage basin geometry as a connected series of land segments and reaches. For this investigation, a segmentation scheme guided the division of a basin's land area into land segments and a basin's drainage network into reaches. Individual land segments that have similar characteristics but are in different locations in a basin were grouped into land-segment types and a single set of process-related parameter values was determined for each land-segment type. A complex mosaic of land use, soils, and slopes was thus represented with relatively few land-segment types. In contrast, reaches were not grouped, so a separate FTABLE was calculated for each reach. The land area draining to a given reach was generally defined as a subbasin and the areal extent of land segments within each subbasin was represented by fixed parameters in the network routine of HSPF.

HSPF includes a network routine for simulating the connections between land segments and reaches. Outflows calculated for any land segment or reach, such as ground-water discharge or stream discharge, can be routed to any other land segment or reach. Not all of the spatial characteristics of a basin are explicitly represented in HSPF. For example, simulated outflows from all land segments in a subbasin are simultaneously added to the associated reach; the actual flow-path distance between each land segment and the reach is not accounted for. HSPF does, however, include some parameters for controlling outflow rates from the different land-segment types, as previously described.

HSPF can simulate many atypical connections between land segments and reaches. In a typical application, outflows from all land segments in a subbasin are routed directly to the nearest reach, and outflow from a reach is routed to the next downstream reach. However, land segment outflows can also be routed to other land segments, different land segment outflows can be routed to different reaches, and reaches can have multiple outflows, each routed to different locations. In this investigation, for instance, downslope infiltration of overland flow or interflow was simulated by routing those outflows from an upslope land segment into the ground-water system of a downslope land segment. Also, seepage from lakes or stream bottoms was simulated by routing a portion of the incoming streamflow downstream and another portion to the underlying ground-water system. Finally, ground-water recharge to deep flow systems was simulated by routing ground-water discharge out of the basin of interest.

Construction of Numerical Models

Numerical models were constructed for each calibration basin in three steps. The land area was divided into land segments in accordance with the segmentation scheme, the surface-water drainage network was divided into reaches, and the drainage basin geometry was constructed by connecting land segments and reaches.

Land Segments

Land area in the calibration basins was divided into land segments in accordance with a segmentation scheme derived from the conceptual model. The segmentation scheme was based on soil type, land use or cover, and slope, and it defined 12 types of land segments, 1 impervious and 11 pervious.

The six till land-segment types (TFF, TFM, TFS, TGF, TGM, and TGS) represented the areas where a thin, permeable soil covers a nearly impermeable substratum. The first letter in these segment types (T) signifies that areas were underlain by basal till or, occasionally, bedrock. The second letter (F or G) signifies the cover condition—F for forested and undisturbed or G for grassy (or nonforested) and disturbed. The third letter (F, M, or S) signifies the slope group—F for flat (0 to 6 percent), M for moderate (6 to 15 percent), and S for steep (15 percent and greater).

The TFM and TFS segment types represented undisturbed, forested hillslopes where the predominant runoff mechanism was interflow. The TFF segment type represented the undisturbed, forested mildly undulating hilltops or valley bottoms where saturation overland flow could occur. The TGF, TGM, and TGS segment types represented the pervious parcels within disturbed, nonforested areas where Horton overland flow, as well as interflow and saturation overland flow, generated runoff. Most parcels defined as disturbed are lawns, parks, and other landscaped areas. The few pastures and open fields in the basins, which generally had not been graded or covered with additional topsoil, were included in the disturbed land-segment types.

The two outwash land-segment types (OF and OG) represented the undisturbed, forested and the disturbed, nonforested areas, respectively, that were covered by soils formed in outwash deposits or other highly permeable deposits. The OF segment type represented the forested areas where ground-water flow was the predominant source of runoff. The disturbed OG segments could, in addition, generate Horton overland flow. These two segment types were not subdivided into slope groups because slopes in outwash areas were fairly uniform and mild.

The saturated segment type (SA) represented the bottomlands or depressional areas that had seasonally high water tables and could generate substantial quantities of saturated overland flow. This segment type generally included only those areas that were seasonally inundated; it did not include perennial wetlands, ponds, and lakes, which were considered part of the drainage network.

The areas covered by those defined pervious land segments were measured directly from maps made from Soil Conservation Service Soil Survey data on soil type and slope and from County agency data on land use and vegetative cover. A list of the Soil Conservation Service soil types found in the validation basins (U.S. Department of Agriculture, 1973) and the land-segment types by which they were represented in the models can be found in table 2.

The land-segment type labeled effective impervious area (EIA) represented only those impervious surfaces that were directly connected to the drainage network. The extent of EIA in a basin was determined from measurements of areas covered by five land-use types: low-density development (one unit per 2 to 5 acres); medium-density development (one unit per acre); suburban development (four units per acre); high-density development (multi-family or high-density housing); and commercial, industrial, and transportation facilities. The extent of area covered with impervious surfaces within these five land-use types was estimated to be 10 percent, 20 percent, 35 percent, 60 percent, and 90 percent of the total area measured for each respective land-use type (Alley and Veenhuis, 1983; Laenen, 1983; Prych and Ebbert, 1986). The extent of EIA within the five land-use types was then estimated to be 40 percent, 50 percent, 66 percent, 80 percent, and 95 percent of the total impervious area of each land-use type, respectively (Alley and Veenhuis, 1983). These percentage estimates assume that not all impervious surfaces, particularly rooftops, connect directly to the drainage network. The impervious areas considered noneffective were represented by the adjacent pervious land segments onto which they drain. The noneffective impervious area in low-density development areas was divided between undisturbed, forested and disturbed, nonforested segments, but the noneffective impervious area in the other land-use categories was assumed to all be disturbed, nonforested.

Table 2. Soil series found in the validation basins (U.S. Department of Agriculture, 1973) and the land-segment soil type they were represented by in the numerical models

Land-segment soil type	King County soil series
Till	Alderwood gravelly sandy loam
	Arents, Alderwood material
	Beausite gravelly sandy loam
	Kitsap silt loam
Outwash	Arents, Everett material
	Everett gravelly sandy loam
	Indianola loamy fine sand
	Mixed alluvial land
	Neilton very gravelly loamy sand
	Puyallup fine sandy loam
	Ragnar fine sandy loam
	Ragnar-Indianola association
Saturated	Bellingham silt loam
	Briscot silt loam
	Norma sandy loam
	Orcas peat
	Renton silt loam
	Seattle muck
	Shalcar muck
	Snohomish silt loam
	Sultan silt loam
	Tukwila muck
Effective impervious area	Urban land

Reaches

The surface-water drainage networks of the calibration basins were divided into reaches. The reaches were somewhat generalized to simulate only the essential hydraulic characteristics of a drainage network rather than to simulate the flow through every pipe, ditch, pond, and channel in the basins. The beginning and end points of reaches, called nodes in the HSPF program, were located in a drainage network based on three conditions. First, nodes were defined at all points where two or more channels join or where specific flow information is desired, such as at a gaging station site. This condition was required because inflows and outflows from reaches are calculated only at nodes in the HSPF program. Second, nodes were defined at points where a major change in hydraulics occurs, such as at lake inlets and outlets, at wetlands, or at large changes in channel slope. Finally, nodes were defined elsewhere to divide otherwise large subbasins into smaller areas.

A volume-discharge relation for each reach was determined by first identifying and characterizing the reach's primary hydraulic control (the physical element or elements that control the relation between volume and discharge for that reach). The amount of storage available in the reach was then estimated for a number of known discharge values at the control. The hydraulic characteristics of the control points, calculated in the form of a stage-discharge function, were determined by field measurements of the data needed to apply Manning's equation for open channels and to apply the energy equation for culverts, pipes, or contracted openings. The storage volumes corresponding to discharge rates at the control were estimated by field and map measurements of channel, pipe, lake, and wetland geometries.

Drainage Basin Geometry

The geometry of each calibration basin was defined by directing outflows from land segments to reaches or other land segments and by connecting reaches together into a drainage network. In general, all overland flow, interflow, and ground-water flow from the various land segments within a subbasin were routed to the reach within that subbasin, and a single outflow from each reach was routed to the next downstream reach. However, exceptions were made according to the following guidelines.

The first guideline was that all ground-water outflows from outwash and valley-bottom saturated land segments were routed to the reach draining the subbasin in which the land segments were located. These land segments were most often located in or near valley bottoms where ground-water tables lay near the surface and the flow direction was into the stream.

The second guideline was that ground-water outflows from till or from upland, saturated land segments were routed to the first downgradient reach where till no longer mantled the surface. The assumption behind this guideline was that unsaturated flow through the till was mostly vertical and that the saturated flow through the more permeable layers below the till had a horizontal component also. The reach where ground water discharged was not always within the same subbasin where the ground water was recharged. For example, if a subbasin composed entirely of till land segments was located upgradient from a subbasin with outwash land segments, the ground-water outflows from both subbasins were routed to the reach in the outwash-covered subbasin only.

A third guideline was that if available information about ground-water flow suggested that recharge water from any subbasin did not discharge anywhere in the drainage basin, then the ground-water outflow was routed out of the basins. Some general geologic and ground-water information from three available published reports (Liesch and others, 1963; Luzier, 1969; Newcomb, 1952) helped delineate recharge and discharge areas.

A final guideline, determined during the course of the calibration study, involved the routing of interflow from till land segments. In areas where extensive outwash deposits filled the valley bottoms and till mantled the upland areas, the streamflow response to precipitation was very attenuated. The response had the characteristics of ground-water discharge only; the more rapid interflow discharge that was expected was not observed. These results suggested that interflow was being discharged onto downslope outwash deposits and infiltrated into the ground-water system rather than being discharged directly into a channel reach. Hence, in the numerical models for basins where such was suspected, the interflow outflows from some till land segments were routed to the ground-water system in the downslope outwash land segments.

Generalized HSPF Parameter Values

The generalized HSPF parameter values were determined by first setting the values so that the relation between rainfall and runoff for each land-segment type reflected the features of the conceptual model. Parameter values for till segments were set to generate interflow from undisturbed areas and interflow together with some overland flow from disturbed areas, parameter values for all outwash land segments were set to generate runoff primarily through the ground-water system, and parameter values for saturated segments were set to generate mostly overland flow. The process-related parameter values for a given land-segment type were identical in the numerical models for all of the calibration basins.

The parameter values were then adjusted during a trial-and-error calibration procedure to simulate more accurately the 2-year records of observed streamflow. The parameter values for a given land-segment type were identically adjusted in the numerical models for all of the calibration basins. During calibration, adjustments to parameter values modified the simulated rates and magnitudes of actual evapotranspiration (AET), overland flow, interflow, and ground-water flow, but the adjustments did not modify the relative rates and magnitudes between the different land-segment types. The procedure yielded good simulation results for almost all calibration basins, as discussed below, so it was provisionally accepted that the parameter values were representative of the actual rates and magnitudes of AET and runoff. Although it was recognized that these particular parameter values may not be the only ones that could result in good simulations, the consistently good results obtained for the many gage sites gave strong support to the validity of the generalized values.

The generalized HSPF parameter values determined from calibration are given in table 3. The following is a brief description of the runoff and evapotranspiration characteristics simulated for the 10 land-segment types that are represented in the validation basins.

Simulated runoff from undisturbed till hillslope segments (TFM and TFS) was primarily interflow with no overland flow. Low infiltration (INFILT) values restricted vertical drainage through the soil zone and high interflow index (INTFW) values directed this potential runoff to interflow. The interflow runoff rate increased slightly as slope changed from moderate to steep, as controlled by decreased values of the interflow recession constant (IRC) value.

Simulated runoff from disturbed till hillslope segments (TGM and TGS) was primarily interflow also, but some overland flow was generated during large storms. Low infiltration (INFILT) values restricted both vertical drainage through the soil zone, and infiltration into the soil during large storms. Runoff retention and detention, represented by the upper-zone nominal storage parameter (UZSN), and evapotranspiration, represented by the lower-zone evapotranspiration parameter (LZETP), were less in these segments than in the comparable undisturbed segments.

Simulated runoff from the flat-slope till segments (TFF and TGF) was primarily interflow during small storms, and the interflow discharge rate was slower than that from the steeper land segments. However, during large storms, the high values for the infiltration exponent (INFEXP) allowed both of these flat segments to generate substantial quantities of overland flow. The disturbed segments generated more overland flow than the undisturbed segments did.

Simulated runoff from both outwash segments (OF and OG) was primarily ground-water flow, although some overland flow was generated from the disturbed segments during intense storms. High infiltration (INFILT) values and low interflow index (INTFW) values allowed for unrestricted infiltration and vertical drainage. As with the till segments, a lesser lower-zone evapotranspiration parameter (LZETP) resulted in less evapotranspiration from the disturbed segments.

Finally, simulated runoff from the saturated segment (SA) ranged from slight during small storms in the dry season, to nearly 100 percent overland flow during large storms in the wet season. High values for INFILT, INFEXP, and UZSN allowed unrestricted vertical drainage and no runoff when soils were dry, but drainage was quickly restricted and runoff was rapid when soils were wet. The impervious segment (EIA) generated overland flow only.

The conclusion from the calibration study was that the numerical modeling method could, provisionally, be accepted as valid for simulating rainfall-runoff relations in the study area. The aggregate simulation errors for the 21 stream-gage sites in the calibration basins are shown in table 4. The average root-mean-square errors for streamflow simulation were 7.7 percent for annual runoff, 11.7 percent for winter runoff, 13.9 percent for spring runoff, 42.1 percent for summer runoff, 21.3 percent for storm runoff volume,

Table 3. Generalized HSPF parameter values representing the 12 calibrated land-segment types

[Units are printed below parameter name; where units are not listed, the parameter has no units. Land-segment definitions: TFF = till soils, forest cover, flat slopes; TFM = till soils, forest cover, moderate slopes; TFS = till soils, forest cover, steep slopes; TGF = till soils, non-forest cover, flat slopes; TGM = till soils, non-forest cover, moderate slopes; TGS = till soils, non-forest cover, steep slopes; OF = outwash soils, forest cover, all slopes; OG = outwash soils, non-forest cover, all slopes; CNF = Custer-Norma soils, forest cover, all slopes; CNG = Custer-Norma soils, non-forest cover, all slopes; SA = saturated soils, all covers, all slopes; EIA = effective impervious areas, all slopes. LZSN = lower-zone nominal storage; INFILT = infiltration index; LSUR = average length of the overland flow plane; SLSUR = average slope of the overland flow plane; KVARY = ground-water outflow modifier; AGWRC = ground-water recession parameter; INFEXP = infiltration equation exponent; INFILD = ratio of the maximum to mean infiltration rate of a pervious area; BASETP = fraction of available-PET demand that can be met with ground-water outflow; AGWETP = fraction of available-PET demand that can be met with stored ground water; CEPSC = interception storage capacity of plants; UZSN = upper-zone nominal storage; NSUR = average roughness of the overland flow plane; INTFW = interflow index; IRC = interflow recession parameter; LZETP = lower-zone ET index; RETSC = retention storage capacity of impervious areas; in. = inches; in./hr = inches per hour; ft = feet; 1/in. = 1 per inch; 1/day, 1 per day; n/a = not applicable]

	Model Parameter																
Land segment	LZSN (in.)	INFILT (in./hr)	LSUR (ft)	SLSUR	KVARY (1/in.)	AGWRC (1/day)	INFEXP	INFILD	BASETP	AGWETP	CEPSC (in.)	UZSN (in.)	NSUR	INTFW	IRC (1/day)	LZETP	RETSC (in.)
TFF	4.5	0.08	400	0.05	0.5	0.996	3.5	2.0	0.0	0.0	0.2	1.0	0.35	3.0	0.7	0.7	n/a
TFM	4.5	0.08	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.2	0.5	0.35	6.0	0.5	0.7	n/a
TFS	4.5	0.08	200	0.20	0.5	0.996	1.5	2.0	0.0	0.0	0.2	0.3	0.35	7.0	0.3	0.7	n/a
TGF	4.5	0.03	400	0.05	0.5	0.996	3.5	2.0	0.0	0.0	0.1	0.5	0.25	3.0	0.7	0.25	n/a
TGM	4.5	0.03	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.1	0.25	0.25	6.0	0.5	0.25	n/a
TGS	4.5	0.03	200	0.20	0.5	0.996	1.5	2.0	0.0	0.0	0.1	0.15	0.25	7.0	0.3	0.25	n/a
OF	5.0	2.00	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.2	0.5	0.35	0.0	0.7	0.7	n/a
OG	5.0	0.80	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.1	0.5	0.25	0.0	0.7	0.25	n/a
CNF[1]	2.0	0.40	400	0.01	4.0	0.990	3.5	2.0	0.0	0.0	0.2	1.0	0.35	4.0	0.8	0.9	n/a
CNG	2.0	0.16	400	0.01	4.0	0.990	3.5	2.0	0.0	0.0	0.1	0.5	0.25	4.0	0.8	0.9	n/a
SA	4.0	2.00	100	0.001	0.5	0.996	10.0	2.0	0.0	0.7	0.1	3.0	0.50	1.0	0.7	0.8	n/a
EIA	n/a	n/a	500	0.01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.10	n/a	n/a	n/a	0.10

[1] CNF and CNG land segments were present only in the calibration basins.

Table 4. Measures of composite errors in model-simulated annual runoff, seasonal runoff, storm runoff, peak discharges, and daily mean discharges simulated for the 21 stream gages in the calibration basins

Data set name	Mean absolute[1] error		Root-mean-[2] square error		Bias[3]	
	Average	Percent	Average	Percent	Average	Percent
Annual runoff	[4]1.03	5.6	1.53	7.7	0.01	-0.5
Winter runoff	0.81	8.4	1.08	11.7	-0.29	-4.3
Spring runoff	0.53	9.9	0.75	13.9	0.27	5.5
Summer runoff	0.36	31.0	0.42	42.1	-0.02	-9.1
Storm runoff	0.13	15.0	0.19	21.3	0.01	-2.9
Peak discharge	29.24	16.4	50.19	21.5	3.03	1.4
Daily mean discharge[5]						
Low flow	1.71	35.0	2.61	48.4	-0.28	7.5
Medium flow	3.62	27.1	6.22	43.0	-1.13	-3.7
High flow	8.25	24.2	17.35	34.5	0.98	4.2
Total	4.54	28.8	10.80	42.4	-0.13	2.8

[1] Let,

S = simulated value;

O = Observed value; and

N = number of values in the sample.

Then,

Mean absolute error, average = $\Sigma[|S-O|/N]$; and

Mean absolute error, percent = $100 \times \Sigma\{[|S-O|/O]/N\}$.

[2] Root mean square error, average = $\sqrt{\Sigma[(S-O)^2/N]}$.

Root mean square error, percent = $100 \times \sqrt{\Sigma[(S-O^2/O)/N]}$.

[3] Bias, average = $\Sigma[(S-O)/N]$.

Bias, percent = $100 \times \Sigma\{[(S-O)/O]/N\}$.

[4] Average runoff errors are reported in inches per unit area. Average discharge errors are reported in cubic feet per second.

[5] Low, medium, and high flow regimes are the lower, middle, and upper thirds of the flow duration curve of daily mean discharge values, in cubic feet per second, from each station. Total refers to the complete 2-year records of daily mean flows at all stations.

21.5 percent for peak discharge, and 42.4 percent for all daily mean discharges. The simulation errors for the validation basins should be of similar magnitude in order to bolster the conclusion from the calibration study.

VALIDATION OF NUMERICAL MODELING METHOD

The validity of the modeling method was assessed by constructing numerical models for the 11 validation basins and testing the accuracy with which those models simulated streamflow. The numerical models for these additional basins were first constructed with the generalized parameter values according to the method presented in the Previous Investigation section of this report. Those models, referred to as the "initial models," were driven with weather data collected during the 1987-88 water years. The simulated streamflows were then compared to streamflow data collected in the validation basins during those same years, and the resulting errors were compared to the composite simulation errors reported for the calibration basins. If those initial simulation errors had been similar in magnitude to the errors reported for the calibration basins, then all four components of the numerical modeling method (the conceptual model, the HSPF program, the model construction approach, and the generalized parameter values) could have been considered valid for the conditions found in the study area. However, certain errors from the validation models were consistently larger than the calibration errors, so it was obvious that at least one component of the modeling method was not valid. Different components of the initial models, such as parameter values or routing of land-segment outflows, were concurrently modified in the validation models, and the simulations were redone in order to determine the source of the initial errors. If the source of error was a component of the numerical modeling method, rather than observed hydrologic data, then the validity of that component was questionable. This report refers to the fully modified numerical models as "final models." The best, unique set of parameter values for each validation basin was not determined from this assessment; that would have been contrary to the intended use of the generalized parameter values.

The generalized parameter values and the model construction approach were assessed for the study area as a whole. Hence, the assessment concentrated on recurrent errors in the numerical models and on systematic modifications that would reduce those errors in all basins. For example, the initial models for most of the validation basins greatly oversimulated annual runoff. ("Oversimulation" in this report means the simulated streamflow was greater than the observed; the converse results are called "undersimulation"). The portion of ground-water discharge that contributed to streamflow in the initial models was reduced, and the simulation results greatly improved. The original guidelines used to determine ground-water contributions were not consistently valid across the study area, so new guidelines were developed. The construction of models for the validation basins, the data used for validation, the simulation results, and a discussion of those results are presented below.

Construction of Numerical Models for the Validation Basins

As in the calibration study, the initial numerical models for the validation basins were constructed in three steps: the land area was divided into land segments in accordance with the segmentation scheme, the surface-water drainage network was divided into reaches, and the drainage basin geometry was constructed by connecting land segments and reaches. The generalized parameter values were then assigned to the land segments, and the initial conditions for the model runs were set.

The area in the validation basins was divided into one impervious and only nine pervious types of land segments; the Custer-Norma land-segment types defined for the calibration basins were not present in the validation basins. A description of the land-segment types and their areal extent in the validation drainage basins appears in table 5, and the distribution of till, outwash, and saturated land-segment types is illustrated in figures 3 and 4.

The delineated reaches and subbasins for the validation basins are shown in figures 5-7. The FTABLES for these reaches were derived using various theoretical flow equations in combination with measured reach characteristics, such as cross-section, roughness, slope, and length.

Table 5. Areal extent of land segments found in the drainage basins used for model validation

TFF = till soils, forest cover, flat slopes
TFM = till soils, forest cover, moderate slopes
TFS = till soils, forest cover, steep slopes
OF = outwash soils, forest cover, all slopes
SA = saturated soils, all covers, all slopes
TGF = till soils, nonforested cover, flat slopes
TGM = till soils, nonforested cover, moderate slopes
TGS = till soils, nonforested cover, steep slopes
OG = outwash soils, nonforested cover, all slopes
EIA = effective impervious area, all slopes

Station name	Station number	Land segment areas (in percent of area upstream of station)[1]										Total area upstream of station (square miles)
		TFF	TFM	TFS	TGF	TGM	TGS	OF	OG	SA	EIA	
Hylebos Creek at 5th Avenue at Milton	12102900	33.2	12.2	5.5	13.2	7.0	1.2	8.8	3.6	2.4	10.8	5.87
West Tributary to Hylebos Creek at South 356th Street near Milton	12102920	26.8	9.4	5.3	12.0	4.0	0.3	11.3	1.9	6.0	22.7	4.39
West Tributary to Hylebos Creek at South 373rd Street near Milton	12103000	25.3	11.0	5.6	10.8	4.6	0.2	10.6	1.9	10.0	19.8	6.25
Joes Creek at Marine View Drive near Tacoma	12103205	6.4	0.9	1.7	12.5	4.8	1.4	30.2	26.6	1.6	13.3	2.97
Lakota Creek above Sewage Treatment Plant near Tacoma	12103207	1.6	1.3	1.5	11.1	12.2	3.7	16.2	25.2	4.2	22.9	1.74
Redondo Creek #1 at Redondo Shores	12103210	2.6	0.4	2.4	29.2	5.6	0.7	14.9	14.5	1.5	26.4	0.716
Redondo Creek #2 near Des Moines	12103212	7.9	1.3	10.0	15.9	15.3	3.6	6.5	9.2	4.8	20.7	1.10
Unnamed Creek at Saltwater State Park near Des Moines	12103220	8.5	9.2	7.6	22.2	10.1	4.5	3.0	6.0	6.1	22.9	2.88
Laughing Jacobs Creek near Issaquah	12121720	16.6	8.4	6.0	1.5	2.5	0.4	32.2	17.6	6.1	6.0	5.65
Pine Lake Creek near Issaquah	12121815	20.9	13.1	8.0	22.9	4.8	0.4	5.4	2.4	7.1	7.7	1.84
Inglewood Creek near Redmond	12121830	11.3	11.4	15.4	4.2	3.3	4.2	37.4	10.6	5.8	6.4	2.43

[1] When the sum of the percentages is less than 100, the remaining area is covered by water.

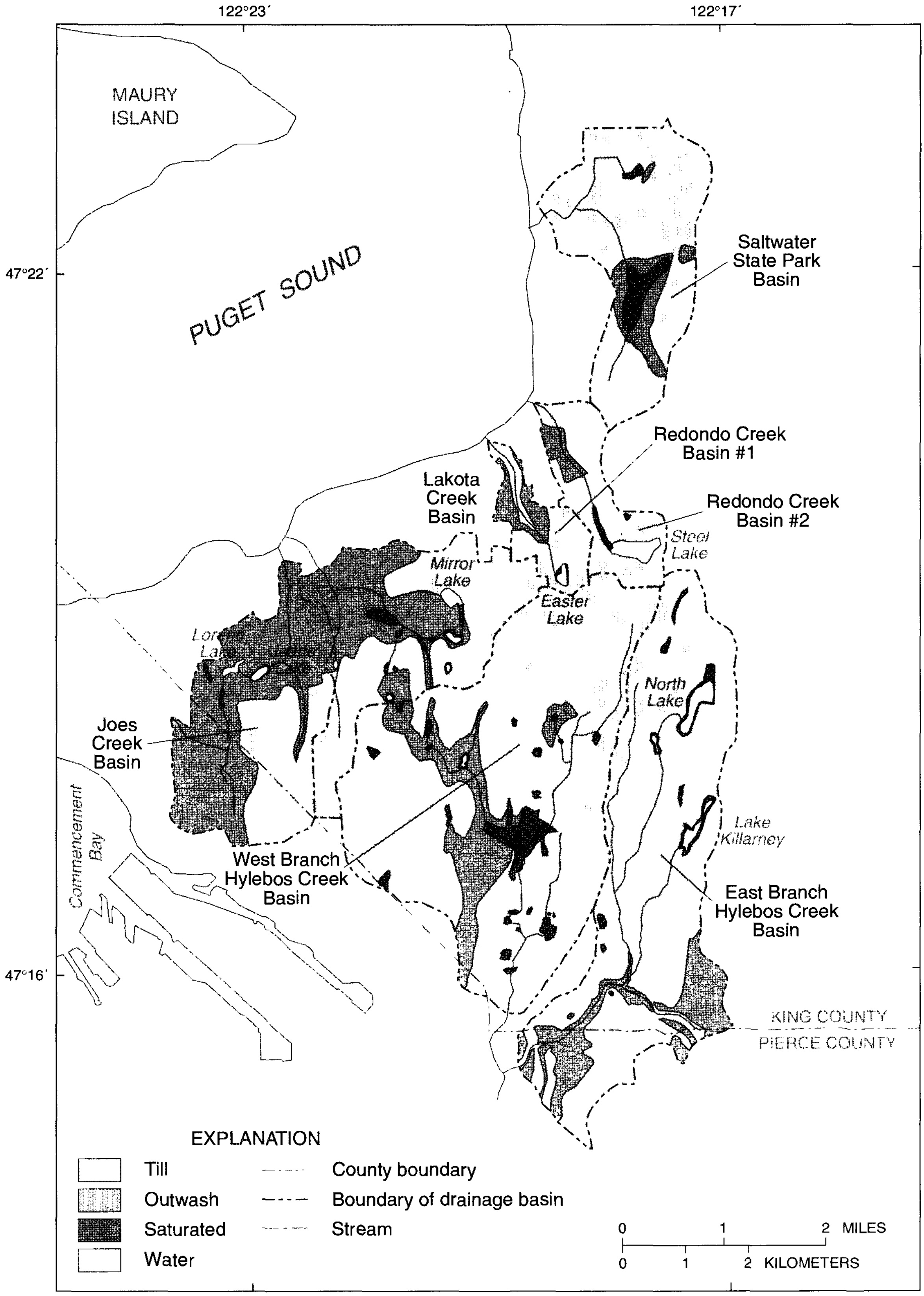

Figure 3. Distribution of till, outwash, and saturated land-segment types in the Hylebos Creek and Lower Puget Sound basins.

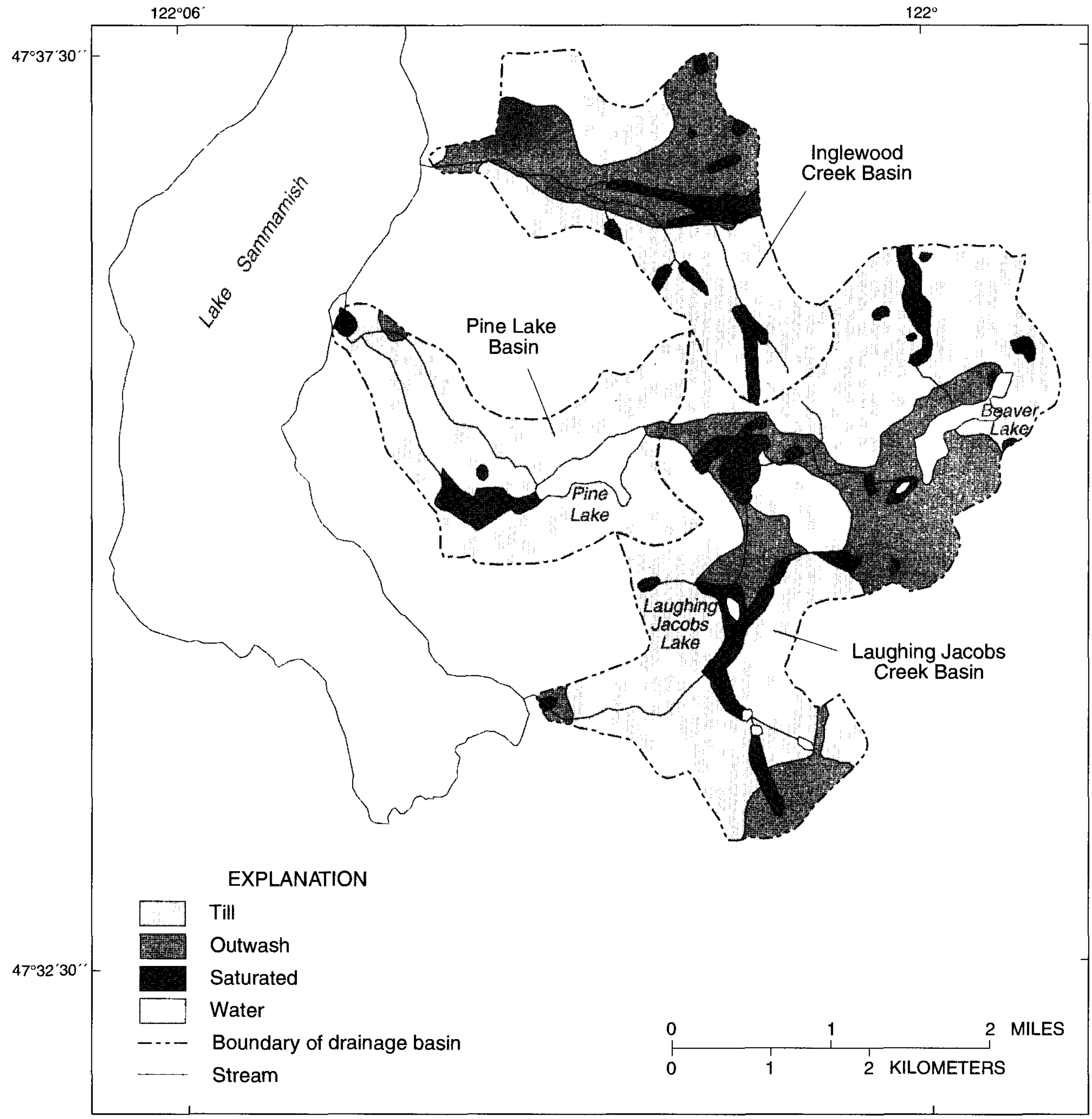

Figure 4. Distribution of till, outwash, and saturated land-segment types in the East Lake Sammamish basins.

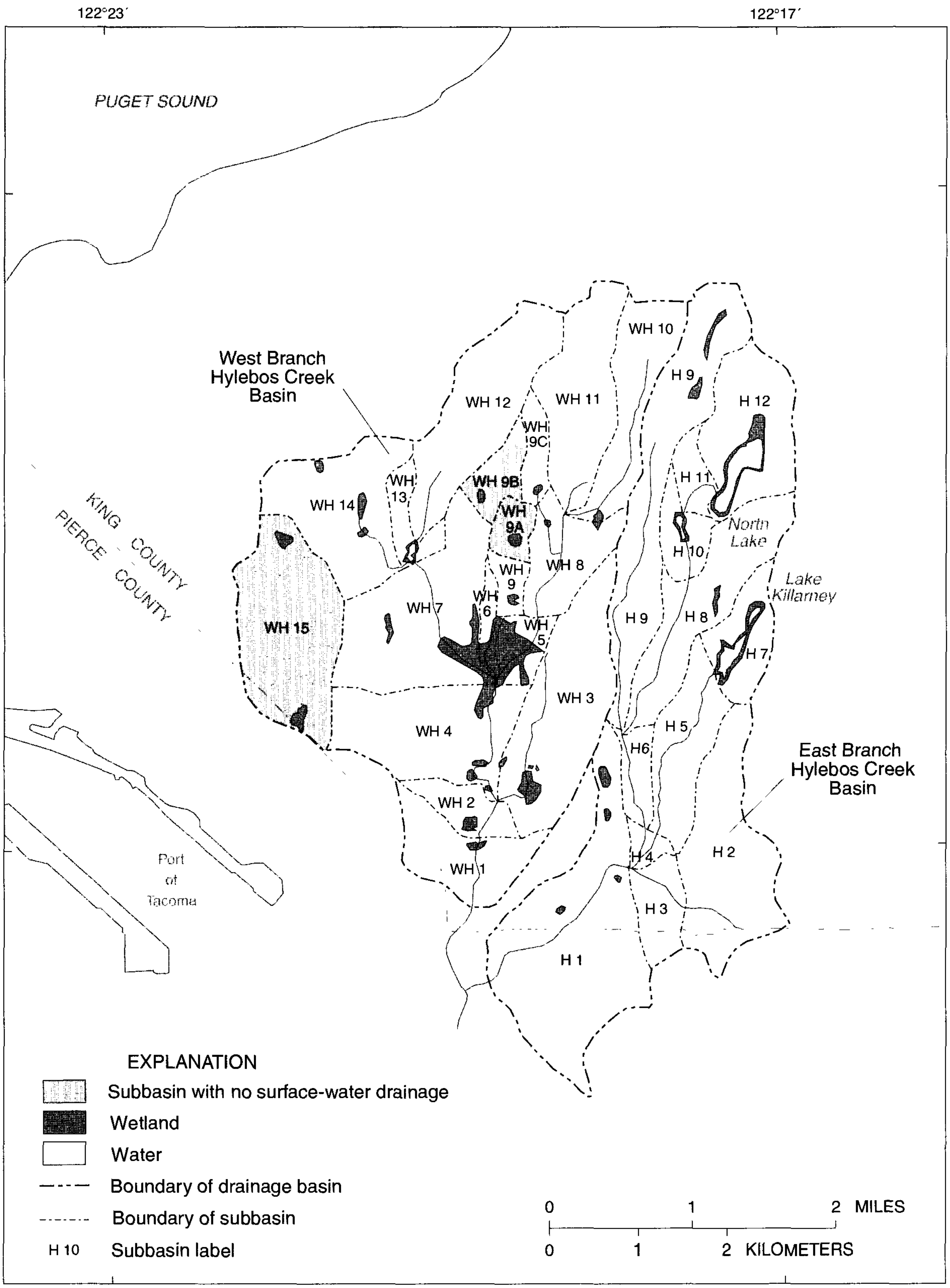

Figure 5. Subbasins delineated for the numerical models of the Hylebos Creek basins.

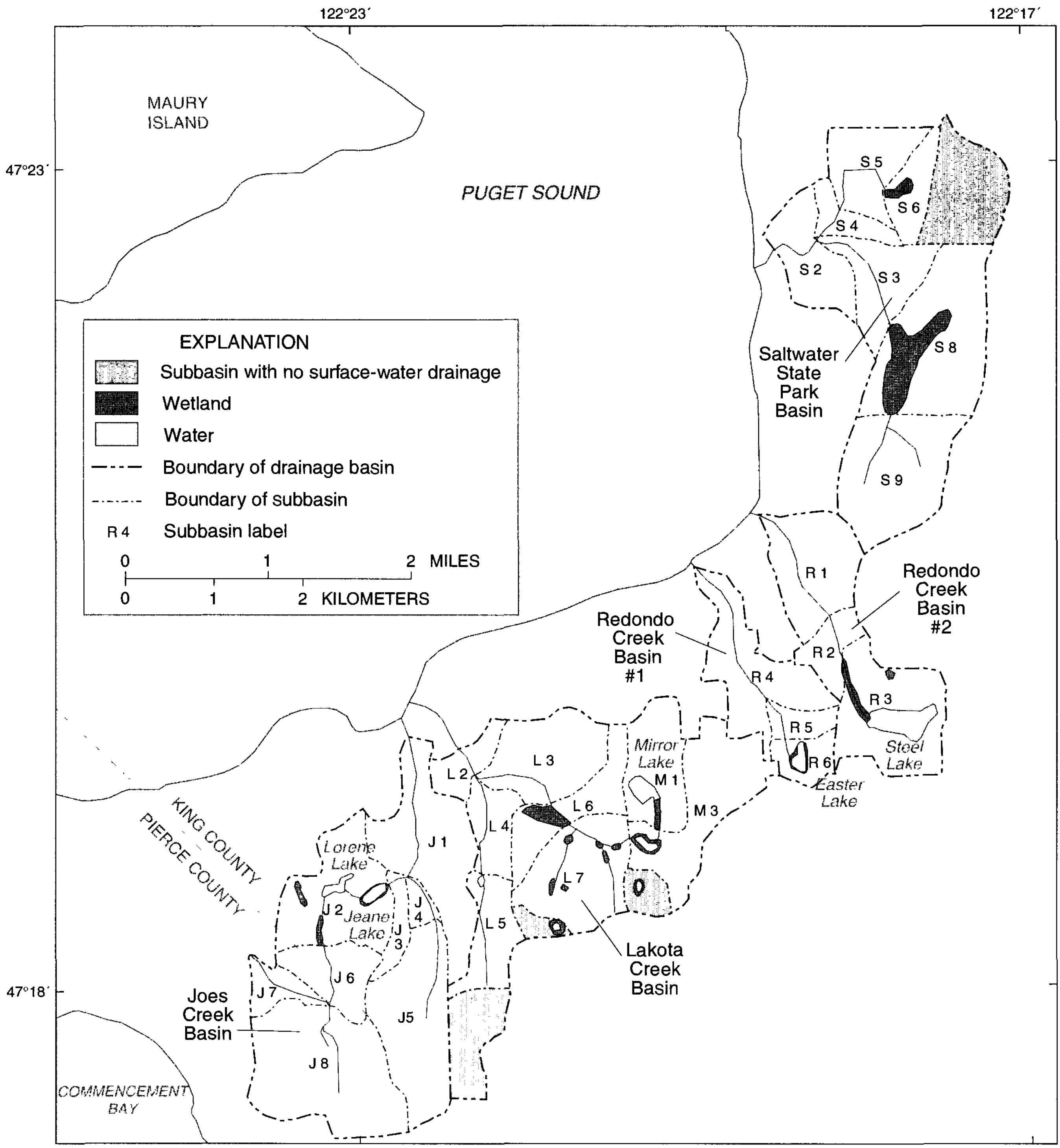

Figure 6. Subbasins delineated for the numerical models of the Lower Puget Sound basins.

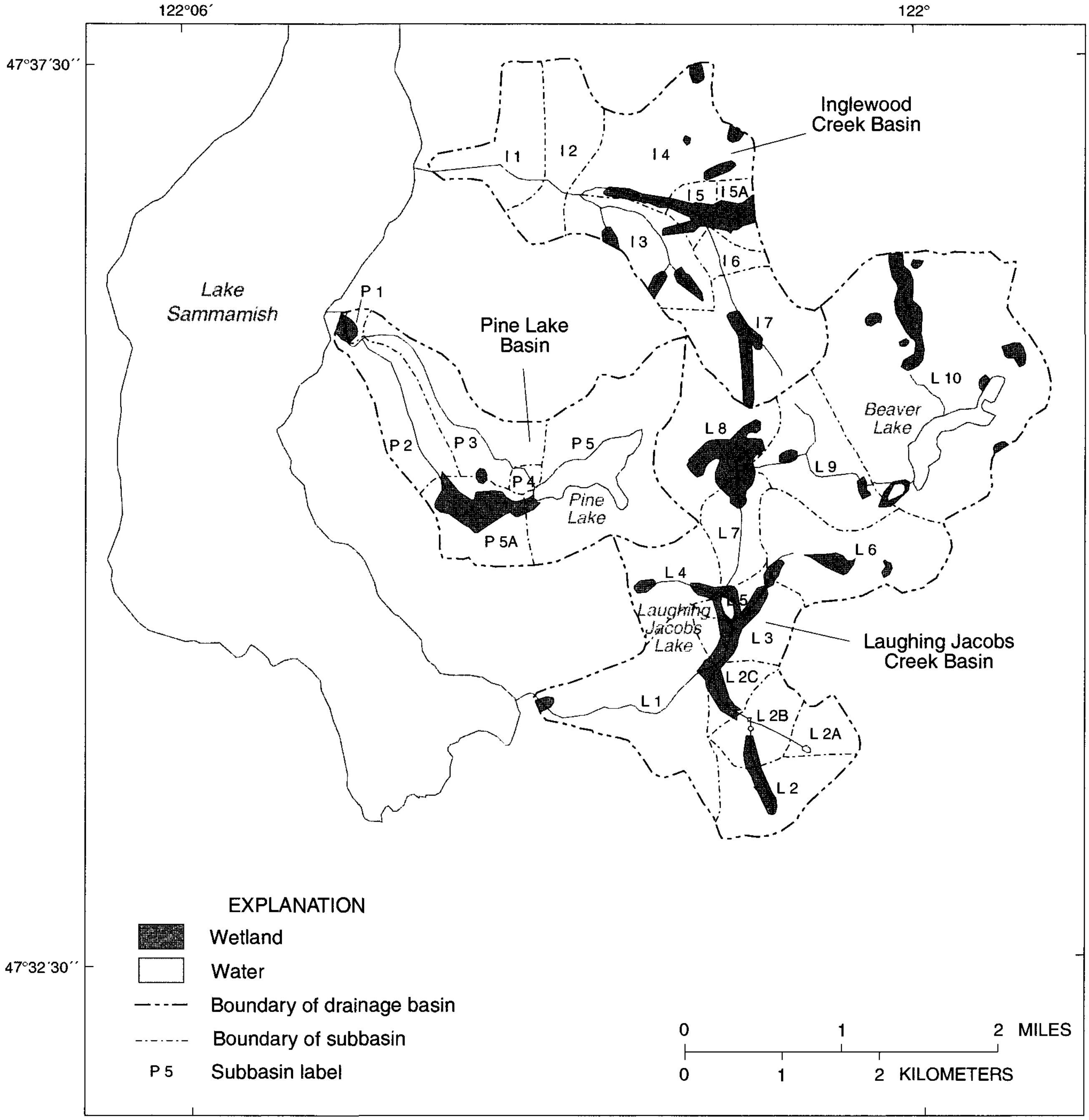

Figure 7. Subbasins delineated for the numerical models of the East Lake Sammamish basins.

Land segments and reaches were connected in the initial models in accordance with the guidelines determined in the calibration study. Channel infiltration and downslope infiltration of runoff into outwash deposits were not represented in the initial models because it was not then evident that such phenomena were important in the validation basins.

Finally, the generalized parameter values shown in table 3 were assigned to the land segments, and the initial storage volumes for the model runs were set. Initial storage in lakes and channels was measured directly. Initial storage in land-segment reservoirs, such as the lower soil zone, was approximated by running the models with 2 years of observed climate data and assigning the resulting storage volumes as initial conditions for the validation runs. This initialization procedure was repeated throughout this investigation whenever parameter values were adjusted.

Data Used for Validation

Data from the validation basins were collected during the 1987-88 water years. Precipitation and streamflow data were collected continuously at 15-minute intervals at 7 precipitation gages and 11 stream gages. The Pine Lake Creek stream gage (station 12121815) was operational only from July 1987 through September 1988. Data from Joes Creek (station 12103205) and Lakota Creek (12103207) were usable only for the 1987 water year. Peak-flow data were collected approximately monthly at two sites, but peak discharges could only be calculated for a few storm events because of unstable hydraulic conditions. Lake stage data were collected monthly or less frequently at eight sites. The precipitation, streamflow, crest-stage, and lake gage sites are shown in figures 8-10.

All observed data are available from the Washington District Office of the U.S. Geological Survey Water Resources Division in Tacoma, Wash. The continuous streamflow data are also published in the annual data report (U.S. Geological Survey, 1991), with the exception of the Joes Creek data, which were unsuitable for publication because of extended periods of missing record. Precipitation, crest-stage gage, and lake gage data are not published.

Potential evapotranspiration (PET) data were estimated using two methods. For March through October, pan evaporation data from the National Weather Station Class A Pan site near Puyallup, Wash., were adjusted by a pan coefficient of 0.75 to estimate PET (Farnsworth and Thompson, 1982). For November through February, when the pan evaporation data were not available, PET was estimated by a version of the Jensen-Haise equations (Bauer and Vaccaro, 1986). Temperature data from the National Weather Service station at Seattle-Tacoma International Airport were used in the Jensen-Haise PET estimations.

The accuracy of the observed precipitation data and the estimated PET data was unknown. There was, on average, one rain gage for every 4.5 square miles of drainage area. This density was most likely adequate for representing rainfall variations in large-frontal-system storms, but the variation in smaller storm-cells was not as well represented. Data from only one evaporation pan and one temperature station were used to estimate PET for all of the validation basins, but they were probably not a large source of error because the mean annual temperature across the validation basins varied only by about 1°F (U.S. Department of Commerce, 1982). Although estimates of daily PET from adjusted pan evaporation data and from the Jensen-Haise method have been questioned in the literature (Doorenbos and Pruitt, 1977; Jensen, 1973), both methods provide commonly accepted approximations.

The accuracy of the published streamflow data was estimated by the U.S. Geological Survey (1991). Two of the streamflow records were rated "good" (within 10 percent of their true values 95 percent of the time), seven were rated "fair" (within 15 percent of their true values 95 percent of the time), two were rated "poor" (greater than 15 percent of their true values 95 percent of the time), and one was not published or rated due to its extensive missing record. The accuracy problems were mostly attributed to extreme scour and fill in the streambed at the gage sites.

Although the simulation errors for the calibration and validation basins were compared directly, the observed streamflow data for the validation basins were less accurate. Only two of the validation streamflow records were rated "good," seven were rated "fair," two were rated "poor," and one was not published due to extensive missing record. In contrast, 10 of the streamflow records used for calibration were rated "good," 10 were rated "fair," and only 1 was rated "poor." Also, peak flow data from the validation stream-gage sites were less accurate due to uncertainty in the upper end of the stage-discharge relations and to uncertainty in streamflow stages recorded during large storms.

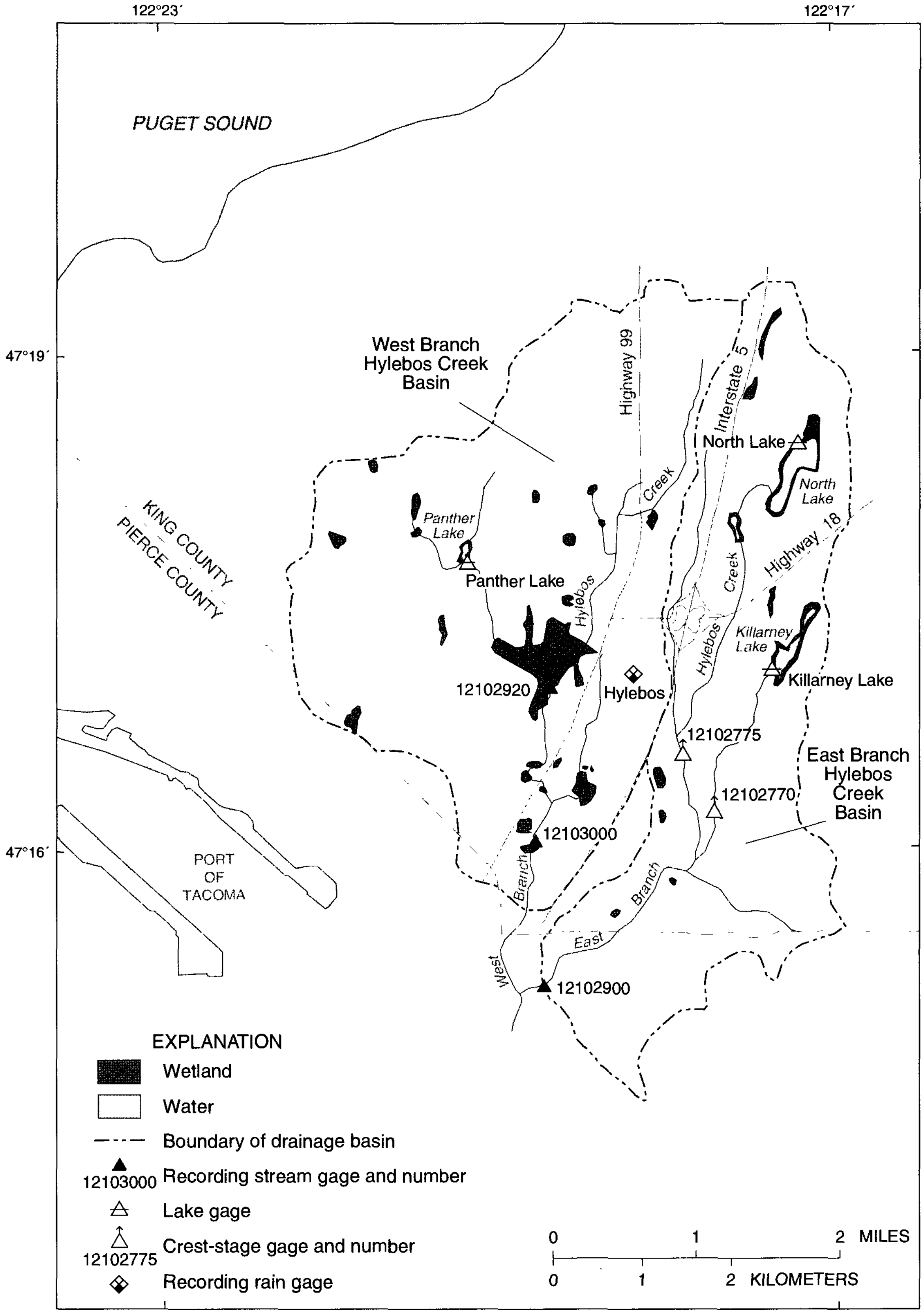

Figure 8. Data-collection network for the Hylebos Creek basins.

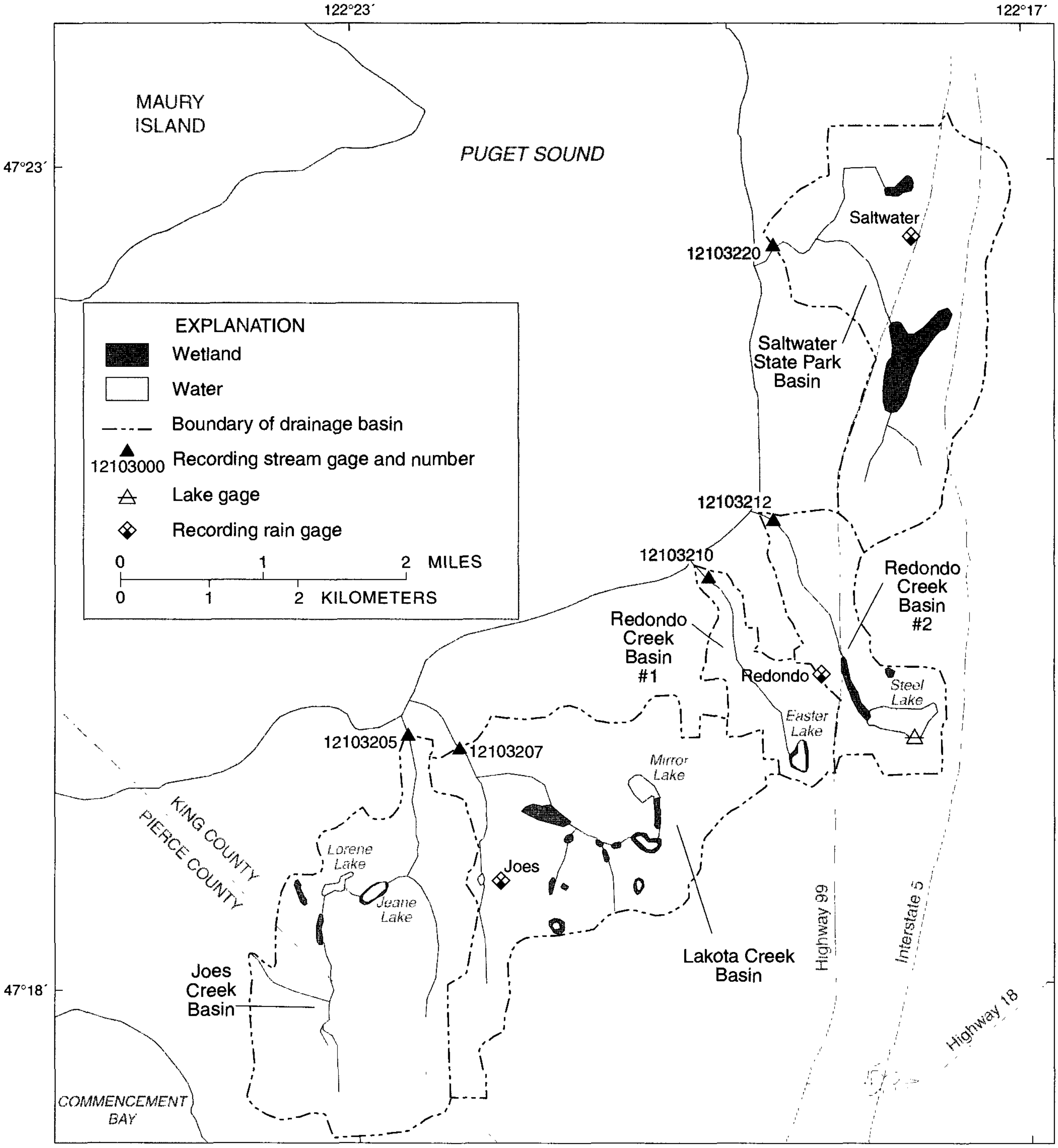

Figure 9. Data-collection network for the Lower Puget Sound basins.

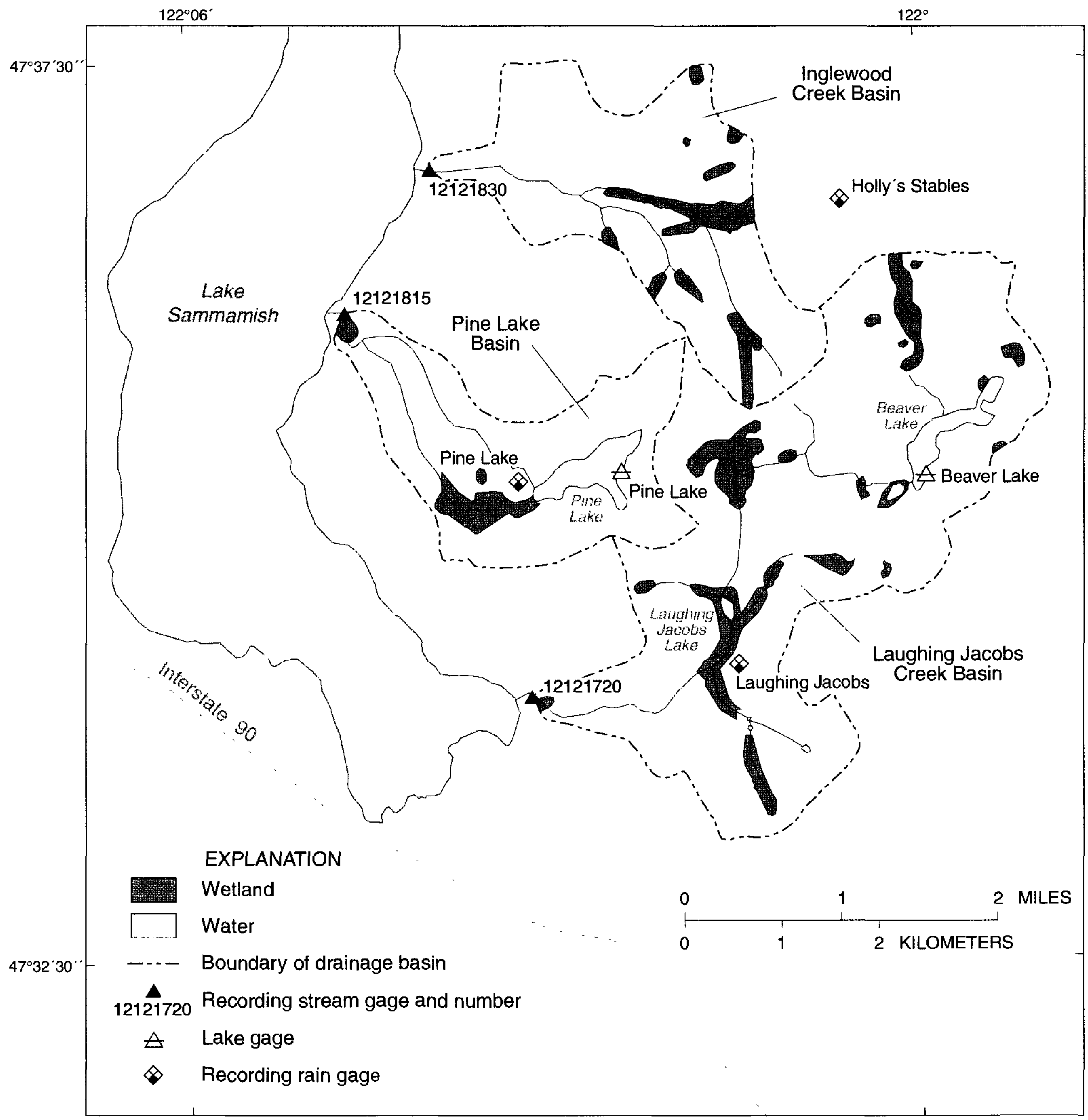

Figure 10. Data-collection network for the East Lake Sammamish basins.

Storm runoff from the smaller and more intensively developed validation basins was observed to significantly scour or fill channels during the course of a runoff event.

Errors in rainfall data were similar for both the calibration and the validation basins; the density of rain gages was similar, and the same type of gage was used. Likewise, errors in PET data were similar because the same estimation methods were used.

Results of Simulations for the Validation Basins

Three systematic modifications were required to correct recurrent errors identified in the initial simulations. The recurrent errors, the systematic modifications, and the final simulation results for the study area as a whole are presented first in this report, followed by a more detailed description of simulation results and model modifications for each basin.

Results for the Study Area as a Whole

Results of the initial simulations were generally poor (figs. 11b-21b). Streamflow was consistently oversimulated; only 2 of the 11 models simulated annual runoff within 10 percent, and the median annual runoff error for all basins was greater than 100 percent. Between-storm streamflow and summer streamflow volumes were generally oversimulated, and the simulated rate of decrease in summer baseflow was oversimulated in all models. Storm runoff volumes were also oversimulated in about half of the models.

Three systematic modifications to the initial models resulted in satisfactory final simulations for 10 basins (figs. 11c-21c and tables 6-8). The three modifications were (1) the portion of ground water contributing to streamflow was modified by adjusting either the DEEPFR parameter value or the routing of ground-water outflows, (2) the rate of ground-water discharge was modified by adjusting the parameter values for AGWRC and KVARY, and (3) storm runoff volumes were reduced by routing interflow (as well as overland flow in one model) from upslope land segments into the ground-water system of downslope outwash segments. Further parameter value adjustments were needed to get satisfactory results in the remaining basin (Pine Lake Creek). The modifications to each model are listed in table 9.

The composite errors for the final simulations in all validation basins (table 10) were compiled from results obtained after all modifications to the initial models were made. The simulations were unbiased for the study area as a whole. The lack of bias suggests that, once the models were modified, there were no recurrent errors in the simulations over the study area as a whole. The root-mean-square errors for the simulation of annual and seasonal runoff were all 23 percent or less. The root-mean-square error for the simulation of storm runoff was 29 percent, and the root-mean-square error for the simulation of peak flows was 46 percent. The root-mean-square errors for the simulation of daily mean discharges ranged from 42 to 61 percent.

The three systematic modifications of the initial models were justified by identifying the simulation errors that were common to most validation basin models and examining alternative explanations regarding the source of those errors. Systematic modification of ground-water contributions to streamflow in the initial models was justified because of the consistent oversimulation of annual runoff volumes, regardless of the pattern or extent of the various land segments in the basins. Three alternative explanations for those results were examined: the observed streamflow data were biased, actual evapotranspiration (AET) was undersimulated, or ground-water contributions to deeper flow systems were undersimulated. With regard to the first explanation, a review of the basic data used to generate the published streamflow records found no reason to suspect that the records were consistently biased. Also, ground-water contributions to streamflow are most evident during low-flow periods, and, with the exception of the Joes Creek gaging station, the stage-discharge ratings were well-defined during low-flow periods. With regard to the second explanation, the estimated PET data used by the models was about 23 inches for each year, and the simulated AET from land segments averaged about 16 inches. The remaining 7 inches of PET was available during the summer months when precipitation was scant and soil-moisture levels were low. When the models were adjusted in trial runs so that simulated AET was made to equal PET, an unlikely case in this climatic regime, the annual runoff was oversimulated for six of the basins and was then undersimulated in four of the basins. Hence, the initial simulation of AET appeared reasonable, leaving the undersimulation of ground-water contributions to deeper flow systems as the most likely explanation. Although this last explanation cannot be fully examined with the data available for this study, it is reasonable to assume that some recharge to deeper flow systems in the region comes from small basins. Figures 11 and 19 most clearly show how simulation results improved after modifying ground-water contributions to streamflow.

Systematic adjustment of the parameter values controlling the rate of ground-water discharge (AGWRC and KVARY) was justified because of the poor baseflow simulation results in most validation basins. Dinicola (1990) showed that the generalized AGWRC and KVARY values for the different land-segment types did not adequately represent the areal variation in ground-water discharge rates. This was because land-segment types were defined to represent the consistent relation between surficial physiography and storm-runoff generation, but the relation between surficial physiography and ground-water discharge rate was not so consistent. The June through October periods in figures 15 and 16 most clearly show how simulation results improved after the values for AGWRC and KVARY were modified.

When both ground-water contributions and discharge rates were modified in the initial models, simulation results improved dramatically for 5 out of the 11 validation basins (East Branch Hylebos Creek, Redondo Creek #1, Redondo Creek #2, Unnamed Creek at Saltwater State Park, and Laughing Jacobs Creek). The results also improved for the other six basins, but large errors remained until other modifications were made. The modifications usually resulted in decreased simulated ground-water discharge volumes, and they always resulted in a more gradual rate of decrease of ground-water discharge during the summer months.

Systematic routing of interflow from some upslope land segments into the ground-water system of downslope outwash segments was justified because of the poor stormflow simulation results obtained for basins with physiographic characteristics conducive to this phenomenon (till-mantled hillslopes draining to outwash-filled valleys). In most of those basins, even after ground-water contributions and timing were modified, storm runoff was still oversimulated. The primary sources of simulated storm runoff in those models were direct overland flow from impervious surfaces and interflow from till-mantled hillslopes. Observed runoff data usually showed a rapid response from direct overland flow, but the delayed runoff indicative of interflow from till segments was not apparent. Two explanations for this lack of interflow response were examined.

The first explanation was that the generalized HSPF parameter values did not adequately represent runoff generation from till land segments in some validation basins. This explanation was rejected because the generalized parameter values for till land segments generally led to reasonable results in basins that are mostly covered with glacial till; it was improbable that those same values would inadequately simulate runoff from till in nearby basins with more extensive outwash deposits. Although it is likely that the generalized parameter values were not representative of runoff generation in all areas throughout the entire region, the consistently good simulation results for the predominantly till-covered calibration and validation basins gave strong support to the validity of the generalized parameter values.

The second, more probable explanation, was that the generation of interflow was adequately simulated but that the interflow was subsequently infiltrated into downslope outwash deposits, thus attenuating the streamflow response. This explanation was originally presented (Dinicola, 1990) to reconcile similar results obtained for two of the calibration basins, but the results from the calibration study were inconclusive as to whether the phenomenon was common throughout the study area or was just a local anomaly. The results from the validation basins suggest that the phenomenon is fairly common.

Figures 12 and 21 most clearly show how simulation results improved after the initial models were modified to simulate this phenomenon. Simulation results improved markedly for five out of the six basins where the phenomenon was likely to be important (upper and lower West Branch Hylebos Creek, Joes Creek, Lakota Creek, and Inglewood Creek). The results improved only slightly for the sixth basin (Redondo Creek #1), but the results for that basin were already good before this modification was made. The improved results for the Inglewood Creek basin required further modification of the model to simulate overland flow from impervious areas being infiltrated into outwash deposits, as discussed in more detail in the following sectioon.

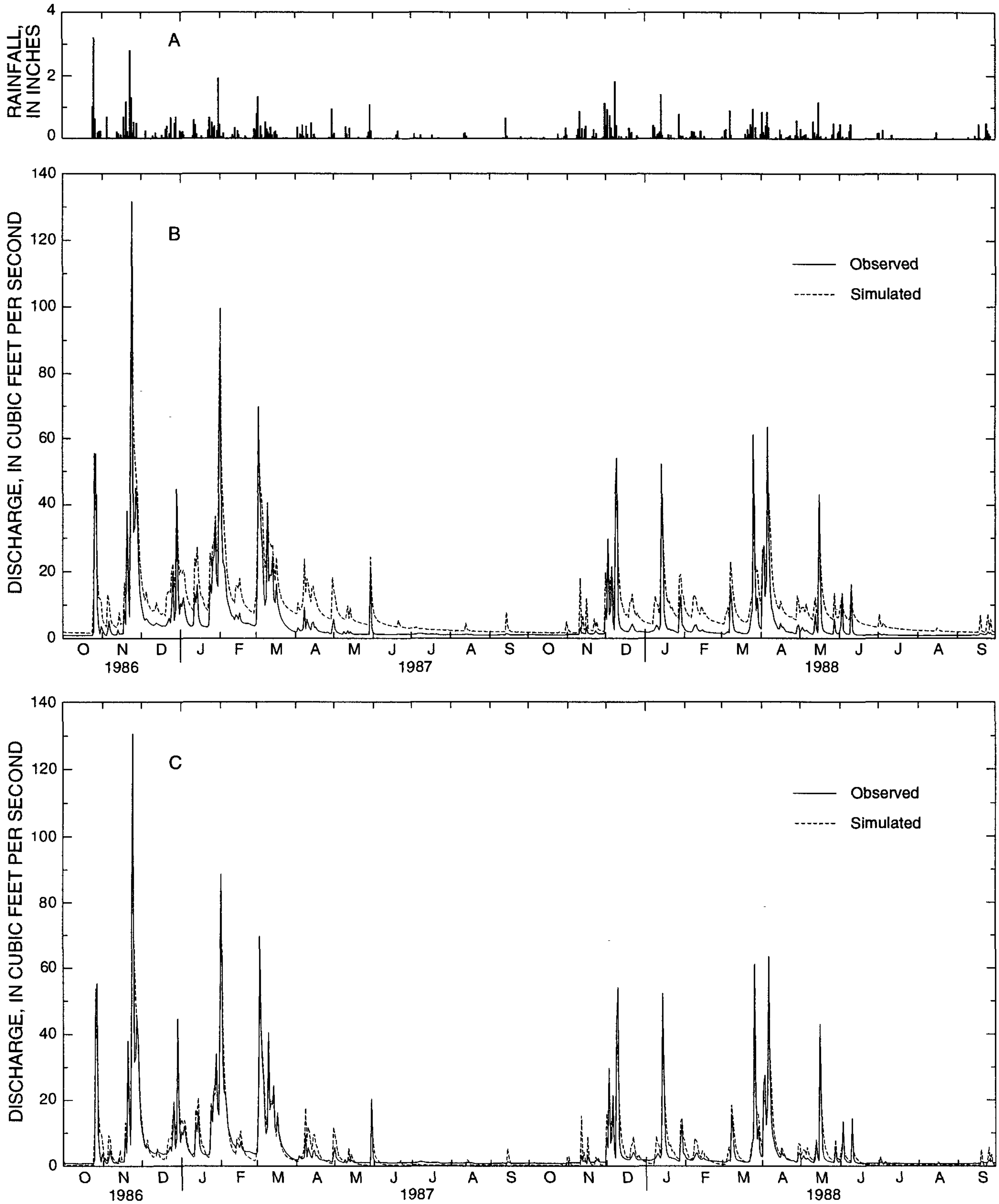

Figure 11. Observed rainfall (A) and observed and simulated daily mean discharge for East Branch Hylebos Creek (station 12102900), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

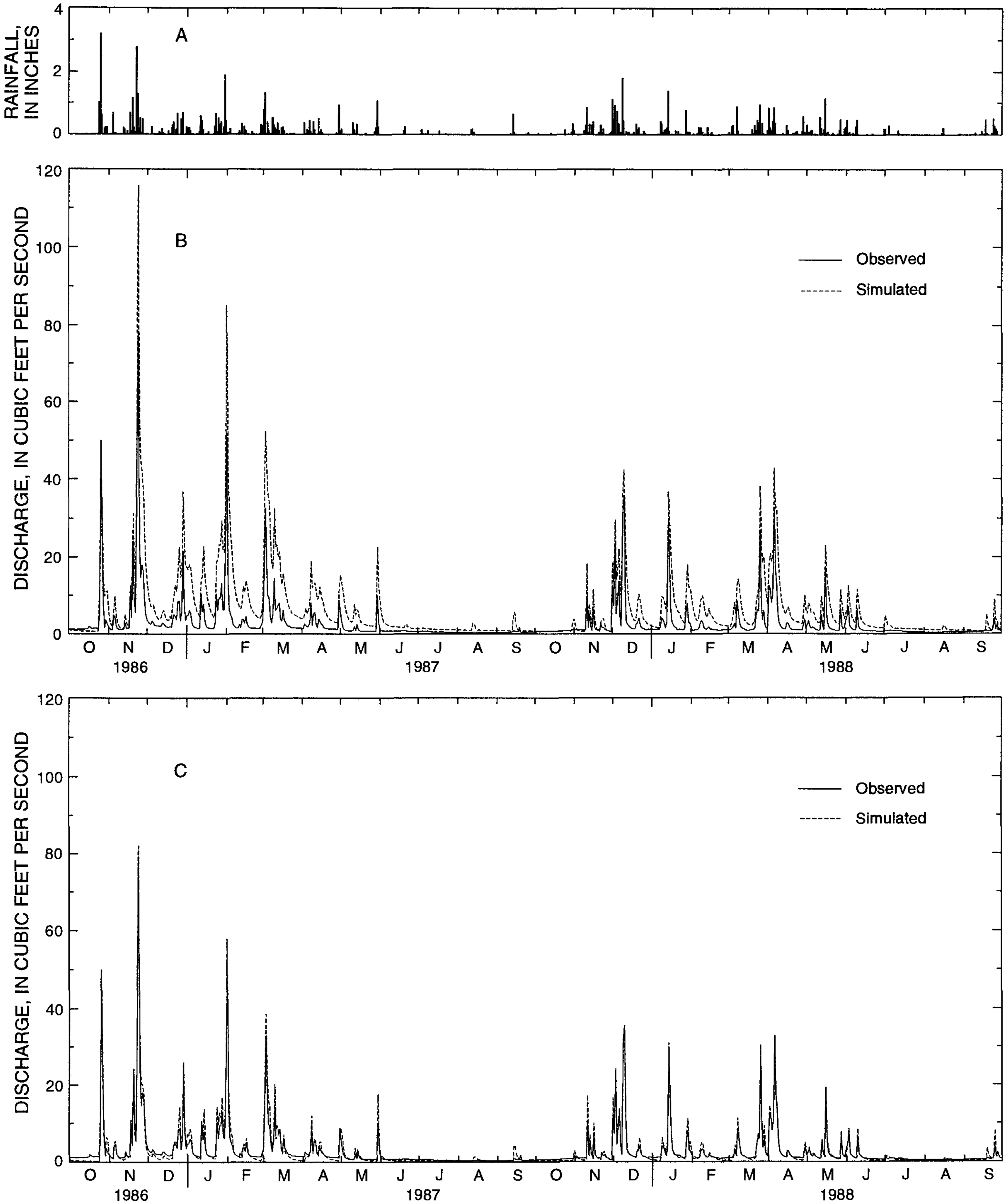

Figure 12. Observed rainfall (A) and observed and simulated daily mean discharge for the upper stream gage on West Branch Hylebos Creek (station 12102920), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

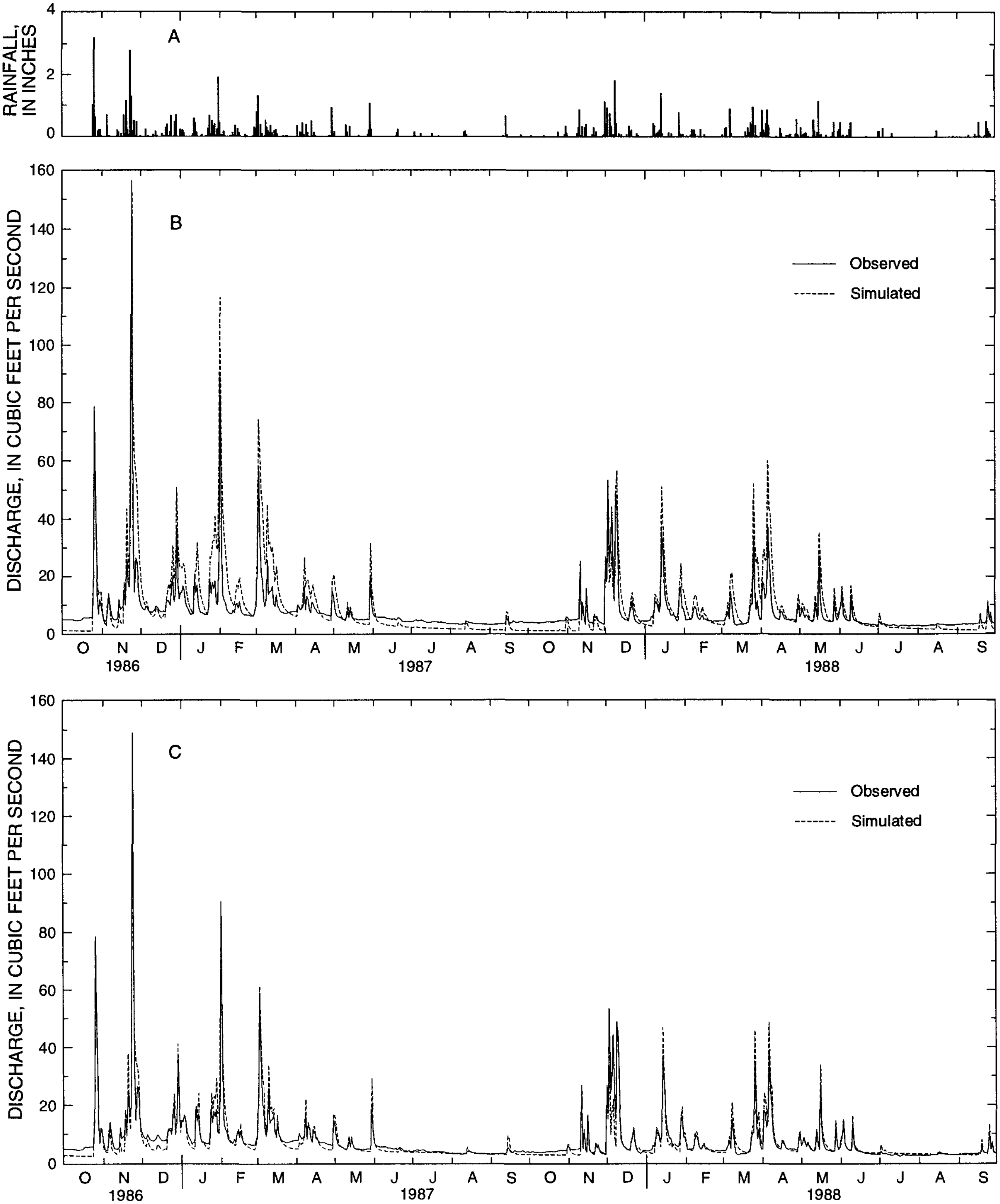

Figure 13. Observed rainfall (A) and observed and simulated daily mean discharge for the lower stream gage on West Branch Hylebos Creek (station 12103000), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

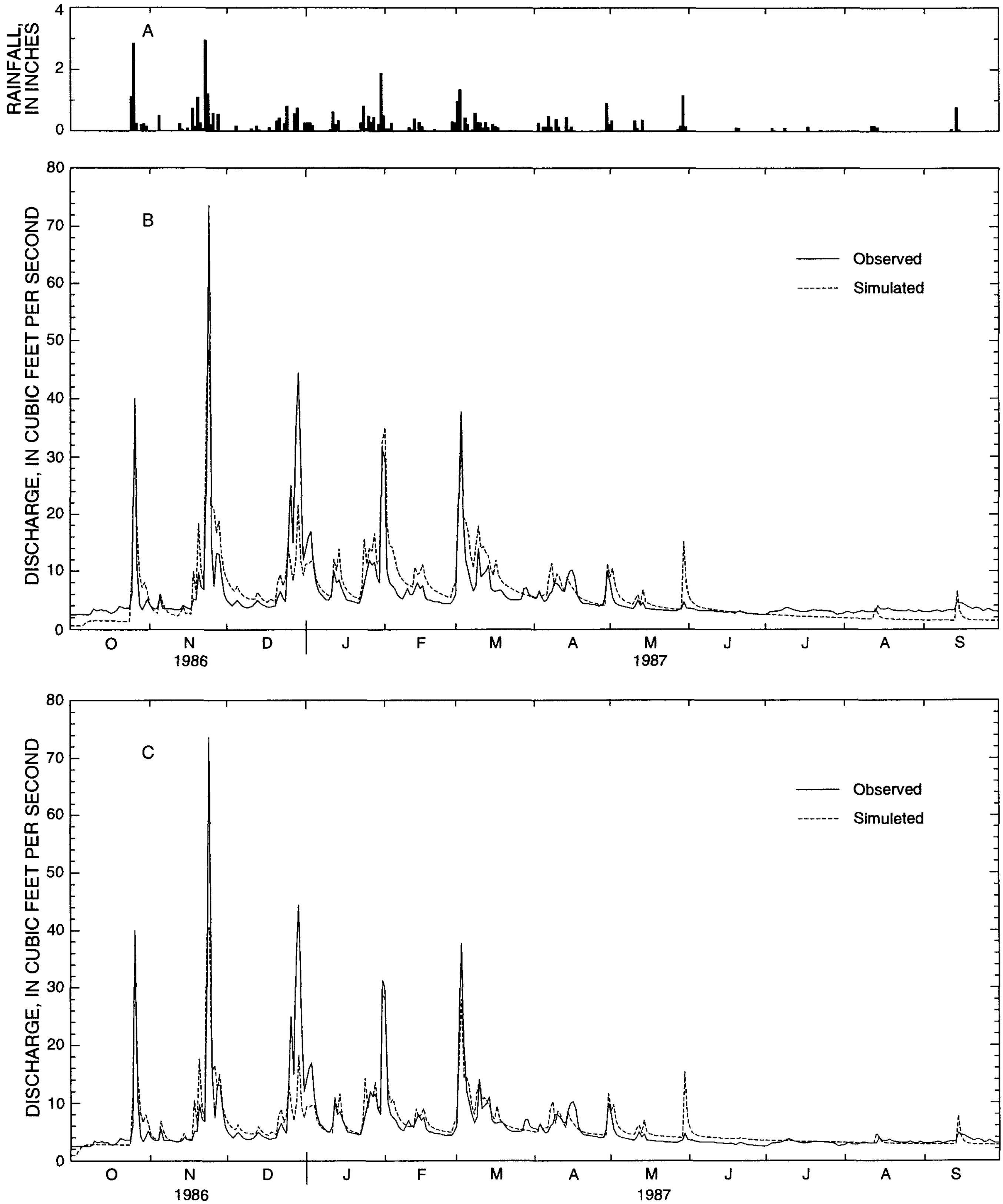

Figure 14. Observed rainfall (A) and observed and simulated daily mean discharge for Joes Creek (station 12103205), October 1986 - September 1987, for (B) the initial numerical model, and (C) the final numerical model.

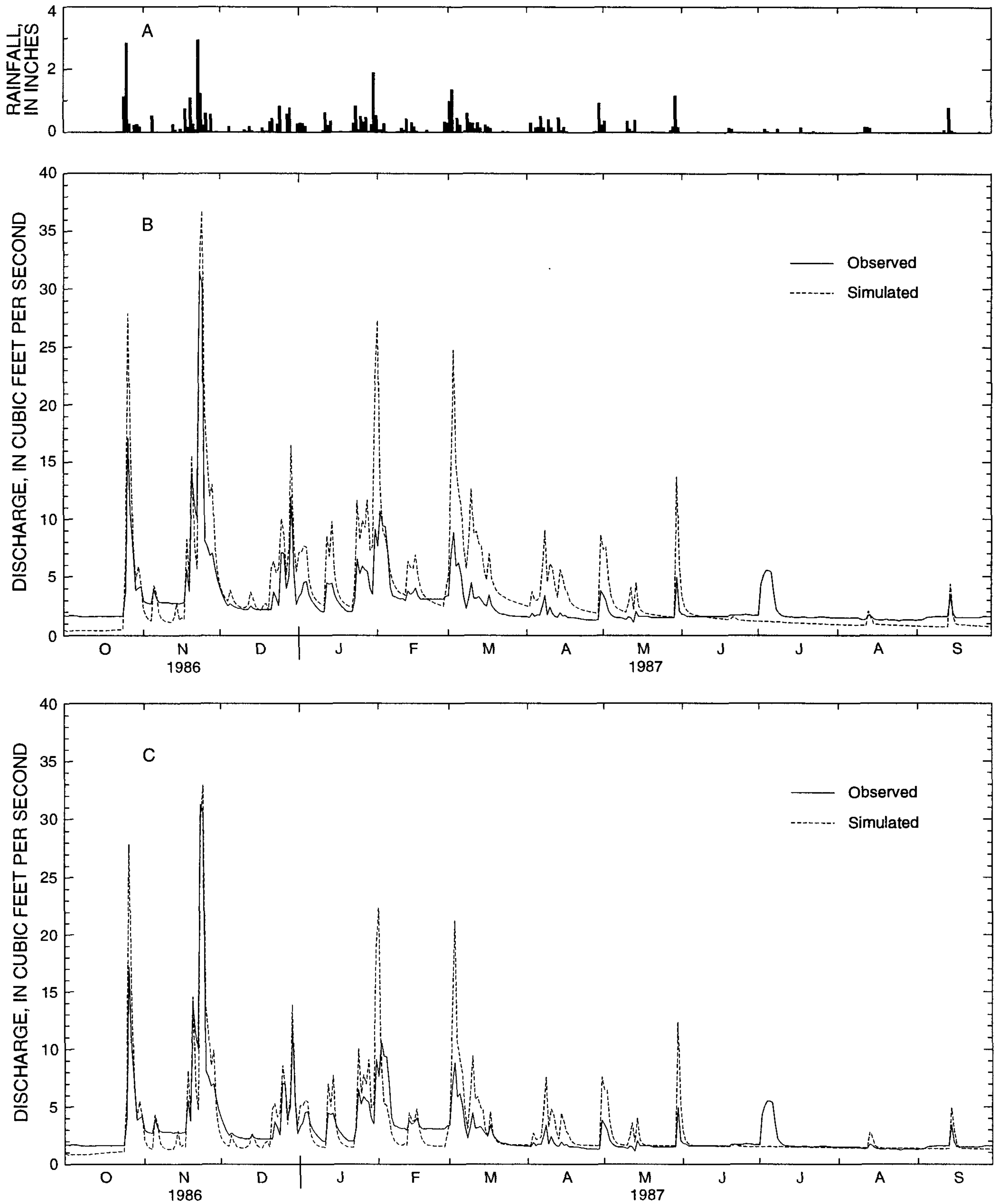

Figure 15. Observed rainfall (A) and observed and simulated daily mean discharge for Lakota Creek (station 12103207), October 1986 - September 1987, for (B) the initial numerical model, and (C) the final numerical model.

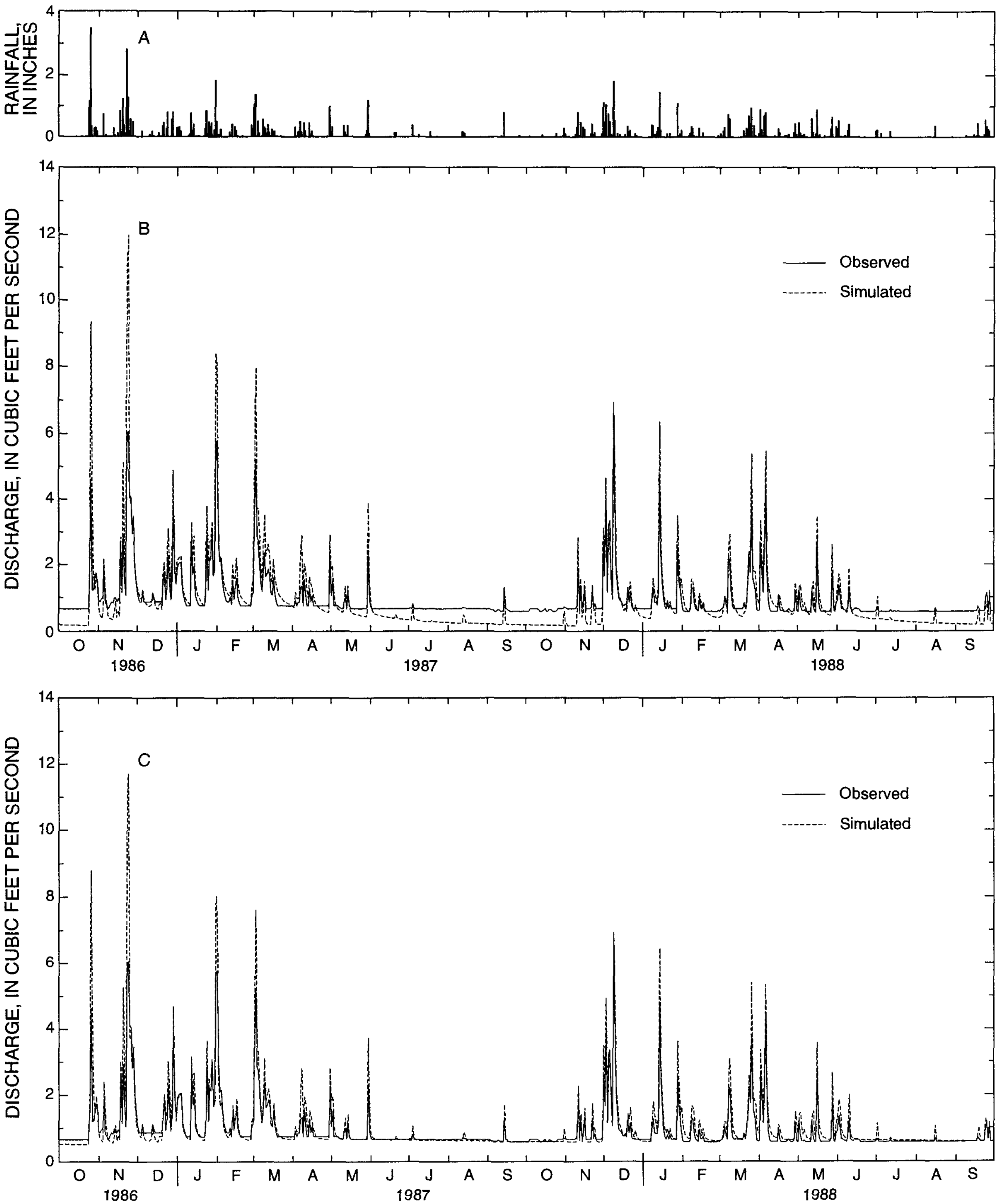

Figure 16. Observed rainfall (A) and observed and simulated daily mean discharge for Redondo Creek #1(station 12103210), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

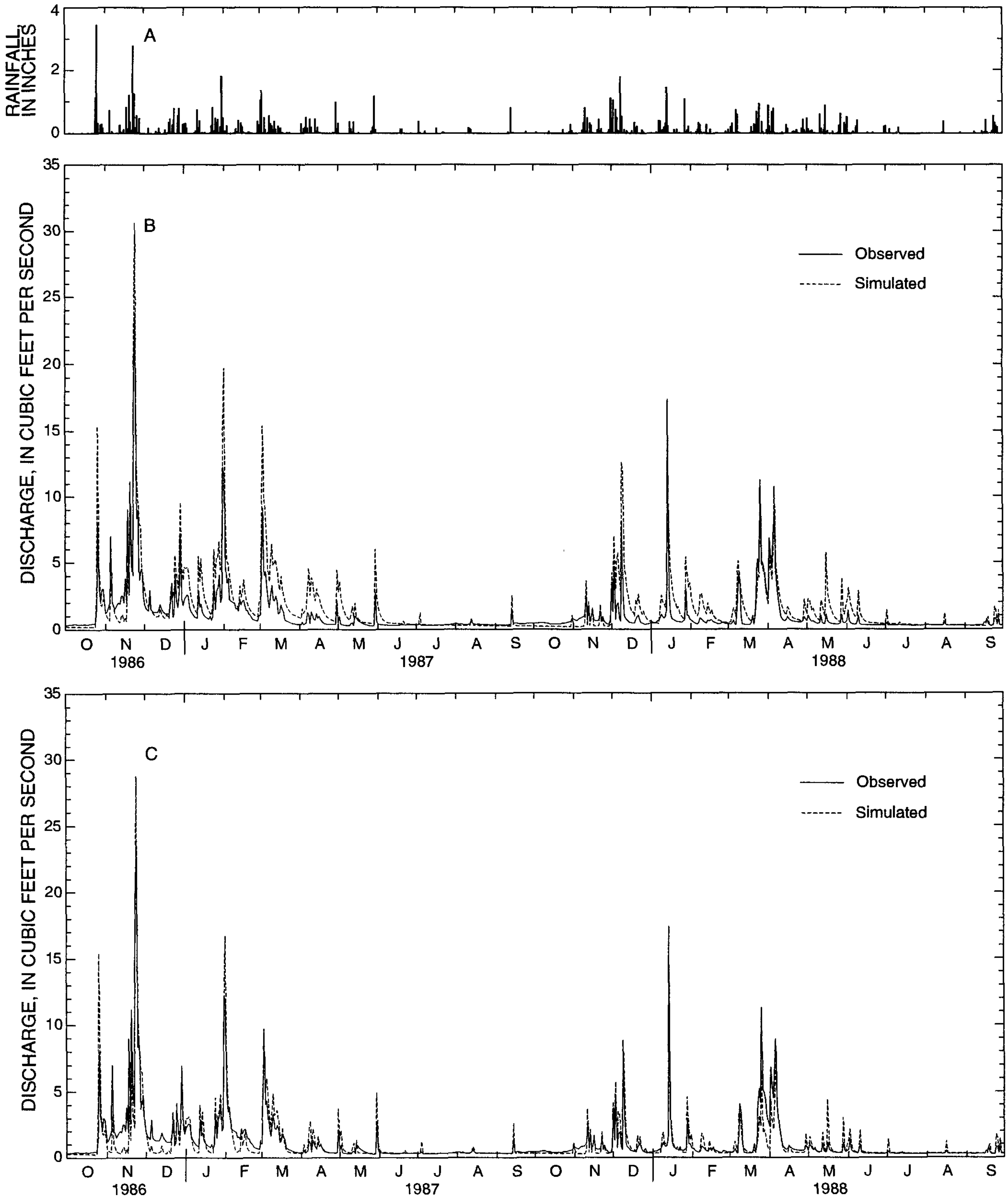

Figure 17. Observed rainfall (A) and observed and simulated daily mean discharge for Redondo Creek #2 (station 12103212), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

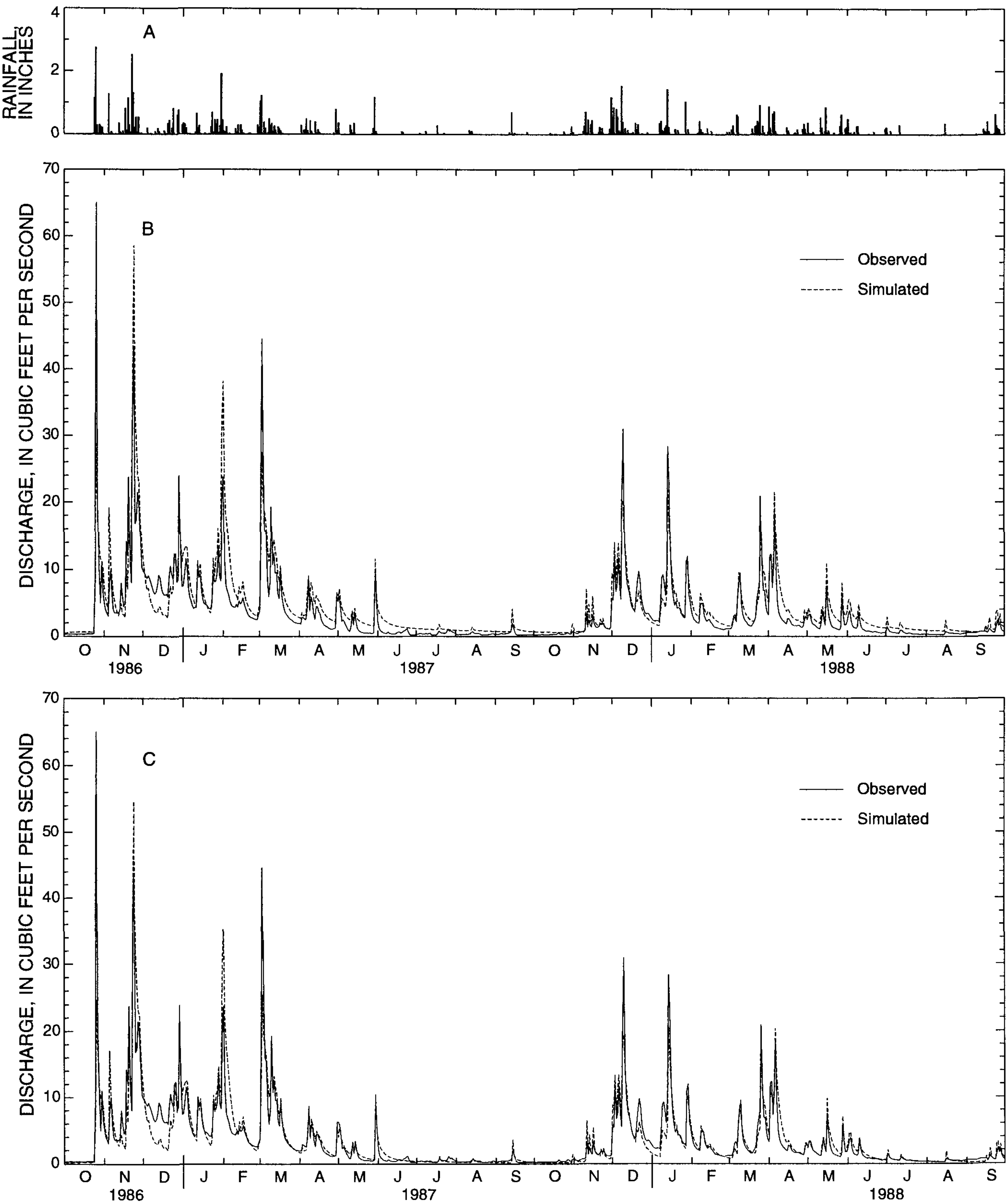

Figure 18. Observed rainfall (A) and observed and simulated daily mean discharge for Unnamed Creek at Saltwater State Park (station 12103220), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

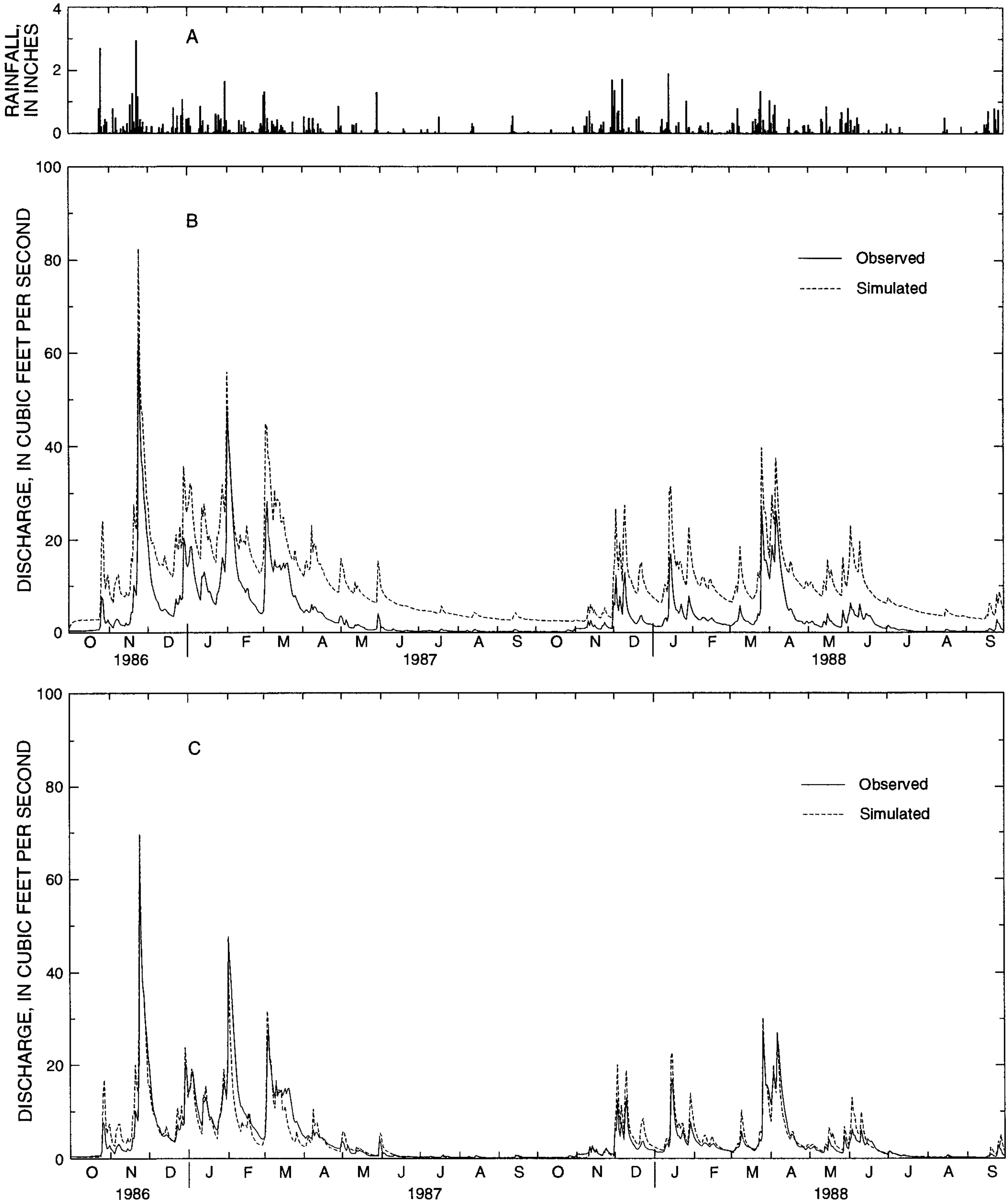

Figure 19. Observed rainfall (A) and observed and simulated daily mean discharge for Laughing Jacobs Creek (station 12121720), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

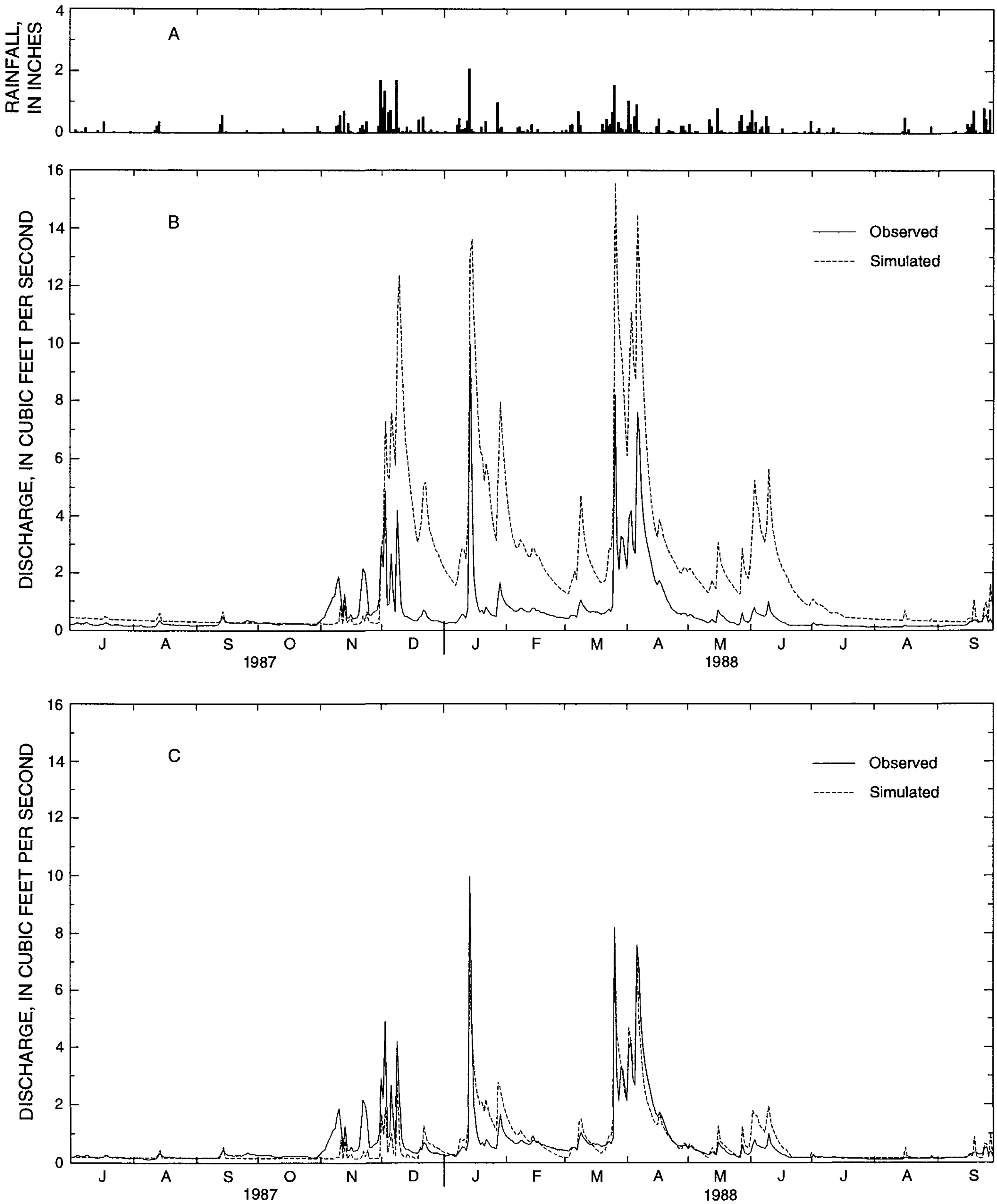

Figure 20. Observed rainfall (A) and observed and simulated daily mean discharge for Pine Lake Creek (station 12121815), July 1987 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

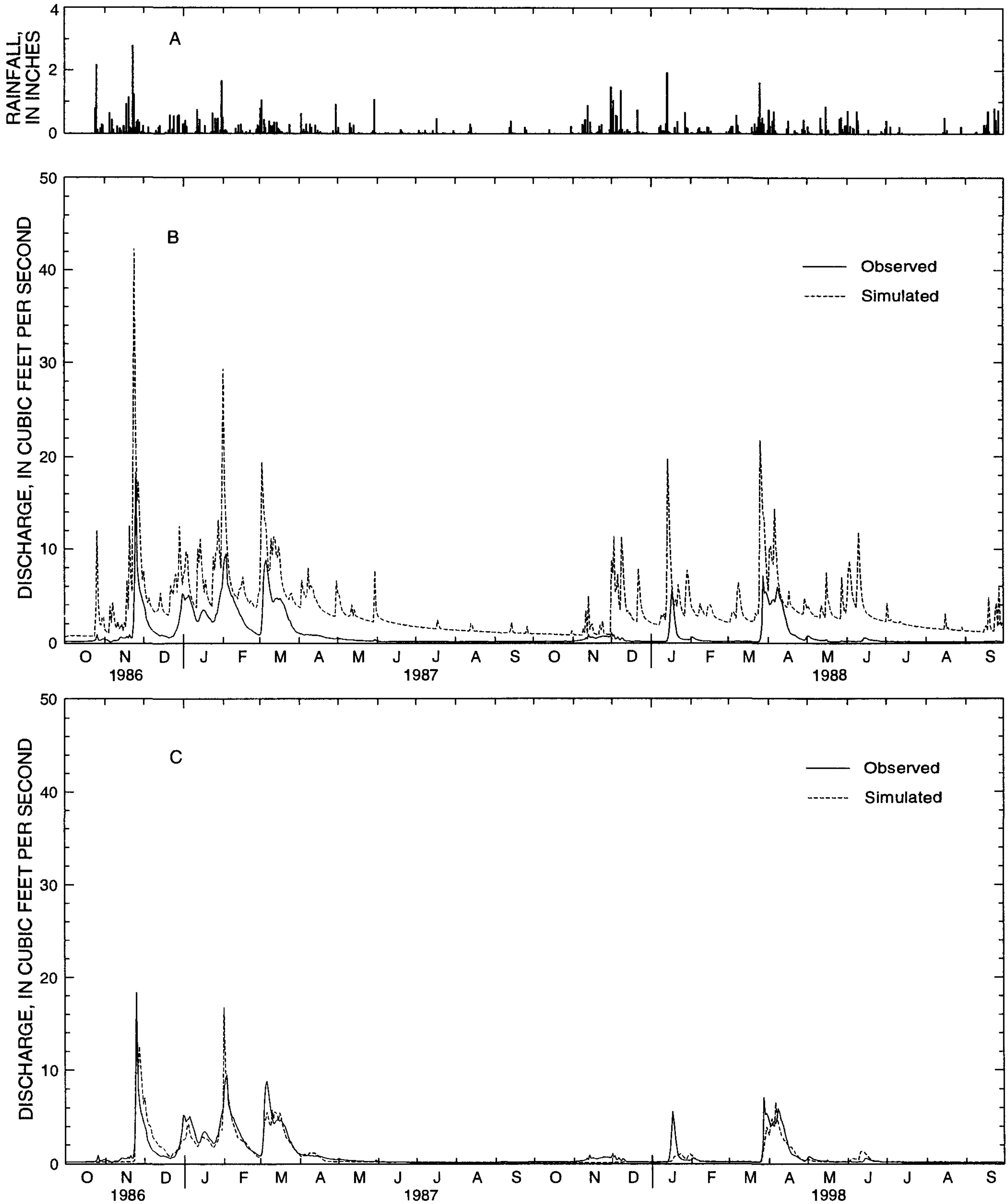

Figure 21. Observed rainfall (A) and observed and simulated daily mean discharge for Inglewood Creek (station 12121830), October 1986 - September 1988, for (B) the initial numerical model, and (C) the final numerical model.

Table 6. *Observed and simulated annual and seasonal runoff for the final models in the validation basins*

[Obs. = Observed value, in inches per unit area; Sim. = Simulated value, in inches per unit area; Difference = Sim. - Obs., in inches per unit area; Difference, percent = 100 x [(Sim. - Obs.)/Obs.], in percent]

Station number	Water year	Annual runoff[1]				Winter runoff[2]				Spring runoff[3]				Summer runoff[4]			
				Difference				Difference				Difference				Difference	
		Obs.	Sim.	Inches	Percent	Obs.	Sim.	Inches	Percent	Obs.	Sim.	Inches	Percent	Obs.	Sim.	Inches	Percent
12102900	1987	13.95	15.06	1.11	8.0	8.60	9.56	0.96	11.2	3.95	4.31	0.36	9.1	0.51	0.22	-0.29	-56.9
	1988	7.82	8.90	1.08	13.8	3.23	4.00	0.77	23.8	4.00	4.56	0.56	14.0	0.43	0.29	-0.14	-32.6
12102920	1987	9.95	10.68	0.73	7.3	5.96	6.41	0.45	7.6	2.70	3.03	0.33	12.2	0.27	0.30	0.03	11.1
	1988	6.96	7.25	0.29	4.2	3.32	3.53	0.21	6.3	3.11	3.25	0.14	4.5	0.38	0.40	0.02	5.3
12103000	1987	19.46	19.24	-0.22	-1.1	9.38	9.49	0.11	1.2	6.21	6.32	0.11	1.8	2.08	1.99	-0.09	-4.3
	1988	14.20	14.31	0.11	0.8	6.50	5.79	-0.71	-10.9	5.13	6.01	0.88	17.2	1.79	1.94	0.15	8.2
12103205	1987	26.57	27.08	0.51	1.9	12.57	12.15	-0.42	-3.3	8.47	9.45	0.98	11.6	3.69	3.60	-0.09	-2.4
12103207	1987	22.13	23.85	1.72	7.8	11.43	11.26	-0.17	1.5	5.40	7.71	2.31	42.8	3.48	2.94	-0.48	-14.0
12103210	1987	22.53	23.41	0.88	3.9	10.37	10.76	0.39	3.8	6.92	7.50	0.58	8.4	3.51	3.25	-0.26	-7.4
	1988	17.87	19.77	1.90	10.6	7.22	7.97	0.75	10.4	6.28	7.51	1.23	19.5	3.23	3.27	0.04	1.2
12103212	1987	16.83	16.16	-0.67	-4.0	11.22	9.28	-1.94	-17.3	3.50	4.50	1.00	28.6	1.12	1.12	0.00	0.0
	1988	10.61	10.13	-0.48	-4.5	4.11	4.40	0.29	7.0	5.10	4.21	-0.89	-17.5	0.92	1.18	0.26	28.7
12103220	1987	23.20	23.41	0.21	0.9	14.36	15.08	0.72	5.0	6.39	6.58	0.19	3.0	0.51	0.42	-0.09	-17.6
	1988	14.26	14.26	0.00	0.0	7.95	7.27	-0.68	-8.6	5.43	6.19	0.76	14.0	0.72	0.730	0.01	1.4
12121720	1987	12.91	12.42	-0.49	-3.8	8.84	8.45	-0.39	-4.4	3.72	3.45	-0.27	-7.3	0.12	0.10	-0.02	16.7
	1988	6.59	8.10	1.51	22.9	2.51	3.53	1.02	40.6	3.83	4.24	0.41	10.7	0.21	0.32	0.11	52.4
12121815	1988	5.30	5.27	-0.03	-0.6	2.24	1.99	-0.25	-11.1	2.62	2.84	0.22	8.5	0.32	0.35	0.03	9.4
12121830	1987	7.62	7.44	-0.18	-2.4	4.92	5.09	0.17	3.5	2.39	2.10	-0.29	-12.1	0.18	0.18	0.00	0.0
	1988	2.96	2.40	-0.56	-18.6	0.87	0.45	-0.42	-48.3	1.86	1.69	-0.17	-9.1	0.16	0.21	0.05	31.2

[1] Annual runoff is the total streamflow volume for each water year (October-September).
[2] Winter runoff is the total streamflow volume for each winter season (November-February).
[3] Spring runoff is the total streamflow volume for each spring season (March-June).
[4] Summer runoff is the total streamflow volume for each summer season (July-September).

Table 7. Observed and simulated storm runoff and peak discharges for the final models in the validation basins

[Obs. = Observed value, in inches per unit area for runoff and in cubic feet per second for discharges; Sim. = Simulated value, in inches per unit area for runoff and in cubic feet per second for discharges; Difference, inches = Sim. - Obs., in inches per unit area for runoff and in cubic feet per second for discharges; Difference, percent = 100 x [(Sim. - Obs.)/Obs.], in percent]

			Storm runoff				Peak discharge			
					Difference				Difference	
Station number	Datre of storm	Date of peak	Obs.	Sim.	Inches	Per-cent	Obs.	Sim.	Cubic feet per second	Per-cent
12102900	10/26-27/86	10/27/86	0.66	0.58	-0.08	-12.1	114.00	99.80	-14.2	-12.5
	11/23-24/86	11/24/86	1.19	1.21	0.02	1.7	176.00	191.00	15.0	8.5
	1/31-2/1/87	2/1/87	0.88	0.90	0.02	2.3	137.00	172.00	35.0	25.6
	12/9-10/87	12/9/87	0.62	0.46	-0.16	-25.8	114.00	98.30	-15.7	-13.8
12102920	11/23-25/86	11/24/86	1.26	1.31	0.05	4.0	112.00	120.00	8.00	7.1
	1/31-2/1/87	2/1/87	0.64	0.72	0.08	12.5	84.00	97.60	13.60	16.2
	12/9-11/87	12/9/87	0.67	0.61	-0.06	-9.0	81.80	68.10	-13.70	-16.7
	4/5-7/88	4/6/88	0.54	0.49	-0.05	-9.3	60.50	50.30	-10.20	-16.9
12103000	10/26-27/86	10/26/86	0.72	0.67	-0.05	-7.5	150.00	116.00	-34.00	-22.7
	11/23-24/86	11/24/86	1.23	1.13	-0.10	-8.8	224.00	183.00	-41.00	-18.3
	1/31-2/1/87	2/1/87	0.71	0.81	0.10	14.1	170.00	143.00	-27.00	-15.9
	12/9-11/87	12/9/87	0.67	0.65	-0.02	-3.0	120.00	96.80	-23.20	-19.3
12103205	10/26/86	10/26/86	0.50	0.44	-0.06	-12.0	110.00	115.00	5.00	4.6
	11/23-24/86	11/24/86	1.26	1.00	-0.26	-20.6	135.00	101.00	-34.00	-25.2
	1/31-2/1/87	1/31/87	0.76	0.71	-0.05	-6.6	106.00	89.70	-16.30	-15.4
	3/2-2/87	3/3/87	0.74	0.56	-0.18	-24.3	62.00	47.60	-14.40	-23.2
12103207	10/26-27/86	10/26/86	0.58	0.92	0.34	58.6	62.00	77.80	15.80	25.5
	11/23-24/86	11/23/86	1.32	1.34	0.02	1.5	73.00	64.10	-8.90	-12.2
	12/25-26/86	12/25/86	0.30	0.33	0.03	10.0	34.00	27.80	-6.20	-18.2
	1/24/87	1/24/87	0.14	0.21	0.07	50.0	30.00	24.00	-6.00	-20.0
12103210	10/26/86	10/26/86	0.27	0.48	0.21	77.8	14.00	37.60	23.60	169.0
	11/23-25/86	11/23/86	0.94	1.45	0.51	54.3	13.00	31.00	18.00	139.0
	1/31-2/1/87	1/31/87	0.67	0.85	0.18	26.9	19.00	28.50	9.50	50.0
	12/9/87	12/9/87	0.40	0.36	-0.04	-10.0	15.50	31.40	15.90	103.0
12103212	11/23-24/86	11/24/86	1.47	1.58	0.11	7.5	83.00	50.60	-32.40	-39.0
	1/31-2/1/87	2/1/87	0.81	0.96	0.15	18.5	47.00	38.20	-8.80	-18.7
	12/9/87	12/9/87	0.28	0.30	0.02	7.1	76.00	37.60	-38.40	-50.5
	1/14/88	1/14/88	0.59	0.29	-0.30	-50.8	50.80	19.50	-31.30	-61.6
12103220	11/23-24/86	11/24/86	1.13	1.29	0.16	14.2	147.00	89.70	-57.30	-39.0
	1/31-2/1/87	2/1/87	0.64	0.95	0.31	48.4	59.00	82.40	23.40	39.7
	3/1-3/87	3/3/87	1.28	0.84	-0.44	-34.4	63.00	41.40	-21.60	-34.3
	12/9-11/87	12/9/87	0.94	0.75	-0.19	-20.2	82.20	55.00	-27.20	-33.1
12121720	11/23-12/4/86	11/24/86	2.24	2.19	-0.05	-2.2	85.00	82.70	-2.30	-2.7
	2/1-8/87	2/1/87	1.58	0.92	-0.66	-41.8	57.80	48.00	-9.80	-17.0
	3/2-7/87	3/3/87	0.78	0.86	0.08	10.3	37.00	40.80	3.80	10.3
	3/25-28/88	3/26/88	0.45	0.49	0.04	8.9	39.80	38.30	-1.50	-3.8
12121815	12/3/87	12/3/87	0.10	0.04	-0.06	-60.0	14.30	8.00	-6.30	-45.0
	12/9-10/87	12/9/87	0.14	0.07	-0.07	-50.0	18.10	23.20	5.10	28.0
	1/14-15/88	1/14/88	0.20	0.22	-0.08	-26.7	20.80	14.60	-6.20	30.0
	3/26-27/88	3/26/86	0.23	0.25	0.02	8.0	16.40	16.70	-0.30-	1.8
12121830	11/24-25/86	11/25/86	0.39	0.33	-0.06	-15.4	24.20	14.30	-9.90	-40.9
	2/1-3/87	2/2/87	0.41	0.54	0.13	31.7	14.90	23.50	8.60	57.7
	3/3-11/87	3/5/87	0.86	0.63	-0.23	-26.7	10.50	6.26	-4.20	-40.4
	3/27-4/17/88	3/28/88	1.40	1.11	-0.29	-20.7	9.00	9.01	0.01	0.0

Table 8. Measures of errors in daily mean discharges simulated by the final models in the validation basins

Station number	Flow[1] regime	Mean absolute error[2]		Root-mean-square error[2]		Bias[2]	
		Average	Percent	Average	Percent	Average	Percent
12102900	Low	0.51	67.3	0.52	68.4	-0.46	-61.0
	Medium	1.01	69.7	1.49	98.2	0.50	24.8
	High	3.62	53.1	5.34	75.9	1.37	37.6
	Total	1.73	65.7	3.22	85.9	0.45	-1.0
12102920	Low	0.19	42.7	0.24	51.5	-0.12	-26.0
	Medium	0.48	46.5	0.65	69.4	-0.22	-18.6
	High	1.50	29.8	2.14	39.1	0.84	10.1
	Total	0.72	39.7	1.30	55.0	0.16	-11.4
12103000	Low	0.40	12.6	0.59	18.6	0.16	5.9
	Medium	0.91	18.1	1.18	22.9	-0.53	-10.7
	High	3.23	22.3	5.07	28.3	0.48	1.0
	Total	1.57	19.2	3.05	24.0	-0.02	-2.8
12103205	Low	0.50	17.1	0.64	22.3	0.25	8.3
	Medium	0.95	23.2	1.49	35.0	0.64	14.9
	High	2.98	23.9	5.87	33.0	-0.62	6.6
	Total	1.44	21.4	3.43	30.6	0.11	10.1
12103207	Low	0.22	14.7	0.35	23.6	0.04	3.3
	Medium	0.60	30.3	0.87	43.2	-0.01	-0.5
	High	2.23	45.0	3.20	55.1	0.64	7.4
	Total	1.01	30.0	1.92	42.6	0.22	3.4
12103210	Low	0.08	11.8	0.13	19.2	0.03	4.9
	Medium	0.31	28.9	0.46	40.5	0.20	16.9
	High	0.72	24.3	1.20	31.2	0.62	20.4
	Total	0.20	16.5	0.46	26.0	0.13	8.9
12103212	Low	0.04	15.1	0.06	20.1	0.03	11.2
	Medium	0.17	34.6	0.24	46.4	-0.03	-6.4
	High	1.05	49.3	1.53	60.8	-0.14	-0.2
	Total	0.42	33.2	0.90	45.8	-0.05	1.4
12103220	Low	0.15	42.3	0.22	58.7	-0.03	-4.6
	Medium	0.51	34.3	0.71	46.2	0.19	12.1
	High	2.41	28.0	4.29	37.4	-0.09	3.3
	Total	1.03	34.9	2.54	48.3	0.02	3.5
12121720	Low	0.14	44.3	0.29	64.8	0.02	8.4
	Medium	1.03	48.0	1.46	64.3	0.89	41.0
	High	2.86	30.7	4.06	40.0	-0.27	4.5
	Total	1.21	41.6	2.33	58.6	0.21	17.7
12121815	Low	0.02	15.8	0.04	26.3	0.01	10.2
	Medium	0.15	43.3	0.21	54.3	0.00	-2.3
	High	0.61	55.0	0.85	74.1	-0.04	14.4
	Total	0.25	38.3	0.49	55.0	-0.01	6.8
12121830	Low	0.04	27.0	0.04	30.1	0.01	12.3
	Medium	0.12	46.6	0.21	90.2	-0.01	1.4
	High	0.84	42.0	1.40	53.2	-0.21	-9.7
	Total	0.33	37.5	0.81	59.6	-0.07	1.9

[1] Low, medium, and high flow regimes are the lower, middle, and upper thirds of the flow duration curve of daily mean discharge values from each station. Total refers to the complete 1- or 2-year record of daily mean flow at the station.

[2] See table 4 footnotes for explanation of error measures.

Table 9. Systematic modifications made to the initial numerical models for the validation basins

Basin name	Modification			
	Ground-water contribution to streamflow	Ground-water discharge rate	Upslope interflow runoff routed to outwash deposits	Other
East Branch Hylebos Creek	X	X		
West Branch Hylebos Creek	X	X	X	
Joes Creek	X	X	X	
Lakota Creek	X	X	X	
Redondo Creek #1	X	X	X	
Redondo Creek #2	X	X	X	
Unnamed Creek at Saltwater State Park	X	X		
Laughing Jacobs Creek	X	X		
Pine Lake Creek	X	X	X	X[1]
Inglewood Creek	X	X	X	X[2]

[1] Values for INFILT and INTFW parameters were changed.
[2] Overland flow, in addition to interflow, was routed to outwash deposits.

Table 10. Measures of composite errors in model-simulated annual runoff, seasonal runoff, storm runoff, peak discharges, and daily mean discharges for the 11 stream gages in the validation basins

Data set name	Mean absolute[1] error		Root-mean-[2] square error		Bias[3]	
	Average	Percent	Average	Percent	Average	Percent
Annual runoff	[4]0.67	6.2	0.87	8.8	-0.39	-2.5
Winter runoff	0.57	11.9	0.71	17.2	-0.05	-0.8
Spring runoff	0.61	13.2	0.80	16.2	-0.44	-8.4
Summer runoff	0.12	15.9	0.18	23.0	0.04	0.2
Storm runoff	0.14	21.6	0.20	28.7	0.02	-0.2
Peak discharge	16.42	31.6	20.70	45.5	7.31	0.5
Daily mean discharge[5]						
Low flow	0.18	28.8	0.31	42.1	-0.02	-2.6
Medium flow	0.59	39.4	0.97	61.2	0.11	5.7
High flow	2.08	37.0	3.67	51.1	0.25	7.7
Total	0.89	35.1	2.11	52.3	0.10	3.0

[1] Let,

S = simulated value;

O = Observed value; and

N = number of values in the sample.

Then,

Mean absolute error, average = $\Sigma[|S - O|/N]$; and

Mean absolute error, percent = $100 \times \Sigma\{[|S - O|/O]/N\}$.

[2] Root mean square error, average = $\sqrt{\Sigma[(S - O)^2/N]}$.

Root mean square error, percent = $100 \times \sqrt{\Sigma[(S - O^2/O)/N]}$.

[3] Bias, average = $\Sigma[(S - O)/N]$.

Bias, percent = $100 \times \Sigma\{[(S - O)/O]/N\}$.

[4] Average runoff errors are reported in inches per unit area. Average discharge errors are reported in cubic feet per second.

[5] Low, medium, and high flow regimes are the lower, middle, and upper thirds of the flow duration curve of daily mean discharge values, in cubic feet per second, from each station. Total refers to the complete 2-year or 1-year records of daily mean flows at all stations.

Results for Individual Basins

Initial and final model results, as well as modifications to each basin model are described below. More detailed information on each basin model is presented in the schematic diagrams of the final modified model networks (figs. 25-33 at back of report) and in the complete listings of the final HSPF input files (Appendix A).

Hylebos Creek Basins

There were three stream gages in the Hylebos Creek basin (fig. 8)—one on the East Branch (station 12102900) and two on the West Branch (stations 12102920 and 12103000). Two separate numerical models were constructed for these basins, one for the East Branch basin and one for the West Branch basin. The simulation results for these basins typify the results for many of the validation basins: after all three of the previously described modifications were applied to these models, the simulations dramatically improved.

East Branch Hylebos Creek

The initial simulation results in the East Branch basin were poor with respect to the annual water balance (fig. 11b); annual runoff was oversimulated by about 100 percent. Simulation of storm runoff and peak flow was good; volume errors ranged up to 20 percent, and peak flow errors ranged up to 34 percent. To correct the errors, the simulated ground-water contribution was reduced, and the simulated daily rate of decrease in ground-water discharge was reduced.

The final simulation results were mostly improved after those modifications (fig. 11c). Annual runoff errors were reduced to less than 14 percent (station 12102900, table 6), and storm runoff and peak flow errors changed little (table 7). The root-mean-square error for daily mean discharges from the final simulation was 86 percent (table 8). That was primarily due to poor simulation of flow between storms and during the dry season.

West Branch Hylebos Creek

The initial simulation results in the West Branch Hylebos Creek basin were poor at the upstream stream-gage site (fig. 12b) and only marginally better at the downstream stream gage (fig. 13c). Annual runoff was oversimulated by more than 100 percent at the upstream gage and by about 25 percent at the downstream gage. Storm runoff and peak flows were generally oversimulated by lesser quantities at both sites. To correct the errors, the simulated ground-water contribution was greatly reduced for the upper basin and slightly reduced in the lower basin, and the simulated daily rate of decrease in ground-water discharge was reduced for both sites.

Simulation results were still poor after those modifications. Even when no ground water was allowed to discharge in the upper basin, annual runoff and storm runoff at the upper gage were oversimulated by about 50 percent, and summer baseflow was undersimulated. Annual runoff was well simulated at the upper gage, but baseflow was undersimulated.

Given that the upper basin is composed of till-mantled hillslopes upslope from a valley filled with outwash deposits, the initial model was further modified to represent the downslope infiltration of interflow runoff from till areas. The following procedure used to modify the initial model was also used, when appropriate, to modify initial models for most other basins. A new land segment called a "ground-water reservoir" was defined, and its area was set equal to the main valley-fill area of outwash deposits in the basin. Inflows to the ground-water reservoir came from four sources: percolation from the outwash land segments that overlie it, ground-water outflows from both the till land segments and the saturated land segments in the upper basin, interflow from till land segments that drain downslope directly to the valley-fill, and seepage from Panther Lake (a lake that overlies part of the valley-fill). Direct precipitation was not applied to the ground-water reservoir because the segment represented subsurface deposits. All direct overland flow was allowed to drain into stream channels directly. Some discharge from the ground-water reservoir was directed to the perennial reach of channel in the upper basin, a larger quantity was directed to the spring-fed reach downstream from the upper stream gage, and the remainder was directed as recharge to deeper ground-water systems. Ground-water contributions to each receiving reach or to the deep ground-water system, and ground-water discharge rates were determined through comparison of simulated to observed flows at both stream-gage sites.

The final simulation results were much improved (figs. 12c and 13c); annual runoff errors for both years at both stream gages (stations 12102920 and 12103000) were reduced to less than 10 percent (table 6). Storm runoff errors were less than 15 percent, and peak flow errors were less than 23 percent (fig. 22 and table 7). Finally, the root-mean-square errors of simulated daily mean discharges were less than 31 percent for both stream gages (table 8).

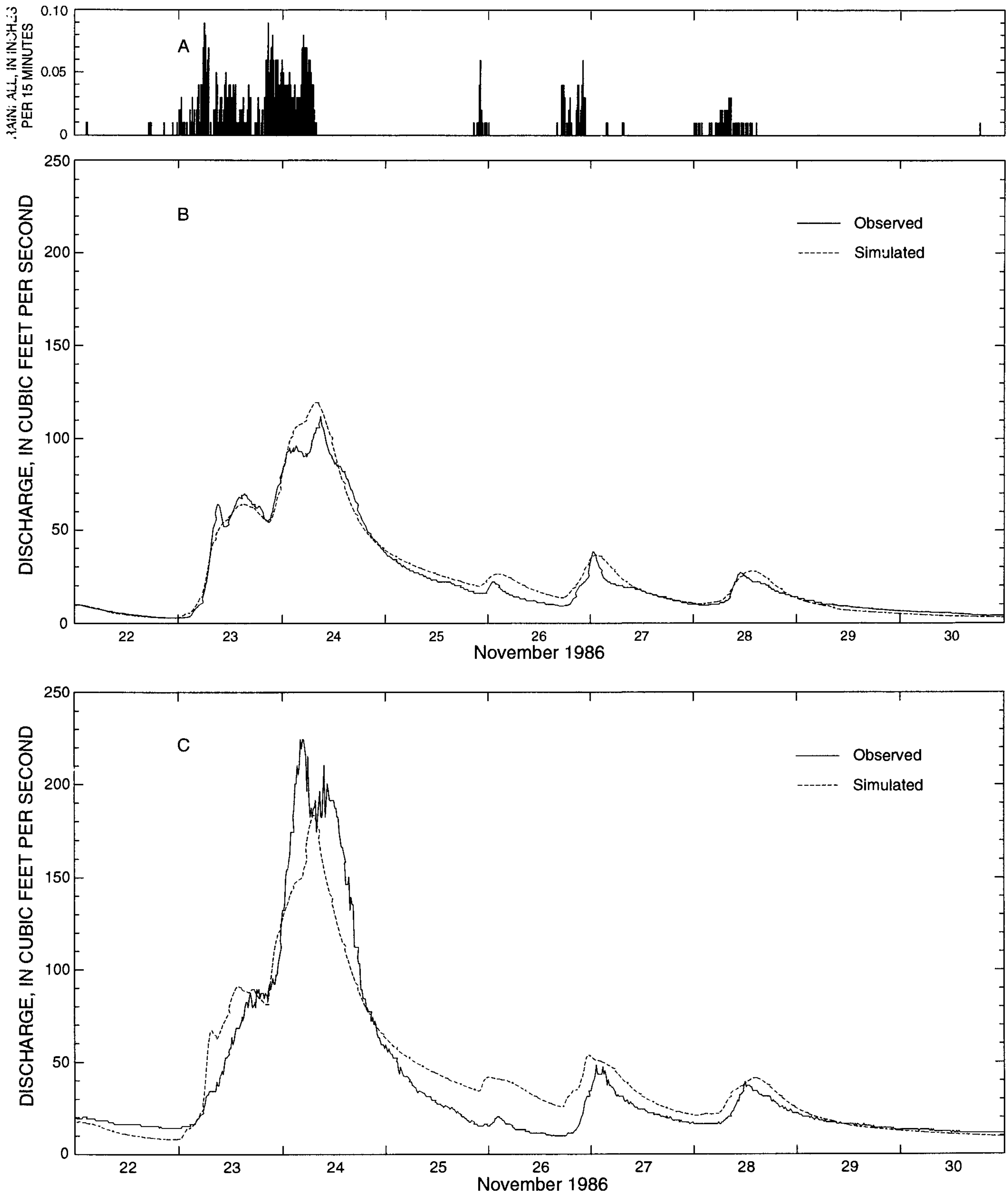

Figure 22. Observed rainfall (A) and observed and simulated discharge for (B) the upper stream gage (station 12102920), and (C) the lower stream gage (station 12103000), on West Branch Hylebos Creek, storm period November 22-30, 1986, for the final numerical model.

Lower Puget Sound Basins

There were five separate basins and stream gages in the Lower Puget Sound group: Joes Creek (station 12103205), Lakota Creek (station 12103207), Redondo Creek #1 (station 12103210), Redondo Creek #2 (station 12103212), and Unnamed Creek at Saltwater State Park (station 12103220). A separate numerical model was constructed for each basin.

Joes Creek

The initial simulation results in Joes Creek appeared to be fair (fig. 14b); annual runoff errors were within 5 percent and storm runoff and peak discharge errors were within 22 percent. However, much of the observed low- and medium-flow discharge record for this basin was estimated rather than measured. Although the observed hydrologic data was questionable, the geologic data for the basin clearly showed that the model should be modified to simulate drainage from till-mantled hillslopes to outwash deposits in the valley. The modifications were made by the previously described "ground-water reservoir" procedure. Also, the simulated ground-water contribution was reduced slightly, and the simulated daily rate of decrease in ground-water discharge was reduced.

The final simulation results were somewhat mixed (fig. 14c); annual runoff error was decreased to less than 2 percent (station 12103205, table 6), but storm runoff errors increased slightly to 24 percent, and peak flow errors increased slightly to 25 percent (table 7). The root-mean-square error of simulated daily mean discharges decreased to less than 31 percent (table 8).

Lakota Creek

The initial simulation results for Lakota Creek were poor with respect to annual runoff and storm runoff and were fair with respect to peak flows (fig. 15b); annual runoff was oversimulated by 29 percent, storm runoff was oversimulated by up to 79 percent, and peak flow errors ranged from -17 to 25 percent. Although the observed discharge record from this basin was rated poor, the initial results and the geologic data suggested that the model should be modified to simulate drainage from till-mantled hill-slopes draining to outwash deposits in the valley. The modifications were made by the previously described "ground-water reservoir" procedure. Also, the simulated ground-water contribution was reduced, and the simulated daily rate of decrease in ground-water discharge was reduced.

Simulation results from the final model were mostly improved (fig. 15c). Annual runoff errors were reduced to 8 percent (station 12103207, table 6), storm runoff errors were reduced to less than 59 percent, and peak flows were mostly unchanged (table 7). The root-mean-square error of simulated daily mean discharges was 43 percent (table 8).

Redondo Creek #1

The initial simulation results for Redondo Creek #1 were good with respect to annual runoff; errors were within 11 percent. However, the simulation of baseflow, storm runoff, and peak flows was poor (fig. 16b); those errors were only within 59 percent, 100 percent, and 171 percent, respectively. These results and the geologic data showed that the model should be modified to simulate drainage from till-mantled hillslopes to outwash deposits in the valley. The modifications were made using the "ground-water reservoir" procedure. Also, the simulated ground-water contribution was slightly increased, and the simulated daily rate of decrease in ground-water discharge was reduced.

The three systematic modifications improved the baseflow simulation and the simulation of runoff between storms, but did not improve the 50 to 171 percent oversimulation errors for peak discharges, so the model was further modified to assess peak flow errors. The observed data suggested that these errors resulted from the oversimulation of overland flow and that the potential sources of overland flow in the model were effective impervious areas and flat-sloping till land segments. In order to determine which source was most significant, the parameter values for the flat-sloping till land segments were changed to those values used for the moderately sloping till land segments, thereby eliminating the till land segments as significant sources of overland flow. The simulation errors were unchanged, so the error in the final model was mostly due to the oversimulation of effective impervious area runoff.

The final simulation results (fig. 16c) improved following the three systematic modifications, but the modification of other parameter values had little effect. Annual runoff errors were still less than 11 percent, and summer runoff errors were reduced to less than 8 percent (station 12103210, table 6). Simulated storm runoff errors were greater than 50 percent for two out of four cases, and simulated peak discharge errors were greater than 100 percent for three out of four cases (table 7). The root-mean-square error of simulated daily mean discharges was 26 percent (table 8).

Redondo Creek #2

The initial simulation results for Redondo Creek #2 were poor (fig. 17b); annual runoff was oversimulated by 45 to 53 percent, and peak flows were undersimulated by up to 57 percent. To correct the annual runoff and baseflow errors, the simulated ground-water contribution was reduced and the simulated daily rate of decrease in ground-water discharge was reduced. Outwash deposits do not fill the valley in this basin, so downslope infiltration of interflow was not suspected.

The final simulation results, with the exception of peak flows, were significantly improved (fig. 17c). Simulation errors for annual runoff from the final model were reduced to less than 5 percent (station 12103212, table 6), and the root-mean-square error for the simulation of daily mean discharge was reduced from 120 to 46 percent (table 8). The results of the storm simulations were mixed (table 7). Three out of four simulated storm runoff volumes were within 20 percent of observed volumes, but all four peak discharges were still undersimulated by 19 to 62 percent.

Unnamed Creek at Saltwater State Park

The initial simulation results for Unnamed Creek at Saltwater State Park were fair (fig. 18b); annual runoff was oversimulated by 16 to 24 percent, and peak flow errors were all within 50 percent. To correct the annual runoff and baseflow errors, the simulated ground-water contribution was reduced and the simulated daily rate of decrease in ground-water discharge was reduced. Outwash deposits do not fill the valley in this basin, so downslope infiltration of interflow was not suspected.

The final simulation results were improved (fig. 18c). Simulation errors for annual runoff from the final model were reduced to less than 1 percent (station 12103220, table 6), and the root-mean-square error for the simulation of daily mean discharge was reduced from 90 to 48 percent (table 8). The results of the storm simulations changed little. Simulated storm runoff volumes were within 48 percent of observed, and simulated peak flows were within 40 percent of observed (table 7).

East Lake Sammamish Basins

There were three separate basins and stream gages in the East Lake Sammamish group: Laughing Jacobs Creek (station 12121720), Pine Lake Creek (station 12121815), and Inglewood Creek (station 12121830). A separate numerical model was constructed for each basin, and the initial simulation results for the basins varied widely.

Laughing Jacobs Creek

The initial simulation results for Laughing Jacobs Creek were poor (fig. 19b); annual runoff and storm runoff were oversimulated by more than 100 percent. To correct the annual runoff and baseflow errors, the simulated ground-water contribution was greatly reduced, and the simulated daily rate of decrease in ground-water discharge was reduced.

The final simulation results improved after those modifications (fig. 19c). Annual runoff errors were reduced to 4 and 23 percent (station 12121720, table 6), and the root-mean-square error for daily mean discharge was 59 percent (table 8). The results of the storm simulations were generally good (table 7); three out of four simulated storm runoff volumes were within 11 percent of observed, and all four peak discharges were within 20 percent of observed peaks. Although there were extensive outwash deposits in upper parts of this basin, the good match between the observed and simulated hydrographs showed that additional modifications to the model were not needed. Even though interflow from till areas may have been infiltrated into those outwash deposits, the storm runoff was greatly attenuated by the many lakes and wetlands in the upper part of the basin. Thus, the effects of downslope infiltration of interflow on streamflow at the basin outlet were masked.

Pine Lake Creek

The initial simulation results for Pine Lake Creek were poor (fig. 20b); annual runoff was oversimulated by more than 100 percent. To correct the annual runoff and baseflow errors, the simulated ground-water contribution was greatly reduced and the simulated daily rate of decrease in ground-water discharge was reduced, but annual runoff was still oversimulated and storm runoff simulations were poor. Even when no ground-water contributions to streamflow were allowed, annual runoff was still oversimulated. Although these results suggested that the simulation could be improved by routing interflow into outwash deposits, the limited outwash deposits shown on the available geologic and soils maps suggested the phenomenon could not be important in this basin. It was assumed that the available geologic information was correct, so the generalized parameter values were modified to examine the source of the error. Because the predominant land-segment types in the basin were associated with till, the parameter values for those land segments were manipulated.

Reasonable simulation results were obtained after the value of the infiltration (INFILT) parameter for till land segments was increased by a factor of five and the value of the interflow index (INTFW) parameter for till land segments was decreased by a factor of 10 (fig. 20c). The volume and timing of simulated runoff from till land segments using these modified parameter values were almost identical to the volume and timing of runoff from outwash land segments. The final simulation errors from the model with the modified till land-segment parameter values were improved; annual and seasonal runoff errors were less than 12 percent (station 12121815, table 6). The simulation errors for storm runoff and peak flows were within 65 percent and 45 percent, respectively (table 7), and the root-mean-square error for daily mean discharge was 55 percent (table 8).

Inglewood Creek

The initial simulation results for Inglewood Creek were poor by all measures (fig. 21b). Both the observed streamflow record and the geologic data suggested that interflow from till could infiltrate into the extensive outwash deposits, so the initial model was modified using the "ground-water reservoir" procedure to simulate the process. Also, the simulated ground-water contribution was dramatically decreased, and the simulated daily rate of decrease in ground-water discharge was reduced. Although the simulated low flows were improved, simulated storm runoff remained poor; rapid runoff was oversimulated and sustained, medium flows after some storm periods were undersimulated, and runoff was simulated from some storms when none was observed. Field observations found that even the channelized overland flow in tributaries draining the till-mantled hillslopes in this basin was often infiltrated into outwash deposits. Also, observed streamflow and rainfall data showed that there were relatively few runoff events in this basin relative to the number of rainfall events. An attempt was made to further modify the numerical model to simulate those observations adequately.

The original conceptual model did not fully explain the data observed in this basin, so the conceptual model was modified as follows. When the water table was low in the outwash deposits filling the Inglewood Creek valley, most runoff from both the till-mantled hillslopes and the impervious areas was subsequently infiltrated. A small portion of this recharge discharged to the perennial channel near the basin outlet, but most either remained in storage or recharged the deep ground-water system. Increased recharge from winter storms caused the water table to rise nearer the ground surface. When the water table rose to the altitude of the mainstem channel, ground water discharged to the stream and channel infiltration was curtailed. Drainage of ground water into the incised channels kept the valley from becoming fully saturated, so the streamflow response was not necessarily rapid. In support of this conceptual model, the observed hydrograph trace (fig. 21b) showed no response to fall rainfall, and the response to winter rainfall was greatly attenuated.

This modified conceptual model was incorporated into the final numerical model for this basin by using the reach-reservoir (RCHRES) routine of HSPF to simulate the ground-water reservoir in the outwash deposits; the PERLND routines used to simulate ground-water reservoirs in other basins were not suitable here because they could not simulate the onset of runoff when the water table rose to a critical altitude. The ground-water reservoir was defined to represent the outwash deposits in the mainstem valley of the basin (fig. 4). Inflows to the reservoir were overland flow and interflow from upslope land segments, discharge from upstream channel reaches, and recharge from the outwash land segments that overlie the reservoir. Direct precipitation was not applied to the reservoir because it represented subsurface outwash deposits. Outflows from the reservoir were directed to a deep ground-water system and to downstream reaches.

The flow tables (FTABLES) for the ground-water reservoir—the HSPF input data that describe storage-discharge relations—were constructed with the following features. The first outflow defined in the tables represented the drainage of stored water to a deep ground-water system. This outflow was relatively small and constant over all storage levels. A second outflow represented discharge to downstream reaches. This outflow increased slowly with increasing storage when storage levels were low, but it increased rapidly with small increases in storage once most of the storage in the ground-water reservoir was filled. The storage level at which the rapid increase in discharge began represented the altitude where ground-water discharge contributed to streamflow. The geometry of the ground-water reservoir, as well as the relation between storage and both of the outflows, was estimated entirely by matching simulated and observed streamflow.

The final simulation results showed that the general response of streamflow to rainfall was well simulated (fig. 21c). Simulated annual and seasonal runoff were usually within 20 percent of observed runoff (station 12121830, table 6), and the root-mean-square error for the simulation of daily mean discharge was about 60 percent (table 8). Simulated storm runoff and peak flows were within 1 to 60 percent of observed data (table 7).

DISCUSSION OF RESULTS

Most measures of the composite errors for the final validation simulations (table 10) were similar to those reported for the calibration basins (table 4), and the differences were not large enough to reject the validity of the numerical modeling method, as modified in this report. Two error measures from the validation were significantly greater than those for the calibration: errors for daily mean discharges were about 10 percent greater, and peak flow errors were about 25 percent greater. Those differences can be mostly attributed to less accurate observed streamflow data for the validation basins. The final validation results were unbiased, suggesting that the systematic modifications corrected the pervasive deficiencies in the modeling method.

The recurrent simulation errors, as well as other nonrecurring errors, highlighted shortcomings in all four components of the numerical modeling method. The modifications used in this investigation corrected problems in the conceptual model, in the model construction approach, and in some of the generalized parameter values, but limitations related to the HSPF program were merely identified. An important finding for the modeling method as a whole was that at least some observed streamflow data were needed to correct the problems; the simulation errors would have been much larger if the observed data were not available. This topic is discussed further in the "Guidelines for Application" section of this report.

The recurrent errors related to ground-water contributions and discharge rates showed that the original model construction approach and the generalized values for the AGWRC and KVARY parameters were invalid for the study area as a whole. The original guidelines for delineating ground-water discharge zones worked well for the calibration basins, but they worked poorly for the validation basins. This was probably because most ground-water recharge did contribute to streamflow above the gaging sites in the generally larger calibration basins, but much recharge in the smaller validation basins emerged somewhere below the gage sites. The validity of using the generalized values for the parameters AGWRC and KVARY had been questioned in the calibration report, and the values resulted in consistently poor baseflow simulations in this investigation. As discussed previously, the different land-segment types defined for the numerical models did not adequately represent the areal variation in ground-water discharge rates because land-segment types were not defined to represent the relation between surficial physiography and ground-water discharge rate.

The modification of ground-water contributions and discharge rates in the numerical models relied entirely on observed streamflow data, and no discernible relation was found between surficial drainage basin characteristics and the quantity and timing of ground-water discharge. For example, streams draining the East Lake Sammamish and Lower Puget Sound basins all originated on till-mantled uplands, and they all cut down completely through the till deposits on their way to their outlets. When similar settings were found in the calibration basins, it was observed that most recharge within such basins discharged from springs emerging from deposits either above or immediately below the till. However, measured ground-water discharge as a percentage of recharge was less than 10 percent in the East Lake Sammamish basins, and it ranged from less than 20 percent to greater than 100 percent in the Lower Puget Sound basins. (Basins where ground-water discharge was greater than 100 percent of recharge receive ground-water contributions from outside of their topographic boundaries.) Also, although the generalized values for KVARY and AGWRC gave at least somewhat consistent results for the calibration basins, different values for those parameters gave equally consistent results in the validation basins. Thus it was concluded that calibration to observed streamflow data was the only available method to accurately simulate ground-water discharge characteristics in the validation basins. The minimum amount of data required is discussed in the "Guidelines for Application" section of this report.

The recurrent errors related to downslope infiltration of runoff into outwash deposits showed that the importance of this phenomenon was understated in the conceptual model, that it was not adequately addressed in the model construction approach, and that there are limitations in HSPF for simulating the phenomenon.

Downslope infiltration of runoff was important at only 2 out of 21 sites in the calibration basins, so it was not recognized to be a widespread phenomenon, and methods to simulate it were not described in the model construction approach. However, it was important in at least 5 out of 11 validation basins, so the model construction approach was modified accordingly.

The model modifications needed to simulate this phenomenon relied heavily on observed streamflow data, and limitations in using HSPF to do the simulations were identified. HSPF explicitly simulates runoff generation for all land segments within a basin, but it does not explicitly simulate the path that runoff follows from its point of generation to its eventual appearance in a stream channel. Hence, the simulated runoff from any land segment is not explicitly affected by the runoff from any other land segment. In basins that do not have extensive outwash deposits, results showed that this simplification was reasonable. However, in basins that do have extensive outwash deposits, results showed the simplification to be inadequate. The modifications to the model construction approach showed that HSPF could be adapted to more accurately simulate streamflow in such basins, but the modifications were highly empirical, and the actual processes controlling the infiltration of upslope runoff were not simulated. This limitation has important implications for predicting the effects of land-use changes on streamflow, as discussed in the "Guidelines for Application" section of this report.

The peak-flow simulation errors unique to the two adjacent Redondo Creek basins highlighted possible shortcomings in applying the numerical modeling method to small, highly urbanized basins. The errors in the Redondo Creek #1 model resulted from too much impervious area runoff simulated in the basin, and the errors in the Redondo Creek #2 model would have been reduced if more impervious area runoff had been simulated. It is possible that some of the impervious area within the topographic boundaries of the Redondo Creek #1 basin actually discharges runoff to Redondo Creek #2. The upstream areas in these basins are highly urbanized and they have mild relief, so it would not be unlikely that the man-made drainage divide differs from the measured topographic divide. A field inspection of these areas could not discern the basin boundary defined by storm-drainage system. An alternate explanation for those peak-flow errors is that the effective impervious area (EIA) estimates were inaccurate in those particular basins. The EIA estimates produced reasonable simulation results for other basins, but the Redondo Creek basins have the smallest drainage areas, so any local variation in the area-wide relation between total and effective impervious area could lead to large simulation errors. A final alternate explanation is that the generalized parameter values for impervious area runoff were not valid in these basins. However, the simulation of impervious area runoff is insensitive to changes in the few process-related parameters that control it.

The poor storm-runoff simulations unique to the Pine Lake Creek basin highlighted some undetermined shortcomings in the numerical modeling method. The streamflow response observed in this predominantly till-covered basin was indicative of extensive outwash deposits. The generalized parameter values for till land segments that had worked well in most other basins (see fig. 23 for an example from the adjacent Laughing Jacobs Creek basin) did not work well in Pine Lake Creek basin. A possible explanation for this is that the soils and geology are inaccurately mapped in this basin, and that there are actually more outwash deposits in the basin than maps showed. An alternate explanation is that the soils in this basin have characteristics that lay between the defined till and outwash soils. The soil depth overlying the basal till varies across the study area; most till soils are 3-feet deep, but others are up to 6-feet deep soils before they are mapped as outwash soils. An additional 3 feet of soil would result in a runoff response that would be better represented by the outwash land-segment parameter values. Regardless of the explanation, these simulation errors alone were not convincing evidence for invalidating the generalized parameter values. They were, however, indicative of the varied results to be expected from using a generalized approach toward modeling complex and unique watersheds. Again, the most reliable way to avoid uncertainties in such cases is to collect some observed streamflow data to validate the parameter values in the particular basin of interest.

The storm-runoff simulation errors unique to Inglewood Creek basin highlighted additional limitations in using the HSPF program to simulate complex ground-water surface-water interactions. The modifications to the numerical model greatly improved stormflow simulations, but even the modified model failed to produce good simulations of the timing of runoff pulses and peaks during the prolonged wet periods (fig. 24). These results showed that the representation of the ground-water surface-water interactions by the RCHRES routines in HSPF was oversimplified.

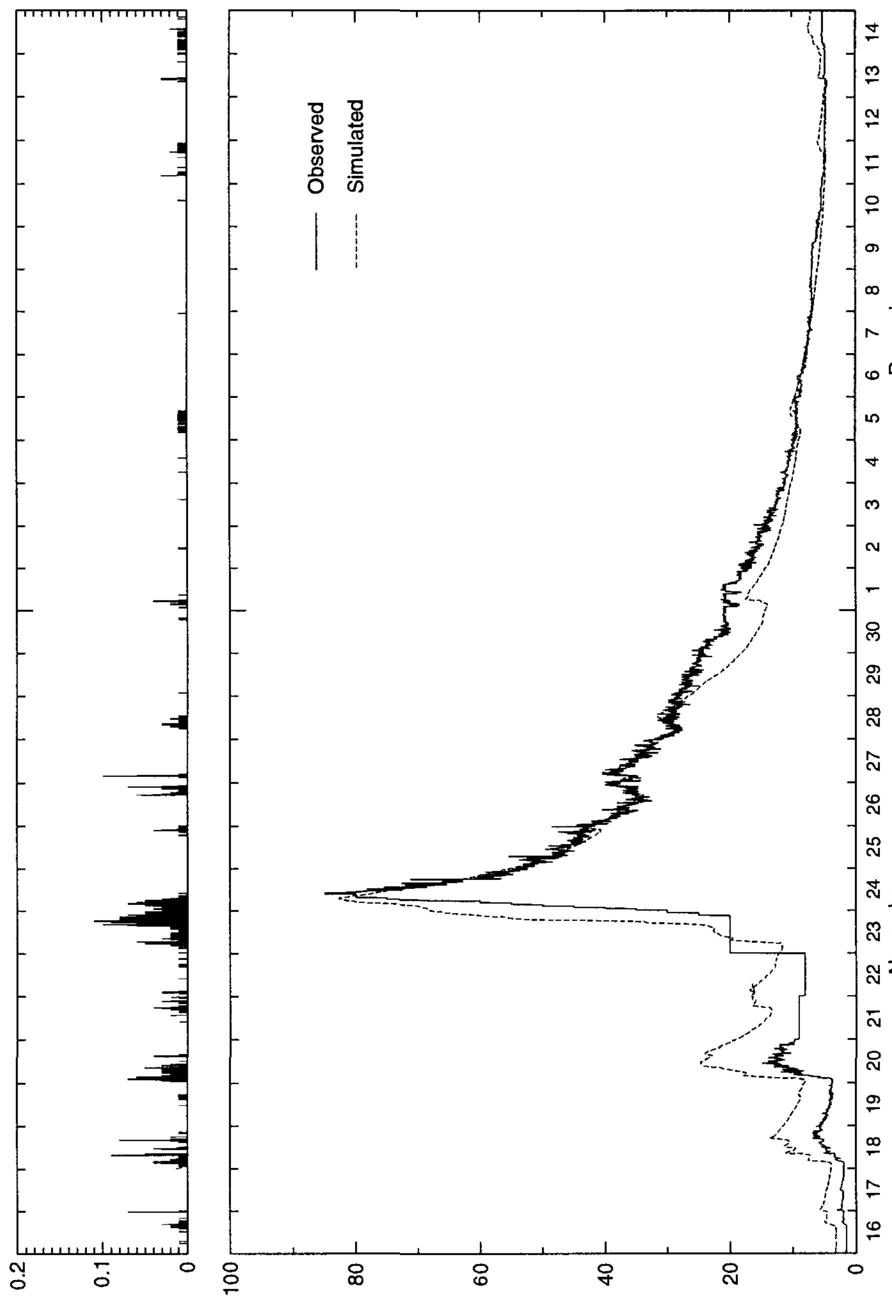

Figure 23. Observed rainfall and observed and simulated discharge for Laughing Jacobs Creek (station 12121720), storm period November 16 - December 14, 1986, for the final numerical model.

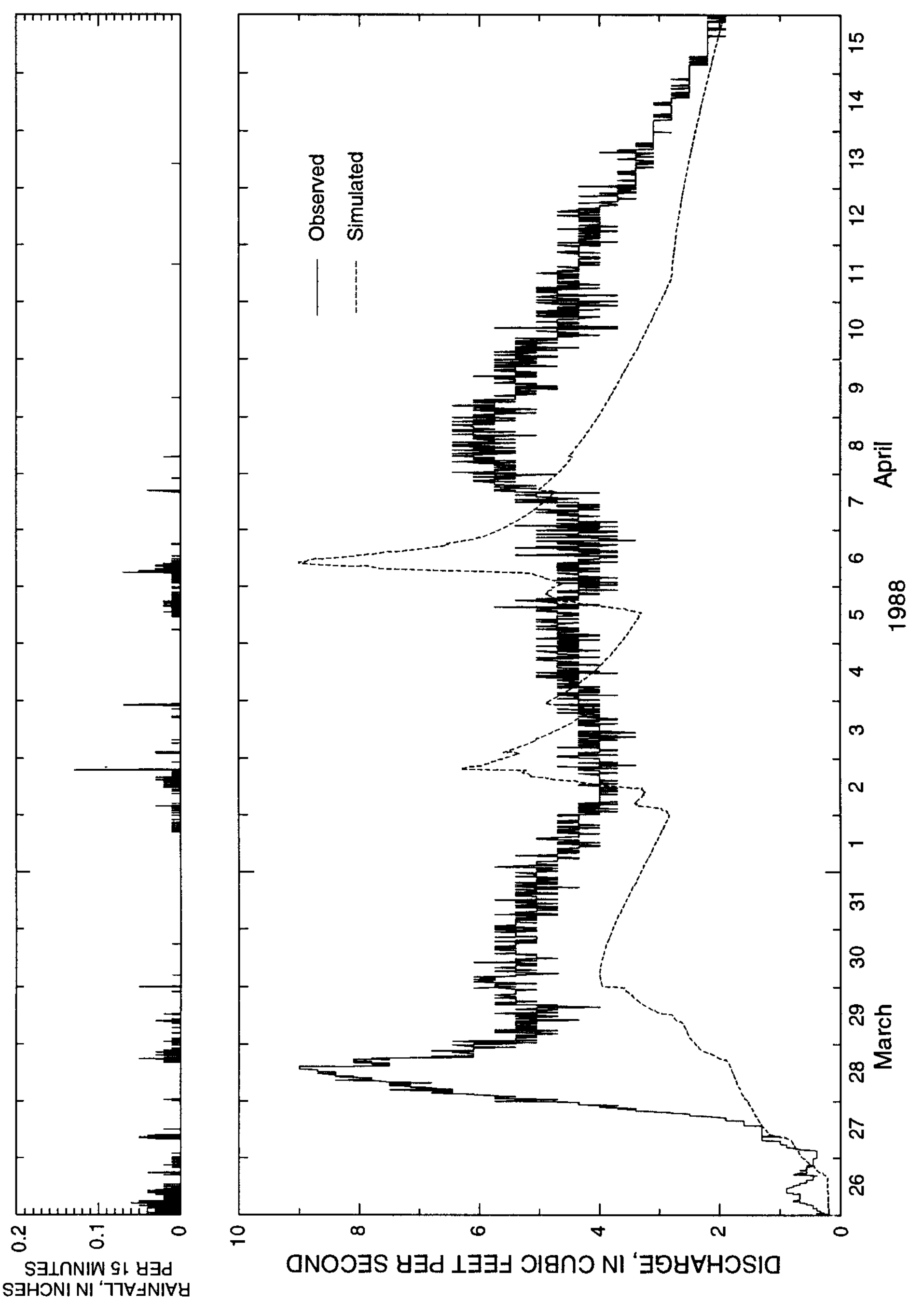

Figure 24. Observed rainfall and observed and simulated discharge for Inglewood Creek (station 12121830), storm period March 26 - April 15, 1988, for the final numerical model.

More detailed refinements of the Inglewood Creek model may have produced better simulations of the short-term observed streamflow record, but the HSPF program is not easily modified to represent the ground-water surface-water interactions observed in this basin. The simplified modifications of the Inglewood Creek model required a complete streamflow record; further modifications would require runoff data from multiple locations in the basin. Also, only analysis of observed streamflow data revealed that the outwash deposits in this basin are particularly deep and permeable. The limitations highlighted by these results also have important implications for predicting the effects of land-use changes on streamflow, as discussed in the "Guidelines for Application" section of this report.

Finally, the sources of the remaining simulation errors could not be fully assessed with the data available for this investigation. As was discussed throughout this report, there were errors in the observed data. For example, the composite errors for the final simulation of annual and seasonal runoff volumes are approximately equal to the errors estimated for the observed streamflow data. The composite errors for peak discharge, storm runoff, and daily mean discharge undoubtedly reflect errors introduced from the many approximations and simplifications incorporated into the numerical modeling method. For example, the HSPF program does not explicitly simulate the generation of saturation overland flow, so a method was devised to approximate the process with the existing HSPF algorithms. The magnitude of the errors resulting from this approximation could not be assessed.

Thus, the conceptual model appeared to be correct, although the phenomenon of upslope runoff draining into outwash deposits was initially understated. HSPF was able to represent most hydrologic processes of interest, except those related to complex interactions between ground water and surface water. The initial approach used for constructing numerical models was not adequate for all basins, but modifications related to ground-water contributions to streamflow, and upslope runoff draining into outwash deposits resolved the major shortcomings. The generalized parameter values, except for those determined for AGWRC and KVARY, resulted in reasonable simulations of most components of the rainfall-runoff relations in the study area. No single values for AGWRC and KVARY were generally valid across the study area. Finally, with the exception of the values for the ground-water rate parameters AGWRC and KVARY, the generalized HSPF parameter values appeared valid for simulating most components of the rainfall-runoff relations in the study area.

GUIDELINES FOR APPLICATION

It was intended that the numerical modeling method described in this report would allow planners and engineers to simulate both pre- and post-urbanization rainfall-runoff relations for most headwater drainage basins in western King and Snohomish Counties. There are some general limitations to and requirements for such applications.

The generalized parameter values are representative of physiographic and land-use conditions found in headwater basins in western King and Snohomish County. The parameter values resulted in reasonable simulations in three Thurston County basins (Berris, 1995) and in three Pierce County basins (Mastin, 1996), but models for those basins required extensive modifications to account for interactions between ground water and surface water. Although the conceptual model used for this investigation was developed for the Puget Sound Lowlands as a whole, the validity of the parameter values outside of the four-county area is untested.

Even within western King and Snohomish Counties, observed streamflow data are required to construct models that will simulate streamflow with the same accuracy as those constructed for this investigation. For all basins, data from a minimum of two or three discharge measurements made during summer and winter baseflow periods are required to estimate both ground-water contributions to streamflow and the values for the parameters AGWRC and KVARY. If the valley portion of a basin is filled with glacial outwash deposits, multiple discharge measurements during at least a few storms would also be required to determine the importance of upslope runoff infiltration into those deposits and to construct the numerical model accordingly. If particularly extensive outwash deposits are present and if streams that cross those deposits are known to lose water, continuous streamflow data for at least one winter season would be required to realistically construct the numerical model. Finally, because using generalized parameter values can be expected to yield varied simulation results, the uncertainty in results for any basin could be greatly reduced if at least 1-year records of observed rainfall and streamflow were available.

In general, the parameter values representing the flat and moderately sloping till land segments, outwash land segments, and effective-impervious area segments were the most thoroughly tested in this assessment. These land-segment types were widespread throughout many basins, so their associated parameter values were well supported by the observed data. The least certain parameter values were those representing the steeply sloping till land segments and the saturated land segments. These land-segment types were not predominant in any of the study basins, so the simulation results at stream-gage sites were not particularly sensitive to changes in the parameter values associated with these land segments.

The nonforested cover condition defined in the modeling method refers primarily to turfgrass in areas that have been cleared of their native vegetation, graded with machinery, and, in some cases, covered with imported topsoil. Hence, the nonforested land-segment type represents disturbed pervious areas in general rather than areas with just a specific vegetal cover. The parameter values representing nonforested land segments were calibrated and validated with data from areas as described above, so their applicability to other nonforested areas such as pastures or natural prairies is untested. Investigators in Thurston and Pierce Counties determined different parameter values for pasture land (Berris, 1995; Mastin, 1996).

The applicability of the generalized parameter values for catchments smaller than the subbasins commonly delineated for this investigation—about 100 acres—is unknown. Some of the runoff processes represented in the HSPF program, particularly the generation of interflow runoff, are scale-dependent, so the simulation of those processes is also scale-dependent. For example, the total discharge of interflow from a 100-acre parcel of till-mantled hillslope may be well simulated by HSPF, but the portion of that interflow that is discharged within each 1-acre parcel of the larger area may not be well simulated. Additional data is needed to validate or refute the applicability of the generalized parameter values for small catchments.

Individual fluxes or storages of water simulated for land segments, such as recharge or soil moisture, were not checked for accuracy; the model was calibrated and validated to streamflow data only. Although such "internal" components may be well simulated, the results may be inconsistent. For example, because the infiltration exponent (INFEXP) was increased to help simulate saturation overland flow, less recharge was simulated in the flat-slope segments relative to the steeper segments; it is generally assumed that more recharge occurs in flat areas. Comparison of simulated runoff hydrographs showed that the rate of interflow discharge from flat segments was similar to the rate of ground-water discharge from steeper segments. Thus, the overall runoff simulated for flat segments was realistic, but the simulated source of runoff was questionable. Such results are to be expected when streamflow hydrographs are the only data available for calibration, so the modeler must be aware of possibly misleading results.

Finally, the simulation of post-urbanization streamflow will often require the modeler to make many untested assumptions, and the simulation results should be interpreted with caution. For example, in basins where upslope runoff can infiltrate into outwash deposits, it has been observed that fine sediments transported from construction areas can decrease the infiltration capacity of channel bottoms in the outwash. In order to represent this for runoff simulations under different land use, the modeler would have to make an assumption regarding the magnitude of the decrease. Also, simulations for future land-use conditions could result in dramatic decreases in ground-water recharge in a basin, and the simulated ground-water discharge rate would be decreased accordingly. However, many perennial springs that supply local streams with summer baseflow may actually be recharged from regional flow systems insensitive to changes in local land use. The simplified approximation of ground-water flow in this numerical modeling method assumes that only one flow system contributes to streamflow. Thus, the modeler should always use sound hydrologic judgement when interpreting simulation results.

SUMMARY

The validity of a method to simulate pre- and post-urbanization rainfall-runoff relations for headwater basins in western King and Snohomish Counties was assessed. It was intended that additional numerical models constructed with this method, along with existing physiographic, land-use, and climate data, could be used by planners and engineers to help mitigate the hydrologic effects of urbanization in drainage basins throughout the region.

This report documents an assessment of the validity of four primary components of the numerical modeling method: the conceptual model, the HSPF program, the approach used to construct numerical models, and 12 sets of generalized HSPF parameter values determined in a previous investigation. Numerical simulation models were constructed for 11 drainage basins in western King County with the generalized HSPF parameters and the approach outlined in the previous study and were run with rainfall and potential evapotranspiration data collected during the 1987-88 water years. Those initial simulation results were compared to observed streamflow data, and the models were subsequently modified to determine the source of simulation errors. The validity of each of the four components of the modeling method was assessed by analyzing recurrent simulation errors.

Large and recurrent simulation errors were identified in the initial models, but three systematic modifications of the models corrected those errors for 10 out of 11 basins. Initially, streamflow was significantly oversimulated for most basins, the rate of decrease in summer baseflow was oversimulated for all basins, and storm runoff volumes were consistently oversimulated for about half the basins. To correct those errors, the portion of ground water contributing to streamflow in the models was decreased, the parameter values controlling the simulated ground-water discharge rate (AGWRC and KVARY) were adjusted, and simulated storm runoff from certain hillslopes was routed downslope into the ground-water system of pervious outwash deposits. After modifications, the composite simulation errors for all validation basins were unbiased, and the root-mean-square errors for annual runoff, storm runoff, and daily mean discharges were about 9 percent, 29 percent, and 52 percent, respectively.

The validity of the numerical modeling method for simulating rainfall-runoff relations in the study area, as modified during this investigation, was not rejected, but observed streamflow data were required to get the reported results. The conceptual model appeared to be correct, although the phenomenon of upslope runoff draining into outwash deposits was initially understated. HSPF was able to represent most hydrologic processes of interest, except those related to complex interactions between ground water and surface water. The initial approach used for constructing numerical models was not adequate for all basins, but the systematic modifications resolved the major shortcomings. Finally, the generalized parameter values, except for those determined for AGWRC and KVARY, resulted in reasonable simulations of most components of the rainfall-runoff relations in the study area. No single values for AGWRC and KVARY were found to be generally valid across the study area.

There are limitations to and requirements for applying the numerical modeling method to other drainage basins. The generalized parameter values have resulted in reasonable simulations of streamflow in western King, Snohomish, Thurston, and Pierce Counties; the validity of those values outside those areas is unknown. Observed streamflow data are required to estimate ground-water contributions to streamflow, values for the AGWRC and KVARY parameters, and the importance of upslope runoff draining into outwash deposits. The nonforested cover condition defined in the modeling method refers primarily to turfgrass in areas that have been cleared of their native vegetation, graded with machinery, and, in some cases, covered with imported topsoil. The applicability of the generalized parameter values for catchments smaller than the subbasins commonly delineated for this investigation—about 100 acres—is unknown. Individual fluxes or storages of water simulated for land segments, such as recharge or soil moisture, were not checked for accuracy; the model was calibrated and validated to streamflow data only. The simulation of post-urbanization streamflow will often require the modeler to make many untested assumptions, and the simulation results should be interpreted with caution. Finally, the uncertainty in results for any basin could be greatly reduced if at least 1-year records of observed rainfall and streamflow were available.

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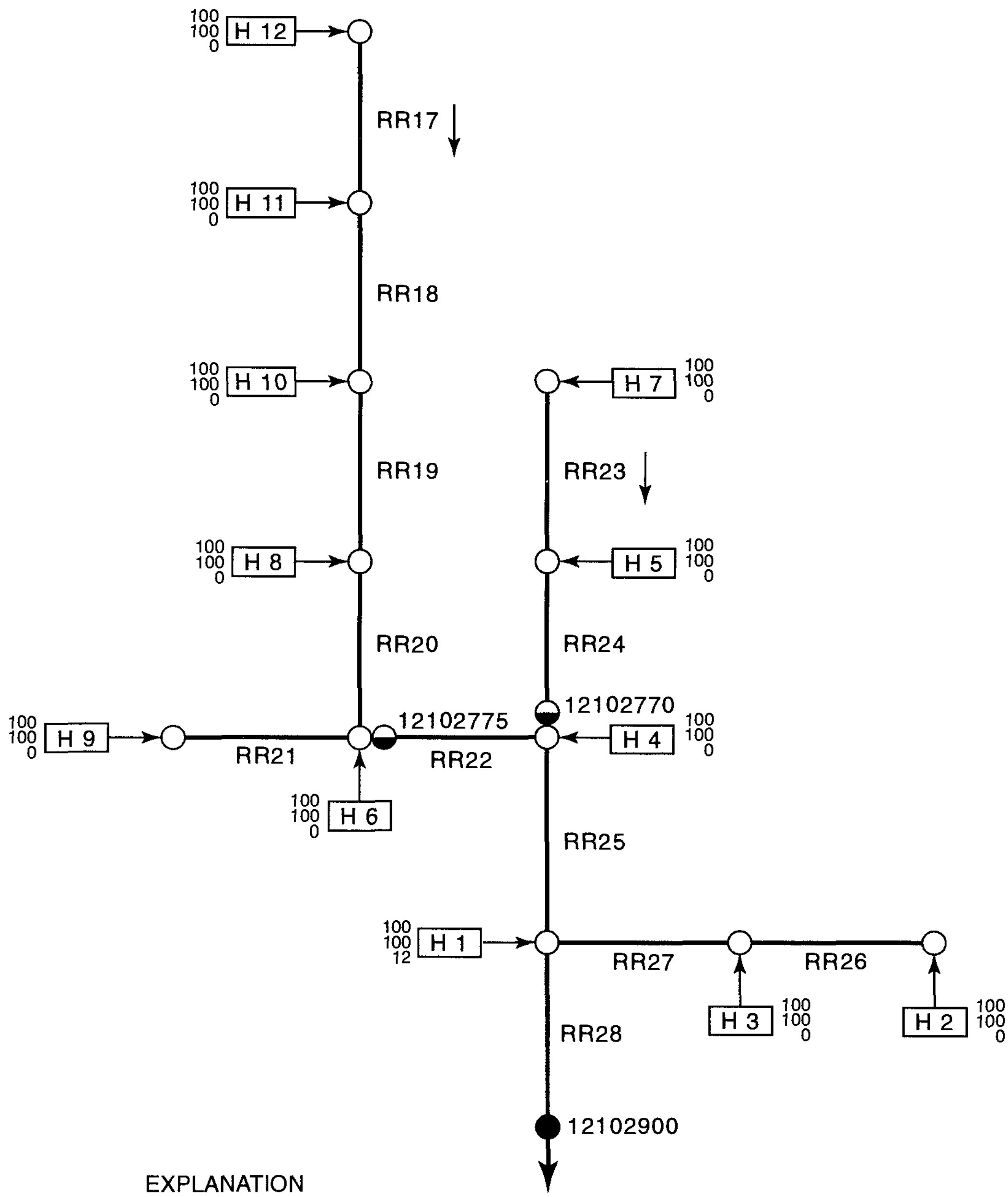
Figures 25 through 33



EXPLANATION

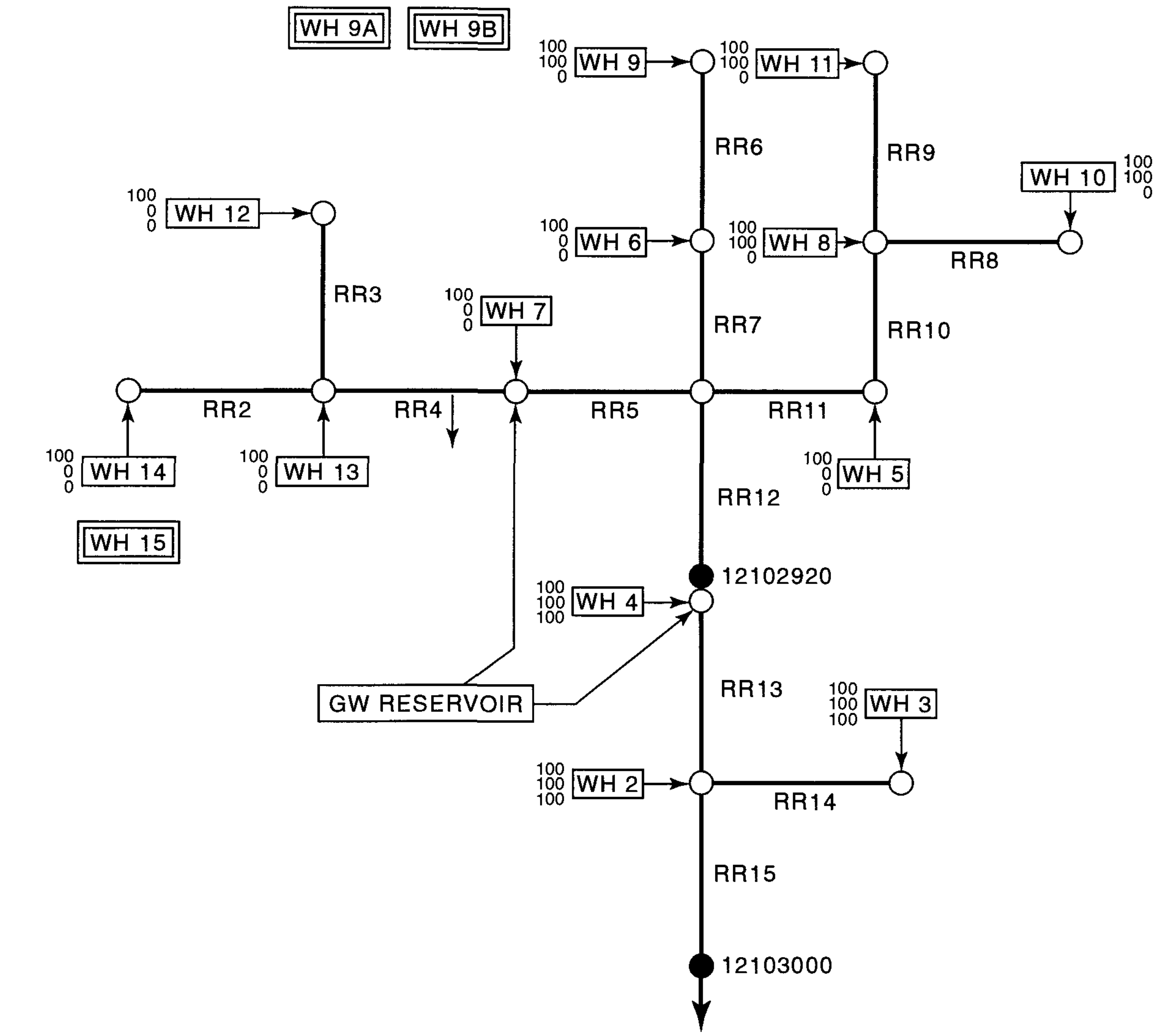
100 / 100 / 12 [H 1] → Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach

RR21 ↓ Reach and number-- Presence of arrow indicates the reach has a second outflow to simulate channel losses or lake seepage

● 12102900 Recording stream gage and number

◒ 12102775 Crest-stage gage and number

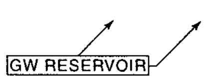
Figure 25. Schematic diagram showing the connections between subbasins and reaches for the final version of the East Branch Hylebos Creek model.



EXPLANATION

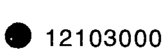
Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach

Subbasin with no connection to the drainage network



Ground-water resevoir-- Arrows show where outflows drain to reaches

Reach and number-- Presence of arrow indicates the reach has a second outflow to simulate channel losses or lake seepage



Recording stream gage and number

Figure 26. Schematic diagram showing the connections between subbasins and reaches for the final version of the West Branch Hylebos Creek model.

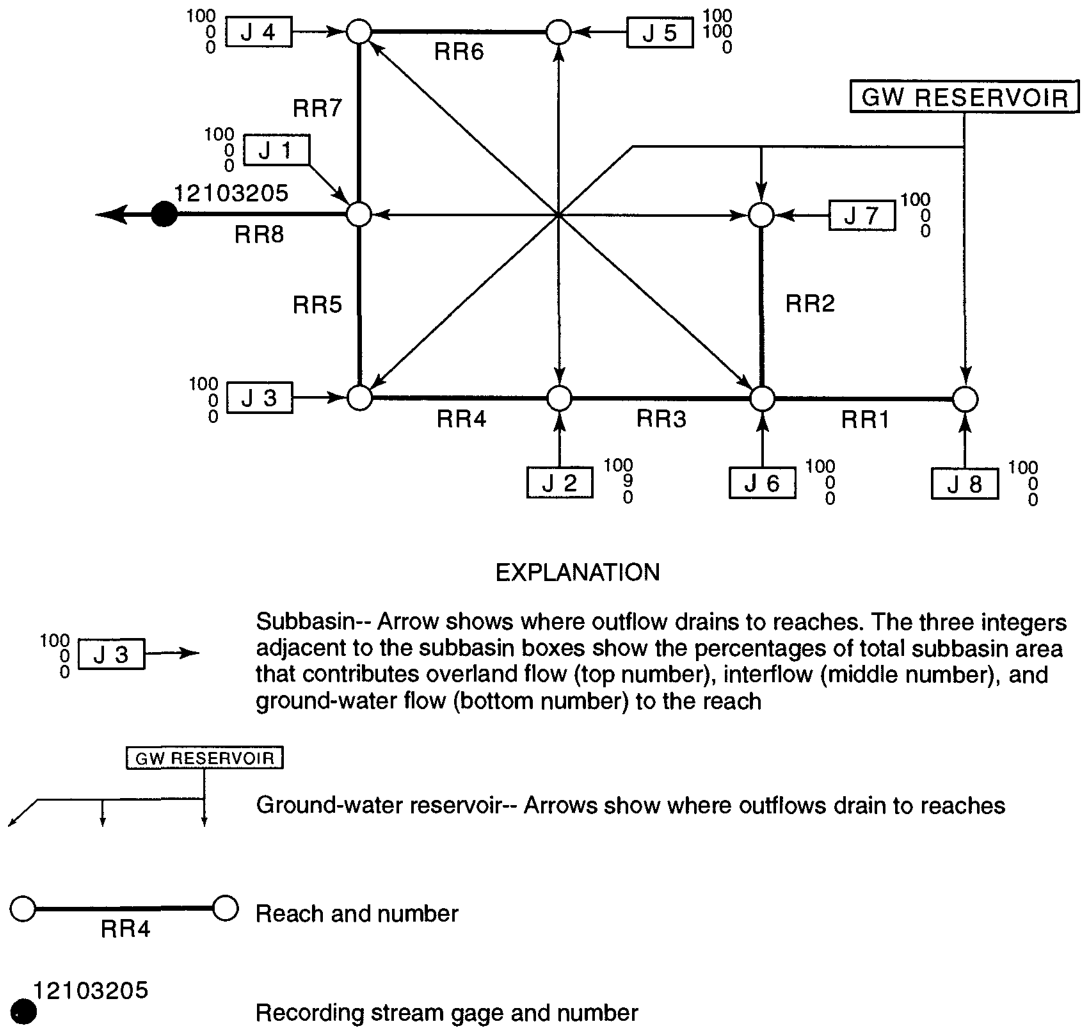
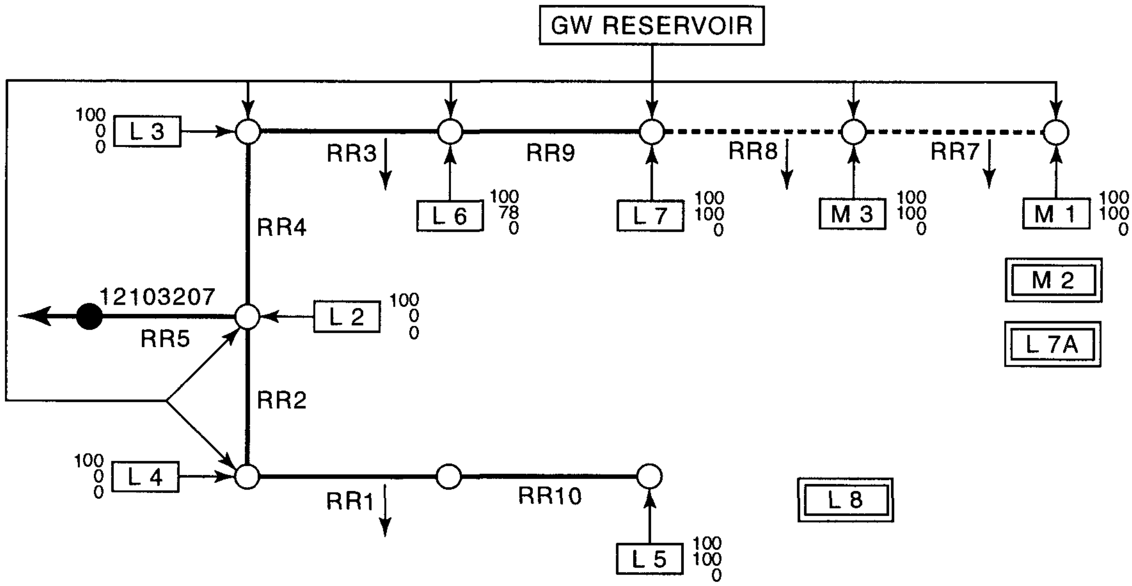
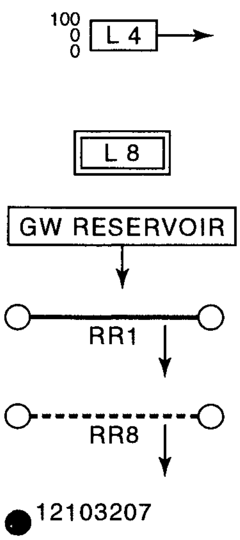


Figure 27. Schematic diagram showing the connections between subbasins and reaches for the final version of the Joes Creek model.



EXPLANATION



Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach

Subbasin with no connection to the drainage network

Ground-water reservoir-- Arrow shows where outflow drains to reaches

Reach and number-- Presence of arrow indicates the reach has a second outflow to simulate channel losses or lake seepage

Reach that is only connected to the drainage network during extreme runoff events

Recording stream gage and number

Figure 28. Schematic diagram showing the connections between subbasins and reaches for the final version of the Lakota Creek model.

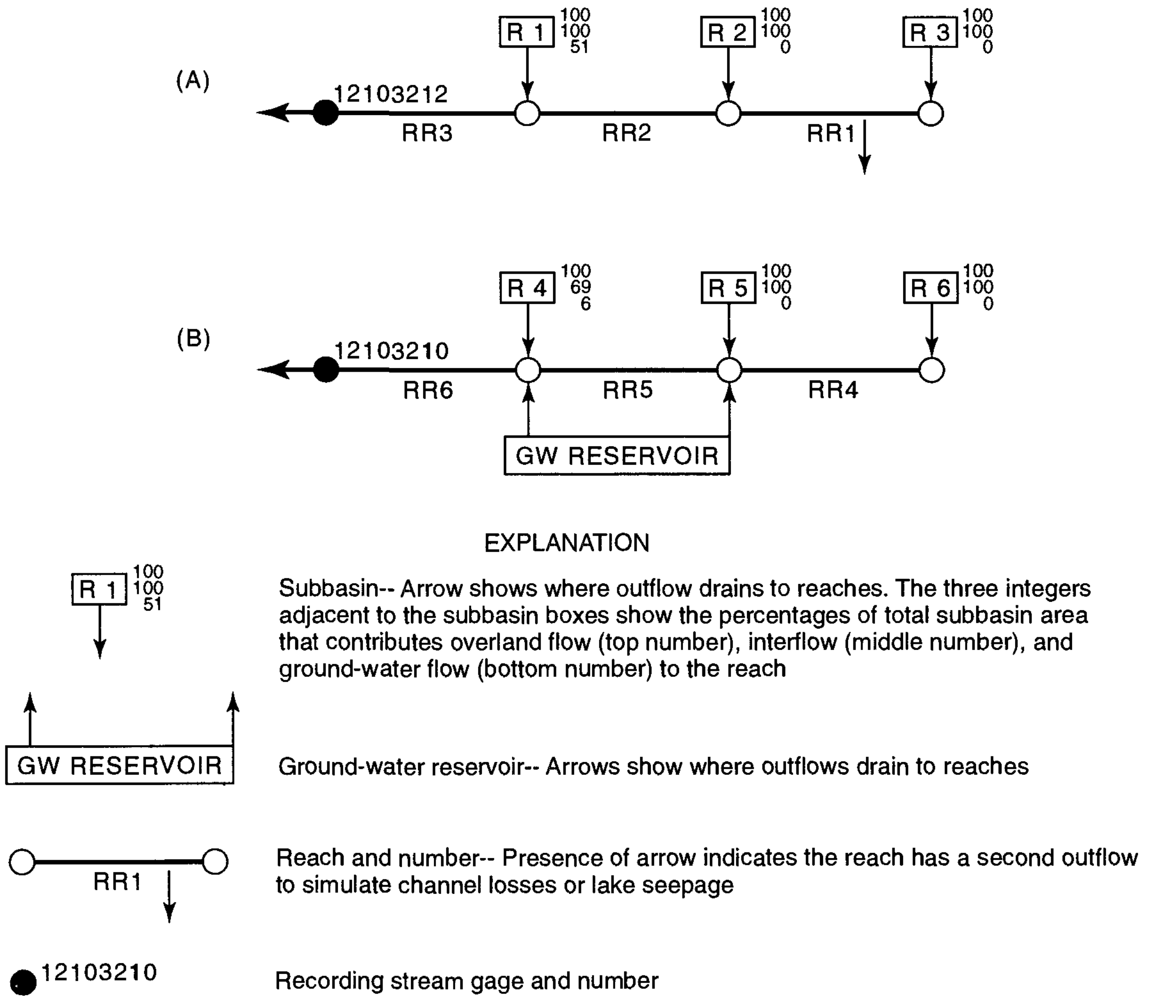
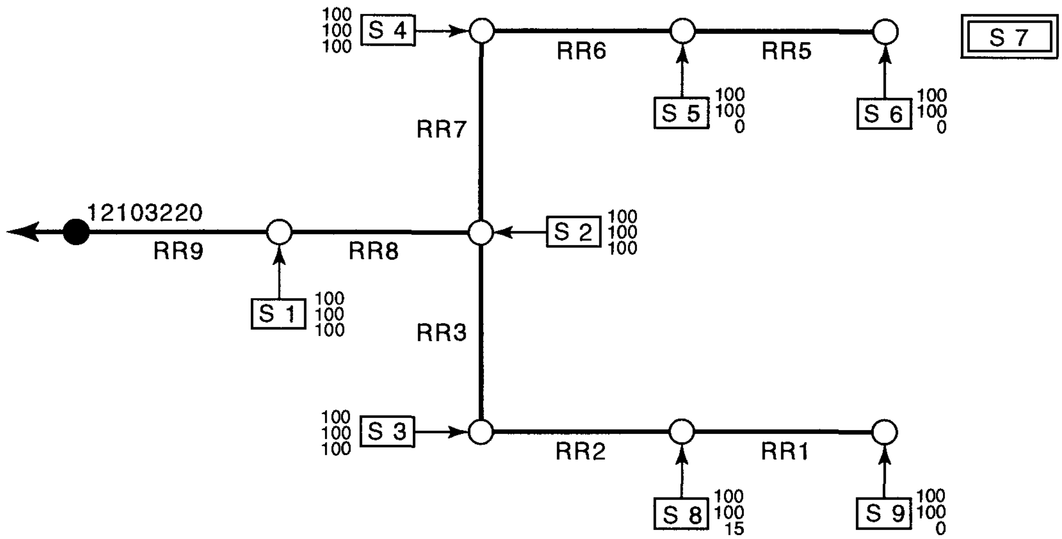


Figure 29. Schematic diagram showing the connections between subbasins and reaches for the final version of (A) the Redondo Creek #1 model and (B) the Redondo Creek #2 model.



EXPLANATION

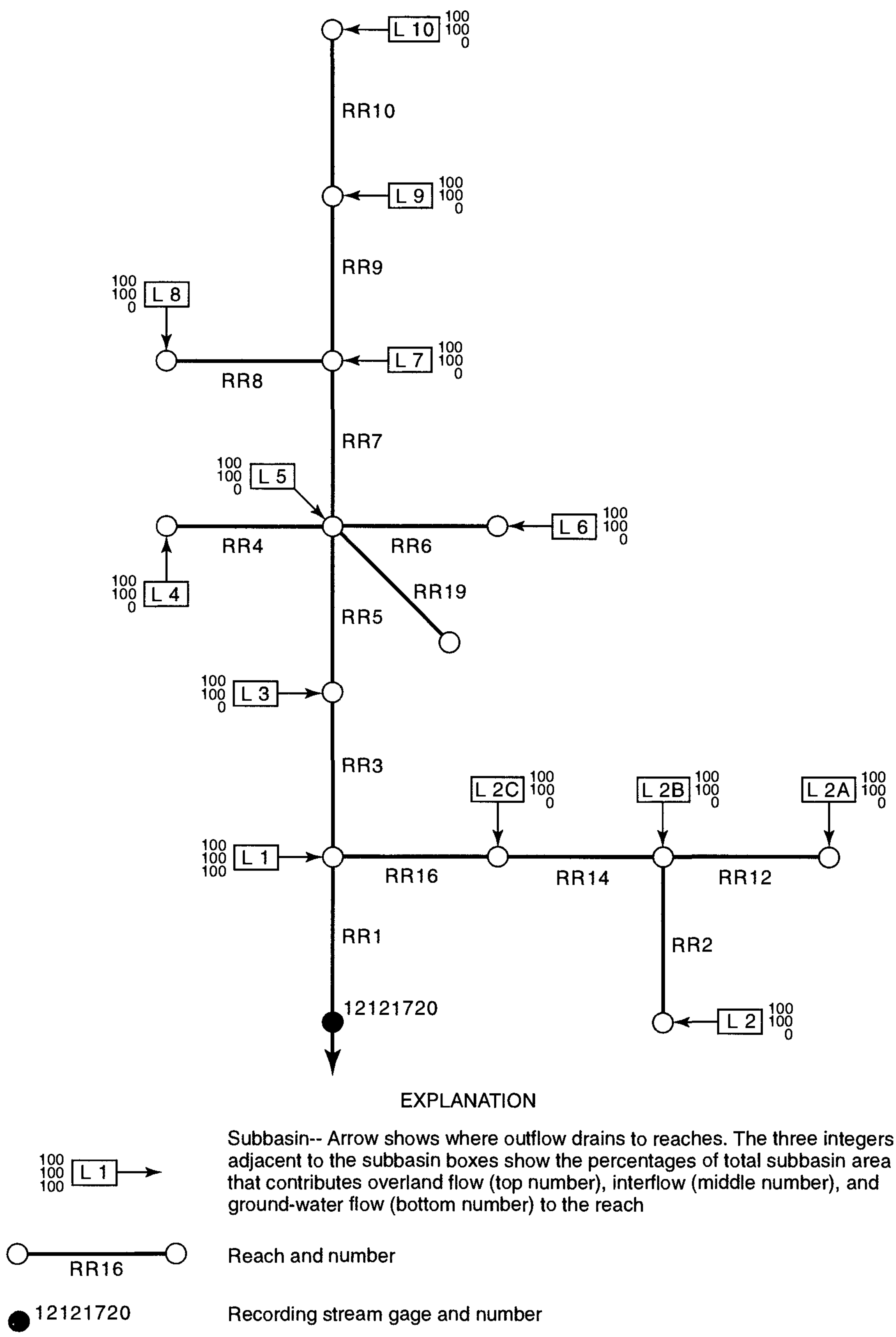
S 1 100 100 100 — Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach

S 7 — Subbasin with no connection to the drainage network

RR2 — Reach and number

12103220 — Recording stream gage and number

Figure 30. Schematic diagram showing the connections between subbasins and reaches for the final version of the Unnamed Creek at Saltwater State Park model.

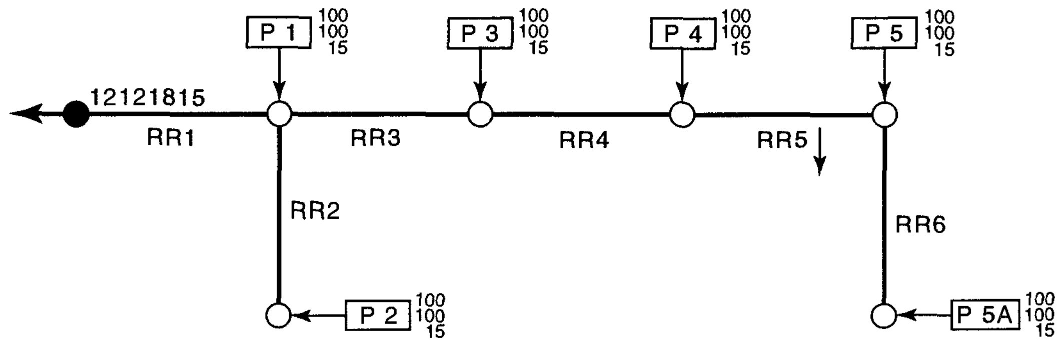


Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach

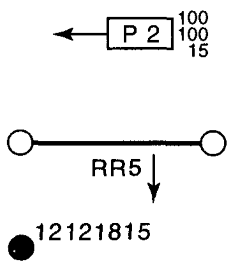
Reach and number

Recording stream gage and number

Figure 31. Schematic diagram showing the connections between subbasins and reaches for the final version of the Laughing Jacobs Creek model.



EXPLANATION

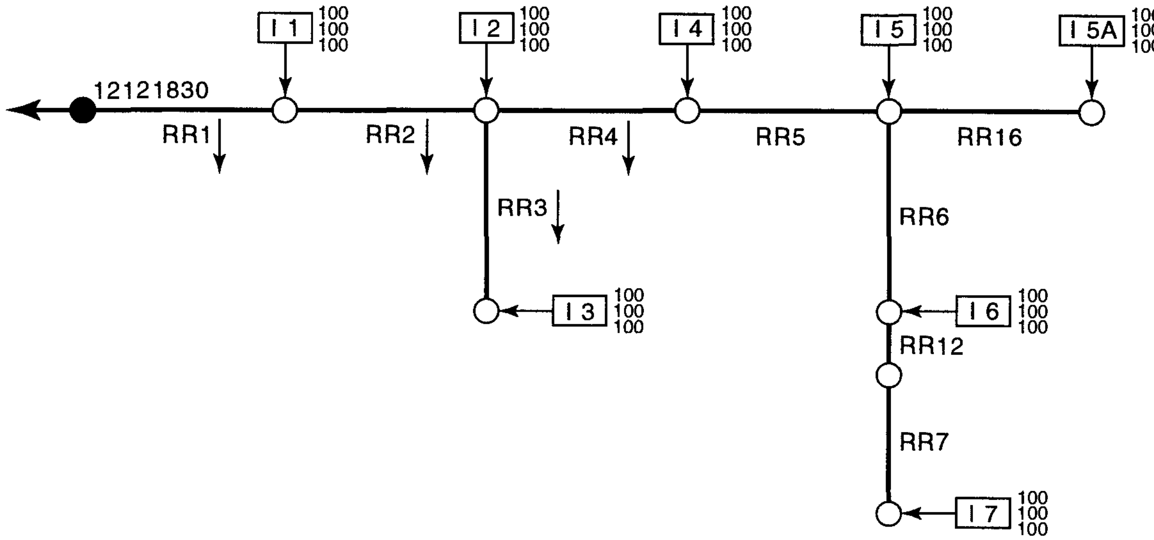


Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach

Reach and number-- Presence of arrow indicates the reach has a second outflow to simulate channel losses or lake seepage

Recording stream gage and number

Figure 32. Schematic diagram showing the connections between subbasins and reaches for the final version of the Pine Lake Creek model.



EXPLANATION

I 1 100 100 100	Subbasin-- Arrow shows where outflow drains to reaches. The three integers adjacent to the subbasin boxes show the percentages of total subbasin area that contributes overland flow (top number), interflow (middle number), and ground-water flow (bottom number) to the reach
RR2	Reach and number-- Presence of arrow indicates the reach has a second outflow to simulate channel losses or lake seepage
12121830	Recording stream gage and number

Figure 33. Schematic diagram showing the connections between subbasins and reaches for the final version of the Inglewood Creek model.

APPENDIX A. HSPF Input Files

Appendix A1. Final version of the HSPF input file used for the East Branch Hylebos Creek Basin

```
RUN
GLOBAL
  HYLEBOS CREEK - 4/9A  - FINAL VALIDATION MODEL
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME      0 RUN      1 TSSFL     15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      RCHRES      17
      RCHRES      18
      RCHRES      19
      RCHRES      20
      RCHRES      21
      RCHRES      29
      RCHRES      22
      RCHRES      23
      RCHRES      24
      RCHRES      25
      RCHRES      26
      RCHRES      27
      RCHRES      28
      DISPLY       1
      DISPLY       2
      DISPLY       3
      DISPLY       4
      DISPLY       5
      DISPLY       6
    END INGRP
END OPN SEQUENCE
                                                                      ***
PERLND
  GEN-INFO
    <PLS >      Name          NBLKS   Unit-systems   Printer              ***
    # -  #                         User  t-series Engl Metr               ***
                                         in   out                         ***
   11       TF/MILD              1    1    1    1    6    0
   15       TF/MODERATE          1    1    1    1    6    0
   17       TF/STEEP             1    1    1    1    6    0
   21       TG/MILD              1    1    1    1    6    0
   25       TG/MODERATE          1    1    1    1    6    0
   27       TG/STEEP             1    1    1    1    6    0
   31       OF/MILD              1    1    1    1    6    0
   41       OG/MILD              1    1    1    1    6    0
   51       WETLANDS             1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
```

```
  <PLS > ************* Active Sections *****************************
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC      ***
 11   51    0    0    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  <PLS > ********************* Print-flags ************************ PIVL  PYR
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
 11   51    0    0    5    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > ***************** Flags ********************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                      ***
 11   51    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11            0.75    4.5000    0.0800    400.00    0.0500    0.0000    0.9980
 15            0.75    4.5000    0.0800    400.00    0.1000    0.0000    0.9980
 17            0.75    4.5000    0.0800    200.00    0.2000    0.0000    0.9980
 21            0.05    4.5000    0.0300    400.00    0.0500    0.0000    0.9980
 25            0.05    4.5000    0.0300    400.00    0.1000    0.0000    0.9980
 27            0.05    4.5000    0.0300    200.00    0.2000    0.0000    0.9980
 31            0.75    5.0000    2.0000    400.00    0.0500    0.0000    0.9980
 41            0.05    5.0000    0.8000    400.00    0.0500    0.0000    0.9980
 51            0.75    4.0000    2.0000    100.00    0.0010    0.0000    0.9980
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11                           3.5000    2.0000      1.00        0.        0.
 15                           2.0000    2.0000      1.00        0.        0.
 17                           1.5000    2.0000      1.00        0.        0.
 21                           3.5000    2.0000      1.00        0.        0.
 25                           2.0000    2.0000      1.00        0.        0.
 27                           1.5000    2.0000      1.00        0.        0.
 31                           2.0000    2.0000      0.00        0.        0.
 41                           2.0000    2.0000      0.00        0.        0.
 51                           10.000    2.0000      0.00        0.       0.7
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                             ***
  # -  #      CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 11          0.2000    1.0000    0.3500     3.000    0.7000    0.7000
 15          0.2000    0.5000    0.3500     6.000    0.5000    0.7000
 17          0.2000    0.3000    0.3500     7.000    0.3000    0.7000
 21          0.1000    0.5000    0.2500     3.000    0.7000    0.2500
 25          0.1000    0.2500    0.2500     6.000    0.5000    0.2500
 27          0.1000    0.1500    0.2500     7.000    0.3000    0.2500
 31          0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 41          0.1000    0.5000    0.2500     0.000    0.7000    0.2500
 51          0.1000    3.0000    0.5000     1.000    0.7000    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***    CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 11              0.        0.    0.0030        0.      .954      0.00      .017
 15              0.        0.    0.0060        0.     .9420      0.00      .016
 17              0.        0.    0.0140        0.      .933      0.00      .016
 21              0.        0.    0.0310        0.      2.78      0.00      .095
```

```
   25              0.         0.     0.0280         0.       2.47       0.00       .068
   27              0.         0.     0.0120         0.       2.36       0.00       .062
   31              0.         0.     0.0010         0.       .966       22.0       .090
   41              0.         0.     0.0250         0.       4.08       26.0       .390
   51              0.         0.     0.1620         0.       3.39       10.0       .162
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name            Unit-systems   Printer                             ***
    # -  #                  User  t-series Engl Metr                           ***
                                   in  out                                     ***
   11      IMPERVIOUS           1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >          Flags           ***                                        ***
    # -  # CSNO RTOP  VRS  VNN RTLI    ***                                        ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                     ***
    # -  #       LSUR     SLSUR      NSUR     RETSC                            ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                     ***
    # -  #     PETMAX    PETMIN                                                ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                             ***
    # -  #       RETS      SURS                                                ***
   11       1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                               ***
EXT SOURCES
                                                                               ***
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                               ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      1 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      1 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES  17     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES  19     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES  23     EXTNL  PREC
WDM      3 PET      ENGL                   PERLND  11 51  EXTNL  PETINP
WDM      3 PET      ENGL                   IMPLND  11     EXTNL  PETINP
WDM      3 PET      ENGL                   RCHRES  17     EXTNL  POTEV
```

```
WDM       3 PET       ENGL                       RCHRES  19      EXTNL  POTEV
WDM       3 PET       ENGL                       RCHRES  23      EXTNL  POTEV
END EXT SOURCES
                                                                                ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>    #        <Name> # #<-factor->strg <Name>    # <Name>    tem strg strg***
RCHRES   28 HYDR   ROVOL  1        48.4 SAME WDM       7 SIMQ      ENGL      REPL
END EXT TARGETS
                                                                                ***
NETWORK
                                                                                ***
*** NOTE: MFACTOR= 53.33 X SEGMENT AREA (SQ.MILES) TO CONVERT INCHES TO AC-FT.
***
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>    #        <Name> # #<-factor->strg <Name>    #   #        <Name> # #  ***
*** SUB-BASIN     H12  RUNOFF FROM LAND SEGMENTS
PERLND   11 PWATER SURO        17.4510       RCHRES  17      EXTNL  IVOL
PERLND   11 PWATER IFWO        17.4510       RCHRES  17      EXTNL  IVOL
PERLND   15 PWATER SURO         3.3067       RCHRES  17      EXTNL  IVOL
PERLND   15 PWATER IFWO         3.3067       RCHRES  17      EXTNL  IVOL
PERLND   21 PWATER SURO         5.0523       RCHRES  17      EXTNL  IVOL
PERLND   21 PWATER IFWO         5.0523       RCHRES  17      EXTNL  IVOL
PERLND   25 PWATER SURO         0.0417       RCHRES  17      EXTNL  IVOL
PERLND   25 PWATER IFWO         0.0417       RCHRES  17      EXTNL  IVOL
PERLND   51 PWATER SURO         0.6250       RCHRES  17      EXTNL  IVOL
PERLND   51 PWATER IFWO         0.6250       RCHRES  17      EXTNL  IVOL
IMPLND   11 IWATER SURO         2.4983       RCHRES  17      EXTNL  IVOL
*** SUB-BASIN     H11  RUNOFF FROM LAND SEGMENTS
PERLND   11 PWATER SURO         3.4417       RCHRES  18      EXTNL  IVOL
PERLND   11 PWATER IFWO         3.4417       RCHRES  18      EXTNL  IVOL
PERLND   15 PWATER SURO         0.5500       RCHRES  18      EXTNL  IVOL
PERLND   15 PWATER IFWO         0.5500       RCHRES  18      EXTNL  IVOL
PERLND   21 PWATER SURO         2.5375       RCHRES  18      EXTNL  IVOL
PERLND   21 PWATER IFWO         2.5375       RCHRES  18      EXTNL  IVOL
IMPLND   11 IWATER SURO         0.0458       RCHRES  18      EXTNL  IVOL
*** SUB-BASIN     H10  RUNOFF FROM LAND SEGMENTS
PERLND   11 PWATER SURO         3.0667       RCHRES  19      EXTNL  IVOL
PERLND   11 PWATER IFWO         3.0667       RCHRES  19      EXTNL  IVOL
PERLND   15 PWATER SURO         1.7333       RCHRES  19      EXTNL  IVOL
PERLND   15 PWATER IFWO         1.7333       RCHRES  19      EXTNL  IVOL
PERLND   21 PWATER SURO         1.8158       RCHRES  19      EXTNL  IVOL
PERLND   21 PWATER IFWO         1.8158       RCHRES  19      EXTNL  IVOL
PERLND   25 PWATER SURO         0.7675       RCHRES  19      EXTNL  IVOL
PERLND   25 PWATER IFWO         0.7675       RCHRES  19      EXTNL  IVOL
PERLND   51 PWATER SURO         0.8583       RCHRES  19      EXTNL  IVOL
PERLND   51 PWATER IFWO         0.8583       RCHRES  19      EXTNL  IVOL
IMPLND   11 IWATER SURO         0.9917       RCHRES  19      EXTNL  IVOL
*** SUB-BASIN     H9   RUNOFF FROM LAND SEGMENTS
PERLND   11 PWATER SURO        22.7303       RCHRES  21      EXTNL  IVOL
PERLND   11 PWATER IFWO        22.7303       RCHRES  21      EXTNL  IVOL
PERLND   15 PWATER SURO         7.1297       RCHRES  21      EXTNL  IVOL
PERLND   15 PWATER IFWO         7.1297       RCHRES  21      EXTNL  IVOL
PERLND   17 PWATER SURO         1.6333       RCHRES  21      EXTNL  IVOL
PERLND   17 PWATER IFWO         1.6333       RCHRES  21      EXTNL  IVOL
PERLND   21 PWATER SURO         5.8773       RCHRES  21      EXTNL  IVOL
PERLND   21 PWATER IFWO         5.8773       RCHRES  21      EXTNL  IVOL
PERLND   25 PWATER SURO         1.7946       RCHRES  21      EXTNL  IVOL
PERLND   25 PWATER IFWO         1.7946       RCHRES  21      EXTNL  IVOL
PERLND   27 PWATER SURO         0.2080       RCHRES  21      EXTNL  IVOL
```

```
PERLND  27 PWATER IFWO         0.2080       RCHRES  21      EXTNL  IVOL
PERLND  51 PWATER SURO         0.5250       RCHRES  21      EXTNL  IVOL
PERLND  51 PWATER IFWO         0.5250       RCHRES  21      EXTNL  IVOL
IMPLND  11 IWATER SURO        10.4352       RCHRES  21      EXTNL  IVOL
*** SUB-BASIN     H8    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO        16.8077       RCHRES  20      EXTNL  IVOL
PERLND  11 PWATER IFWO        16.8077       RCHRES  20      EXTNL  IVOL
PERLND  15 PWATER SURO         4.9000       RCHRES  20      EXTNL  IVOL
PERLND  15 PWATER IFWO         4.9000       RCHRES  20      EXTNL  IVOL
PERLND  17 PWATER SURO         0.0667       RCHRES  20      EXTNL  IVOL
PERLND  17 PWATER IFWO         0.0667       RCHRES  20      EXTNL  IVOL
PERLND  21 PWATER SURO         6.8657       RCHRES  20      EXTNL  IVOL
PERLND  21 PWATER IFWO         6.8657       RCHRES  20      EXTNL  IVOL
PERLND  25 PWATER SURO         3.0746       RCHRES  20      EXTNL  IVOL
PERLND  25 PWATER IFWO         3.0746       RCHRES  20      EXTNL  IVOL
PERLND  51 PWATER SURO         0.3500       RCHRES  20      EXTNL  IVOL
PERLND  51 PWATER IFWO         0.3500       RCHRES  20      EXTNL  IVOL
IMPLND  11 IWATER SURO         4.4437       RCHRES  20      EXTNL  IVOL
*** SUB-BASIN     H7    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         7.0470       RCHRES  23      EXTNL  IVOL
PERLND  11 PWATER IFWO         7.0470       RCHRES  23      EXTNL  IVOL
PERLND  15 PWATER SURO         0.9270       RCHRES  23      EXTNL  IVOL
PERLND  15 PWATER IFWO         0.9270       RCHRES  23      EXTNL  IVOL
PERLND  17 PWATER SURO         0.6210       RCHRES  23      EXTNL  IVOL
PERLND  17 PWATER IFWO         0.6210       RCHRES  23      EXTNL  IVOL
PERLND  21 PWATER SURO         2.0892       RCHRES  23      EXTNL  IVOL
PERLND  21 PWATER IFWO         2.0892       RCHRES  23      EXTNL  IVOL
PERLND  25 PWATER SURO         0.9000       RCHRES  23      EXTNL  IVOL
PERLND  25 PWATER IFWO         0.9000       RCHRES  23      EXTNL  IVOL
PERLND  27 PWATER SURO         0.7188       RCHRES  23      EXTNL  IVOL
PERLND  27 PWATER IFWO         0.7188       RCHRES  23      EXTNL  IVOL
PERLND  51 PWATER SURO         0.1667       RCHRES  23      EXTNL  IVOL
PERLND  51 PWATER IFWO         0.1667       RCHRES  23      EXTNL  IVOL
IMPLND  11 IWATER SURO         1.3471       RCHRES  23      EXTNL  IVOL
*** SUB-BASIN     H6    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         1.9167       RCHRES  22      EXTNL  IVOL
PERLND  11 PWATER IFWO         1.9167       RCHRES  22      EXTNL  IVOL
PERLND  15 PWATER SURO         0.5333       RCHRES  22      EXTNL  IVOL
PERLND  15 PWATER IFWO         0.5333       RCHRES  22      EXTNL  IVOL
PERLND  17 PWATER SURO         1.9667       RCHRES  22      EXTNL  IVOL
PERLND  17 PWATER IFWO         1.9667       RCHRES  22      EXTNL  IVOL
PERLND  25 PWATER SURO         0.2875       RCHRES  22      EXTNL  IVOL
PERLND  25 PWATER IFWO         0.2875       RCHRES  22      EXTNL  IVOL
PERLND  31 PWATER SURO         0.4417       RCHRES  22      EXTNL  IVOL
PERLND  31 PWATER IFWO         0.4417       RCHRES  22      EXTNL  IVOL
IMPLND  11 IWATER SURO         0.0958       RCHRES  22      EXTNL  IVOL
*** SUB-BASIN     H5    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         6.7770       RCHRES  24      EXTNL  IVOL
PERLND  11 PWATER IFWO         6.7770       RCHRES  24      EXTNL  IVOL
PERLND  15 PWATER SURO         4.9623       RCHRES  24      EXTNL  IVOL
PERLND  15 PWATER IFWO         4.9623       RCHRES  24      EXTNL  IVOL
PERLND  17 PWATER SURO         0.3000       RCHRES  24      EXTNL  IVOL
PERLND  17 PWATER IFWO         0.3000       RCHRES  24      EXTNL  IVOL
PERLND  21 PWATER SURO         5.3904       RCHRES  24      EXTNL  IVOL
PERLND  21 PWATER IFWO         5.3904       RCHRES  24      EXTNL  IVOL
PERLND  25 PWATER SURO         3.7000       RCHRES  24      EXTNL  IVOL
PERLND  25 PWATER IFWO         3.7000       RCHRES  24      EXTNL  IVOL
PERLND  31 PWATER SURO         0.0833       RCHRES  24      EXTNL  IVOL
PERLND  31 PWATER IFWO         0.0833       RCHRES  24      EXTNL  IVOL
IMPLND  11 IWATER SURO         3.1953       RCHRES  24      EXTNL  IVOL
```

```
*** SUB-BASIN      H4   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          0.0333      RCHRES  25      EXTNL   IVOL
PERLND  11 PWATER IFWO          0.0333      RCHRES  25      EXTNL   IVOL
PERLND  15 PWATER SURO          0.1000      RCHRES  25      EXTNL   IVOL
PERLND  15 PWATER IFWO          0.1000      RCHRES  25      EXTNL   IVOL
PERLND  17 PWATER SURO          0.0333      RCHRES  25      EXTNL   IVOL
PERLND  17 PWATER IFWO          0.0333      RCHRES  25      EXTNL   IVOL
PERLND  31 PWATER SURO          0.3583      RCHRES  25      EXTNL   IVOL
PERLND  31 PWATER IFWO          0.3583      RCHRES  25      EXTNL   IVOL
*** SUB-BASIN      H2   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          7.4033      RCHRES  26      EXTNL   IVOL
PERLND  11 PWATER IFWO          7.4033      RCHRES  26      EXTNL   IVOL
PERLND  15 PWATER SURO          1.8623      RCHRES  26      EXTNL   IVOL
PERLND  15 PWATER IFWO          1.8623      RCHRES  26      EXTNL   IVOL
PERLND  17 PWATER SURO          7.4947      RCHRES  26      EXTNL   IVOL
PERLND  17 PWATER IFWO          7.4947      RCHRES  26      EXTNL   IVOL
PERLND  21 PWATER SURO          5.3663      RCHRES  26      EXTNL   IVOL
PERLND  21 PWATER IFWO          5.3663      RCHRES  26      EXTNL   IVOL
PERLND  25 PWATER SURO          0.7277      RCHRES  26      EXTNL   IVOL
PERLND  25 PWATER IFWO          0.7277      RCHRES  26      EXTNL   IVOL
PERLND  27 PWATER SURO          0.2208      RCHRES  26      EXTNL   IVOL
PERLND  27 PWATER IFWO          0.2208      RCHRES  26      EXTNL   IVOL
PERLND  31 PWATER SURO         14.5653      RCHRES  26      EXTNL   IVOL
PERLND  31 PWATER IFWO         14.5653      RCHRES  26      EXTNL   IVOL
PERLND  41 PWATER SURO          4.1645      RCHRES  26      EXTNL   IVOL
PERLND  41 PWATER IFWO          4.1645      RCHRES  26      EXTNL   IVOL
PERLND  51 PWATER SURO          1.0917      RCHRES  26      EXTNL   IVOL
PERLND  51 PWATER IFWO          1.0917      RCHRES  26      EXTNL   IVOL
IMPLND  11 IWATER SURO          2.5533      RCHRES  26      EXTNL   IVOL
*** SUB-BASIN      H3   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          2.5165      RCHRES  27      EXTNL   IVOL
PERLND  11 PWATER IFWO          2.5165      RCHRES  27      EXTNL   IVOL
PERLND  15 PWATER SURO          1.8332      RCHRES  27      EXTNL   IVOL
PERLND  15 PWATER IFWO          1.8332      RCHRES  27      EXTNL   IVOL
PERLND  17 PWATER SURO          0.7750      RCHRES  27      EXTNL   IVOL
PERLND  17 PWATER IFWO          0.7750      RCHRES  27      EXTNL   IVOL
PERLND  21 PWATER SURO          1.2999      RCHRES  27      EXTNL   IVOL
PERLND  21 PWATER IFWO          1.2999      RCHRES  27      EXTNL   IVOL
PERLND  25 PWATER SURO          1.8332      RCHRES  27      EXTNL   IVOL
PERLND  25 PWATER IFWO          1.8332      RCHRES  27      EXTNL   IVOL
PERLND  27 PWATER SURO          0.0917      RCHRES  27      EXTNL   IVOL
PERLND  27 PWATER IFWO          0.0917      RCHRES  27      EXTNL   IVOL
PERLND  31 PWATER SURO          2.0415      RCHRES  27      EXTNL   IVOL
PERLND  31 PWATER IFWO          2.0415      RCHRES  27      EXTNL   IVOL
PERLND  41 PWATER SURO          0.1000      RCHRES  27      EXTNL   IVOL
PERLND  41 PWATER IFWO          0.1000      RCHRES  27      EXTNL   IVOL
IMPLND  11 IWATER SURO          1.5666      RCHRES  27      EXTNL   IVOL
*** SUB-BASIN      H1   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         14.8220      RCHRES  28      EXTNL   IVOL
PERLND  11 PWATER IFWO         14.8220      RCHRES  28      EXTNL   IVOL
PERLND  15 PWATER SURO         10.3327      RCHRES  28      EXTNL   IVOL
PERLND  15 PWATER IFWO         10.3327      RCHRES  28      EXTNL   IVOL
PERLND  17 PWATER SURO          4.3833      RCHRES  28      EXTNL   IVOL
PERLND  17 PWATER IFWO          4.3833      RCHRES  28      EXTNL   IVOL
PERLND  21 PWATER SURO          4.9761      RCHRES  28      EXTNL   IVOL
PERLND  21 PWATER IFWO          4.9761      RCHRES  28      EXTNL   IVOL
PERLND  25 PWATER SURO          8.4298      RCHRES  28      EXTNL   IVOL
PERLND  25 PWATER IFWO          8.4298      RCHRES  28      EXTNL   IVOL
PERLND  27 PWATER SURO          2.3010      RCHRES  28      EXTNL   IVOL
PERLND  27 PWATER IFWO          2.3010      RCHRES  28      EXTNL   IVOL
```

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PERLND  31 PWATER SURO        10.2023       RCHRES  28      EXTNL  IVOL
PERLND  31 PWATER IFWO        10.2023       RCHRES  28      EXTNL  IVOL
PERLND  31 PWATER AGWO         5.1012       RCHRES  28      EXTNL  IVOL
PERLND  41 PWATER SURO         7.1238       RCHRES  28      EXTNL  IVOL
PERLND  41 PWATER IFWO         7.1238       RCHRES  28      EXTNL  IVOL
PERLND  41 PWATER AGWO         3.0619       RCHRES  28      EXTNL  IVOL
PERLND  51 PWATER SURO         3.8167       RCHRES  28      EXTNL  IVOL
PERLND  51 PWATER IFWO         3.8167       RCHRES  28      EXTNL  IVOL
IMPLND  11 IWATER SURO         6.5707       RCHRES  28      EXTNL  IVOL
***
*** NOTE: MFACTOR 48.4 CONVERTS ACRE-FEET OF RUNOFF TO AVERAGE CFS PER MINUTE.
***       IT IS TIMESTEP DEPENDENT. THE OTHER MFACTORS CONVERT ACRE-FEET
***       OF RUNOFF TO INCHES.
***
RCHRES  17 HYDR   OVOL   1                  RCHRES  18      EXTNL  IVOL
RCHRES  17 HYDR   STAGE                     DISPLY   2      INPUT  TIMSER 1
RCHRES  18 HYDR   ROVOL  1                  RCHRES  19      EXTNL  IVOL
RCHRES  19 HYDR   ROVOL  1                  RCHRES  20      EXTNL  IVOL
RCHRES  20 HYDR   ROVOL  1                  RCHRES  22      EXTNL  IVOL
RCHRES  21 HYDR   ROVOL  1                  RCHRES  29      EXTNL  IVOL
RCHRES  21 HYDR   RO     1                  DISPLY   4      INPUT  TIMSER 1
RCHRES  29 HYDR   ROVOL  1                  RCHRES  22      EXTNL  IVOL
RCHRES  22 HYDR   ROVOL  1                  RCHRES  25      EXTNL  IVOL
RCHRES  23 HYDR   OVOL   1                  RCHRES  24      EXTNL  IVOL
RCHRES  23 HYDR   STAGE  1                  DISPLY   3      INPUT  TIMSER 1
RCHRES  24 HYDR   ROVOL  1                  RCHRES  25      EXTNL  IVOL
RCHRES  24 HYDR   RO     1                  DISPLY   5      INPUT  TIMSER 1
RCHRES  25 HYDR   ROVOL  1                  RCHRES  28      EXTNL  IVOL
RCHRES  26 HYDR   ROVOL  1                  RCHRES  27      EXTNL  IVOL
RCHRES  27 HYDR   ROVOL  1                  RCHRES  28      EXTNL  IVOL
RCHRES  28 HYDR   ROVOL  1   .003197        DISPLY   1      INPUT  TIMSER 1
RCHRES  28 HYDR   RO     1                  DISPLY   6      INPUT  TIMSER 1
END NETWORK
RCHRES
  GEN-INFO
    RCHRES       Name         Nexits   Unit Systems   Printer                ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG           ***
                                          in  out                            ***
   17     H12 - NORTH LAKE        2    1    1    1    6    0    1
   18     H11                     1    1    1    1    6    0    0
   19     H10 -WEYER. LAKE        1    1    1    1    6    0    1
   20     H8 -                    1    1    1    1    6    0    0
   21     H9 - CSG 12102775       1    1    1    1    6    0    0
   22     H6                      1    1    1    1    6    0    0
   23     H7 - LK. KILLARNEY      2    1    1    1    6    0    1
   24     H5 - CSG 12102770       1    1    1    1    6    0    0
   25     H4                      1    1    1    1    6    0    0
   26     H2                      1    1    1    1    6    0    0
   27     H3                      1    1    1    1    6    0    0
   28     H1 - GAGE 12102900      1    1    1    1    6    0    0
   29     KITS CORNER XING        1    1    1    1    6    0    0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                 ***
    17  29    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    RCHRES *************** Printout Flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
```

```
   17   29    6     0     0     0     0     0     0     0     0     0     1     9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                          ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
   17        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
   18        0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   19        0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   20   22   0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   23        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
   24   25   0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   26        0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   27        0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   28        0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   29        0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                       ***
    # -  #    FTABNO      LEN      DELTH     STCOR        KS      DB50         ***
  <------><--------><--------><--------><--------><--------><-------->       ***
***
   17             17   0.710               -32.76          0.5
   18             18   0.398                               0.0
   19             19   0.454                               0.5
   20             20   1.515                               0.0
   21             21   2.689                               0.0
   22             22   0.568                               0.0
   23             23   0.568                -13.40         0.5
   24             24   1.496                               0.0
   25             25   0.076                               0.0
   26             26   0.568                               0.0
   27             27   0.474                               0.0
   28             28   1.345                               0.0
   29             29     .20                               0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                             ***
    # -  # ***   VOL     Initial  value  of COLIND    Initial  value  of OUTDGT
           *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
   17      727.            4.0  5.0
   18      0.1200          4.0
   19      57.9            4.0
   20      0.5625          4.0
   21      0.0480          4.0
   22      0.4243          4.0
   23      260.            4.0  5.0
   24      0.4500          4.0
   25      0.4500          4.0
   26      0.4500          4.0
   27      0.4500          4.0
   28      0.4500          4.0
   29      0.00            4.0
  END HYDR-INIT
END RCHRES
                                                                                 ***
FTABLES
  FTABLE     17
```

```
ROWS COLS      (H12) NORTH LAKE- Outflow2 is seepage estimated from stage data**
   5    5
    Depth       Area     Volume  Outflow1   Outflow2                        ***
     (ft)    (acres)  (acre-ft)    (cfs)      (cfs)                         ***
    0.0       0.0       0.0       0.0       0.0
    33.0      50.5      730.      0.0       .02
    34.0      50.5      770.      0.0       .02
    35.0      50.5      830.      2.0       .00
    36.0      50.5      888.      15.0      .00
  END FTABLE 17
  FTABLE     18
ROWS COLS      (H11)                                                        ***
   4    4
    Depth       Area     Volume  Outflow1                                   ***
     (ft)    (acres)  (acre-ft)    (cfs)                                    ***
    0.0       0.0       0.0       0.0
    2.0       0.10      0.24      5.0
    4.0       0.19      0.58      15.0
    5.0       0.19      1.20      33.2
  END FTABLE 18
  FTABLE     19
ROWS COLS      (H10) WEYERHAUSER LAKE                                       ***
   7    4
    Depth       Area     Volume  Outflow1                                   ***
     (ft)    (acres)  (acre-ft)    (cfs)                                    ***
    0.0       0.0       0.0       0.0
    7.0       8.90      50.0      0.0
    8.0       8.90      58.0      0.0
    8.1       8.90      58.5      1.0
    9.0       8.90      66.9      5.0
    10.0      8.90      76.0      15.0
    11.       8.90      90.0      30.3
  END FTABLE 19
  FTABLE     20
Rows Cols      (H8)                                                         ***
   3    4
    Depth       Area     Volume  Outflow1                                   ***
     (ft)    (acres)  (acre-ft)    (cfs)                                    ***
    0.0       0.0       0.0       0.0
    0.5       1.49      0.77      2.0
    5.0       10.5      42.4      625.
  END FTABLE 20
  FTABLE     21
Rows cols      (H9)                                                         ***
   4    4
    Depth       Area     Volume  Outflow1                                   ***
     (ft)    (acres)  (acre-ft)    (cfs)                                    ***
    0.0       0.0       0.0       0.0
    0.5       1.04      0.73      3.0
    3.0       7.34      9.48      125.
    6.0       7.34      44.0      375.
  END FTABLE 21
  FTABLE     22
Rows Cols      (H6)                                                         ***
   3    4
    Depth       Area     Volume  Outflow1                                   ***
     (ft)    (acres)  (acre-ft)    (cfs)                                    ***
    0.0       0.0       0.0       0.0
    0.5       0.55      0.24      2.0
    5.5       0.69      3.34      400.
```

```
 END FTABLE 22
 FTABLE     23
ROWS COLS     (H7) LAKE KILLARNEY-Outflow2 is seepage from stage data        ***
   6    5
    Depth      Area    Volume  Outflow1  Outflow2                           ***
     (ft)   (acres) (acre-ft)   (cfs)     (cfs)                             ***
    0.0      0.0      0.0      0.0       0.0
    14.0     32.4     260.     0.0      .013
    15.0     32.4     290.     0.0      .013
    15.5     32.4     305.     1.0      .013
    16.0     32.4     322.     10.0      .00
    17.0     32.4     330.     14.2      .00
 END FTABLE 23
 FTABLE     24
Rows Cols     (H5)                                                          ***
   4    4
    Depth      Area    Volume  Outflow1                                     ***
     (ft)   (acres) (acre-ft)   (cfs)                                       ***
    0.0      0.0      0.0      0.0
    1.0      1.59     1.27     10.0
    3.0      2.60     6.53     40.0
    8.0      4.19     22.8     70.0
 END FTABLE 24
 FTABLE     25
ROWS COLS     (H4)                                                          ***
   3    4
    Depth      Area    Volume  Outflow1                                     ***
     (ft)   (acres) (acre-ft)   (cfs)                                       ***
    0.0      0.0      0.0      0.0
    0.5      0.07     .03      2.00
    5.5       .09     2.0      400.0
 END FTABLE 25
 FTABLE     26
Rows Cols     (H2)                                                          ***
   4    4
    Depth      Area    Volume  Outflow1                                     ***
     (ft)   (acres) (acre-ft)   (cfs)                                       ***
    0.0      0.0      0.0      0.0
    0.5      0.70     0.70     1.0
    3.0      0.70     16.0     50.0
    5.0      0.70     42.0     125.
 END FTABLE 26
 FTABLE     27
Rows Cols     (H3)                                                          ***
   3    4
    Depth      Area    Volume  Outflow1                                     ***
     (ft)   (acres) (acre-ft)   (cfs)                                       ***
    0.0      0.0      0.0      0.0
    0.5      0.46     0.20     2.0
    5.5      0.57     2.78     500.
 END FTABLE 27
 FTABLE     28
Rows Cols     (H1)                                                          ***
   6    4
    Depth      Area    Volume  Outflow1                                     ***
     (ft)   (acres) (acre-ft)   (cfs)                                       ***
    0.0      0.0      0.0      0.0
    0.5      2.60     0.40     1.0
    0.75     2.60     3.00     2.50
    1.0      2.60     3.82     10.0
```

```
    3.0       2.60      15.0       100.
    8.0       2.60      110.       1500.
  END FTABLE 28
  FTABLE     29
 ROWS COLS      (KITT CORNER RD XING)                                              ***
   6    4
    Depth       Area    Volume  Outflow1                                           ***
     (ft)    (acres) (acre-ft)    (cfs)                                            ***
    0.0       0.0       0.0       0.0
    2.5       2.60       .02      24.5
    6.8       2.60       .40      44.5
    8.5       2.60       2.9      51.0
   10.5       2.60       5.6      55.0
   11.5       2.60       8.6      120.
  END FTABLE 29
END FTABLES
                                                                                   ***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply--->  <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1   PYR DIG2 FIL2 YRND
    1        HYLEBOS AT 5TH SIMQ  (IN)   SUM     0    3    6     1    3    6    9
    2        NORTH LAKE STAGE (FEET)     MAX     0    2    6     1    2    6    9
    3        LAKE KILLARNEY STG (FEET)   MAX     0    2    6     1    2    6    9
    4        CSG 12102775 (CFS)          MAX     0    2    6     1    2    6    9
    5        CSG 12102770 (CFS)          MAX     0    2    6     1    2    6    9
    6        HYL5 SIMPEAKS CFS -4/9A     MAX     0    2    6     1    2    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A2. Final version of the HSPF input file used for the West Branch Hylebos Creek Basin

```
RUN
GLOBAL
  HYLEBOS CREEK - WEST BRANCH - Final validation run
  *** GROUNDWATER RESERVOIR (PERLND 99) HAS KV=0, AGWRC=.998
  *** IFWO FROM TILL IN WH14,WH13,WH12,WH7,WH6,WH5 AND 1/2 WH4 FLOWS TO P99.
  *** AGWO (AND AGWI FOR OW) FROM ALL PERLNDS IN ABOVE SUBBASINS FLOWS TO P99.
  *** P99 OUTFLOW GOES MOSTLY TO RCHRES 13, WITH SOME TO RCHRES 5.
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      PERLND      12
      PERLND      16
      PERLND      18
      PERLND      22
      PERLND      26
      PERLND      28
      PERLND      32
      PERLND      42
      IMPLND      12
      PERLND      52
      RCHRES       2
      RCHRES       3
      RCHRES       4
      PERLND      99
      RCHRES       5
      RCHRES       6
      RCHRES       7
      RCHRES       8
      RCHRES       9
      RCHRES      10
      RCHRES      11
      RCHRES      12
      RCHRES      13
      RCHRES      14
      RCHRES      15
      DISPLY       1
      DISPLY       2
      DISPLY       3
      DISPLY       4
      DISPLY       5
    END INGRP
END OPN SEQUENCE
                                                                       ***
PERLND
```

```
GEN-INFO
  <PLS >       Name           NBLKS   Unit-systems   Printer                ***
  # -  #                            User  t-series Engl Metr                ***
                                          in  out                           ***
 11    12 TF/MILD              1    1    1    1    6    0
 15    16 TF/MODERATE          1    1    1    1    6    0
 17    18 TF/STEEP             1    1    1    1    6    0
 21    22 TG/MILD              1    1    1    1    6    0
 25    26 TG/MODERATE          1    1    1    1    6    0
 27    28 TG/STEEP             1    1    1    1    6    0
 31    32 OF/MILD              1    1    1    1    6    0
 41    42 OG/MILD              1    1    1    1    6    0
 51    52 WETLANDS             1    1    1    1    6    0
 99       GW RESERVOIR         1    1    1    1    6    0
END GEN-INFO
ACTIVITY
  <PLS > ************* Active Sections ****************************
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC        ***
 11    99    0    0    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  <PLS > ********************* Print-flags ************************ PIVL  PYR
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
 11    99    0    0    5    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > ***************** Flags *******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                       ***
 11    99    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11    12      0.75    4.5000    0.0800    400.00    0.0500    0.5000    0.9960
 15    16      0.75    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
 17    18      0.75    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
 21    22      0.05    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
 25    26      0.05    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
 27    28      0.05    4.5000    0.0300    200.00    0.2000    0.5000    0.9960
 31    32      0.75    5.0000    2.0000    400.00    0.0500    0.3000    0.9960
 41    42      0.05    5.0000    0.8000    400.00    0.0500    0.3000    0.9960
 51    52      0.75    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
 99            0.75    5.0000    2.0000    400.00    0.0500    0.0000    0.9980
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11    12                       3.5000    2.0000       .00        0.        0.
 15    16                       2.0000    2.0000       .00        0.        0.
 17    18                       1.5000    2.0000       .00        0.        0.
 21    22                       3.5000    2.0000       .00        0.        0.
 25    26                       2.0000    2.0000       .00        0.        0.
 27    28                       1.5000    2.0000       .00        0.        0.
 31    32                       2.0000    2.0000       .00        0.        0.
 41    42                       2.0000    2.0000       .00        0.        0.
 51    52                       10.000    2.0000       .00        0.       0.7
 99                             2.0000    2.0000       .00        0.        0.
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                            ***
```

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    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
   11   12    0.2000    1.0000    0.3500     3.000    0.7000    0.7000
   15   16    0.2000    0.5000    0.3500     6.000    0.5000    0.7000
   17   18    0.2000    0.3000    0.3500     7.000    0.3000    0.7000
   21   22    0.1000    0.5000    0.2500     3.000    0.7000    0.2500
   25   26    0.1000    0.2500    0.2500     6.000    0.5000    0.2500
   27   28    0.1000    0.1500    0.2500     7.000    0.3000    0.2500
   31   32    0.2000    0.5000    0.3500     0.000    0.7000    0.7000
   41   42    0.1000    0.5000    0.2500     0.000    0.7000    0.2500
   51   52    0.1000    3.0000    0.5000     1.000    0.7000    0.8000
   99         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   11   12        0.        0.    0.0030        0.      .954      3.00      .017
   15   16        0.        0.    0.0060        0.     .9420      3.30      .016
   17   18        0.        0.    0.0140        0.      .933      3.40      .016
   21   22        0.        0.    0.1310        0.      2.78      2.40      .095
   25   26        0.        0.    0.2480        0.      2.47      2.50      .068
   27   28        0.        0.    0.2220        0.      2.36      2.60      .062
   31   32        0.        0.    0.0010        0.      .966      6.00      .052
   41   42        0.        0.    0.0250        0.      4.08      6.60      .257
   51   52        0.        0.    0.6620        0.      3.39      0.10      .162
   99             0.        0.    0.0010        0.      .001      100.      .052
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name             Unit-systems   Printer                      ***
    # -  #                     User  t-series Engl Metr                      ***
                                      in  out                                ***
   11   12 IMPERVIOUS             1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11   12    0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11   12    0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >        Flags            ***                                       ***
    # -  # CSNO RTOP  VRS  VNN RTLI    ***                                   ***
   11   12    0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                   ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                           ***
   11   12    500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                   ***
    # -  #    PETMAX    PETMIN                                               ***
   11   12
  END IWAT-PARM3
  IWAT-STATE1
```

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    <ILS >  IWATER state variables                                            ***
    # -  #       RETS      SURS                                               ***
   11   12 1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                              ***
EXT SOURCES
                                                                              ***
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
***       P99 recieves (almost) no precip - it is underground.
                                                                              ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #   ***
WDM      2 PREC     ENGL                   PERLND  12     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  16     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  18     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  22     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  26     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  28     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  32     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  42     EXTNL  PREC
WDM      2 PREC     ENGL                   PERLND  52     EXTNL  PREC
WDM      2 PREC     ENGL      0.0001       PERLND  99     EXTNL  PREC
WDM      2 PREC     ENGL                   IMPLND  12     EXTNL  PREC
WDM      2 PREC     ENGL                   RCHRES   4     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  11     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  15     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  17     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  21     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  25     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  27     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  31     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  41     EXTNL  PREC
WDM      1 PREC     ENGL                   PERLND  51     EXTNL  PREC
WDM      1 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      3 PET      ENGL                   PERLND  11 99  EXTNL  PETINP
WDM      3 PET      ENGL                   IMPLND  11 12  EXTNL  PETINP
WDM      3 PET      ENGL                   RCHRES   4     EXTNL  POTEV
END EXT SOURCES
                                                                              ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES  12 HYDR   ROVOL  1        48.4 SAME WDM      8 SIMQ     ENGL      REPL
RCHRES  15 HYDR   ROVOL  1        48.4 SAME WDM      9 SIMQ     ENGL      REPL
END EXT TARGETS
                                                                              ***
NETWORK
                                                                              ***
*** NOTE: MFACTOR= 53.33 X SEGMENT AREA (SQ.MILES) TO CONVERT INCHES TO AC-FT.
  *** SUB-BASIN WH15 ***
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #   ***
  ***
  *** IFWO FROM TILL IN WH14,WH13,WH12,WH7,WH6,WH5, 1/2 WH4 TO P99 GW RESERVOIR.
  *** RESERVOIR AREA=468.2 ACRES - MFACTS ARE RATIOS OF PERLND AREA TO RES AREA.
  ***
PERLND  12 PWATER IFWO          1.1425       PERLND  99     EXTNL  AGWLI
PERLND  16 PWATER IFWO          0.4344       PERLND  99     EXTNL  AGWLI
PERLND  18 PWATER IFWO          0.3338       PERLND  99     EXTNL  AGWLI
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PERLND  22 PWATER IFWO         0.5058      PERLND  99     EXTNL  AGWLI
PERLND  26 PWATER IFWO         0.1818      PERLND  99     EXTNL  AGWLI
PERLND  28 PWATER IFWO         0.0201      PERLND  99     EXTNL  AGWLI
  ***
  *** AGWO FROM TILL AND SATURATED SEGS IN ABOVE SUBBASINS PLUS WH15 TO P99.
  ***
PERLND  12 PWATER AGWO         1.6995      PERLND  99     EXTNL  AGWLI
PERLND  16 PWATER AGWO         0.4474      PERLND  99     EXTNL  AGWLI
PERLND  18 PWATER AGWO         0.3338      PERLND  99     EXTNL  AGWLI
PERLND  22 PWATER AGWO         1.0208      PERLND  99     EXTNL  AGWLI
PERLND  26 PWATER AGWO         0.1818      PERLND  99     EXTNL  AGWLI
PERLND  28 PWATER AGWO         0.0201      PERLND  99     EXTNL  AGWLI
PERLND  52 PWATER AGWO         0.3259      PERLND  99     EXTNL  AGWLI
  ***
  *** AGWI FROM OUTWASH IN ABOVE SUBBASINS TO P99
  ***
PERLND  32 PWATER AGWI         0.8430      PERLND  99     EXTNL  AGWLI
PERLND  42 PWATER AGWI         0.1570      PERLND  99     EXTNL  AGWLI
  ***
  *** CHANNEL NETWORK LINKAGES ***
*** SUB-BASIN     WH14 RUNOFF FROM LAND SEGMENTS
PERLND  12 PWATER SURO        10.2500      RCHRES   2     EXTNL  IVOL
PERLND  16 PWATER SURO         4.7250      RCHRES   2     EXTNL  IVOL
PERLND  18 PWATER SURO         4.9000      RCHRES   2     EXTNL  IVOL
PERLND  22 PWATER SURO         1.9473      RCHRES   2     EXTNL  IVOL
PERLND  26 PWATER SURO         3.9146      RCHRES   2     EXTNL  IVOL
PERLND  28 PWATER SURO         0.2500      RCHRES   2     EXTNL  IVOL
PERLND  32 PWATER SURO        10.6917      RCHRES   2     EXTNL  IVOL
PERLND  42 PWATER SURO         1.9182      RCHRES   2     EXTNL  IVOL
PERLND  52 PWATER SURO         1.0083      RCHRES   2     EXTNL  IVOL
IMPLND  12 IWATER SURO         3.1165      RCHRES   2     EXTNL  IVOL
*** SUB-BASIN     WH13 RUNOFF FROM LAND SEGMENTS
PERLND  12 PWATER SURO         2.1667      RCHRES   4     EXTNL  IVOL
PERLND  16 PWATER SURO         1.2000      RCHRES   4     EXTNL  IVOL
PERLND  18 PWATER SURO         0.3917      RCHRES   4     EXTNL  IVOL
PERLND  22 PWATER SURO         0.2787      RCHRES   4     EXTNL  IVOL
PERLND  26 PWATER SURO         0.4033      RCHRES   4     EXTNL  IVOL
PERLND  28 PWATER SURO         0.3153      RCHRES   4     EXTNL  IVOL
PERLND  32 PWATER SURO         2.1333      RCHRES   4     EXTNL  IVOL
PERLND  42 PWATER SURO         0.4167      RCHRES   4     EXTNL  IVOL
IMPLND  12 IWATER SURO         0.5416      RCHRES   4     EXTNL  IVOL
  *** PANTHER LAKE SEEPAGE TO GW RESERVOIR ***
RCHRES   4 HYDR   OVOL   2    .000178      PERLND  99     EXTNL  AGWLI
  ***
*** SUB-BASIN     WH12 RUNOFF FROM LAND SEGMENTS
PERLND  12 PWATER SURO         9.5500      RCHRES   3     EXTNL  IVOL
PERLND  16 PWATER SURO         1.7167      RCHRES   3     EXTNL  IVOL
PERLND  18 PWATER SURO         1.4000      RCHRES   3     EXTNL  IVOL
PERLND  22 PWATER SURO        21.2906      RCHRES   3     EXTNL  IVOL
PERLND  26 PWATER SURO         3.4473      RCHRES   3     EXTNL  IVOL
PERLND  32 PWATER SURO         1.6333      RCHRES   3     EXTNL  IVOL
PERLND  42 PWATER SURO         0.4750      RCHRES   3     EXTNL  IVOL
IMPLND  12 IWATER SURO        10.8827      RCHRES   3     EXTNL  IVOL
*** SUB-BASIN     WH11 RUNOFF FROM LAND SEGMENTS
PERLND  12 PWATER SURO         7.3750      RCHRES   9     EXTNL  IVOL
PERLND  12 PWATER IFWO         7.3750      RCHRES   9     EXTNL  IVOL
PERLND  16 PWATER SURO         1.8333      RCHRES   9     EXTNL  IVOL
PERLND  16 PWATER IFWO         1.8333      RCHRES   9     EXTNL  IVOL
PERLND  22 PWATER SURO         4.5174      RCHRES   9     EXTNL  IVOL
PERLND  22 PWATER IFWO         4.5174      RCHRES   9     EXTNL  IVOL
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PERLND  26 PWATER SURO          0.0887      RCHRES   9      EXTNL  IVOL
PERLND  26 PWATER IFWO          0.0887      RCHRES   9      EXTNL  IVOL
PERLND  32 PWATER SURO          0.7250      RCHRES   9      EXTNL  IVOL
PERLND  42 PWATER SURO          0.0275      RCHRES   9      EXTNL  IVOL
IMPLND  12 IWATER SURO         17.2497      RCHRES   9      EXTNL  IVOL
*** SUB-BASIN    WH10 RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          5.3583      RCHRES   8      EXTNL  IVOL
PERLND  11 PWATER IFWO          5.3583      RCHRES   8      EXTNL  IVOL
PERLND  15 PWATER SURO          3.7833      RCHRES   8      EXTNL  IVOL
PERLND  15 PWATER IFWO          3.7833      RCHRES   8      EXTNL  IVOL
PERLND  17 PWATER SURO          0.0320      RCHRES   8      EXTNL  IVOL
PERLND  17 PWATER IFWO          0.0320      RCHRES   8      EXTNL  IVOL
PERLND  21 PWATER SURO          3.6438      RCHRES   8      EXTNL  IVOL
PERLND  21 PWATER IFWO          3.6438      RCHRES   8      EXTNL  IVOL
PERLND  25 PWATER SURO          2.5651      RCHRES   8      EXTNL  IVOL
PERLND  25 PWATER IFWO          2.5651      RCHRES   8      EXTNL  IVOL
PERLND  51 PWATER SURO          0.1500      RCHRES   8      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.1500      RCHRES   8      EXTNL  IVOL
IMPLND  11 IWATER SURO         10.6175      RCHRES   8      EXTNL  IVOL
*** SUB-BASIN    WH9  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          1.4600      RCHRES   6      EXTNL  IVOL
PERLND  11 PWATER IFWO          1.4600      RCHRES   6      EXTNL  IVOL
PERLND  15 PWATER SURO          0.9407      RCHRES   6      EXTNL  IVOL
PERLND  15 PWATER IFWO          0.9407      RCHRES   6      EXTNL  IVOL
PERLND  21 PWATER SURO          0.2275      RCHRES   6      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.2275      RCHRES   6      EXTNL  IVOL
PERLND  25 PWATER SURO          0.0588      RCHRES   6      EXTNL  IVOL
PERLND  25 PWATER IFWO          0.0588      RCHRES   6      EXTNL  IVOL
PERLND  51 PWATER SURO          0.4417      RCHRES   6      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.4417      RCHRES   6      EXTNL  IVOL
IMPLND  11 IWATER SURO          1.2964      RCHRES   6      EXTNL  IVOL
*** SUB-BASIN    WH8  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          9.3183      RCHRES  10      EXTNL  IVOL
PERLND  11 PWATER IFWO          9.3183      RCHRES  10      EXTNL  IVOL
PERLND  15 PWATER SURO          1.7167      RCHRES  10      EXTNL  IVOL
PERLND  15 PWATER IFWO          1.7167      RCHRES  10      EXTNL  IVOL
PERLND  21 PWATER SURO          1.4492      RCHRES  10      EXTNL  IVOL
PERLND  21 PWATER IFWO          1.4492      RCHRES  10      EXTNL  IVOL
PERLND  25 PWATER SURO          0.2225      RCHRES  10      EXTNL  IVOL
PERLND  25 PWATER IFWO          0.2225      RCHRES  10      EXTNL  IVOL
PERLND  31 PWATER SURO          0.5667      RCHRES  10      EXTNL  IVOL
PERLND  41 PWATER SURO          0.0350      RCHRES  10      EXTNL  IVOL
PERLND  51 PWATER SURO          0.8333      RCHRES  10      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.8333      RCHRES  10      EXTNL  IVOL
IMPLND  11 IWATER SURO          5.4917      RCHRES  10      EXTNL  IVOL
*** SUB-BASIN    WH7  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         14.0313      RCHRES   5      EXTNL  IVOL
PERLND  15 PWATER SURO          5.9167      RCHRES   5      EXTNL  IVOL
PERLND  17 PWATER SURO          5.7500      RCHRES   5      EXTNL  IVOL
PERLND  21 PWATER SURO          1.5747      RCHRES   5      EXTNL  IVOL
PERLND  25 PWATER SURO          0.6997      RCHRES   5      EXTNL  IVOL
PERLND  27 PWATER SURO          0.2804      RCHRES   5      EXTNL  IVOL
PERLND  31 PWATER SURO         10.5340      RCHRES   5      EXTNL  IVOL
PERLND  41 PWATER SURO          2.0033      RCHRES   5      EXTNL  IVOL
PERLND  51 PWATER SURO          5.2583      RCHRES   5      EXTNL  IVOL
PERLND  51 PWATER IFWO          5.2583      RCHRES   5      EXTNL  IVOL
IMPLND  11 IWATER SURO          2.6099      RCHRES   5      EXTNL  IVOL
   ***
   *** AGWO CONTRIBUTIONS FROM P99 (4% OF TOTAL P99 AGWO)
   ***
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PERLND  99 PWATER AGWO         1.6000      RCHRES   5      EXTNL  IVOL
*** SUB-BASIN     WH6  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         0.7723      RCHRES   7      EXTNL  IVOL
PERLND  15 PWATER SURO         0.2973      RCHRES   7      EXTNL  IVOL
PERLND  21 PWATER SURO         0.4175      RCHRES   7      EXTNL  IVOL
PERLND  31 PWATER SURO         0.1490      RCHRES   7      EXTNL  IVOL
PERLND  41 PWATER SURO         0.2333      RCHRES   7      EXTNL  IVOL
PERLND  51 PWATER SURO         2.6250      RCHRES   7      EXTNL  IVOL
PERLND  51 PWATER IFWO         2.6250      RCHRES   7      EXTNL  IVOL
IMPLND  11 IWATER SURO         0.2555      RCHRES   7      EXTNL  IVOL
*** SUB-BASIN     WH5  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         2.4777      RCHRES  11      EXTNL  IVOL
PERLND  21 PWATER SURO         0.6625      RCHRES  11      EXTNL  IVOL
PERLND  51 PWATER SURO         3.8250      RCHRES  11      EXTNL  IVOL
PERLND  51 PWATER IFWO         3.8250      RCHRES  11      EXTNL  IVOL
IMPLND  11 IWATER SURO         1.1598      RCHRES  11      EXTNL  IVOL
*** SUB-BASIN     WH4  RUNOFF FROM LAND SEGMENTS
  *** REMEMBER, 1/2 OF TILL IFWO AND AGWO ROUTED TO GW RES.
PERLND  11 PWATER SURO        10.6507      RCHRES  13      EXTNL  IVOL
PERLND  11 PWATER IFWO         5.3254      RCHRES  13      EXTNL  IVOL
PERLND  11 PWATER AGWO         5.3254      RCHRES  13      EXTNL  IVOL
PERLND  15 PWATER SURO         6.1887      RCHRES  13      EXTNL  IVOL
PERLND  15 PWATER IFWO         3.0944      RCHRES  13      EXTNL  IVOL
PERLND  15 PWATER AGWO         3.0944      RCHRES  13      EXTNL  IVOL
PERLND  17 PWATER SURO         1.1583      RCHRES  13      EXTNL  IVOL
PERLND  17 PWATER IFWO         0.5791      RCHRES  13      EXTNL  IVOL
PERLND  17 PWATER AGWO         0.5791      RCHRES  13      EXTNL  IVOL
PERLND  21 PWATER SURO         3.1537      RCHRES  13      EXTNL  IVOL
PERLND  21 PWATER IFWO         1.5768      RCHRES  13      EXTNL  IVOL
PERLND  21 PWATER AGWO         1.5768      RCHRES  13      EXTNL  IVOL
PERLND  25 PWATER SURO         1.5988      RCHRES  13      EXTNL  IVOL
PERLND  25 PWATER IFWO         0.7994      RCHRES  13      EXTNL  IVOL
PERLND  25 PWATER AGWO         0.7994      RCHRES  13      EXTNL  IVOL
PERLND  27 PWATER SURO         0.1313      RCHRES  13      EXTNL  IVOL
PERLND  27 PWATER IFWO         0.0656      RCHRES  13      EXTNL  IVOL
PERLND  27 PWATER AGWO         0.0656      RCHRES  13      EXTNL  IVOL
PERLND  31 PWATER SURO         7.7490      RCHRES  13      EXTNL  IVOL
PERLND  41 PWATER SURO         1.6487      RCHRES  13      EXTNL  IVOL
PERLND  51 PWATER SURO         5.3833      RCHRES  13      EXTNL  IVOL
PERLND  51 PWATER IFWO         5.3833      RCHRES  13      EXTNL  IVOL
PERLND  51 PWATER AGWO         5.3833      RCHRES  13      EXTNL  IVOL
IMPLND  11 IWATER SURO         3.3125      RCHRES  13      EXTNL  IVOL
   ***
   *** AGWO CONTRIBUTIONS FROM P99 (58% OF TOTAL P99 AGWO)
   ***
PERLND  99 PWATER AGWO        22.6000      RCHRES  13      EXTNL  IVOL
   ***
*** SUB-BASIN     WH3  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         9.7090      RCHRES  14      EXTNL  IVOL
PERLND  11 PWATER IFWO         9.7090      RCHRES  14      EXTNL  IVOL
PERLND  11 PWATER AGWO         9.7090      RCHRES  14      EXTNL  IVOL
PERLND  15 PWATER SURO         7.1493      RCHRES  14      EXTNL  IVOL
PERLND  15 PWATER IFWO         7.1493      RCHRES  14      EXTNL  IVOL
PERLND  15 PWATER AGWO         7.1493      RCHRES  14      EXTNL  IVOL
PERLND  17 PWATER SURO         1.7957      RCHRES  14      EXTNL  IVOL
PERLND  17 PWATER IFWO         1.7957      RCHRES  14      EXTNL  IVOL
PERLND  17 PWATER AGWO         1.7957      RCHRES  14      EXTNL  IVOL
PERLND  21 PWATER SURO         4.8396      RCHRES  14      EXTNL  IVOL
PERLND  21 PWATER IFWO         4.8396      RCHRES  14      EXTNL  IVOL
PERLND  21 PWATER AGWO         4.8396      RCHRES  14      EXTNL  IVOL
```

```
PERLND  25 PWATER SURO          4.0805       RCHRES  14      EXTNL  IVOL
PERLND  25 PWATER IFWO          4.0805       RCHRES  14      EXTNL  IVOL
PERLND  25 PWATER AGWO          4.0805       RCHRES  14      EXTNL  IVOL
PERLND  51 PWATER SURO         10.2917       RCHRES  14      EXTNL  IVOL
PERLND  51 PWATER IFWO         10.2917       RCHRES  14      EXTNL  IVOL
PERLND  51 PWATER AGWO         10.2917       RCHRES  14      EXTNL  IVOL
IMPLND  11 IWATER SURO          9.2343       RCHRES  14      EXTNL  IVOL
*** SUB-BASIN      WH2  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          1.0827       RCHRES  15      EXTNL  IVOL
PERLND  11 PWATER IFWO          1.0827       RCHRES  15      EXTNL  IVOL
PERLND  11 PWATER AGWO          1.0827       RCHRES  15      EXTNL  IVOL
PERLND  15 PWATER SURO          1.0783       RCHRES  15      EXTNL  IVOL
PERLND  15 PWATER IFWO          1.0783       RCHRES  15      EXTNL  IVOL
PERLND  15 PWATER AGWO          1.0783       RCHRES  15      EXTNL  IVOL
PERLND  17 PWATER SURO          3.1440       RCHRES  15      EXTNL  IVOL
PERLND  17 PWATER IFWO          3.1440       RCHRES  15      EXTNL  IVOL
PERLND  17 PWATER AGWO          3.1440       RCHRES  15      EXTNL  IVOL
PERLND  21 PWATER SURO          0.1287       RCHRES  15      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.1287       RCHRES  15      EXTNL  IVOL
PERLND  21 PWATER AGWO          0.1287       RCHRES  15      EXTNL  IVOL
PERLND  25 PWATER SURO          0.4500       RCHRES  15      EXTNL  IVOL
PERLND  25 PWATER IFWO          0.4500       RCHRES  15      EXTNL  IVOL
PERLND  25 PWATER AGWO          0.4500       RCHRES  15      EXTNL  IVOL
PERLND  31 PWATER SURO          1.1203       RCHRES  15      EXTNL  IVOL
PERLND  31 PWATER IFWO          1.1203       RCHRES  15      EXTNL  IVOL
PERLND  31 PWATER AGWO          1.1203       RCHRES  15      EXTNL  IVOL
PERLND  41 PWATER SURO          0.0250       RCHRES  15      EXTNL  IVOL
PERLND  41 PWATER IFWO          0.0250       RCHRES  15      EXTNL  IVOL
PERLND  41 PWATER AGWO          0.0250       RCHRES  15      EXTNL  IVOL
PERLND  51 PWATER SURO          3.5250       RCHRES  15      EXTNL  IVOL
PERLND  51 PWATER IFWO          3.5250       RCHRES  15      EXTNL  IVOL
PERLND  51 PWATER AGWO          3.5250       RCHRES  15      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.3459       RCHRES  15      EXTNL  IVOL
*** NOTE: MFACTOR 48.4 CONVERTS ACRE-FEET OF RUNOFF TO AVG CFS PER 15 MINUTE.
***       IT IS TIMESTEP DEPENDENT. THE OTHER MFACTORS CONVERT ACRE-FEET
***       OF RUNOFF TO INCHES.
RCHRES   2 HYDR   ROVOL  1                   RCHRES   4      EXTNL  IVOL
RCHRES   3 HYDR   ROVOL  1                   RCHRES   4      EXTNL  IVOL
RCHRES   4 HYDR   STAGE  1                   DISPLY   3      INPUT  TIMSER 1
RCHRES   4 HYDR   OVOL   1                   RCHRES   5      EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1                   RCHRES  12      EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1                   RCHRES   7      EXTNL  IVOL
RCHRES   7 HYDR   ROVOL  1                   RCHRES  12      EXTNL  IVOL
RCHRES   8 HYDR   ROVOL  1                   RCHRES  10      EXTNL  IVOL
RCHRES   9 HYDR   ROVOL  1                   RCHRES  10      EXTNL  IVOL
RCHRES  10 HYDR   ROVOL  1                   RCHRES  11      EXTNL  IVOL
RCHRES  11 HYDR   ROVOL  1                   RCHRES  12      EXTNL  IVOL
RCHRES  12 HYDR   ROVOL  1   .004268         DISPLY   1      INPUT  TIMSER 1
RCHRES  12 HYDR   RO     1                   DISPLY   4      INPUT  TIMSER 1
RCHRES  12 HYDR   ROVOL  1                   RCHRES  13      EXTNL  IVOL
RCHRES  13 HYDR   ROVOL  1                   RCHRES  15      EXTNL  IVOL
RCHRES  14 HYDR   ROVOL  1                   RCHRES  15      EXTNL  IVOL
RCHRES  15 HYDR   ROVOL  1   .003000         DISPLY   2      INPUT  TIMSER 1
RCHRES  15 HYDR   RO     1                   DISPLY   5      INPUT  TIMSER 1
END NETWORK
RCHRES
  GEN-INFO
    RCHRES        Name        Nexits  Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                              in  out                        ***
```

```
  2     WH14                    1    1    1    1    6    0    0
  3     WH12                    1    1    1    1    6    0    0
  4     WH13 - PANTHER LAKE     2    1    1    1    6    0    1
  5     WH7                     1    1    1    1    6    0    0
  6     WH9                     1    1    1    1    6    0    0
  7     WH6                     1    1    1    1    6    0    0
  8     WH10                    1    1    1    1    6    0    0
  9     WH11 - HWY. 99 PIPE     1    1    1    1    6    0    0
 10     WH8                     1    1    1    1    6    0    0
 11     WH5 - BROOK LAKE        1    1    1    1    6    0    0
 12     GAGE REACH-12102920     1    1    1    1    6    0    0
 13     WH4                     1    1    1    1    6    0    0
 14     WH3                     1    1    1    1    6    0    0
 15     WH2 - GAGE 12103000     1    1    1    1    6    0    1
END GEN-INFO
ACTIVITY
  RCHRES *************** Active Sections *****************
  # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                 ***
  2   15    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  RCHRES *************** Printout Flags ***************** PIVL  PYR
  # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
  2    3    6    0    0    0    0    0    0    0    0    0    1    9
  4         5    0    0    0    0    0    0    0    0    0    1    9
  5   15    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
HYDR-PARM1
  RCHRES  Flags for each HYDR Section                                     ***
  # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
          FG FG FG FG  possible  exit  *** possible  exit      possible  exit
           *  *  *  *    *  *  *  *  *        *  *  *  *  *        ***
  2    3   0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
  4        0  1  0  0    4  5  0  0  0        0  0  0  0  0      2  2  2  2  2
  5        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
  6   15   0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
END HYDR-PARM1
HYDR-PARM2
  RCHRES                                                                  ***
  # -  #     FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
<------><--------><--------><--------><--------><--------><-------->      ***
  2              2   1.042                             0.0
  3              3   1.421                             0.0
  4              4   0.133                232.6        0.5
  5              5   1.061                             0.0
  6              6   0.070                             0.5
  7              7   0.587                             0.0
  8              8   1.326                             0.0
  9              9   1.591                             0.0
 10             10   0.758                             0.0
 11             11   0.606                             0.5
 12             12   0.010                             0.0
 13             13   1.002                             0.5
 14             14   1.364                             0.0
 15             15   0.284                             0.0
END HYDR-PARM2
HYDR-INIT
  RCHRES  Initial conditions for each HYDR section                        ***
  # -  # ***    VOL     Initial  value  of COLIND    Initial  value  of OUTDGT
         *** ac-ft      for each possible exit       for each possible exit
```

```
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    2     0.0              4.0
    3     0.0              4.0
    4     3.50             4.0  5.0
    5     0.02             4.0
    6     23.200           4.0
    7     .05              4.0
    8     .05              4.0
    9     .05              4.0
   10     .25              4.0
   11     2.0              4.0
   12     .004             4.0
   13     .12              4.0
   14     0.6050           4.0
   15     0.3100           4.0
  END HYDR-INIT
END RCHRES
                                                                            ***
FTABLES
  FTABLE      2
 Rows Cols    (WH14)                                                        ***
    4    4
     Depth      Area    Volume  Outflow1                                    ***
      (ft)    (acres) (acre-ft)  (cfs)                                      ***
     0.0       0.0      0.0       0.0
     0.5       0.57     0.27      2.0
     3.0       13.1     17.3      50.0
     8.0       14.0     84.3      650.0
  END FTABLE  2
  FTABLE      3
 Rows Cols     (WH12)                                                       ***
    4    4
     Depth      Area    Volume  Outflow1                                    ***
      (ft)    (acres) (acre-ft)  (cfs)                                      ***
     0.0       0.0      0.0       0.0
     0.5       0.51     0.26      1.00
     3.0       0.86     2.07      55.0
     6.0       1.21     5.17      230.
  END FTABLE  3
***
*** OUTFLOW 2 BASED ON GAGE DATA
  FTABLE      4
 ROWS COLS     (WH13) PANTHER LAKE - SEEPAGE FROM LAKE BOTTOM               ***
   10    5
     DEPTH      AREA    VOLUME  OUTFLOW1  OUTFLOW2                          ***
      (FT)    (ACRES) (ACRE-FT)  (CFS) LAST ROW WAS EXTRAPOLATED            ***
     0.0       0.0      0.0       0.0        0.0
     2.0       8.20     16.4      0.0         .25
     4.0       8.20     32.8      0.0         .30
     6.0       8.20     49.2      0.0         .35
     10.0      8.20     65.0      0.0         .40
     12.0      8.20     100.      0.0         .50
     13.0      8.20     110.      5.0        1.25
     15.0      8.20     135.      20.0       1.75
     17.0      8.20     150.      50.0       2.00
     18.0      8.20     170.      90.0       2.10
  END FTABLE  4
  FTABLE      5
 Rows Cols     (WH7)                                                        ***
    4    4
```

```
    Depth      Area     Volume  Outflow1                                         ***
     (ft)    (acres) (acre-ft)   (cfs)                                           ***
    0.0       0.0       0.0      0.0         0.0
    0.5       0.90      0.17     3.00        0.9
    2.0       0.90      45.5     40.0        1.0
    5.0       0.90      227.     265.        1.3
 END FTABLE  5
 FTABLE      6
Rows Cols     (WH9)                                                              ***
  5    4
    Depth      Area     Volume  Outflow1                                         ***
     (FT)    (ACRES) (ACRE-FT)   (CFS)  LAST ROW WAS EXTRAPOLATED                ***
    0.0       0.0       0.0      0.0
    5.0       5.50      23.0     0.0
    5.5       5.50      26.3     2.50
    6.5       5.50      33.0     20.
    6.7       5.50      40.0     38.3
 END FTABLE  6
 FTABLE      7
Rows Cols     (WH6)                                                              ***
  4    4
    Depth      Area     Volume  Outflow1                                         ***
     (ft)    (acres) (acre-ft)   (cfs)                                           ***
    0.0       0.0       0.0      0.0
    0.50      0.25      0.14     3.0
    2.00      16.0      12.2     30.0
    5.00      32.0      84.2     185.
 END FTABLE  7
 FTABLE      8
Rows Cols     (WH10)                                                             ***
  5    4
    Depth      Area     Volume  Outflow1                                         ***
     (ft)    (acres) (acre-ft)   (cfs)                                           ***
    0.0       0.0       0.0      0.0
    0.5       0.35      0.12     2.5
    1.0       0.70      0.35     10.0
    1.5       2.28      1.14     20.0
    2.5       2.50      3.54     60.0
 END FTABLE  8
 FTABLE      9
Rows Cols     (WH11)                                                             ***
  7    4
    Depth      Area     Volume  Outflow1                                         ***
     (ft)    (acres) (acre-ft)   (cfs)                                           ***
    0.0       0.0       0.0      0.0
    0.5       0.42      0.14     2.4
    1.0       0.54      0.39     12.
    1.5       0.58      0.68     25.
    2.0       0.58      0.95     44.
    2.5       0.58      1.21     70.
    3.0       0.58      2.00    149.
 END FTABLE  9
 FTABLE     10
Rows Cols     (WH8)                                                              ***
  5    5
    Depth      Area     Volume  Outflow1                                         ***
     (ft)    (acres) (acre-ft)   (cfs)                                           ***
    0.0       0.0       0.0      0.0
    0.5       1.2       0.80     5.0
    1.00      1.2       3.30     20.
```

```
    2.00      1.2       13.2      75.
    5.00      1.2       50.0      400.
  END FTABLE 10
  FTABLE     11
 Rows Cols     (WH5)                                                   ***
   6    4
    Depth      Area     Volume  Outflow1                               ***
     (ft)    (acres) (acre-ft)   (cfs)                                 ***
    0.0       0.0       0.0       0.0
    0.1       1.00      2.0       0.2
    0.25      1.00      8.0       1.5
    0.5       1.00      10.0      5.0
    6.0       1.00      180.      575.
    12.0      1.00      370.      2000.
  END FTABLE 11
  FTABLE     12
 Rows Cols     (GAGE 12102920)                                         ***
   4    4
    Depth      Area     Volume  Outflow1                               ***
     (ft)    (acres) (acre-ft)   (cfs)                                 ***
    0.0       0.0       0.0       0.0
    3.0       0.018     0.027     100.
    6.0       0.028     0.096     360.
    8.0       0.073     0.197     575.
  END FTABLE 12
  FTABLE     13
 Rows Cols     (WH4)                                                   ***
   4    4
    Depth      Area     Volume  Outflow1                               ***
     (ft)    (acres) (acre-ft)   (cfs)                                 ***
    0.0       0.0       0.0       0.0
    3.0       1.80      10.0      100.
    6.0       1.80       25.      360.
    8.0       1.80       75.      575.
  END FTABLE 13
  FTABLE     14
 Rows Cols     (WH3)                                                   ***
   4    4
    Depth      Area     Volume  Outflow1                               ***
     (ft)    (acres) (acre-ft)   (cfs)                                 ***
    0.0       0.0       0.0       0.0
    0.5       0.50      0.25      2.0
    2.0       62.0      1.32      40.
    5.0       124.      10.       210.
  END FTABLE 14
  FTABLE     15
 Rows Cols     (WH2)                                                   ***
   5    4
    Depth      Area     Volume  Outflow1                               ***
     (ft)    (acres) (acre-ft)   (cfs)                                 ***
    0.0       0.0       0.0       0.0
    0.5       1.70      1.70      0.0
    1.0       1.70      1.90      5.0
    3.0       1.70      11.0      200.
    8.0       1.70      100.      1300.
  END FTABLE 15
END FTABLES
                                                                       ***
DISPLY
  DISPLY-INFO1
```

```
    #thru#***<----------Title-------->         <-short-span->
          ***                                  <---disply---> <annual summary ->
          ***                              TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        HYLEBOS 356 SIMQ (IN)4/10     SUM     0    3    6    1    3    6    9
    2        HYLEBOS 373 SIMQ (IN)4/10     SUM     0    3    6    1    3    6    9
    3        PANTHER LK STAGE (FEET)       MAX     0    2    6    1    2    6    9
    4        HYLEBOS 356 SIMPKS    4/10    MAX     0    3    6    1    3    6    9
    5        HYLEBOS 373 SIMPKS    4/10    MAX     0    3    6    1    3    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A3. Final version of the HSPF input file used for the Joes Creek Basin

```
RUN
GLOBAL
  JOES CREEK FINAL VALIDATION RUN - 5/9B - GW RES - TILL IF THRU OW
  START       1986/10/01 00:00  END    1987/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      PERLND      99
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       5
      RCHRES       6
      RCHRES       7
      RCHRES       8
      DISPLY       1
    END INGRP
END OPN SEQUENCE
                                                                               ***
PERLND
  GEN-INFO
    <PLS >        Name          NBLKS   Unit-systems   Printer                 ***
    # -  #                            User  t-series Engl Metr                 ***
                                              in   out                         ***
   11       TF/MILD               1    1    1    1    6    0
   15       TF/MODERATE           1    1    1    1    6    0
   17       TF/STEEP              1    1    1    1    6    0
   21       TG/MILD               1    1    1    1    6    0
   25       TG/MODERATE           1    1    1    1    6    0
   27       TG/STEEP              1    1    1    1    6    0
   31       OF/MILD               1    1    1    1    6    0
   41       OG/MILD               1    1    1    1    6    0
   51       WETLANDS              1    1    1    1    6    0
   99       GW RESERVOIR          1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC         ***
   11   99    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ********************* Print-flags ************************* PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   11   99    0    0    5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
```

```
PWAT-PARM1
  <PLS > ***************** Flags *******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                        ***
 11   99    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11            0.75    4.5000    0.0800    400.00    0.0500    0.5000    0.9960
 15            0.75    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
 17            0.75    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
 21            0.05    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
 25            0.05    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
 27            0.05    4.5000    0.0300    200.00    0.2000    0.5000    0.9960
 31            0.75    5.0000    2.0000    400.00    0.0500    0.3000    0.9960
 41            0.05    5.0000    0.8000    400.00    0.0500    0.3000    0.9960
 51            0.75    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
 99            0.75    5.0000    2.0000    400.00    0.0500    0.1000    0.998
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11                             3.5000    2.0000       .00        0.        0.
 15                             2.0000    2.0000       .00        0.        0.
 17                             1.5000    2.0000       .00        0.        0.
 21                             3.5000    2.0000       .00        0.        0.
 25                             2.0000    2.0000       .00        0.        0.
 27                             1.5000    2.0000       .00        0.        0.
 31                             2.0000    2.0000       .00        0.        0.
 41                             2.0000    2.0000       .00        0.        0.
 51                             10.000    2.0000       .00        0.       0.7
 99                             2.0000    2.0000       .00        0.        0.
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                       ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 11         0.2000    1.0000    0.3500     3.000    0.7000    0.7000
 15         0.2000    0.5000    0.3500     6.000    0.5000    0.7000
 17         0.2000    0.3000    0.3500     7.000    0.3000    0.7000
 21         0.1000    0.5000    0.2500     3.000    0.7000    0.2500
 25         0.1000    0.2500    0.2500     6.000    0.5000    0.2500
 27         0.1000    0.1500    0.2500     7.000    0.3000    0.2500
 31         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 41         0.1000    0.5000    0.2500     0.000    0.7000    0.2500
 51         0.1000    3.0000    0.5000     1.000    0.7000    0.8000
 99         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 11              0.        0.    0.0150        0.      1.50      3.00       .07
 15              0.        0.    0.0100        0.      1.40      3.30       .06
 17              0.        0.    0.0200        0.      1.40      3.40       .06
 21              0.        0.    0.3100        0.      3.70      2.40       .28
 25              0.        0.    0.3800        0.      3.50      2.50       .23
 27              0.        0.    0.2700        0.      3.40      2.60       .22
 31              0.        0.    0.0010        0.      1.50      6.00       .07
 41              0.        0.    0.0270        0.      4.90      6.60       .65
 51              0.        0.    1.2700        0.      5.30      0.10       .77
 99              0.        0.    0.0010        0.      .001      33.6       .07
```

```
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name             Unit-systems   Printer                        ***
    # -  #                      User  t-series Engl Metr                       ***
                                       in  out                                 ***
   11      IMPERVIOUS             1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags          ***                                        ***
    # -  # CSNO RTOP  VRS  VNN RTLI   ***                                      ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                     ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                             ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                     ***
    # -  #    PETMAX    PETMIN                                                 ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                             ***
    # -  #      RETS      SURS                                                 ***
   11      1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                               ***
EXT SOURCES
                                                                               ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #   ***
WDM      1 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      1 PREC     ENGL      0.0001       PERLND  99     EXTNL  PREC
WDM      1 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   4     EXTNL  PREC
WDM      5 PET      ENGL                   PERLND  11  51 EXTNL  PETINP
WDM      5 PET      ENGL      0.0001       PERLND  99     EXTNL  PETINP
WDM      5 PET      ENGL                   IMPLND  11     EXTNL  PETINP
WDM      5 PET      ENGL                   RCHRES   4     EXTNL  POTEV
END EXT SOURCES
                                                                               ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   8 HYDR   ROVOL  1       48.4 SAME WDM     11 SIMQ      ENGL      REPL
END EXT TARGETS
```

```
                                                                                  ***
NETWORK
                                                                                  ***
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
  *** RECHARGE INTO THE GW RESERVOIR - MFACTS ARE RATIO OF CONTRIBUTING PERLND
  *** AREA TO GW RESERVOIR AREA (GW AREA=TOTAL BASIN AREA=1079.0 ACRES)
      *** IFWO FROM ALL TILL IN J1,J7,J8 SUB-BASINS ***
PERLND  11 PWATER IFWO          .0284     PERLND  99     EXTNL  AGWLI
PERLND  15 PWATER IFWO    ***   .0000     PERLND  99     EXTNL  AGWLI
PERLND  17 PWATER IFWO          .0082     PERLND  99     EXTNL  AGWLI
PERLND  21 PWATER IFWO          .0423     PERLND  99     EXTNL  AGWLI
PERLND  25 PWATER IFWO          .0123     PERLND  99     EXTNL  AGWLI
PERLND  27 PWATER IFWO          .0010     PERLND  99     EXTNL  AGWLI
      *** AGWO FROM ALL TILL AND SATURATED AREAS ***
PERLND  11 PWATER AGWO          .1133     PERLND  99     EXTNL  AGWLI
PERLND  15 PWATER AGWO          .0167     PERLND  99     EXTNL  AGWLI
PERLND  17 PWATER AGWO          .0308     PERLND  99     EXTNL  AGWLI
PERLND  21 PWATER AGWO          .2195     PERLND  99     EXTNL  AGWLI
PERLND  25 PWATER AGWO          .0837     PERLND  99     EXTNL  AGWLI
PERLND  27 PWATER AGWO          .0247     PERLND  99     EXTNL  AGWLI
PERLND  51 PWATER AGWO          .0283     PERLND  99     EXTNL  AGWLI
      *** AGWI FROM ALL OUTWASH ***
PERLND  31 PWATER AGWI          .5312     PERLND  99     EXTNL  AGWLI
PERLND  41 PWATER AGWI          .4688     PERLND  99     EXTNL  AGWLI
***
  *** SUB-BASIN J8  ***
PERLND  11 PWATER SURO          2.475     RCHRES   1     EXTNL  IVOL
PERLND  21 PWATER SURO          0.925     RCHRES   1     EXTNL  IVOL
PERLND  31 PWATER SURO         21.283     RCHRES   1     EXTNL  IVOL
PERLND  41 PWATER SURO         10.792     RCHRES   1     EXTNL  IVOL
PERLND  99 PWATER AGWO         32.075     RCHRES   1     EXTNL  IVOL
PERLND  51 PWATER SURO          0.108     RCHRES   1     EXTNL  IVOL
PERLND  51 PWATER IFWO          0.108     RCHRES   1     EXTNL  IVOL
IMPLND  11 IWATER SURO          1.117     RCHRES   1     EXTNL  IVOL
  *** SUB-BASIN J7   ***
PERLND  31 PWATER SURO          5.900     RCHRES   2     EXTNL  IVOL
PERLND  99 PWATER AGWO    ***   5.900     RCHRES   2     EXTNL  IVOL
  *** SUB-BASIN J6    ***
PERLND  15 PWATER SURO          0.767     RCHRES   3     EXTNL  IVOL
PERLND  17 PWATER SURO          1.392     RCHRES   3     EXTNL  IVOL
PERLND  21 PWATER SURO          0.550     RCHRES   3     EXTNL  IVOL
PERLND  25 PWATER SURO          0.300     RCHRES   3     EXTNL  IVOL
PERLND  27 PWATER SURO          0.225     RCHRES   3     EXTNL  IVOL
PERLND  31 PWATER SURO          7.033     RCHRES   3     EXTNL  IVOL
PERLND  41 PWATER SURO          1.158     RCHRES   3     EXTNL  IVOL
PERLND  99 PWATER AGWO          8.191     RCHRES   3     EXTNL  IVOL
IMPLND  11 IWATER SURO          1.133     RCHRES   3     EXTNL  IVOL
  *** SUB-BASIN J2    ***
PERLND  15 PWATER SURO          0.125     RCHRES   4     EXTNL  IVOL
PERLND  25 PWATER SURO          1.125     RCHRES   4     EXTNL  IVOL
PERLND  27 PWATER SURO          0.650     RCHRES   4     EXTNL  IVOL
PERLND  31 PWATER SURO          4.633     RCHRES   4     EXTNL  IVOL
PERLND  41 PWATER SURO         13.350     RCHRES   4     EXTNL  IVOL
PERLND  99 PWATER AGWO         17.983     RCHRES   4     EXTNL  IVOL
PERLND  51 PWATER SURO          2.433     RCHRES   4     EXTNL  IVOL
PERLND  51 PWATER IFWO          2.433     RCHRES   4     EXTNL  IVOL
IMPLND  11 IWATER SURO          4.600     RCHRES   4     EXTNL  IVOL
  *** SUB-BASIN J3   ***
PERLND  21 PWATER SURO          0.875     RCHRES   5     EXTNL  IVOL
```

```
PERLND   25 PWATER SUROO          1.217      RCHRES   5      EXTNL  IVOL
PERLND   41 PWATER SURO          1.442      RCHRES   5      EXTNL  IVOL
PERLND   99 PWATER AGWO          1.442      RCHRES   5      EXTNL  IVOL
IMPLND   11 IWATER SURO          1.108      RCHRES   5      EXTNL  IVOL
  *** SUB-BASIN J5   ***
PERLND   11 PWATER SURO          7.633      RCHRES   6      EXTNL  IVOL
PERLND   11 PWATER IFWO          7.633      RCHRES   6      EXTNL  IVOL
PERLND   15 PWATER SURO          0.608      RCHRES   6      EXTNL  IVOL
PERLND   15 PWATER IFWO          0.608      RCHRES   6      EXTNL  IVOL
PERLND   17 PWATER SURO          0.633      RCHRES   6      EXTNL  IVOL
PERLND   17 PWATER IFWO          0.633      RCHRES   6      EXTNL  IVOL
PERLND   21 PWATER SURO         14.508      RCHRES   6      EXTNL  IVOL
PERLND   21 PWATER IFWO         14.508      RCHRES   6      EXTNL  IVOL
PERLND   25 PWATER SURO          3.417      RCHRES   6      EXTNL  IVOL
PERLND   25 PWATER IFWO          3.417      RCHRES   6      EXTNL  IVOL
PERLND   27 PWATER SURO          0.833      RCHRES   6      EXTNL  IVOL
PERLND   27 PWATER IFWO          0.833      RCHRES   6      EXTNL  IVOL
PERLND   31 PWATER SURO          1.667      RCHRES   6      EXTNL  IVOL
PERLND   41 PWATER SURO          0.383      RCHRES   6      EXTNL  IVOL
PERLND   99 PWATER AGWO          2.050      RCHRES   6      EXTNL  IVOL
IMPLND   11 IWATER SURO          6.867      RCHRES   6      EXTNL  IVOL
  *** SUB-BASIN J4    ***
PERLND   25 PWATER SURO          0.358      RCHRES   7      EXTNL  IVOL
PERLND   27 PWATER SURO          0.433      RCHRES   7      EXTNL  IVOL
PERLND   31 PWATER SURO          0.217      RCHRES   7      EXTNL  IVOL
PERLND   41 PWATER SURO          1.167      RCHRES   7      EXTNL  IVOL
PERLND   99 PWATER AGWO          1.384      RCHRES   7      EXTNL  IVOL
IMPLND   11 IWATER SURO          0.517      RCHRES   7      EXTNL  IVOL
  *** SUB-BASIN J1    ***
PERLND   11 PWATER SURO          0.075      RCHRES   8      EXTNL  IVOL
PERLND   17 PWATER SURO          0.742      RCHRES   8      EXTNL  IVOL
PERLND   21 PWATER SURO          2.875      RCHRES   8      EXTNL  IVOL
PERLND   25 PWATER SURO          1.108      RCHRES   8      EXTNL  IVOL
PERLND   27 PWATER SURO          0.092      RCHRES   8      EXTNL  IVOL
PERLND   31 PWATER SURO          7.033      RCHRES   8      EXTNL  IVOL
PERLND   41 PWATER SURO         13.867      RCHRES   8      EXTNL  IVOL
PERLND   99 PWATER AGWO         20.900      RCHRES   8      EXTNL  IVOL
IMPLND   11 IWATER SURO          5.792      RCHRES   8      EXTNL  IVOL
                                                                             ***
  *** CHANNEL NETWORK LINKAGES ***
                                                                             ***
RCHRES    1 HYDR    ROVOL  1                RCHRES   3      EXTNL  IVOL
RCHRES    2 HYDR    ROVOL  1                RCHRES   3      EXTNL  IVOL
RCHRES    3 HYDR    ROVOL  1                RCHRES   4      EXTNL  IVOL
RCHRES    4 HYDR    ROVOL  1                RCHRES   5      EXTNL  IVOL
RCHRES    5 HYDR    ROVOL  1                RCHRES   8      EXTNL  IVOL
RCHRES    6 HYDR    ROVOL  1                RCHRES   7      EXTNL  IVOL
RCHRES    7 HYDR    ROVOL  1                RCHRES   8      EXTNL  IVOL
RCHRES    8 HYDR    ROVOL  1  .00631512     DISPLY   1      INPUT  TIMSER 1
                                                                             ***
END NETWORK
                                                                             ***
RCHRES
  GEN-INFO
    RCHRES        Name         Nexits   Unit Systems   Printer               ***
    # -   #<------------------><---> User T-series  Engl Metr LKFG           ***
                                              in   out                       ***
    1      J8                       1    1    1    1    6    0    0
    2      J7                       1    1    1    1    6    0    0
    3      J6                       1    1    1    1    6    0    0
```

```
    4     J2                      1     1     1     1     6     0     1
    5     J3                      1     1     1     1     6     0     0
    6     J5                      1     1     1     1     6     0     0
    7     J4                      1     1     1     1     6     0     0
    8     J1 - GAGE 12103205      1     1     1     1     6     0     0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                ***
    1    8    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    RCHRES *************** Printout Flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    1    8    5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                     ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
              *  *  *  *    *  *  *  *  *        *  *  *  *  *        ***
    1    3   0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    4        0  1  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    5    8   0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                  ***
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50      ***
  <------><--------><--------><--------><--------><--------><-------->      ***
    1              1   0.701                             0.5
    2              2   0.625                             0.5
    3              3   0.398                             0.5
    4              4   0.814                             0.5
    5              5   0.123                             0.5
    6              6   0.985                             0.5
    7              7   0.350                             0.5
    8              8   1.004                             0.5
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                        ***
    # -  # ***   VOL     Initial  value  of COLIND    Initial  value  of OUTDGT
           *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1     0.0              4.0
    2     0.0              4.0
    3     0.0              4.0
    4     160.             4.0
    5     0.008            4.0
    6     0.021            4.0
    7     0.008            4.0
    8     0.100            4.0
  END HYDR-INIT
END RCHRES
                                                                            ***
FTABLES
  FTABLE      1
 Rows Cols   (J8)                                                           ***
    3    4
     Depth      Area    Volume  Outflow1                                    ***
      (ft)   (acres) (acre-ft)    (cfs)                                     ***
```

```
     0.0       0.0       0.0        0.0
     1.0       0.21      0.19       2.00
     4.0       0.34      1.02       50.0
  END FTABLE   1
  FTABLE       2
 Rows Cols    (J7)                                                   ***
   3    4
     Depth      Area     Volume   Outflow1                           ***
      (ft)    (acres)  (acre-ft)   (cfs)                             ***
     0.0       0.0       0.0        0.0
     1.0       0.19      0.17       5.00
     5.0       0.38      1.33       120.
  END FTABLE   2
  FTABLE       3
 Rows Cols      (J6)                                                 ***
   4    4
     Depth      Area     Volume   Outflow1                           ***
      (ft)    (acres)  (acre-ft)   (cfs)                             ***
     0.0       0.0       0.0        0.0
     1.5       0.14      0.07       2.00
     3.0       0.24      0.58       50.0
     5.0       0.34      1.45       175.
  END FTABLE   3
  FTABLE       4
 Rows Cols      (J2)                                                 ***
   6    4
     Depth      Area     Volume   Outflow1                           ***
      (ft)    (acres)  (acre-ft)   (cfs)                             ***
     0.0       0.0       0.0        0.0
     9.5       10.1      160.       0.0
     10.0      10.1      170.       0.0
     10.5      10.1      182.       5.00
     11.0      10.1      200.       20.0
     12.0      10.1      240.       40.0
  END FTABLE   4
  FTABLE       5
 Rows Cols      (J3)                                                 ***
   3    4
     Depth      Area     Volume   Outflow1                           ***
      (ft)    (acres)  (acre-ft)   (cfs)                             ***
     0.0       0.0       0.0        0.0
     0.5       0.06      0.03       2.00
     4.0       0.10      0.30       120.
  END FTABLE   5
  FTABLE       6
 Rows Cols      (J5)                                                 ***
   3    4
     Depth      Area     Volume   Outflow1                           ***
      (ft)    (acres)  (acre-ft)   (cfs)                             ***
     0.0       0.0       0.0        0.0
     0.50      0.48      0.21       5.00
     4.00      1.19      3.10       125.
  END FTABLE   6
  FTABLE       7
 Rows Cols      (J4)                                                 ***
   3    4
     Depth      Area     Volume   Outflow1                           ***
      (ft)    (acres)  (acre-ft)   (cfs)                             ***
     0.0       0.0       0.0        0.0
     0.5       0.17      0.08       5.00
```

```
    4.0       0.42      1.10      185.
  END FTABLE  7
  FTABLE      8
 Rows Cols      (J1)                                                         ***
   5    4
    Depth       Area     Volume  Outflow1                                    ***
     (ft)   (acres) (acre-ft)    (cfs)                                       ***
    0.0       0.0       0.0       0.0
    1.0       0.37      0.37      7.00
    1.5       0.79      0.74      15.0
    3.0       1.03      1.83      80.0
    8.0       1.82      8.51      625.
  END FTABLE  8
END FTABLES
                                                                             ***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply--->  <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        JOES CREEK SIMQ (INCHES)    SUM     0    2    6    1    2    6    9
  END DISPLY-INFO1
END DISPLY
                                                                            *
```

Appendix A4. Final version of the HSPF input file used for the Lakota Creek Basin

```
RUN
GLOBAL
  LAKOTA CREEK FINAL VALIDATION RUN - 5/17A- GW RES WITH L2-L4 AND L6 TILL IFWO
*** ROUTED INTO IT
  START       1986/10/01 00:00  END    1987/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL     15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      PERLND      99
      RCHRES      10
      RCHRES       1
      RCHRES       2
      RCHRES       7
      RCHRES       8
      RCHRES       9
      RCHRES       3
      RCHRES       4
      RCHRES       5
      RCHRES       6
      DISPLY       1
      DISPLY       2
      DISPLY       3
      DISPLY       4
    END INGRP
END OPN SEQUENCE
                                                                              ***
PERLND
  GEN-INFO
    <PLS >       Name          NBLKS   Unit-systems   Printer                 ***
    # -  #                           User  t-series Engl Metr                 ***
                                             in  out                          ***
   11      TF/MILD                 1    1    1    1    6    0
   15      TF/MODERATE             1    1    1    1    6    0
   17      TF/STEEP                1    1    1    1    6    0
   21      TG/MILD                 1    1    1    1    6    0
   25      TG/MODERATE             1    1    1    1    6    0
   27      TG/STEEP                1    1    1    1    6    0
   31      OF/MILD                 1    1    1    1    6    0
   41      OG/MILD                 1    1    1    1    6    0
   51      WETLANDS                1    1    1    1    6    0
   99      GW RESERVOIR            1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC          ***
   11   99    0    0    1    0    0    0    0    0    0    0    0    0
```

```
END ACTIVITY
PRINT-INFO
  <PLS > ******************** Print-flags ************************ PIVL  PYR
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
 11   99    0    0    5    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > **************** Flags ******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                        ***
 11   99    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11             0.75    4.5000    0.0800    400.00    0.0500    0.5000    0.9960
 15             0.75    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
 17             0.75    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
 21             0.05    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
 25             0.05    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
 27             0.05    4.5000    0.0300    200.00    0.2000    0.5000    0.9960
 31             0.75    5.0000    2.0000    400.00    0.0500    0.3000    0.9960
 41             0.05    5.0000    0.8000    400.00    0.0500    0.3000    0.9960
 51             0.75    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
 99             0.05    5.0000    2.0000    400.00    0.0500    0.0000    0.9980
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11                             3.5000    2.0000       .00        0.        0.
 15                             2.0000    2.0000       .00        0.        0.
 17                             1.5000    2.0000       .00        0.        0.
 21                             3.5000    2.0000       .00        0.        0.
 25                             2.0000    2.0000       .00        0.        0.
 27                             1.5000    2.0000       .00        0.        0.
 31                             2.0000    2.0000       .00        0.        0.
 41                             2.0000    2.0000       .00        0.        0.
 51                             10.000    2.0000       .00        0.       0.7
 99                             2.0000    2.0000       .00        0.        0.
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                               ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 11           0.2000    1.0000    0.3500     3.000    0.7000    0.7000
 15           0.2000    0.5000    0.3500     6.000    0.5000    0.7000
 17           0.2000    0.3000    0.3500     7.000    0.3000    0.7000
 21           0.1000    0.5000    0.2500     3.000    0.7000    0.2500
 25           0.1000    0.2500    0.2500     6.000    0.5000    0.2500
 27           0.1000    0.1500    0.2500     7.000    0.3000    0.2500
 31           0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 41           0.1000    0.5000    0.2500     0.000    0.7000    0.2500
 51           0.1000    3.0000    0.5000     1.000    0.7000    0.8000
 99           0.2000    0.5000    0.3500     0.000    0.7000    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***     CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 11               0.        0.    0.0030        0.      .954      2.90      .017
 15               0.        0.    0.0060        0.      .942      3.19      .016
 17               0.        0.    0.0140        0.      .933      3.31      .016
 21               0.        0.    0.1310        0.      2.78      2.29      .095
```

```
   25             0.         0.    0.2480        0.       2.47       2.32       .068
   27             0.         0.    0.2220        0.       2.36       2.37       .062
   31             0.         0.    0.0010        0.       .966       0.01       .026
   41             0.         0.    0.0250        0.       4.08       0.01       .257
   51             0.         0.    0.6620        0.       3.39       0.01       .162
   99             0.         0.    0.0010        0.       .001       34.0       .026
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name            Unit-systems   Printer                         ***
    # -  #                   User  t-series Engl Metr                          ***
                                    in  out                                    ***
   11       IMPERVIOUS          1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags            ***                                      ***
    # -  # CSNO RTOP  VRS  VNN RTLI   ***                                      ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                     ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                             ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                     ***
    # -  #    PETMAX    PETMIN                                                 ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                             ***
    # -  #       RETS      SURS                                                ***
   11       1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                               ***
EXT SOURCES
                                                                               ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      1 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      1 PREC     ENGL      0.00001      PERLND  99     EXTNL  PREC
WDM      1 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   1     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   3     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   7     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   8     EXTNL  PREC
WDM      5 PET      ENGL                   PERLND  11  99 EXTNL  PETINP
WDM      5 PET      ENGL                   IMPLND  11     EXTNL  PETINP
```

```
WDM       5 PET      ENGL                      RCHRES   1      EXTNL  POTEV
WDM       5 PET      ENGL                      RCHRES   3      EXTNL  POTEV
WDM       5 PET      ENGL                      RCHRES   7      EXTNL  POTEV
WDM       5 PET      ENGL                      RCHRES   8      EXTNL  POTEV
END EXT SOURCES
                                                                                ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>    #       <Name> # #<-factor->strg <Name>    # <Name>    tem strg strg***
RCHRES    5 HYDR   ROVOL  1       48.4 SAME WDM      12 SIMQ     ENGL      REPL
END EXT TARGETS
                                                                                ***
NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>    #       <Name> # #<-factor->strg <Name>    #   #       <Name> # #   ***
  *** RECHARGE INTO THE GW RESERVOIR - MFACTS ARE RATIO OF CONTRIBUTING PERLND
  *** AREA TO GW RESERVOIR AREA (GW AREA=OW+WL BASIN AREA=716.30 ACRES)
      *** IFWO FROM ALL TILL IN L2-L4,L6 SUB-BASINS ***
PERLND  11 PWATER IFWO            .0225      PERLND  99      EXTNL  AGWLI
PERLND  15 PWATER IFWO            .0053      PERLND  99      EXTNL  AGWLI
PERLND  17 PWATER IFWO            .0131      PERLND  99      EXTNL  AGWLI
PERLND  21 PWATER IFWO            .0673      PERLND  99      EXTNL  AGWLI
PERLND  25 PWATER IFWO            .0564      PERLND  99      EXTNL  AGWLI
PERLND  27 PWATER IFWO            .0003      PERLND  99      EXTNL  AGWLI
      *** AGWO FROM ALL TILL           AND SATURATED AREAS ***
PERLND  11 PWATER AGWO            .0253      PERLND  99      EXTNL  AGWLI
PERLND  15 PWATER AGWO            .0209      PERLND  99      EXTNL  AGWLI
PERLND  17 PWATER AGWO            .0230      PERLND  99      EXTNL  AGWLI
PERLND  21 PWATER AGWO            .1728      PERLND  99      EXTNL  AGWLI
PERLND  25 PWATER AGWO            .1897      PERLND  99      EXTNL  AGWLI
PERLND  27 PWATER AGWO            .0571      PERLND  99      EXTNL  AGWLI
PERLND  51 PWATER AGWO            .3554      PERLND  99      EXTNL  AGWLI
      *** AGWI FROM ALL OUTWASH ***
PERLND  31 PWATER AGWI            .2521      PERLND  99      EXTNL  AGWLI
PERLND  41 PWATER AGWI            .3924      PERLND  99      EXTNL  AGWLI
***
***
*** SUB-BASIN     L5   RUNOFF FROM LAND SEGMENTS
PERLND  21 PWATER SURO          3.8275       RCHRES  10      EXTNL  IVOL
PERLND  21 PWATER IFWO          3.8275       RCHRES  10      EXTNL  IVOL
PERLND  25 PWATER SURO          5.1396       RCHRES  10      EXTNL  IVOL
PERLND  25 PWATER IFWO          5.1396       RCHRES  10      EXTNL  IVOL
PERLND  31 PWATER SURO          0.0167       RCHRES  10      EXTNL  IVOL
PERLND  41 PWATER SURO          0.3708       RCHRES  10      EXTNL  IVOL
PERLND  51 PWATER SURO          0.2083       RCHRES  10      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.2083       RCHRES  10      EXTNL  IVOL
PERLND  99 PWATER PERO   ***    0.5958       RCHRES  10      EXTNL  IVOL
IMPLND  11 IWATER SURO          3.6167       RCHRES  10      EXTNL  IVOL
*** SUB-BASIN     L4   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          0.1500       RCHRES   2      EXTNL  IVOL
PERLND  17 PWATER SURO          0.1500       RCHRES   2      EXTNL  IVOL
PERLND  21 PWATER SURO          0.0750       RCHRES   2      EXTNL  IVOL
PERLND  25 PWATER SURO          0.3938       RCHRES   2      EXTNL  IVOL
PERLND  31 PWATER SURO          1.7000       RCHRES   2      EXTNL  IVOL
PERLND  41 PWATER SURO          4.5173       RCHRES   2      EXTNL  IVOL
PERLND  99 PWATER PERO          6.2173       RCHRES   2      EXTNL  IVOL
IMPLND  11 IWATER SURO          2.2473       RCHRES   2      EXTNL  IVOL
*** SUB-BASIN     M1   MIRROR LAKE (CLOSED BASIN DURING SIM. PERIOD)
PERLND  11 PWATER SURO          1.8957       RCHRES   7      EXTNL  IVOL ***
PERLND  11 PWATER IFWO          1.8957       RCHRES   7      EXTNL  IVOL ***
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PERLND  15 PWATER SURO        0.9973     RCHRES    7     EXTNL   IVOL ***
PERLND  15 PWATER IFWO        0.9973     RCHRES    7     EXTNL   IVOL ***
PERLND  17 PWATER SURO        2.2787     RCHRES    7     EXTNL   IVOL ***
PERLND  17 PWATER IFWO        2.2787     RCHRES    7     EXTNL   IVOL ***
PERLND  21 PWATER SURO        5.7055     RCHRES    7     EXTNL   IVOL ***
PERLND  21 PWATER IFWO        5.7055     RCHRES    7     EXTNL   IVOL ***
PERLND  25 PWATER SURO        2.3043     RCHRES    7     EXTNL   IVOL ***
PERLND  25 PWATER IFWO        2.3043     RCHRES    7     EXTNL   IVOL ***
PERLND  27 PWATER SURO        1.7147     RCHRES    7     EXTNL   IVOL ***
PERLND  27 PWATER IFWO        1.7147     RCHRES    7     EXTNL   IVOL ***
PERLND  31 PWATER SURO        0.4250     RCHRES    7     EXTNL   IVOL ***
PERLND  41 PWATER SURO        1.0943     RCHRES    7     EXTNL   IVOL ***
PERLND  99 PWATER PERO        1.5193     RCHRES    7     EXTNL   IVOL ***
IMPLND  11 IWATER SURO        4.7762     RCHRES    7     EXTNL   IVOL ***
*** SUB-BASIN     M3   FISCHERS BOG (CLOSED DURING SIM. PERIOD)       ***
PERLND  11 PWATER SURO        1.4250     RCHRES    8     EXTNL   IVOL ***
PERLND  11 PWATER IFWO        1.4250     RCHRES    8     EXTNL   IVOL ***
PERLND  15 PWATER SURO        4.8667     RCHRES    8     EXTNL   IVOL ***
PERLND  15 PWATER IFWO        4.8667     RCHRES    8     EXTNL   IVOL ***
PERLND  17 PWATER SURO        1.0583     RCHRES    8     EXTNL   IVOL ***
PERLND  17 PWATER IFWO        1.0583     RCHRES    8     EXTNL   IVOL ***
PERLND  21 PWATER SURO        2.1775     RCHRES    8     EXTNL   IVOL ***
PERLND  21 PWATER IFWO        2.1775     RCHRES    8     EXTNL   IVOL ***
PERLND  25 PWATER SURO        5.0543     RCHRES    8     EXTNL   IVOL ***
PERLND  25 PWATER IFWO        5.0543     RCHRES    8     EXTNL   IVOL ***
PERLND  27 PWATER SURO        1.9396     RCHRES    8     EXTNL   IVOL ***
PERLND  27 PWATER IFWO        1.9396     RCHRES    8     EXTNL   IVOL ***
PERLND  31 PWATER SURO        0.7750     RCHRES    8     EXTNL   IVOL ***
PERLND  41 PWATER SURO        0.3193     RCHRES    8     EXTNL   IVOL ***
PERLND  99 PWATER PERO        1.0943     RCHRES    8     EXTNL   IVOL ***
IMPLND  11 IWATER SURO        3.3177     RCHRES    8     EXTNL   IVOL ***
*** SUB-BASIN     L7   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO        0.1653     RCHRES    9     EXTNL   IVOL
PERLND  11 PWATER IFWO        0.1653     RCHRES    9     EXTNL   IVOL
PERLND  15 PWATER SURO        0.9333     RCHRES    9     EXTNL   IVOL
PERLND  15 PWATER IFWO        0.9333     RCHRES    9     EXTNL   IVOL
PERLND  17 PWATER SURO        0.5917     RCHRES    9     EXTNL   IVOL
PERLND  17 PWATER IFWO        0.5917     RCHRES    9     EXTNL   IVOL
PERLND  21 PWATER SURO        2.4751     RCHRES    9     EXTNL   IVOL
PERLND  21 PWATER IFWO        2.4751     RCHRES    9     EXTNL   IVOL
PERLND  25 PWATER SURO        2.8161     RCHRES    9     EXTNL   IVOL
PERLND  25 PWATER IFWO        2.8161     RCHRES    9     EXTNL   IVOL
PERLND  27 PWATER SURO        3.3893     RCHRES    9     EXTNL   IVOL
PERLND  27 PWATER IFWO        3.3893     RCHRES    9     EXTNL   IVOL
PERLND  31 PWATER SURO        1.7073     RCHRES    9     EXTNL   IVOL
PERLND  41 PWATER SURO        6.0478     RCHRES    9     EXTNL   IVOL
PERLND  51 PWATER SURO        1.2667     RCHRES    9     EXTNL   IVOL
PERLND  51 PWATER IFWO        1.2667     RCHRES    9     EXTNL   IVOL
PERLND  99 PWATER PERO        9.0218     RCHRES    9     EXTNL   IVOL
IMPLND  11 IWATER SURO        5.4242     RCHRES    9     EXTNL   IVOL
  *** SUB-BASIN L6 *** WETLAND 9 CATCHMENT
PERLND  15 PWATER SURO          0.240    RCHRES    3     EXTNL   IVOL
PERLND  21 PWATER SURO          1.281    RCHRES    3     EXTNL   IVOL
PERLND  25 PWATER SURO          2.416    RCHRES    3     EXTNL   IVOL
PERLND  31 PWATER SURO          4.550    RCHRES    3     EXTNL   IVOL
PERLND  41 PWATER SURO          1.970    RCHRES    3     EXTNL   IVOL
PERLND  51 PWATER SURO          1.850    RCHRES    3     EXTNL   IVOL
PERLND  51 PWATER IFWO          1.850    RCHRES    3     EXTNL   IVOL
PERLND  99 PWATER PERO          8.770    RCHRES    3     EXTNL   IVOL
IMPLND  11 IWATER SURO          3.609    RCHRES    3     EXTNL   IVOL
```

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  *** SUB-BASIN L3 ***
PERLND  11 PWATER SURO          1.192      RCHRES  4      EXTNL  IVOL
PERLND  15 PWATER SURO          0.075      RCHRES  4      EXTNL  IVOL
PERLND  17 PWATER SURO          0.633      RCHRES  4      EXTNL  IVOL
PERLND  21 PWATER SURO          2.637      RCHRES  4      EXTNL  IVOL
PERLND  25 PWATER SURO          0.560      RCHRES  4      EXTNL  IVOL
PERLND  27 PWATER SURO          0.019      RCHRES  4      EXTNL  IVOL
PERLND  31 PWATER SURO          3.267      RCHRES  4      EXTNL  IVOL
PERLND  41 PWATER SURO          7.799      RCHRES  4      EXTNL  IVOL
PERLND  51 PWATER SURO          0.133      RCHRES  4      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.133      RCHRES  4      EXTNL  IVOL
PERLND  99 PWATER PERO         11.200      RCHRES  4      EXTNL  IVOL
IMPLND  11 IWATER SURO          5.576      RCHRES  4      EXTNL  IVOL
  *** SUB-BASIN L2 ***
PERLND  21 PWATER SURO          0.025      RCHRES  5      EXTNL  IVOL
PERLND  31 PWATER SURO          3.808      RCHRES  5      EXTNL  IVOL
PERLND  41 PWATER SURO          2.719      RCHRES  5      EXTNL  IVOL
PERLND  99 PWATER PERO          6.527      RCHRES  5      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.740      RCHRES  5      EXTNL  IVOL
  *** SUB-BASIN L1 ***
PERLND  11 PWATER PERO          0.300      RCHRES  6      EXTNL  IVOL
PERLND  17 PWATER PERO          0.404      RCHRES  6      EXTNL  IVOL
PERLND  31 PWATER PERO          4.807      RCHRES  6      EXTNL  IVOL
PERLND  41 PWATER PERO          0.364      RCHRES  6      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.484      RCHRES  6      EXTNL  IVOL
***
***  THE MFACTOR CONVERTS ACRE-FEET OF RUNOFF TO INCHES.
RCHRES  10 HYDR   ROVOL  1                 RCHRES  1      EXTNL  IVOL
RCHRES   1 HYDR   OVOL   1                 RCHRES  2      EXTNL  IVOL
RCHRES   1 HYDR   STAGE  1                 DISPLY  4      INPUT  TIMSER 1
RCHRES   2 HYDR   ROVOL  1                 RCHRES  5      EXTNL  IVOL
RCHRES   7 HYDR   OVOL   2 1               RCHRES  8      EXTNL  IVOL
RCHRES   8 HYDR   OVOL   2 1   ***         RCHRES  9      EXTNL  IVOL
RCHRES   9 HYDR   ROVOL  1                 RCHRES  3      EXTNL  IVOL
RCHRES   3 HYDR   OVOL   1                 RCHRES  4      EXTNL  IVOL
RCHRES   3 HYDR   STAGE  1                 DISPLY  3      INPUT  TIMSER 1
RCHRES   4 HYDR   ROVOL  1                 RCHRES  5      EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1   .0107739      DISPLY  1      INPUT  TIMSER 1
RCHRES   5 HYDR   RO     1                 DISPLY  2      INPUT  TIMSER 1
RCHRES   5 HYDR   ROVOL  1                 RCHRES  6      EXTNL  IVOL
RCHRES   7 HYDR   STAGE  1     ***         DISPLY  5      INPUT  TIMSER 1
RCHRES   8 HYDR   STAGE  1     ***         DISPLY  6      INPUT  TIMSER 1
END NETWORK
                                                                          ***
RCHRES
  GEN-INFO
    RCHRES       Name         Nexits   Unit Systems   Printer             ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG         ***
                                            in  out                       ***
    1     LK PONCE DE LEON       2     1    1    1    6    0    1
    2     L4                     1     1    1    1    6    0    0
    3     L6 WETLAND 9           2     1    1    1    6    0    1
    4     L3                     1     1    1    1    6    0    0
    5     L2 - GAGE 12103207     1     1    1    1    6    0    0
    6     L1                     1     1    1    1    6    0    0
    7     M1 - MIRROR LAKE       2     1    1    1    6    0    1
    8     M3 - FISCHERS BOG      2     1    1    1    6    0    1
    9     L7                     1     1    1    1    6    0    0
   10     L5                     1     1    1    1    6    0    0
  END GEN-INFO
```

```
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                 ***
    1   10    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    RCHRES *************** Printout Flags ***************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    1   10    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                     ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible   exit *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *        *  *  *  *  *        ***
    1        0  1  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
    2        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
    3        0  1  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
    4    6   0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
    7    8   0  1  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
    9        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
   10        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                  ***
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50      ***
  <------><--------><--------><--------><--------><--------><-------->      ***
    1              1   0.966               5.25         0.5
    2              2   0.568                            0.0
    3              3   0.492               250.         0.5
    4              4   0.644                            0.0
    5              5   0.208                            0.0
    6              6   0.436                            0.0
    7              7   0.500               274.         0.5
    8              8   0.500               285.         0.5
    9              9   0.600                            0.0
   10             10   0.600                            0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                        ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
           *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1       9.00           4.0  5.0
    2      0.140           4.0
    3       4.10           4.0  5.0
    4      0.080           4.0
    5      0.090           4.0
    6      0.060           4.0
    7      236.0           4.0  5.0
    8      62.5            4.0  5.0
    9       0.0            4.0
   10       0.0            4.0
  END HYDR-INIT
END RCHRES
                                                                            ***
FTABLES
  FTABLE      1
 ROWS COLS    PONCE DE LEON                                                 ***
    7    5
```

```
    Depth      Area     Volume   Outflow1                                         ***
     (FT)    (ACRES)  (ACRE-FT)   (CFS)                                           ***
    0.0      0.0       0.0        0.0        0.0
    5.00     1.95      9.75       0.00       0.06
    6.00     1.95      11.7       0.00       0.06
    6.35     1.95      12.4        2.0       0.06
    6.65     1.95     12.96        5.0       0.06
    7.15     1.95     13.94       15.0       0.06
    7.75     1.95     15.11       75.0       0.06
 END FTABLE  1
 FTABLE      2
Rows Cols    (L4)                                                                 ***
  5    4
    Depth      Area     Volume   Outflow1                                         ***
     (ft)    (acres)  (acre-ft)   (cfs)                                           ***
    0.0      0.0       0.0        0.0
    0.5      0.19      0.12       1.00
    1.0      0.28      0.24       5.00
    4.0      0.45      1.31       115.
    7.0      0.65      3.02       365.
 END FTABLE  2
 FTABLE      3
ROWS COLS      (L6) WETLAND 9 AT LAKOTA JR HIGH, PER FED WY WATER & SEWER         ***
  7    5
    Depth      Area     Volume   Outflow1                                         ***
     (ft)    (acres)  (acre-ft)   (cfs)                                           ***
    0.0      0.0       0.0        0.0        .0
    1.00     5.00      5.0        0.00       .15
    2.00     5.00      12.67      0.00       .15
    3.00     5.00      25.2       .5         .15
    4.00     5.00      40.8       13.3       .15
    4.50     5.00      50.6       16.7       .15
    7.00     5.00      90.0       27.7       .15
 END FTABLE  3
 FTABLE      4
Rows Cols      (L3)                                                               ***
  5    4
    Depth      Area     Volume   Outflow1                                         ***
     (ft)    (acres)  (acre-ft)   (cfs)                                           ***
    0.0      0.0       0.0        0.0
    1.0      0.31      0.27       5.00
    3.0      0.51      1.31       85.0
    3.5      2.00      2.00       98.0
    6.0      2.10      7.05       430.
 END FTABLE  4
 FTABLE      5
Rows Cols      (L2)                                                               ***
  5    4
    Depth      Area     Volume   Outflow1                                         ***
     (ft)    (acres)  (acre-ft)   (cfs)                                           ***
    0.0      0.0       0.0        0.0
    0.5      0.15      0.08       5.0
    2.0      0.17      0.32       65.
    4.0      0.20      0.78       110.
    7.0      0.30      1.62       550.
 END FTABLE  5
 FTABLE      6
Rows Cols      (L1)                                                               ***
  5    4
    Depth      Area     Volume   Outflow1                                         ***
```

```
       (ft)    (acres) (acre-ft)    (cfs)                                         ***
      0.0       0.0      0.0       0.0
      1.00      0.16     0.16      5.00
      1.50      0.42     0.31      15.0
      4.00      0.50     1.38      110.
      10.0      0.79     5.26      1000.
   END FTABLE   6
   FTABLE       7
  ROWS COLS      (M1)    MIRROR LK, *** STCOR=274
     4    5
      Depth       Area    Volume  Outflow1  OVERFLOW CHANNEL                    ***
       (ft)    (acres) (acre-ft)    (cfs)    (CFS)                              ***
      0.0       0.0      0.0       0.0       0.
      20.0      14.9     222.       0.       0.
      25.0      14.9     240.       0.       0.0
      27.0      14.9     288.     15.0       2.0
   END FTABLE   7
   FTABLE       8
  ROWS COLS      (M3)    FISCHERS BOG  STCOR=285, ***
     6    5
      Depth       Area    Volume  Outflow1    18" OVERFLOW                        ***
       (ft)    (acres) (acre-ft)    (cfs)      (CFS)                              ***
       0.0      0.0       0.0      0.0        0.
       4.0      6.50     45.0      .10        0.
      10.0      6.50     97.5      .20        0.
      15.0      6.50    145.5      1.0        0.
      17.0      6.50    180.0      1.0        0.0
      19.0      6.50    215.0      4.0        30.
   END FTABLE   8
   FTABLE       9
  ROWS COLS      (L7)                                                             ***
     3    4
      DEPTH       AREA    VOLUME  OUTFLOW1                                        ***
       (FT)    (ACRES) (ACRE-FT)    (CFS)                                         ***
       0.0      0.0      0.0       0.0
       0.5      0.5      .155      3.13
       4.0      2.23     4.13      269.
   END FTABLE   9
   FTABLE      10
  ROWS COLS      (L5)                                                             ***
     3    4
      DEPTH       AREA    VOLUME  OUTFLOW1                                        ***
       (FT)    (ACRES) (ACRE-FT)    (CFS)                                         ***
      0.0       0.0      0.0       0.0
      0.5       0.5      .186      3.13
      4.0       2.23     5.00      269.
   END FTABLE  10
 END FTABLES
                                                                                  ***
 DISPLY
   DISPLY-INFO1
     #thru#***<----------Title-------->        <-short-span->
           ***                                 <---disply--->  <annual summary ->
           ***                            TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND

     1        LAKOTA SIMQ (IN) 5/15A      SUM     0    2    6    1    3    6    9
     2        LAKOTA SIMQ (CFS) 5/15A     MAX     0    2    6    1    3    6    9
     3        WETLND 9 STAGE       (FT)   MAX     0    2    6    1    2    6    9
     4        PONCE DE LEON STAGE  (FT)   MAX     0    2    6    1    2    6    9
```

```
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A5. Final version of the HSPF input file used for the Redondo Creek #1 Basin

```
RUN
GLOBAL
  REDONDO CREEK- GW RES WITH IFWO FROM TILL IN R4 AND MOST AGWO 5/23A
**** FINAL VALIDATION RUN
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      PERLND      99
      RCHRES       4
      RCHRES       5
      RCHRES       6
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
                                                                          ***
PERLND
  GEN-INFO
    <PLS >       Name           NBLKS   Unit-systems   Printer            ***
    # -  #                            User  t-series Engl Metr            ***
                                             in  out                      ***
   11      TF/MILD                  1    1    1    1    6    0
   15      TF/MODERATE              1    1    1    1    6    0
   17      TF/STEEP                 1    1    1    1    6    0
   21      TG/MILD                  1    1    1    1    6    0
   25      TG/MODERATE              1    1    1    1    6    0
   27      TG/STEEP                 1    1    1    1    6    0
   31      OF/MILD                  1    1    1    1    6    0
   41      OG/MILD                  1    1    1    1    6    0
   51      WETLANDS                 1    1    1    1    6    0
   99      GW RESERVOIR             1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC      ***
   11   99    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ******************** Print-flags ************************ PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   11   99    0    0    5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  PWAT-PARM1
    <PLS > **************** Flags *******************
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                    ***
```

```
  11   99     0     0     0     0     0     0     0     0     0
 END PWAT-PARM1
 PWAT-PARM2
   <PLS > ***
   # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  11           0.75    4.5000    0.0800    400.00    0.0500    0.5000    0.9960
  15           0.75    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
  17           0.75    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
  21           0.05    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
  25           0.05    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
  27           0.05    4.5000    0.0300    200.00    0.2000    0.5000    0.9960
  31           0.75    5.0000    2.0000    400.00    0.0500    0.3000    0.9960
  41           0.05    5.0000    0.8000    400.00    0.0500    0.3000    0.9960
  51           0.75    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
  99           0.75    5.0000    2.0000    400.00    0.0500    0.0000    0.9991
 END PWAT-PARM2
 PWAT-PARM3
   <PLS >***
   # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  11                             3.5000    2.0000      0.00        0.        0.
  15                             2.0000    2.0000      0.00        0.        0.
  17                             1.5000    2.0000      0.00        0.        0.
  21                             3.5000    2.0000      0.00        0.        0.
  25                             2.0000    2.0000      0.00        0.        0.
  27                             1.5000    2.0000      0.00        0.        0.
  31                             2.0000    2.0000       .00        0.        0.
  41                             2.0000    2.0000       .00        0.        0.
  51                             10.000    2.0000      0.00        0.       0.7
  99                             2.0000    2.0000      0.00        0.        0.
 END PWAT-PARM3
 PWAT-PARM4
   <PLS >                                                            ***
   # -  #      CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
  11         0.2000    1.0000    0.3500     3.000    0.7000    0.7000
  15         0.2000    0.5000    0.3500     6.000    0.5000    0.7000
  17         0.2000    0.3000    0.3500     7.000    0.3000    0.7000
  21         0.1000    0.5000    0.2500     3.000    0.7000    0.2500
  25         0.1000    0.2500    0.2500     6.000    0.5000    0.2500
  27         0.1000    0.1500    0.2500     7.000    0.3000    0.2500
  31         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
  41         0.1000    0.5000    0.2500     0.000    0.7000    0.2500
  51         0.1000    3.0000    0.5000     1.000    0.7000    0.8000
  99         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 END PWAT-PARM4
 PWAT-STATE1
   <PLS >  PWATER state variables***
   # -  #***     CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  11             0.        0.    0.0030        0.      .954      2.30      .017
  15             0.        0.    0.0060        0.      .942      2.42      .016
  17             0.        0.    0.0140        0.      .933      2.45      .016
  21             0.        0.    0.1310        0.      1.78      2.00      .095
  25             0.        0.    .06200        0.      1.47      2.20      .068
  27             0.        0.    .05500        0.      1.36      2.25      .062
  31             0.        0.    .00100        0.      .966      6.00      .026
  41             0.        0.    0.0250        0.      4.08      6.60      .257
  51             0.        0.    .66200        0.      3.39      0.10      .162
  99             0.        0.    .00100        0.      .001      97.0      .026
 END PWAT-STATE1
END PERLND
IMPLND
```

```
  GEN-INFO
    <ILS >      Name              Unit-systems   Printer                         ***
    # -  #                    User  t-series Engl Metr                         ***
                                     in  out                                   ***
   11      IMPERVIOUS            1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >          Flags         ***                                          ***
    # -  # CSNO RTOP  VRS  VNN RTLI   ***                                      ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                     ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                             ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                     ***
    # -  #    PETMAX    PETMIN                                                 ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                             ***
    # -  #      RETS      SURS                                                 ***
   11      1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                               ***
EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      2 PREC     ENGL     .00001        PERLND  99     EXTNL  PREC
WDM      2 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      2 PREC     ENGL                   RCHRES   4     EXTNL  PREC
WDM      5 PET      ENGL                   PERLND  11  99 EXTNL  PETINP
WDM      5 PET      ENGL                   IMPLND  11     EXTNL  PETINP
WDM      5 PET      ENGL                   RCHRES   4     EXTNL  POTEV
END EXT SOURCES
                                                                               ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   6 HYDR   ROVOL  1        48.4 SAME WDM     13 SIMQ     ENGL      REPL
END EXT TARGETS
                                                                               ***
NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
   *** RECHARGE TO GW RESERVOIR FROM AGWI AND AGWO ***
```

```
PERLND  11 PWATER AGWO         0.0254      PERLND  99     EXTNL  AGWLI
PERLND  15 PWATER AGWO         0.0127      PERLND  99     EXTNL  AGWLI
PERLND  21 PWATER AGWO         0.9894      PERLND  99     EXTNL  AGWLI
PERLND  25 PWATER AGWO         0.1653      PERLND  99     EXTNL  AGWLI
PERLND  31 PWATER AGWI         0.4583      PERLND  99     EXTNL  AGWLI
PERLND  41 PWATER AGWI         0.5417      PERLND  99     EXTNL  AGWLI
PERLND  51 PWATER AGWO         0.0494      PERLND  99     EXTNL  AGWLI
   *** RECHARGE TO GW RESERVOIR FROM IFWO ***
PERLND  21 PWATER IFWO         0.5530      PERLND  99     EXTNL  AGWLI
PERLND  25 PWATER IFWO         0.1229      PERLND  99     EXTNL  AGWLI
*** SUB-BASIN     R6   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         0.3000      RCHRES   4     EXTNL  IVOL
PERLND  11 PWATER IFWO         0.3000      RCHRES   4     EXTNL  IVOL
PERLND  21 PWATER SURO         1.7649      RCHRES   4     EXTNL  IVOL
PERLND  21 PWATER IFWO         1.7649      RCHRES   4     EXTNL  IVOL
PERLND  51 PWATER SURO         0.5833      RCHRES   4     EXTNL  IVOL
PERLND  51 PWATER IFWO         0.5833      RCHRES   4     EXTNL  IVOL
IMPLND  11 IWATER SURO         2.1500      RCHRES   4     EXTNL  IVOL
*** SUB-BASIN     R5   RUNOFF FROM LAND SEGMENTS
PERLND  15 PWATER SURO         0.1500      RCHRES   5     EXTNL  IVOL
PERLND  15 PWATER IFWO         0.1500      RCHRES   5     EXTNL  IVOL
PERLND  21 PWATER SURO         3.3882      RCHRES   5     EXTNL  IVOL
PERLND  21 PWATER IFWO         3.3882      RCHRES   5     EXTNL  IVOL
PERLND  25 PWATER SURO         0.4987      RCHRES   5     EXTNL  IVOL
PERLND  25 PWATER IFWO         0.4987      RCHRES   5     EXTNL  IVOL
PERLND  31 PWATER SURO         0.1083      RCHRES   5     EXTNL  IVOL
IMPLND  11 IWATER SURO         2.6499      RCHRES   5     EXTNL  IVOL
PERLND  99 PWATER AGWO         0.1083      RCHRES   5     EXTNL  IVOL
*** SUB-BASIN     R4   RUNOFF FROM LAND SEGMENTS
*** AREA CORRECTED TO REMOVE CLOSED DEPPRESION 3/17/89
PERLND  17 PWATER PERO         0.9333      RCHRES   6     EXTNL  IVOL
PERLND  21 PWATER SURO         6.5224      RCHRES   6     EXTNL  IVOL
PERLND  25 PWATER SURO         1.4518      RCHRES   6     EXTNL  IVOL
PERLND  27 PWATER PERO         0.3007      RCHRES   6     EXTNL  IVOL
PERLND  31 PWATER SURO         5.3000      RCHRES   6     EXTNL  IVOL
PERLND  41 PWATER SURO         6.3938      RCHRES   6     EXTNL  IVOL
IMPLND  11 IWATER SURO         0.7850      RCHRES   6     EXTNL  IVOL
PERLND  99 PWATER AGWO        11.6938      RCHRES   6     EXTNL  IVOL
***
  *** CHANNEL NETWORK LINKAGES ***
RCHRES   4 HYDR   ROVOL  1                 RCHRES   5     EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1                 RCHRES   6     EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1      0.0277     DISPLY   1     INPUT  TIMSER 1
RCHRES   6 HYDR   RO     1                 DISPLY   2     INPUT  TIMSER 1
END NETWORK
                                                                        ***
RCHRES
  GEN-INFO
    RCHRES       Name         Nexits   Unit Systems   Printer           ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG      ***
                                           in  out                      ***
    4     R6 EASTER LAKE          1    1    1    1    6    0    0
    5     R5                      1    1    1    1    6    0    0
    6     R4 - GAGE 12103210      1    1    1    1    6    0    0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG             ***
    4    6    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    RCHRES *************** Printout Flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    4    6    5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible   exit  *** possible  exit      possible  exit
             *  *  *  *   *  *  *  *  *        *  *  *  *  *         ***
    4        0  1  0  0   4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
    5    6   0  0  0  0   4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                   ***
    # -  #    FTABNO       LEN     DELTH      STCOR        KS       DB50     ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    4             4   0.500                                0.5
    5             5   0.436                                0.5
    6             6   1.080                                0.5
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL      Initial  value  of COLIND     Initial  value  of OUTDGT
         *** ac-ft      for each possible exit        for each possible exit
  <------><-------->      <---><---><---><---><---> *** <---><---><---><---><--->
    4     44.0            4.0
    5     0.014           4.0
    6     0.039           4.0
  END HYDR-INIT
END RCHRES
                                                                             ***
FTABLES
  FTABLE      4
 ROWS COLS      (R6) EASTER LAKE        ESTIMATED-3/22/89                    ***
   11    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)   (cfs)                                      ***
     0.0      0.0       0.0       0.0
     10.0     8.50      50.0      0.0
     10.5     8.50      54.2      3.90
     11.0     8.50      58.4      5.60
     12.5     8.50      63.5      6.80
     13.0     8.50      70.0      7.90
     13.5     8.50      77.0      8.80
     14.0     8.50      85.0      9.60
     14.5     8.50      93.5     10.40
     15.0     8.50     103.0     11.20
     15.5     8.50     114.4     12.40
  END FTABLE  4
  FTABLE      5
 Rows Cols      (R5)                                                         ***
    3    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)   (cfs)                                      ***
     0.0      0.0       0.0       0.0
     0.5      0.24      0.11      4.0
     4.0      0.48      1.37      135.
  END FTABLE  5
  FTABLE      6
```

```
 Rows Cols      (R4)                                                             ***
    3    4
     Depth      Area     Volume  Outflow1                                        ***
      (ft)    (acres) (acre-ft)    (cfs)                                         ***
     0.0       0.0       0.0       0.0
     0.50      0.79      0.39      5.00
     3.00      0.85      2.36      125.
  END FTABLE  6
END FTABLES
***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply---> <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        REDONDO 1 SIMQ(IN) 5/23A    SUM     0    2    6    1    3    6    9
    2        REDONDO 1 SIMQ(CFS) 5/23A   MAX     0    2    6    1    3    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A6. Final version of the HSPF input file used for the Redondo Creek #2 Basin

```
RUN
GLOBAL
  REDONDO CONDO - 5/6A , RC=.999, KV=0 - FINAL VALIDATION RUN
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      RCHRES       1
      RCHRES       2
      RCHRES       3
      DISPLY       1
      DISPLY       2
      DISPLY       3
    END INGRP
END OPN SEQUENCE
                                                                         ***
PERLND
  GEN-INFO
    <PLS >      Name          NBLKS   Unit-systems   Printer             ***
    # -  #                         User  t-series Engl Metr              ***
                                          in  out                        ***
   11      TF/MILD               1    1    1    1    6    0
   15      TF/MODERATE           1    1    1    1    6    0
   17      TF/STEEP              1    1    1    1    6    0
   21      TG/MILD               1    1    1    1    6    0
   25      TG/MODERATE           1    1    1    1    6    0
   27      TG/STEEP              1    1    1    1    6    0
   31      OF/MILD               1    1    1    1    6    0
   41      OG/MILD               1    1    1    1    6    0
   51      WETLANDS              1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC       ***
   11   51    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ******************** Print-flags ************************ PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   11   51    0    0    5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  PWAT-PARM1
    <PLS > **************** Flags *******************
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                     ***
   11   51    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
```

```
  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   11            0.75    4.5000    0.0800    400.00    0.0500    0.0000    0.9990
   15            0.75    4.5000    0.0800    400.00    0.1000    0.0000    0.9990
   17            0.75    4.5000    0.0800    200.00    0.2000    0.0000    0.9990
   21            0.05    4.5000    0.0300    400.00    0.0500    0.0000    0.9990
   25            0.05    4.5000    0.0300    400.00    0.1000    0.0000    0.9990
   27            0.05    4.5000    0.0300    200.00    0.2000    0.0000    0.9990
   31            0.75    5.0000    2.0000    400.00    0.0500    0.0000    0.9990
   41            0.05    5.0000    0.8000    400.00    0.0500    0.0000    0.9990
   51            0.75    4.0000    2.0000    100.00    0.0010    0.0000    0.9990
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   11                             3.5000    2.0000      0.00        0.        0.
   15                             2.0000    2.0000      0.00        0.        0.
   17                             1.5000    2.0000      0.00        0.        0.
   21                             3.5000    2.0000      0.00        0.        0.
   25                             2.0000    2.0000      0.00        0.        0.
   27                             1.5000    2.0000      0.00        0.        0.
   31                             2.0000    2.0000      0.00        0.        0.
   41                             2.0000    2.0000      0.00        0.        0.
   51                             10.000    2.0000      0.00        0.       0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                          ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
   11         0.2000    1.0000    0.3500     3.000    0.7000    0.7000
   15         0.2000    0.5000    0.3500     6.000    0.5000    0.7000
   17         0.2000    0.3000    0.3500     7.000    0.3000    0.7000
   21         0.1000    0.5000    0.2500     3.000    0.7000    0.2500
   25         0.1000    0.2500    0.2500     6.000    0.5000    0.2500
   27         0.1000    0.1500    0.2500     7.000    0.3000    0.2500
   31         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
   41         0.1000    0.5000    0.2500     0.000    0.7000    0.2500
   51         0.1000    3.0000    0.5000     1.000    0.7000    0.8000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   11             0.        0.    0.0030        0.      .954     22.60      .017
   15             0.        0.    0.0060        0.      .942     25.80      .016
   17             0.        0.    0.0140        0.      .933     27.00      .016
   21             0.        0.    0.1310        0.      2.78     15.00      .095
   25             0.        0.    .24800        0.      2.47     15.10      .068
   27             0.        0.    .22200        0.      2.36     15.20      .062
   31             0.        0.    .00100        0.      .966     46.40      .026
   41             0.        0.    0.0250        0.      4.08     55.10      .257
   51             0.        0.    .66200        0.      3.39     19.30      .162
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name            Unit-systems   Printer                      ***
    # -  #                    User  t-series Engl Metr                      ***
                                     in  out                                ***
   11       IMPERVIOUS          1    1    1    6    0
  END GEN-INFO
```

```
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >          Flags          ***                                      ***
    # -  # CSNO RTOP  VRS  VNN RTLI   ***                                      ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                   ***
    # -  #       LSUR     SLSUR      NSUR     RETSC                          ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                   ***
    # -  #    PETMAX    PETMIN                                              ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                           ***
    # -  #       RETS       SURS                                            ***
   11       1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                           ***
EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      2 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      2 PREC     ENGL                   RCHRES   1     EXTNL  PREC
WDM      5 PET      ENGL                   PERLND  11  51 EXTNL  PETINP
WDM      5 PET      ENGL                   IMPLND  11     EXTNL  PETINP
WDM      5 PET      ENGL                   RCHRES   1     EXTNL  POTEV
END EXT SOURCES
                                                                           ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   3 HYDR   ROVOL  1        48.4 SAME WDM      14 SIMQ     ENGL      REPL
END EXT TARGETS
                                                                           ***
NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
*** AGWO FROM PARTS OF R1 ONLY
*** SUB-BASIN      R3   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          2.9250      RCHRES   1      EXTNL  IVOL
PERLND  11 PWATER IFWO          2.9250      RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER SURO          0.7667      RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER IFWO          0.7667      RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER SURO          1.4250      RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER IFWO          1.4250      RCHRES   1      EXTNL  IVOL
```

```
PERLND  21 PWATER SURO          3.2211       RCHRES   1     EXTNL  IVOL
PERLND  21 PWATER IFWO          3.2211       RCHRES   1     EXTNL  IVOL
PERLND  25 PWATER SURO          8.9563       RCHRES   1     EXTNL  IVOL
PERLND  25 PWATER IFWO          8.9563       RCHRES   1     EXTNL  IVOL
PERLND  27 PWATER SURO          0.2000       RCHRES   1     EXTNL  IVOL
PERLND  27 PWATER IFWO          0.2000       RCHRES   1     EXTNL  IVOL
PERLND  51 PWATER SURO          2.8167       RCHRES   1     EXTNL  IVOL
PERLND  51 PWATER IFWO          2.8167       RCHRES   1     EXTNL  IVOL
IMPLND  11 IWATER SURO          5.1142       RCHRES   1     EXTNL  IVOL
*** SUB-BASIN     R2   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          0.6083       RCHRES   2     EXTNL  IVOL
PERLND  11 PWATER IFWO          0.6083       RCHRES   2     EXTNL  IVOL
PERLND  17 PWATER SURO          0.8917       RCHRES   2     EXTNL  IVOL
PERLND  17 PWATER IFWO          0.8917       RCHRES   2     EXTNL  IVOL
PERLND  21 PWATER SURO          3.0142       RCHRES   2     EXTNL  IVOL
PERLND  21 PWATER IFWO          3.0142       RCHRES   2     EXTNL  IVOL
PERLND  27 PWATER SURO          0.5313       RCHRES   2     EXTNL  IVOL
PERLND  27 PWATER IFWO          0.5313       RCHRES   2     EXTNL  IVOL
IMPLND  11 IWATER SURO          2.2796       RCHRES   2     EXTNL  IVOL
*** SUB-BASIN     R1   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          1.0667       RCHRES   3     EXTNL  IVOL
PERLND  11 PWATER IFWO          1.0667       RCHRES   3     EXTNL  IVOL
PERLND  17 PWATER SURO          3.5417       RCHRES   3     EXTNL  IVOL
PERLND  17 PWATER IFWO          3.5417       RCHRES   3     EXTNL  IVOL
PERLND  17 PWATER AGWO          1.7709       RCHRES   3     EXTNL  IVOL
PERLND  21 PWATER SURO          3.0773       RCHRES   3     EXTNL  IVOL
PERLND  21 PWATER IFWO          3.0773       RCHRES   3     EXTNL  IVOL
PERLND  27 PWATER SURO          1.3927       RCHRES   3     EXTNL  IVOL
PERLND  27 PWATER IFWO          1.3927       RCHRES   3     EXTNL  IVOL
PERLND  27 PWATER AGWO          0.6964       RCHRES   3     EXTNL  IVOL
PERLND  31 PWATER SURO          3.7792       RCHRES   3     EXTNL  IVOL
PERLND  31 PWATER IFWO          3.7792       RCHRES   3     EXTNL  IVOL
PERLND  31 PWATER AGWO          3.7792       RCHRES   3     EXTNL  IVOL
PERLND  41 PWATER SURO          5.3712       RCHRES   3     EXTNL  IVOL
PERLND  41 PWATER IFWO          5.3712       RCHRES   3     EXTNL  IVOL
PERLND  41 PWATER AGWO          5.3712       RCHRES   3     EXTNL  IVOL
IMPLND  11 IWATER SURO          4.7546       RCHRES   3     EXTNL  IVOL
  *** CHANNEL NETWORK LINKAGES ***
RCHRES    1 HYDR   OVOL   1                  RCHRES   2     EXTNL  IVOL
RCHRES    1 HYDR   STAGE  1                  DISPLY   3     INPUT  TIMSER 1
RCHRES    2 HYDR   ROVOL  1                  RCHRES   3     EXTNL  IVOL
RCHRES    3 HYDR   ROVOL  1   .017072        DISPLY   1     INPUT  TIMSER 1
RCHRES    3 HYDR   RO     1                  DISPLY   2     INPUT  TIMSER 1
END NETWORK
                                                                         ***
RCHRES
  GEN-INFO
    RCHRES        Name         Nexits   Unit Systems   Printer           ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG        ***
                                               in  out                   ***
    1     R3                     2    1    1    1    6    0    1
    2     R2                     1    1    1    1    6    0    0
    3     R1 - GAGE 12103212     1    1    1    1    6    0    0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG              ***
    1    3    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
```

```
    RCHRES *************** Printout Flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    1    3    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible   exit *** possible   exit     possible   exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
    1        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    2    3   0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                   ***
    # -  #    FTABNO       LEN      DELTH      STCOR        KS      DB50     ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1   1.000                -18.82       0.5
    2             2   0.284                             0.5
    3             3   0.890                             0.5
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL      Initial  value  of COLIND     Initial  value  of OUTDGT
           *** ac-ft      for each possible exit        for each possible exit
  <------><-------->      <---><---><---><---><---> *** <---><---><---><---><--->
    1     500.              4.0  5.0
    2     0.008             4.0
    3     0.022             4.0
  END HYDR-INIT
END RCHRES
                                                                             ***
FTABLES
  FTABLE      1
 ROWS COLS    (R3) STEEL LAKE                                                ***
    6    5
     Depth      Area    Volume  Outflow1                                    ***
      (ft)    (acres) (acre-ft)   (cfs)                                      ***
     0.0       0.0       0.0       0.0       0.0
     22.0      34.1      500.      0.00      0.1
     24.0      34.1      568.      0.00      1.1
     24.5      34.1      585.      2.50      1.5
     25.0      34.1      602.      20.0      1.6
     26.0      34.1      636.      35.0      1.8
  END FTABLE  1
  FTABLE      2
 Rows Cols    (R2)                                                           ***
    5    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)   (cfs)                                      ***
     0.0       0.0       0.0       0.0
     1.0       0.17      0.16      10.0
     2.0       0.20      0.34      30.0
     3.0       0.24      0.56      60.0
     5.0       0.28      1.03      300.
  END FTABLE  2
  FTABLE      3
 Rows Cols     (R1)                                                          ***
    5    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)   (cfs)                                      ***
```

```
      0.0       0.0       0.0        0.0
      0.5       0.86      0.43       10.0
      1.0       0.92      0.86       30.0
      2.0       1.00      1.86       85.0
      4.0       1.29      4.32       350.
  END FTABLE  3
END FTABLES

DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply--->  <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        CONDO SIMQ (IN) 5/6         SUM     0    2    6    1    3    6    9
    2        CONDO SIMPKS (CFS) 5/6      MAX     0    2    6    1    2    6    9
    3        STEEL LAKE STAGE (FEET)     MAX     0    2    6    1    2    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A7. Final version of the HSPF input file used for the Unnamed Creek at Saltwater State Park Basin

```
RUN
GLOBAL
  SALTWATER CREEK - 3/11A, KV=2.0, AGWRC=.998 - FINAL VALIDATION RUN
*** NO TILL AGWO FROM S9, S8, S6, S5
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       5
      RCHRES       6
      RCHRES       7
      RCHRES       8
      RCHRES       9
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
                                                                              ***
PERLND
  GEN-INFO
    <PLS >      Name          NBLKS   Unit-systems   Printer                  ***
    # -  #                          User  t-series Engl Metr                  ***
                                          in  out                             ***
   11       TF/MILD              1    1    1    1    6    0
   15       TF/MODERATE          1    1    1    1    6    0
   17       TF/STEEP             1    1    1    1    6    0
   21       TG/MILD              1    1    1    1    6    0
   25       TG/MODERATE          1    1    1    1    6    0
   27       TG/STEEP             1    1    1    1    6    0
   31       OF/MILD              1    1    1    1    6    0
   41       OG/MILD              1    1    1    1    6    0
   51       WETLANDS             1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC         ***
   11   51    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ********************* Print-flags ************************* PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
```

```
 11   51    0    0    5    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > **************** Flags *******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                        ***
 11   51    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11             0.75    4.5000    0.0800    400.00    0.0500    2.0000    .99800
 15             0.75    4.5000    0.0800    400.00    0.1000    2.0000    .99800
 17             0.75    4.5000    0.0800    200.00    0.2000    2.0000    .99800
 21             0.05    4.5000    0.0300    400.00    0.0500    2.0000    .99800
 25             0.05    4.5000    0.0300    400.00    0.1000    2.0000    .99800
 27             0.05    4.5000    0.0300    200.00    0.2000    2.0000    .99800
 31             0.75    5.0000    2.0000    400.00    0.0500    2.0000    .99800
 41             0.05    5.0000    0.8000    400.00    0.0500    2.0000    .99800
 51             0.75    4.0000    2.0000    100.00    0.0010    2.0000    .99800
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11                             3.5000    2.0000       .00        0.        0.
 15                             2.0000    2.0000       .00        0.        0.
 17                             1.5000    2.0000       .00        0.        0.
 21                             3.5000    2.0000       .00        0.        0.
 25                             2.0000    2.0000       .00        0.        0.
 27                             1.5000    2.0000       .00        0.        0.
 31                             2.0000    2.0000       .00        0.        0.
 41                             2.0000    2.0000       .00        0.        0.
 51                             10.000    2.0000       .00        0.       0.7
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                               ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 11         0.2000    1.0000    0.3500     3.000    0.7000    0.7000
 15         0.2000    0.5000    0.3500     6.000    0.5000    0.7000
 17         0.2000    0.3000    0.3500     7.000    0.3000    0.7000
 21         0.1000    0.5000    0.2500     3.000    0.7000    0.2500
 25         0.1000    0.2500    0.2500     6.000    0.5000    0.2500
 27         0.1000    0.1500    0.2500     7.000    0.3000    0.2500
 31         0.2000    0.5000    0.3500     0.000    0.5000    0.7000
 41         0.1000    0.5000    0.2500     0.000    0.5000    0.2500
 51         0.1000    3.0000    0.5000     1.000    0.5000    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***     CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 11               0.        0.    0.0030        0.      .954      4.50      .017
 15               0.        0.    0.0060        0.      .942      5.00      .016
 17               0.        0.    0.0140        0.      .933      5.00      .016
 21               0.        0.    0.1310        0.      2.78      3.90      .095
 25               0.        0.    0.2480        0.      2.47      2.90      .068
 27               0.        0.    0.2220        0.      2.36      3.95      .062
 31               0.        0.    0.0010        0.      .966      5.00      .026
 41               0.        0.    0.0250        0.      4.08      5.50      .257
 51               0.        0.    .66200        0.      3.39      2.50      .162
END PWAT-STATE1
END PERLND
```

```
IMPLND
  GEN-INFO
    <ILS >      Name             Unit-systems   Printer                          ***
    # -  #                      User  t-series Engl Metr                         ***
                                        in  out                                  ***
   11      IMPERVIOUS            1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags          ***                                          ***
    # -  # CSNO RTOP  VRS  VNN RTLI  ***                                         ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                       ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                              ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                       ***
    # -  #    PETMAX    PETMIN                                                  ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                              ***
    # -  #      RETS      SURS                                                  ***
   11       1..0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                                ***
EXT SOURCES
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      3 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      3 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      5 PET      ENGL                   PERLND  11  51 EXTNL  PETINP
WDM      5 PET      ENGL                   IMPLND  11     EXTNL  PETINP
END EXT SOURCES
                                                                                ***
*** NOTE: MFACTOR 48.4 CONVERTS ACRE-FEET OF RUNOFF TO AVERAGE CFS PER MINUTE.
***       IT IS TIMESTEP DEPENDENT.
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   8 HYDR   ROVOL  1       48.4 SAME WDM     15 SIMQ     ENGL      REPL
END EXT TARGETS
                                                                                ***
NETWORK
***
*** NO AGWO FROM S5,S6,S8,S9
```

```
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #         <Name> # #   ***
  *** SUB-BASIN S9   ***
PERLND  11 PWATER SURO          3.708      RCHRES   1      EXTNL  IVOL
PERLND  11 PWATER IFWO          3.708      RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER SURO          5.220      RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER IFWO          5.220      RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER SURO          0.958      RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER IFWO          0.958      RCHRES   1      EXTNL  IVOL
PERLND  21 PWATER SURO          4.247      RCHRES   1      EXTNL  IVOL
PERLND  21 PWATER IFWO          4.247      RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER SURO          3.784      RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER IFWO          3.784      RCHRES   1      EXTNL  IVOL
PERLND  27 PWATER SURO          3.515      RCHRES   1      EXTNL  IVOL
PERLND  27 PWATER IFWO          3.515      RCHRES   1      EXTNL  IVOL
PERLND  31 PWATER SURO          0.733      RCHRES   1      EXTNL  IVOL
PERLND  31 PWATER IFWO          0.733      RCHRES   1      EXTNL  IVOL
PERLND  41 PWATER SURO          1.990      RCHRES   1      EXTNL  IVOL
PERLND  41 PWATER IFWO          1.990      RCHRES   1      EXTNL  IVOL
PERLND  51 PWATER SURO          0.275      RCHRES   1      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.275      RCHRES   1      EXTNL  IVOL
IMPLND  11 IWATER SURO          7.652      RCHRES   1      EXTNL  IVOL
  *** SUB-BASIN S8 ***
PERLND  11 PWATER SURO          0.528      RCHRES   2      EXTNL  IVOL
PERLND  11 PWATER IFWO          0.528      RCHRES   2      EXTNL  IVOL
PERLND  15 PWATER SURO          4.686      RCHRES   2      EXTNL  IVOL
PERLND  15 PWATER IFWO          4.686      RCHRES   2      EXTNL  IVOL
PERLND  17 PWATER SURO          2.475      RCHRES   2      EXTNL  IVOL
PERLND  17 PWATER IFWO          2.475      RCHRES   2      EXTNL  IVOL
PERLND  21 PWATER SURO          5.125      RCHRES   2      EXTNL  IVOL
PERLND  21 PWATER IFWO          5.125      RCHRES   2      EXTNL  IVOL
PERLND  25 PWATER SURO          2.897      RCHRES   2      EXTNL  IVOL
PERLND  25 PWATER IFWO          2.897      RCHRES   2      EXTNL  IVOL
PERLND  27 PWATER SURO          1.252      RCHRES   2      EXTNL  IVOL
PERLND  27 PWATER IFWO          1.252      RCHRES   2      EXTNL  IVOL
PERLND  31 PWATER SURO          3.131      RCHRES   2      EXTNL  IVOL
PERLND  31 PWATER IFWO          3.131      RCHRES   2      EXTNL  IVOL
PERLND  31 PWATER AGWO          3.131      RCHRES   2      EXTNL  IVOL
PERLND  41 PWATER SURO          3.191      RCHRES   2      EXTNL  IVOL
PERLND  41 PWATER IFWO          3.191      RCHRES   2      EXTNL  IVOL
PERLND  41 PWATER AGWO          3.191      RCHRES   2      EXTNL  IVOL
PERLND  51 PWATER SURO          8.100      RCHRES   2      EXTNL  IVOL
PERLND  51 PWATER IFWO          8.100      RCHRES   2      EXTNL  IVOL
PERLND  51 PWATER AGWO          8.100      RCHRES   2      EXTNL  IVOL
IMPLND  11 IWATER SURO          7.581      RCHRES   2      EXTNL  IVOL
  *** SUB-BASIN S3 ***
PERLND  11 PWATER PERO          2.393      RCHRES   3      EXTNL  IVOL
PERLND  15 PWATER PERO          0.983      RCHRES   3      EXTNL  IVOL
PERLND  17 PWATER PERO          3.044      RCHRES   3      EXTNL  IVOL
PERLND  21 PWATER PERO          3.377      RCHRES   3      EXTNL  IVOL
PERLND  25 PWATER PERO          0.543      RCHRES   3      EXTNL  IVOL
PERLND  27 PWATER PERO          0.298      RCHRES   3      EXTNL  IVOL
PERLND  31 PWATER PERO          0.417      RCHRES   3      EXTNL  IVOL
PERLND  41 PWATER PERO          0.716      RCHRES   3      EXTNL  IVOL
IMPLND  11 IWATER SURO          3.837      RCHRES   3      EXTNL  IVOL
  *** SUB-BASIN S7 ***  (CLOSED BASIN - MIDWAY LANDFILL)
PERLND  11 PWATER PERO          2.375      RCHRES   4      EXTNL  IVOL
PERLND  15 PWATER PERO          0.083      RCHRES   4      EXTNL  IVOL
PERLND  17 PWATER PERO          0.233      RCHRES   4      EXTNL  IVOL
PERLND  21 PWATER PERO          5.881      RCHRES   4      EXTNL  IVOL
```

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PERLND  25 PWATER PERO          0.799      RCHRES   4        EXTNL  IVOL
PERLND  27 PWATER PERO          0.300      RCHRES   4        EXTNL  IVOL
PERLND  31 PWATER PERO          0.283      RCHRES   4        EXTNL  IVOL
PERLND  41 PWATER PERO          3.116      RCHRES   4        EXTNL  IVOL
IMPLND  11 IWATER SURO          6.796      RCHRES   4        EXTNL  IVOL
  *** SUB-BASIN S6 ***
PERLND  11 PWATER SURO          0.358      RCHRES   5        EXTNL  IVOL
PERLND  11 PWATER IFWO          0.358      RCHRES   5        EXTNL  IVOL
PERLND  15 PWATER SURO          1.383      RCHRES   5        EXTNL  IVOL
PERLND  15 PWATER IFWO          1.383      RCHRES   5        EXTNL  IVOL
PERLND  21 PWATER SURO          2.575      RCHRES   5        EXTNL  IVOL
PERLND  21 PWATER IFWO          2.575      RCHRES   5        EXTNL  IVOL
PERLND  25 PWATER SURO          1.066      RCHRES   5        EXTNL  IVOL
PERLND  25 PWATER IFWO          1.066      RCHRES   5        EXTNL  IVOL
PERLND  31 PWATER SURO          0.075      RCHRES   5        EXTNL  IVOL
PERLND  31 PWATER IFWO          0.075      RCHRES   5        EXTNL  IVOL
PERLND  41 PWATER SURO          0.151      RCHRES   5        EXTNL  IVOL
PERLND  41 PWATER IFWO          0.151      RCHRES   5        EXTNL  IVOL
PERLND  51 PWATER SURO          1.000      RCHRES   5        EXTNL  IVOL
PERLND  51 PWATER IFWO          1.000      RCHRES   5        EXTNL  IVOL
IMPLND  11 IWATER SURO          2.607      RCHRES   5        EXTNL  IVOL
  *** SUB-BASIN S5 ***
PERLND  11 PWATER SURO          2.967      RCHRES   6        EXTNL  IVOL
PERLND  11 PWATER IFWO          2.967      RCHRES   6        EXTNL  IVOL
PERLND  21 PWATER SURO          7.555      RCHRES   6        EXTNL  IVOL
PERLND  21 PWATER IFWO          7.555      RCHRES   6        EXTNL  IVOL
PERLND  25 PWATER SURO          1.760      RCHRES   6        EXTNL  IVOL
PERLND  25 PWATER IFWO          1.760      RCHRES   6        EXTNL  IVOL
PERLND  27 PWATER SURO          0.362      RCHRES   6        EXTNL  IVOL
PERLND  27 PWATER IFWO          0.362      RCHRES   6        EXTNL  IVOL
IMPLND  11 IWATER SURO          3.014      RCHRES   6        EXTNL  IVOL
  *** SUB-BASIN S4 ***
PERLND  11 PWATER PERO          0.200      RCHRES   7        EXTNL  IVOL
PERLND  15 PWATER PERO          0.308      RCHRES   7        EXTNL  IVOL
PERLND  17 PWATER PERO          1.558      RCHRES   7        EXTNL  IVOL
PERLND  21 PWATER PERO          2.273      RCHRES   7        EXTNL  IVOL
PERLND  25 PWATER PERO          0.531      RCHRES   7        EXTNL  IVOL
PERLND  27 PWATER PERO          0.156      RCHRES   7        EXTNL  IVOL
IMPLND  11 IWATER SURO          0.973      RCHRES   7        EXTNL  IVOL
  *** SUB-BASIN S2 ***
PERLND  11 PWATER PERO          0.575      RCHRES   8        EXTNL  IVOL
PERLND  15 PWATER PERO          1.433      RCHRES   8        EXTNL  IVOL
PERLND  17 PWATER PERO          3.442      RCHRES   8        EXTNL  IVOL
PERLND  21 PWATER PERO          3.044      RCHRES   8        EXTNL  IVOL
PERLND  25 PWATER PERO          4.127      RCHRES   8        EXTNL  IVOL
PERLND  27 PWATER PERO          1.025      RCHRES   8        EXTNL  IVOL
IMPLND  11 IWATER SURO          2.737      RCHRES   8        EXTNL  IVOL
  *** SUB-BASIN S1 ***
PERLND  11 PWATER PERO          0.342      RCHRES   9        EXTNL  IVOL
PERLND  15 PWATER PERO          0.217      RCHRES   9        EXTNL  IVOL
PERLND  17 PWATER PERO          2.158      RCHRES   9        EXTNL  IVOL
                                                                           ***
  *** CHANNEL NETWORK LINKAGES ***
                                                                           ***
RCHRES    1 HYDR    ROVOL  1               RCHRES   2        EXTNL  IVOL
RCHRES    2 HYDR    ROVOL  1               RCHRES   3        EXTNL  IVOL
RCHRES    3 HYDR    ROVOL  1               RCHRES   8        EXTNL  IVOL
RCHRES    5 HYDR    ROVOL  1               RCHRES   6        EXTNL  IVOL
RCHRES    6 HYDR    ROVOL  1               RCHRES   7        EXTNL  IVOL
RCHRES    7 HYDR    ROVOL  1               RCHRES   8        EXTNL  IVOL
```

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RCHRES   8 HYDR   ROVOL  1   .0073162     DISPLY   1    INPUT  TIMSER 1
RCHRES   8 HYDR   RO     1                DISPLY   2    INPUT  TIMSER 1
RCHRES   8 HYDR   ROVOL  1                RCHRES   9    EXTNL  IVOL
END NETWORK
                                                                     ***
RCHRES
  GEN-INFO
    RCHRES       Name         Nexits   Unit Systems   Printer        ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG    ***
                                           in  out                   ***
    1     S9                      1    1    1    1    6    0    0
    2     S8                      1    1    1    1    6    0    0
    3     S3                      1    1    1    1    6    0    0
    4     S7 - MIDWAY             1    1    1    1    6    0    0
    5     S6                      1    1    1    1    6    0    0
    6     S5                      1    1    1    1    6    0    0
    7     S4                      1    1    1    1    6    0    0
    8     S2 - GAGE 12103220      1    1    1    1    6    0    0
    9     S1                      1    1    1    1    6    0    0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG          ***
    1    9    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    RCHRES *************** Printout Flags ***************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    1    9    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                              ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each    FUNCT  for each
            FG FG FG FG  possible   exit *** possible  exit     possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *          ***
    1        0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
    2        0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
    3    9   0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                           ***
    # -  #    FTABNO       LEN     DELTH      STCOR        KS       DB50      ***
  <------><--------><--------><--------><--------><--------><-------->      ***
    1              1   0.890                              0.5
    2              2   0.663                              0.5
    3              3   0.833                              0.5
    4              4   0.500                              0.5
    5              5   0.208                              0.5
    6              6   0.549                              0.5
    7              7   0.246                              0.5
    8              8   0.398                              0.5
    9              9   0.208                              0.5
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                 ***
    # -  # ***    VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
           *** ac-ft      for each possible exit        for each possible exit
  <------><-------->      <---><---><---><---><---> *** <---><---><---><---><--->
    1      0.008            4.0
    2      0.008            4.0
```

```
    3      0.010             4.0
    4      0.000             4.0
    5      0.125             4.0
    6      0.005             4.0
    7      0.003             4.0
    8      0.008             4.0
    9      0.005             4.0
  END HYDR-INIT
END RCHRES
                                                                             ***
FTABLES
  FTABLE       1
 Rows Cols    (S9)                                                           ***
    4    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)  (cfs)                                       ***
      0.0      0.0      0.0       0.0
      0.5      0.60     0.23      3.00
      2.0      0.60     4.60      50.0
      3.0      0.60     8.50      125.
  END FTABLE   1
  FTABLE       2
 Rows Cols    (S8)                                                           ***
    4    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)  (cfs)                                       ***
      0.0      0.0      0.0       0.0
      1.0      32.2     30.0      2.50
      2.0      90.0     110.      12.0
      3.0      97.2     210.      50.0
  END FTABLE   2
  FTABLE       3
 Rows Cols      (S3)                                                         ***
    6    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)  (cfs)                                       ***
      0.0      0.0      0.0       0.0
      0.5      0.45     0.21      3.00
      1.0      0.50     0.45      10.
      2.0      0.55     1.00      35.
      3.0      0.61     1.52      85.0
      7.0      0.81     4.34      390.
  END FTABLE   3
  FTABLE       4
 Rows Cols      (S7) - MIDWAY DUMMY TABLE (IT DOESN'T DRAIN ANYWHERE)        ***
    4    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)  (cfs)                                       ***
      0.0      0.0      0.0       0.0
      0.5      0.45     0.21      3.00
      3.0      0.61     1.52      85.0
      7.0      0.81     4.34      390.
  END FTABLE   4
  FTABLE       5
 Rows Cols      (S6)                                                         ***
    4    4
     Depth      Area    Volume  Outflow1                                     ***
      (ft)    (acres) (acre-ft)  (cfs)                                       ***
      0.0      0.0      0.0       0.0
      0.5      5.70     4.00      2.00
```

```
     1.0      8.80     10.0      8.00
     2.0      12.0     21.0      40.0
  END FTABLE  5
  FTABLE      6
 Rows Cols      (S5)                                                        ***
    4    4
     Depth      Area    Volume   Outflow1                                   ***
      (ft)   (acres) (acre-ft)    (cfs)                                     ***
     0.0      0.0      0.0       0.0
     0.5      0.20     0.10      2.00
     3.0      0.33     0.80      60.0
     6.0      0.53     2.10      240.
  END FTABLE  6
  FTABLE      7
 Rows Cols      (S4)                                                        ***
    4    4
     Depth      Area    Volume   Outflow1                                   ***
      (ft)   (acres) (acre-ft)    (cfs)                                     ***
     0.0      0.0      0.0       0.0
     0.5      0.09     0.04      2.00
     3.0      0.15     0.36      90.0
     6.0      0.21     0.90      375.
  END FTABLE  7
  FTABLE      8
 Rows Cols      (S2)                                                        ***
    5    4
     Depth      Area    Volume   Outflow1                                   ***
      (ft)   (acres) (acre-ft)    (cfs)                                     ***
     0.0      0.0      0.0       0.0
     1.0      0.19     0.14      5.00
     1.5      0.51     0.39      20.0
     4.0      0.60     1.77      220.
     8.0      0.72     4.36      880.
  END FTABLE  8
  FTABLE      9
 Rows Cols      (S1)                                                        ***
    4    4
     Depth      Area    Volume   Outflow1                                   ***
      (ft)   (acres) (acre-ft)    (cfs)                                     ***
     0.0      0.0      0.0       0.0
     0.5      0.15     0.08      5.00
     3.0      0.20     0.52      90.0
     6.0      0.25     1.19      300.
  END FTABLE  9
END FTABLES
***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply--->  <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        SALTWATER SIMQ(IN) 1/11A    SUM     0    2    6    1    3    6    9
    2        SALTWATER SIMPKS 1/11A      MAX     0    2    6    1    3    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A8. Final version of the HSPF input file used for the Laughing Jacobs Creek Basin

```
RUN
GLOBAL
  LAUGHING JACOBS 2/22A - FINAL VALIDATION RUN
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      RCHRES      10
      RCHRES       9
      RCHRES       8
      RCHRES       7
      RCHRES       6
      RCHRES      19
      RCHRES       4
      RCHRES       5
      RCHRES       3
      RCHRES      12
      RCHRES       2
      RCHRES      14
      RCHRES      16
      RCHRES       1
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
                                                                                         ***
PERLND
  GEN-INFO
    <PLS >       Name           NBLKS   Unit-systems   Printer                           ***
    # -  #                            User  t-series Engl Metr                           ***
                                             in  out                                     ***
   11       TF/MILD                 1    1    1    1    6    0
   15       TF/MODERATE             1    1    1    1    6    0
   17       TF/STEEP                1    1    1    1    6    0
   21       TG/MILD                 1    1    1    1    6    0
   25       TG/MODERATE             1    1    1    1    6    0
   27       TG/STEEP                1    1    1    1    6    0
   31       OF/MILD                 1    1    1    1    6    0
   41       OG/MILD                 1    1    1    1    6    0
   51       WETLANDS                1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC                   ***
   11   51    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
PRINT-INFO
  <PLS > ******************** Print-flags ************************ PIVL  PYR
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
 11   51    0    0    5    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > **************** Flags *******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                       ***
 11   51    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11           0.75    4.5000    0.0800    400.00    0.0500    4.0000    0.9980
 15           0.75    4.5000    0.0800    400.00    0.1000    4.0000    0.9980
 17           0.75    4.5000    0.0800    200.00    0.2000    4.0000    0.9980
 21           0.05    4.5000    0.0300    400.00    0.0500    4.0000    0.9980
 25           0.05    4.5000    0.0300    400.00    0.1000    4.0000    0.9980
 27           0.05    4.5000    0.0300    200.00    0.2000    4.0000    0.9980
 31           0.75    5.0000    2.0000    400.00    0.0500    4.0000    0.9980
 41           0.05    5.0000    0.8000    400.00    0.0500    4.0000    0.9980
 51           0.75    4.0000    2.0000    100.00    0.0010    4.0000    0.9980
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11                             3.5000    2.0000       .00        0.        0.
 15                             2.0000    2.0000       .00        0.        0.
 17                             1.5000    2.0000       .00        0.        0.
 21                             3.5000    2.0000       .00        0.        0.
 25                             2.0000    2.0000       .00        0.        0.
 27                             1.5000    2.0000       .00        0.        0.
 31                             2.0000    2.0000       .00        0.        0.
 41                             2.0000    2.0000       .00        0.        0.
 51                             10.000    2.0000       .00        0.       0.7
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                            ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 11         0.2000    1.0000    0.3500     3.000    0.7000    0.7000
 15         0.2000    0.5000    0.3500     6.000    0.5000    0.7000
 17         0.2000    0.3000    0.3500     7.000    0.3000    0.7000
 21         0.1000    0.5000    0.2500     3.000    0.7000    0.2500
 25         0.1000    0.2500    0.2500     6.000    0.5000    0.2500
 27         0.1000    0.1500    0.2500     7.000    0.3000    0.2500
 31         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 41         0.1000    0.5000    0.2500     0.000    0.7000    0.2500
 51         0.1000    3.0000    0.5000     1.000    0.7000    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 11             0.        0.    0.1310      .001      1.68      6.49      .020
 15             0.        0.    0.2650      .001      1.44      6.67      .030
 17             0.        0.    0.2980        0.      1.37      6.75      .030
 21             0.        0.    0.8100      .060      3.08      5.85      .070
 25             0.        0.    0.3640      .038      2.83      5.89      .050
 27             0.        0.    0.1850      .006      2.64      5.94      .050
 31             0.        0.    0.0110      .000      1.76      7.00      .060
 41             0.        0.    0.1890      .000      4.72      7.30      .250
```

```
   51              0.         0.    2.5900      .003      4.74      2.14      .050
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name             Unit-systems   Printer                        ***
    # -  #                     User  t-series Engl Metr                        ***
                                       in  out                                 ***
   11      IMPERVIOUS            1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags          ***                                        ***
    # -  # CSNO RTOP  VRS  VNN RTLI    ***                                     ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                     ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                             ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                     ***
    # -  #    PETMAX    PETMIN                                                 ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                             ***
    # -  #      RETS      SURS                                                 ***
   11      1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                               ***
EXT SOURCES
                                                                               ***
*** WDM 4 IS PET DATA
*** WDM 5 IS LAUGING JACOBS OBSQ DATA
*** WDM 8  IS LAUGHING JACOBS SIMQ DATA
*** WDM 1  IS LAUGHING JACOBS PREC DATA
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                               ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #   ***
WDM      1 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      1 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   2     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES   5     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES  10     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES  12     EXTNL  PREC
WDM      1 PREC     ENGL                   RCHRES  14     EXTNL  PREC
WDM      4 PET      ENGL                   PERLND  11  51 EXTNL  PETINP
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WDM       4 PET      ENGL                      IMPLND  11      EXTNL  PETINP
WDM       4 PET      ENGL                      RCHRES   2      EXTNL  POTEV
WDM       4 PET      ENGL                      RCHRES   5      EXTNL  POTEV
WDM       4 PET      ENGL                      RCHRES  10      EXTNL  POTEV
WDM       4 PET      ENGL                      RCHRES  12      EXTNL  POTEV
WDM       4 PET      ENGL                      RCHRES  14      EXTNL  POTEV
END EXT SOURCES
                                                                            ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>    #       <Name> # #<-factor->strg <Name>    # <Name>    tem strg strg***
RCHRES    1 HYDR   ROVOL  1       48.4 SAME WDM       8 SIMQ     ENGL       REPL
END EXT TARGETS
                                                                            ***
                                                                            ***
NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>    #       <Name> # #<-factor->strg <Name>    #   #       <Name> # #  ***
***
***   AGWO FROM L1 ONLY
***
*** SUB-BASIN     L1   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO        0.0917       RCHRES   1      EXTNL  IVOL
PERLND  11 PWATER IFWO        0.0917       RCHRES   1      EXTNL  IVOL
PERLND  11 PWATER AGWO        0.0917       RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER SURO        1.2500       RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER IFWO        1.2500       RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER AGWO        1.2500       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER SURO        6.8073       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER IFWO        6.8073       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER AGWO        6.8073       RCHRES   1      EXTNL  IVOL
PERLND  21 PWATER SURO        0.1446       RCHRES   1      EXTNL  IVOL
PERLND  21 PWATER IFWO        0.1446       RCHRES   1      EXTNL  IVOL
PERLND  21 PWATER AGWO        0.1446       RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER SURO        0.6948       RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER IFWO        0.6948       RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER AGWO        0.6948       RCHRES   1      EXTNL  IVOL
PERLND  31 PWATER SURO        9.4333       RCHRES   1      EXTNL  IVOL
PERLND  31 PWATER IFWO        9.4333       RCHRES   1      EXTNL  IVOL
PERLND  31 PWATER AGWO        9.4333       RCHRES   1      EXTNL  IVOL
PERLND  41 PWATER SURO        3.6682       RCHRES   1      EXTNL  IVOL
PERLND  41 PWATER IFWO        3.6682       RCHRES   1      EXTNL  IVOL
PERLND  41 PWATER AGWO        3.6682       RCHRES   1      EXTNL  IVOL
PERLND  51 PWATER SURO        0.5250       RCHRES   1      EXTNL  IVOL
PERLND  51 PWATER IFWO        0.5250       RCHRES   1      EXTNL  IVOL
PERLND  51 PWATER AGWO        0.5250       RCHRES   1      EXTNL  IVOL
IMPLND  11 IWATER SURO        1.3434       RCHRES   1      EXTNL  IVOL
*** SUB-BASIN    BL1   RUNOFF FROM BEDROCK TREATED AS TILL
PERLND  15 PWATER SURO        4.9417       RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER IFWO        4.9417       RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER AGWO        4.9417       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER SURO        7.1917       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER IFWO        7.1917       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER AGWO        7.1917       RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER SURO        1.5423       RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER IFWO        1.5423       RCHRES   1      EXTNL  IVOL
PERLND  25 PWATER AGWO        1.5423       RCHRES   1      EXTNL  IVOL
PERLND  27 PWATER SURO        0.2577       RCHRES   1      EXTNL  IVOL
PERLND  27 PWATER IFWO        0.2577       RCHRES   1      EXTNL  IVOL
PERLND  27 PWATER AGWO        0.2577       RCHRES   1      EXTNL  IVOL
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IMPLND   11 IWATER SUROM         0.5750       RCHRES   1      EXTNL  IVOL
*** SUB-BASIN      L2    RUNOFF FROM LAND SEGMENTS
PERLND   15 PWATER SURO          0.2683       RCHRES   2      EXTNL  IVOL
PERLND   15 PWATER IFWO          0.2683       RCHRES   2      EXTNL  IVOL
PERLND   25 PWATER SURO          0.4170       RCHRES   2      EXTNL  IVOL
PERLND   25 PWATER IFWO          0.4170       RCHRES   2      EXTNL  IVOL
PERLND   27 PWATER SURO          0.3583       RCHRES   2      EXTNL  IVOL
PERLND   27 PWATER IFWO          0.3583       RCHRES   2      EXTNL  IVOL
PERLND   31 PWATER SURO          6.2093       RCHRES   2      EXTNL  IVOL
PERLND   31 PWATER IFWO          6.2093       RCHRES   2      EXTNL  IVOL
PERLND   41 PWATER SURO          5.0994       RCHRES   2      EXTNL  IVOL
PERLND   41 PWATER IFWO          5.0994       RCHRES   2      EXTNL  IVOL
PERLND   51 PWATER SURO          1.1666       RCHRES   2      EXTNL  IVOL
PERLND   51 PWATER IFWO          1.1666       RCHRES   2      EXTNL  IVOL
IMPLND   11 IWATER SURO          0.8143       RCHRES   2      EXTNL  IVOL
*** SUB-BASIN     BL2    RUNOFF FROM BEDROCK TREATED AS TILL
PERLND   15 PWATER SURO          0.9227       RCHRES   2      EXTNL  IVOL
PERLND   15 PWATER IFWO          0.9227       RCHRES   2      EXTNL  IVOL
PERLND   17 PWATER SURO          1.2193       RCHRES   2      EXTNL  IVOL
PERLND   17 PWATER IFWO          1.2193       RCHRES   2      EXTNL  IVOL
PERLND   21 PWATER SURO          0.2250       RCHRES   2      EXTNL  IVOL
PERLND   21 PWATER IFWO          0.2250       RCHRES   2      EXTNL  IVOL
PERLND   25 PWATER SURO          0.2320       RCHRES   2      EXTNL  IVOL
PERLND   25 PWATER IFWO          0.2320       RCHRES   2      EXTNL  IVOL
IMPLND   11 IWATER SURO          0.0343       RCHRES   2      EXTNL  IVOL
*** SUB-BASIN      L2A   RUNOFF FROM LAND SEGMENTS
PERLND   11 PWATER SURO          0.6250       RCHRES  12      EXTNL  IVOL
PERLND   11 PWATER IFWO          0.6250       RCHRES  12      EXTNL  IVOL
PERLND   21 PWATER SURO          0.2938       RCHRES  12      EXTNL  IVOL
PERLND   21 PWATER IFWO          0.2938       RCHRES  12      EXTNL  IVOL
PERLND   31 PWATER SURO          2.9000       RCHRES  12      EXTNL  IVOL
PERLND   31 PWATER IFWO          2.9000       RCHRES  12      EXTNL  IVOL
PERLND   41 PWATER SURO          2.0438       RCHRES  12      EXTNL  IVOL
PERLND   41 PWATER IFWO          2.0438       RCHRES  12      EXTNL  IVOL
IMPLND   11 IWATER SURO          0.7792       RCHRES  12      EXTNL  IVOL
*** SUB-BASIN      L2B   RUNOFF FROM LAND SEGMENTS
PERLND   25 PWATER SURO          0.9250       RCHRES  14      EXTNL  IVOL
PERLND   25 PWATER IFWO          0.9250       RCHRES  14      EXTNL  IVOL
PERLND   27 PWATER SURO          0.4257       RCHRES  14      EXTNL  IVOL
PERLND   27 PWATER IFWO          0.4257       RCHRES  14      EXTNL  IVOL
PERLND   31 PWATER SURO          2.6350       RCHRES  14      EXTNL  IVOL
PERLND   31 PWATER IFWO          2.6350       RCHRES  14      EXTNL  IVOL
PERLND   41 PWATER SURO          4.6289       RCHRES  14      EXTNL  IVOL
PERLND   41 PWATER IFWO          4.6289       RCHRES  14      EXTNL  IVOL
PERLND   51 PWATER SURO          0.8583       RCHRES  14      EXTNL  IVOL
PERLND   51 PWATER IFWO          0.8583       RCHRES  14      EXTNL  IVOL
IMPLND   11 IWATER SURO          0.8521       RCHRES  14      EXTNL  IVOL
*** SUB-BASIN     BL2B   RUNOFF FROM BEDROCK TREATED AS TILL
PERLND   15 PWATER SURO          0.4167       RCHRES  14      EXTNL  IVOL
PERLND   15 PWATER IFWO          0.4167       RCHRES  14      EXTNL  IVOL
PERLND   17 PWATER SURO          0.2333       RCHRES  14      EXTNL  IVOL
PERLND   17 PWATER IFWO          0.2333       RCHRES  14      EXTNL  IVOL
*** SUB-BASIN      L2C   RUNOFF FROM LAND SEGMENTS
PERLND   31 PWATER SURO          0.4210       RCHRES  16      EXTNL  IVOL
PERLND   31 PWATER IFWO          0.4210       RCHRES  16      EXTNL  IVOL
PERLND   41 PWATER SURO          1.7784       RCHRES  16      EXTNL  IVOL
PERLND   41 PWATER IFWO          1.7784       RCHRES  16      EXTNL  IVOL
PERLND   51 PWATER SURO          0.4833       RCHRES  16      EXTNL  IVOL
PERLND   51 PWATER IFWO          0.4833       RCHRES  16      EXTNL  IVOL
IMPLND   11 IWATER SURO          0.0506       RCHRES  16      EXTNL  IVOL
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*** SUB-BASIN      L3   RUNOFF FROM LAND SEGMENTS
PERLND  31 PWATER SURO          1.9547       RCHRES   3      EXTNL  IVOL
PERLND  31 PWATER IFWO          1.9547       RCHRES   3      EXTNL  IVOL
PERLND  41 PWATER SURO          1.9208       RCHRES   3      EXTNL  IVOL
PERLND  41 PWATER IFWO          1.9208       RCHRES   3      EXTNL  IVOL
PERLND  51 PWATER SURO          1.2417       RCHRES   3      EXTNL  IVOL
PERLND  51 PWATER IFWO          1.2417       RCHRES   3      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.3412       RCHRES   3      EXTNL  IVOL
*** SUB-BASIN      L4   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          4.6810       RCHRES   4      EXTNL  IVOL
PERLND  11 PWATER IFWO          4.6810       RCHRES   4      EXTNL  IVOL
PERLND  15 PWATER SURO          1.7550       RCHRES   4      EXTNL  IVOL
PERLND  15 PWATER IFWO          1.7550       RCHRES   4      EXTNL  IVOL
PERLND  21 PWATER SURO          0.7753       RCHRES   4      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.7753       RCHRES   4      EXTNL  IVOL
PERLND  25 PWATER SURO          1.1647       RCHRES   4      EXTNL  IVOL
PERLND  25 PWATER IFWO          1.1647       RCHRES   4      EXTNL  IVOL
PERLND  31 PWATER SURO          3.2167       RCHRES   4      EXTNL  IVOL
PERLND  31 PWATER IFWO          3.2167       RCHRES   4      EXTNL  IVOL
PERLND  41 PWATER SURO          0.9760       RCHRES   4      EXTNL  IVOL
PERLND  41 PWATER IFWO          0.9760       RCHRES   4      EXTNL  IVOL
PERLND  51 PWATER SURO          0.5250       RCHRES   4      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.5250       RCHRES   4      EXTNL  IVOL
IMPLND  11 IWATER SURO          1.9731       RCHRES   4      EXTNL  IVOL
*** SUB-BASIN     BL4   RUNOFF FROM BEDROCK TREATED AS TILL
PERLND  15 PWATER SURO          0.0500       RCHRES   4      EXTNL  IVOL
PERLND  15 PWATER IFWO          0.0500       RCHRES   4      EXTNL  IVOL
*** SUB-BASIN      L5   RUNOFF FROM LAND SEGMENTS
PERLND  31 PWATER SURO          3.5847       RCHRES   5      EXTNL  IVOL
PERLND  31 PWATER IFWO          3.5847       RCHRES   5      EXTNL  IVOL
PERLND  41 PWATER SURO          5.1303       RCHRES   5      EXTNL  IVOL
PERLND  41 PWATER IFWO          5.1303       RCHRES   5      EXTNL  IVOL
PERLND  51 PWATER SURO          1.4417       RCHRES   5      EXTNL  IVOL
PERLND  51 PWATER IFWO          1.4417       RCHRES   5      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.9934       RCHRES   5      EXTNL  IVOL
*** SUB-BASIN      L6   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          0.0333       RCHRES   6      EXTNL  IVOL
PERLND  11 PWATER IFWO          0.0333       RCHRES   6      EXTNL  IVOL
PERLND  21 PWATER SURO          0.0775       RCHRES   6      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.0775       RCHRES   6      EXTNL  IVOL
PERLND  31 PWATER SURO         15.1147       RCHRES   6      EXTNL  IVOL
PERLND  31 PWATER IFWO         15.1147       RCHRES   6      EXTNL  IVOL
PERLND  41 PWATER SURO          7.0833       RCHRES   6      EXTNL  IVOL
PERLND  41 PWATER IFWO          7.0833       RCHRES   6      EXTNL  IVOL
PERLND  51 PWATER SURO          1.7668       RCHRES   6      EXTNL  IVOL
PERLND  51 PWATER IFWO          1.7668       RCHRES   6      EXTNL  IVOL
IMPLND  11 IWATER SURO          3.1912       RCHRES   6      EXTNL  IVOL
*** SUB-BASIN      L7   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          2.4667       RCHRES   7      EXTNL  IVOL
PERLND  11 PWATER IFWO          2.4667       RCHRES   7      EXTNL  IVOL
PERLND  15 PWATER SURO          1.9250       RCHRES   7      EXTNL  IVOL
PERLND  15 PWATER IFWO          1.9250       RCHRES   7      EXTNL  IVOL
PERLND  21 PWATER SURO          0.4311       RCHRES   7      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.4311       RCHRES   7      EXTNL  IVOL
PERLND  25 PWATER SURO          0.0542       RCHRES   7      EXTNL  IVOL
PERLND  25 PWATER IFWO          0.0542       RCHRES   7      EXTNL  IVOL
PERLND  31 PWATER SURO          4.7083       RCHRES   7      EXTNL  IVOL
PERLND  31 PWATER IFWO          4.7083       RCHRES   7      EXTNL  IVOL
PERLND  41 PWATER SURO          4.0512       RCHRES   7      EXTNL  IVOL
PERLND  41 PWATER IFWO          4.0512       RCHRES   7      EXTNL  IVOL
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PERLND  51 PWATER SURO          0.7333      RCHRES   7      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.7333      RCHRES   7      EXTNL  IVOL
IMPLND  11 IWATER SURO          1.3802      RCHRES   7      EXTNL  IVOL
 *** SUB-BASIN     L8   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          4.4187      RCHRES   8      EXTNL  IVOL
PERLND  11 PWATER IFWO          4.4187      RCHRES   8      EXTNL  IVOL
PERLND  15 PWATER SURO          4.0593      RCHRES   8      EXTNL  IVOL
PERLND  15 PWATER IFWO          4.0593      RCHRES   8      EXTNL  IVOL
PERLND  17 PWATER SURO          2.5743      RCHRES   8      EXTNL  IVOL
PERLND  17 PWATER IFWO          2.5743      RCHRES   8      EXTNL  IVOL
PERLND  21 PWATER SURO          1.3117      RCHRES   8      EXTNL  IVOL
PERLND  21 PWATER IFWO          1.3117      RCHRES   8      EXTNL  IVOL
PERLND  25 PWATER SURO          1.3704      RCHRES   8      EXTNL  IVOL
PERLND  25 PWATER IFWO          1.3704      RCHRES   8      EXTNL  IVOL
PERLND  27 PWATER SURO          0.1438      RCHRES   8      EXTNL  IVOL
PERLND  27 PWATER IFWO          0.1438      RCHRES   8      EXTNL  IVOL
PERLND  31 PWATER SURO          4.6880      RCHRES   8      EXTNL  IVOL
PERLND  31 PWATER IFWO          4.6880      RCHRES   8      EXTNL  IVOL
PERLND  41 PWATER SURO          2.8073      RCHRES   8      EXTNL  IVOL
PERLND  41 PWATER IFWO          2.8073      RCHRES   8      EXTNL  IVOL
PERLND  51 PWATER SURO          3.7667      RCHRES   8      EXTNL  IVOL
PERLND  51 PWATER IFWO          3.7667      RCHRES   8      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.8516      RCHRES   8      EXTNL  IVOL
 *** SUB-BASIN     L9   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO          2.2747      RCHRES   9      EXTNL  IVOL
PERLND  11 PWATER IFWO          2.2747      RCHRES   9      EXTNL  IVOL
PERLND  15 PWATER SURO          3.9787      RCHRES   9      EXTNL  IVOL
PERLND  15 PWATER IFWO          3.9787      RCHRES   9      EXTNL  IVOL
PERLND  21 PWATER SURO          0.4438      RCHRES   9      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.4438      RCHRES   9      EXTNL  IVOL
PERLND  25 PWATER SURO          1.2396      RCHRES   9      EXTNL  IVOL
PERLND  25 PWATER IFWO          1.2396      RCHRES   9      EXTNL  IVOL
PERLND  31 PWATER SURO          5.6427      RCHRES   9      EXTNL  IVOL
PERLND  31 PWATER IFWO          5.6427      RCHRES   9      EXTNL  IVOL
PERLND  41 PWATER SURO          6.7501      RCHRES   9      EXTNL  IVOL
PERLND  41 PWATER IFWO          6.7501      RCHRES   9      EXTNL  IVOL
PERLND  51 PWATER SURO          0.2500      RCHRES   9      EXTNL  IVOL
PERLND  51 PWATER IFWO          0.2500      RCHRES   9      EXTNL  IVOL
IMPLND  11 IWATER SURO          1.8789      RCHRES   9      EXTNL  IVOL
 *** SUB-BASIN     L10  RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER SURO         35.3007      RCHRES  10      EXTNL  IVOL
PERLND  11 PWATER IFWO         35.3007      RCHRES  10      EXTNL  IVOL
PERLND  15 PWATER SURO          5.5917      RCHRES  10      EXTNL  IVOL
PERLND  15 PWATER IFWO          5.5917      RCHRES  10      EXTNL  IVOL
PERLND  21 PWATER SURO          0.9250      RCHRES  10      EXTNL  IVOL
PERLND  21 PWATER IFWO          0.9250      RCHRES  10      EXTNL  IVOL
PERLND  25 PWATER SURO          0.0188      RCHRES  10      EXTNL  IVOL
PERLND  25 PWATER IFWO          0.0188      RCHRES  10      EXTNL  IVOL
PERLND  31 PWATER SURO         36.4703      RCHRES  10      EXTNL  IVOL
PERLND  31 PWATER IFWO         36.4703      RCHRES  10      EXTNL  IVOL
PERLND  41 PWATER SURO          7.0958      RCHRES  10      EXTNL  IVOL
PERLND  41 PWATER IFWO          7.0958      RCHRES  10      EXTNL  IVOL
PERLND  51 PWATER SURO          5.6167      RCHRES  10      EXTNL  IVOL
PERLND  51 PWATER IFWO          5.6167      RCHRES  10      EXTNL  IVOL
IMPLND  11 IWATER SURO          3.0727      RCHRES  10      EXTNL  IVOL
 *** SUB-BASIN    BL2C  RUNOFF FROM BEDROCK TREATED LIKE TILL
PERLND  17 PWATER SURO          0.0400      RCHRES  10      EXTNL  IVOL
PERLND  17 PWATER IFWO          0.0400      RCHRES  10      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.0017      RCHRES  10      EXTNL  IVOL
  *** CHANNEL NETWORK LINKAGES ***
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RCHRES  10 HYDR   ROVOL  1                 RCHRES   9     EXTNL  IVOL
RCHRES   9 HYDR   ROVOL  1                 RCHRES   7     EXTNL  IVOL
RCHRES   8 HYDR   ROVOL  1                 RCHRES   7     EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1                 RCHRES  19     EXTNL  IVOL
RCHRES   7 HYDR   ROVOL  1                 RCHRES   5     EXTNL  IVOL
RCHRES   4 HYDR   ROVOL  1                 RCHRES   5     EXTNL  IVOL
RCHRES  19 HYDR   ROVOL  1                 RCHRES   5     EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1                 RCHRES   3     EXTNL  IVOL
RCHRES  12 HYDR   ROVOL  1                 RCHRES  14     EXTNL  IVOL
RCHRES   2 HYDR   ROVOL  1                 RCHRES  14     EXTNL  IVOL
RCHRES  14 HYDR   ROVOL  1                 RCHRES  16     EXTNL  IVOL
RCHRES   3 HYDR   ROVOL  1                 RCHRES   1     EXTNL  IVOL
RCHRES  16 HYDR   ROVOL  1                 RCHRES   1     EXTNL  IVOL
RCHRES   1 HYDR   ROVOL  1   .0033172      DISPLY   1     INPUT  TIMSER 1
RCHRES   1 HYDR   RO     1                 DISPLY   2     INPUT  TIMSER 1
END NETWORK
                                                                    ***
RCHRES
  GEN-INFO
    RCHRES       Name         Nexits   Unit Systems   Printer       ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG   ***
                                             in  out                ***
    1      L1/GAGE 12121720       1    1    1    1    6    0    0
    2      L2/BROOKSHIRE          1    1    1    1    6    0    1
    3      L3                     1    1    1    1    6    0    0
    4      L4                     1    1    1    1    6    0    0
    5      L5/LAUGHING JACOBS     1    1    1    1    6    0    1
    6      L6/QUEENS BOG          1    1    1    1    6    0    0
    7      L7                     1    1    1    1    6    0    0
    8      L8/WETLAND 26          1    1    1    1    6    0    0
    9      L9                     1    1    1    1    6    0    0
   10      L10/BEAVER LAKE        1    1    1    1    6    0    1
   12      L2A/DENT 2             1    1    1    1    6    0    1
   14      L2B/DENT 1             1    1    1    1    6    0    1
   16      L2C                    1    1    1    1    6    0    0
   19      WETLAND 70             1    1    1    1    6    0    0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG         ***
    1   19    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    RCHRES *************** Printout Flags ***************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    1   19    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                              ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *        *  *  *  *  *         ***
    1        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    2        0  1  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    3        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    4        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    5        0  1  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    6        0  1  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    7        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    8        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
```

```
    9          0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   10          0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   12          0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   14          0  1  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   16          0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
   19          0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                    ***
    # -  #     FTABNO      LEN     DELTH     STCOR        KS      DB50        ***
  <------><--------><--------><--------><--------><--------><-------->        ***
    1              1   0.360                             0.5
    2              2   0.455                             0.5
    3              3   0.360                             0.5
    4              4   0.455                             0.5
    5              5   0.360                             0.5
    6              6   0.455                             0.5
    7              7   0.360                             0.5
    8              8   0.455                             0.5
    9              9   0.360                             0.5
   10             10   0.455                             0.5
   12             12   0.360                             0.5
   14             14   0.455                             0.5
   16             16   0.360                             0.5
   19             19   0.360                             0.5
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                          ***
    # -  # ***   VOL     Initial  value  of COLIND    Initial  value  of OUTDGT
           *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1     0.01            4.0
    2     0.02            4.0
    3     0.01            4.0
    4     0.01            4.0
    5     29.60           4.0
    6     40.20           4.0
    7     0.01            4.0
    8     0.01            4.0
    9     0.01            4.0
   10     1779.0          4.0
   12     6.10            4.0
   14     8.80            4.0
   16     0.01            4.0
   19     0.01            4.0
  END HYDR-INIT
END RCHRES
                                                                              ***
FTABLES
  FTABLE       1
 ROWS COLS          CROSS-SECTION:    4 (BEAVER LAKE)                   ***
   23    4
     DEPTH      AREA    VOLUME  OUTFLOW1                                ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                ***
       0.0      0.00      0.00      0.00
        .5      1.31       .33      4.92
       1.0      2.62      1.31     31.24
       1.5      3.94      2.95     92.10
       2.0      4.42      5.04    210.60
       2.5      4.90      7.37    373.20
```

```
      3.0       5.26       9.93     586.97
      3.5       5.45      12.60     854.70
      4.0       5.63      15.37    1163.60
      4.5       5.82      18.24    1511.91
      5.0       6.01      21.19    1898.31
      5.5       6.19      24.24    2321.78
      6.0       6.38      27.38    2781.48
      6.5       6.56      30.62    3276.78
      7.0       6.75      33.95    3807.12
      7.5       6.94      37.37    4372.07
      8.0       7.12      40.89    4971.27
      8.5       7.56      44.56    5610.82
      9.0       8.00      48.45    6286.53
      9.5       8.44      52.56    6999.58
     10.0       8.88      56.89    7750.91
     10.5       9.32      61.44    8541.36
     10.9       9.67      65.23    9202.40
  END FTABLE  1
  FTABLE      2
 ROWS COLS         BROOKSHIRE                                   ***
   5    4
    DEPTH      AREA     VOLUME   OUTFLOW1                       ***
     (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                       ***
      0.0       0.00       0.00       0.00
      0.5       1.00       0.35       1.00
      2.0       1.00       1.65       1.85
      3.0       1.00       2.68       7.14
      7.2       1.00      18.00      21.60
  END FTABLE  2
  FTABLE      3
 ROWS COLS         CROSS-SECTION:   8 (BEAVER LAKE)             ***
   9    4
    DEPTH      AREA     VOLUME   OUTFLOW1                       ***
     (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                       ***
      0.0       0.00       0.00       0.00
       .5        .28        .09        .79
      1.0        .42        .26       3.99
      1.5        .48        .49      10.10
      2.0        .50        .74      18.93
      2.5        .51        .99      30.00
      3.0        .53       1.25      43.16
      3.5        .54       1.52      58.27
      3.9       1.35       1.86      72.21
  END FTABLE  3
  FTABLE      4
 ROWS COLS         CROSS-SECTION:   12 (BEAVER LAKE)            ***
   4    4
    DEPTH      AREA     VOLUME   OUTFLOW1                       ***
     (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                       ***
      0.0       0.00       0.00       0.00
       .5       3.19       1.00      20.08
      1.0       5.03       3.05      92.81
      1.3       6.13       4.73     165.27
  END FTABLE  4
  FTABLE      5
 ROWS COLS         LAUGHING JACOBS LAKE                         ***
   9    4
    DEPTH      AREA     VOLUME   OUTFLOW1                       ***
     (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                       ***
      0.0       0.00       0.00       0.00
```

```
      4.0     11.00     29.60      0.00
      5.0     11.00     38.85      1.50
      5.5     11.00     45.32      6.50
      6.0     11.00     53.10     21.60
      6.5     11.00     63.60     35.51
      7.0     11.00     73.80     50.00
      7.2     11.00     77.80     62.90
      7.5     11.00     83.80    115.44
 END FTABLE   5
 FTABLE       6
ROWS COLS         QUEENS BOG                                       ***
  7    4
    DEPTH      AREA    VOLUME  OUTFLOW1                            ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                            ***
      0.0      0.00      0.00      0.00
      2.0     20.10     40.20      0.00
      2.1     20.10     42.20      0.74
      2.2     20.10     44.20      4.16
      2.3     20.10     46.20     11.46
      2.4     20.10     48.20     25.49
      2.5     20.10     50.20     43.19
 END FTABLE   6
 FTABLE       7
ROWS COLS         CROSS-SECTION:   13A (BEAVER LAKE)               ***
  5    4
    DEPTH      AREA    VOLUME  OUTFLOW1                            ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                            ***
      0.0      0.00      0.00      0.00
       .5       .57       .14      1.17
      1.0       .83       .49      7.45
      1.5      1.09       .97     18.55
      2.0      1.34      1.58     34.61
 END FTABLE   7
 FTABLE       8
ROWS COLS         WETLAND 26                                       ***
  6    4
    DEPTH      AREA    VOLUME  OUTFLOW1                            ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                            ***
      0.0      0.00      0.00      0.00
       .5       .20       .07       .75
      1.0       .24       .19      3.07
      1.5       .28     18.80      6.75
      2.0       .32     37.56     11.79
      2.3       .34     48.65     15.49
 END FTABLE   8
 FTABLE       9
ROWS COLS         CROSS-SECTION:   20D (BEAVER LAKE)               ***
  6    4
    DEPTH      AREA    VOLUME  OUTFLOW1                            ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                            ***
      0.0      0.00      0.00      0.00
       .5      2.50       .62      2.63
      1.0      4.99      2.50     16.73
      1.5      7.49      5.62     49.32
      2.0      9.99      9.99    106.21
      2.1     10.49     11.01    120.97
 END FTABLE   9
 FTABLE      10
ROWS COLS         BEAVER LAKE                                      ***
 11    4
```

```
    DEPTH      AREA     VOLUME  OUTFLOW1                                    ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                     ***
      0.0      0.00       0.00      0.00
     10.0     83.00      61.15      0.00
     20.0     83.00     254.95      0.00
     30.0     83.00     794.05      0.00
     40.0     83.00    1084.00      0.00
     50.0     83.00    1779.00      0.00
     50.5     83.00    1822.00      1.70
     51.1     83.00    1866.00      6.34
     51.6     83.00    1911.00     20.17
     52.1     83.00    1956.00     37.84
     52.5     83.00    1983.00     51.51
  END FTABLE 10
  FTABLE     12
 ROWS COLS         KLAHANIE DENT 2                                          ***
   8    4
    DEPTH      AREA     VOLUME  OUTFLOW1                                    ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                     ***
      0.0      0.00       0.00      0.00
      3.9      2.85       6.10      0.00
      4.0      2.85       6.31      0.20
      5.0      2.85       8.60      0.73
      6.0      2.85      11.45      1.46
      7.0      2.85      14.76      2.07
      8.0      2.85      18.45      2.53
      9.0      2.85      22.44      8.99
  END FTABLE 12
  FTABLE     14
 ROWS COLS         KLAHANIE DENT 1                                          ***
   7    4
    DEPTH      AREA     VOLUME  OUTFLOW1                                    ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                     ***
      0.0      0.00       0.00      0.00
      4.4      2.10       8.80      0.00
      5.0      2.10      10.54      2.38
      6.0      2.10      13.62      9.25
      7.0      2.10      17.10     23.00
      8.0      2.10      20.67     37.00
      9.0      2.10      25.20     39.30
  END FTABLE 14
  FTABLE     16
 ROWS COLS         CROSS-SECTION:   REACH 16 (BVR LAKE)                     ***
   7    4
    DEPTH      AREA     VOLUME  OUTFLOW1                                    ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                     ***
      0.0      0.00       0.00      0.00
       .5       .14        .07      2.72
      1.0       .15        .14      8.66
      1.5       .15        .22     17.07
      2.0       .16        .29     27.66
      2.5       .16        .37     40.24
      3.0       .17        .45     54.70
  END FTABLE 16
  FTABLE     19
 ROWS COLS         WETLAND 70                                               ***
   7    4
    DEPTH      AREA     VOLUME  OUTFLOW1                                    ***
     (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                     ***
      0.0      0.00       0.00      0.00
```

```
      1.0       1.00       1.00       1.36
      1.4       1.00       1.44       3.43
      1.5       1.00       1.52       4.37
      2.4       1.25       2.56       8.31
      2.9       1.50       3.14      10.19
      5.3       3.00       8.68      22.00
  END FTABLE 19
END FTABLES
                                                                       ***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->       <-short-span->
          ***                                <---disply--->  <annual summary ->
          ***                           TRAN PIVL DIG1 FIL1   PYR DIG2 FIL2 YRND
    1        JAKE SIMQ (IN) 2/22A       SUM     0    2    6     1    3    6    9
    2        JAKE SIMQ PK CFS 2/22A     MAX     0    2    6     1    2    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A9. Final version of the HSPF input file used for the Pine Lake Creek Basin

```
RUN
GLOBAL
  PINE LAKE 9/18B  FINAL VALIDATION RUN
  START       1987/07/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT  0:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      31
      PERLND      41
      IMPLND      11
      PERLND      51
      RCHRES       6
      RCHRES       5
      RCHRES       4
      RCHRES       3
      RCHRES       2
      RCHRES       1
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
                                                                        ***
PERLND
  GEN-INFO
    <PLS >      Name           NBLKS  Unit-systems   Printer            ***
    # -  #                          User  t-series Engl Metr            ***
                                          in  out                       ***
   11      TF/MILD                 1    1    1    1    6    0
   15      TF/MODERATE             1    1    1    1    6    0
   17      TF/STEEP                1    1    1    1    6    0
   21      TG/MILD                 1    1    1    1    6    0
   25      TG/MODERATE             1    1    1    1    6    0
   27      TG/STEEP                1    1    1    1    6    0
   31      OF/MILD                 1    1    1    1    6    0
   41      OG/MILD                 1    1    1    1    6    0
   51      WETLANDS                1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC      ***
   11   51    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ******************** Print-flags ************************ PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   11   51    0    0    5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  PWAT-PARM1
    <PLS > **************** Flags *******************
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                     ***
```

```
    11   51    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    11          0.75    4.5000    0.4000    400.00    0.0500    0.0000    0.9980
    15          0.75    4.5000    0.4000    400.00    0.1000    0.0000    0.9980
    17          0.75    4.5000    0.4000    200.00    0.2000    0.0000    0.9980
    21          0.05    4.5000    0.1500    400.00    0.0500    0.0000    0.9980
    25          0.05    4.5000    0.1500    400.00    0.1000    0.0000    0.9980
    27          0.05    4.5000    0.1500    200.00    0.2000    0.0000    0.9980
    31          0.75    5.0000    2.0000    400.00    0.0500    0.0000    0.9980
    41          0.05    5.0000    0.8000    400.00    0.0500    0.0000    0.9980
    51          0.75    4.0000    2.0000    100.00    0.0010    0.0000    0.9980
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    11                            3.5000    2.0000      0.85        0.        0.
    15                            2.0000    2.0000      0.85        0.        0.
    17                            1.5000    2.0000      0.85        0.        0.
    21                            3.5000    2.0000      0.85        0.        0.
    25                            2.0000    2.0000      0.85        0.        0.
    27                            1.5000    2.0000      0.85        0.        0.
    31                            2.0000    2.0000      0.85        0.        0.
    41                            2.0000    2.0000      0.85        0.        0.
    51                            10.000    2.0000      0.85        0.       0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                       ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
    11        0.2000    1.0000    0.3500     0.300    0.7000    0.7000
    15        0.2000    0.5000    0.3500     0.600    0.5000    0.7000
    17        0.2000    0.3000    0.3500     0.700    0.3000    0.7000
    21        0.1000    0.5000    0.2500     0.300    0.5000    0.2500
    25        0.1000    0.2500    0.2500     0.600    0.5000    0.2500
    27        0.1000    0.1500    0.2500     0.700    0.3000    0.2500
    31        0.2000    0.5000    0.3500     0.000    0.7000    0.7000
    41        0.1000    0.5000    0.2500     0.000    0.7000    0.2500
    51        0.1000    3.0000    0.5000     1.000    0.7000    0.8000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    11            0.        0.    0.0015        0.      2.04      4.70      .017
    15            0.        0.    0.0030        0.      2.02      4.80      .016
    17            0.        0.    0.0070        0.      2.03      4.90      .016
    21            0.        0.    0.0710        0.      3.78      5.10      .095
    25            0.        0.    0.1240        0.      3.47      5.40      .068
    27            0.        0.    0.1110        0.      3.36      5.50      .062
    31            0.        0.    0.0010        0.      2.06      5.60      .026
    41            0.        0.    0.0250        0.      4.58      6.90      .257
    51            0.        0.    .66200        0.      5.39      0.05      .162
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name              Unit-systems   Printer                       ***
    # -  #                     User  t-series Engl Metr                        ***
                                      in   out                                 ***
```

```
   11       IMPERVIOUS             1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >          Flags            ***                                ***
    # -  # CSNO RTOP  VRS  VNN RTLI   ***                                ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                        ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                ***
    # -  #    PETMAX    PETMIN                                            ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                        ***
    # -  #      RETS      SURS                                            ***
   11       1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                          ***
EXT SOURCES
                                                                          ***
*** WDM 4 IS PET DATA
*** WDM 6 IS PINE LAKE CREEK OBSQ DATA
*** WDM 9 IS PINE LAKE CREEK SIMQ DATA
*** WDM 2 IS PINE LAKE BASIN PREC DATA
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                          ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      2 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      2 PREC     ENGL                   RCHRES   5     EXTNL  PREC
WDM      4 PET      ENGL                   PERLND  11  51 EXTNL  PETINP
WDM      4 PET      ENGL                   IMPLND  11     EXTNL  PETINP
WDM      4 PET      ENGL                   RCHRES   5     EXTNL  POTEV
END EXT SOURCES
                                                                          ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   1 HYDR   ROVOL  1        48.4 SAME WDM      9 SIMQ     ENGL      REPL
END EXT TARGETS
                                                                          ***
                                                                          ***
NETWORK
```

```
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->   ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #   ***
***
*** SUB-BASIN      P1    RUNOFF FROM LAND SEGMENTS (AGWO FROM P51 ONLY)
PERLND  11 PWATER PERO          0.3977       RCHRES   1      EXTNL  IVOL
PERLND  15 PWATER PERO          0.2083       RCHRES   1      EXTNL  IVOL
PERLND  17 PWATER PERO          0.2950       RCHRES   1      EXTNL  IVOL
PERLND  51 PWATER PERO          0.7083       RCHRES   1      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.0073       RCHRES   1      EXTNL  IVOL
*** SUB-BASIN      P2    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          1.3100       RCHRES   2      EXTNL  IVOL
PERLND  15 PWATER PERO          4.7120       RCHRES   2      EXTNL  IVOL
PERLND  17 PWATER PERO          3.1673       RCHRES   2      EXTNL  IVOL
PERLND  21 PWATER PERO          0.5688       RCHRES   2      EXTNL  IVOL
PERLND  25 PWATER PERO          1.4965       RCHRES   2      EXTNL  IVOL
PERLND  27 PWATER PERO          0.0640       RCHRES   2      EXTNL  IVOL
PERLND  31 PWATER PERO          1.9053       RCHRES   2      EXTNL  IVOL
PERLND  51 PWATER PERO          0.1250       RCHRES   2      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.7928       RCHRES   2      EXTNL  IVOL
*** SUB-BASIN      P3    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          6.1703       RCHRES   3      EXTNL  IVOL
PERLND  15 PWATER PERO          5.5617       RCHRES   3      EXTNL  IVOL
PERLND  17 PWATER PERO          3.6167       RCHRES   3      EXTNL  IVOL
PERLND  21 PWATER PERO          1.2079       RCHRES   3      EXTNL  IVOL
PERLND  25 PWATER PERO          1.9748       RCHRES   3      EXTNL  IVOL
PERLND  31 PWATER PERO          2.1293       RCHRES   3      EXTNL  IVOL
PERLND  41 PWATER PERO          0.1625       RCHRES   3      EXTNL  IVOL
PERLND  51 PWATER PERO          0.5917       RCHRES   3      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.7684       RCHRES   3      EXTNL  IVOL
*** SUB-BASIN      P4    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          0.1500       RCHRES   4      EXTNL  IVOL
PERLND  21 PWATER PERO          1.0210       RCHRES   4      EXTNL  IVOL
PERLND  25 PWATER PERO          0.2560       RCHRES   4      EXTNL  IVOL
PERLND  51 PWATER PERO          0.2667       RCHRES   4      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.2063       RCHRES   4      EXTNL  IVOL
*** SUB-BASIN      P5    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          9.6477       RCHRES   5      EXTNL  IVOL
PERLND  15 PWATER PERO          1.0220       RCHRES   5      EXTNL  IVOL
PERLND  17 PWATER PERO          0.8027       RCHRES   5      EXTNL  IVOL
PERLND  21 PWATER PERO         14.1088       RCHRES   5      EXTNL  IVOL
PERLND  25 PWATER PERO          0.7854       RCHRES   5      EXTNL  IVOL
PERLND  27 PWATER PERO          0.3125       RCHRES   5      EXTNL  IVOL
PERLND  31 PWATER PERO          1.3627       RCHRES   5      EXTNL  IVOL
PERLND  41 PWATER PERO          2.1586       RCHRES   5      EXTNL  IVOL
PERLND  51 PWATER PERO          0.6667       RCHRES   5      EXTNL  IVOL
IMPLND  11 IWATER SURO          4.9580       RCHRES   5      EXTNL  IVOL
*** SUB-BASIN      P5A   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          2.8320       RCHRES   6      EXTNL  IVOL
PERLND  15 PWATER PERO          1.3877       RCHRES   6      EXTNL  IVOL
PERLND  21 PWATER PERO          5.5736       RCHRES   6      EXTNL  IVOL
PERLND  25 PWATER PERO          0.1600       RCHRES   6      EXTNL  IVOL
PERLND  51 PWATER PERO          4.5833       RCHRES   6      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.8468       RCHRES   6      EXTNL  IVOL
  *** CHANNEL NETWORK LINKAGES ***
RCHRES   6 HYDR   ROVOL  1                   RCHRES   5      EXTNL  IVOL
RCHRES   5 HYDR   OVOL   1                   RCHRES   4      EXTNL  IVOL
RCHRES   4 HYDR   ROVOL  1                   RCHRES   3      EXTNL  IVOL
RCHRES   3 HYDR   ROVOL  1                   RCHRES   1      EXTNL  IVOL
RCHRES   2 HYDR   ROVOL  1                   RCHRES   1      EXTNL  IVOL
RCHRES   1 HYDR   ROVOL  1   .01018070       DISPLY   1      INPUT  TIMSER 1
```

```
RCHRES    1 HYDR   RO      1                 DISPLY   2     INPUT  TIMSER 1
END NETWORK
                                                                            ***
RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG           ***
                                              in  out                       ***
    1       P1                   1    1    1    1    6    0    0
    2       P2                   1    1    1    1    6    0    1
    3       P3                   1    1    1    1    6    0    0
    4       P4                   1    1    1    1    6    0    0
    5       P5/PINE LAKE         2    1    1    1    6    0    1
    6       P6/WETLAND 9         1    1    1    1    6    0    1
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                ***
    1    6    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    RCHRES *************** Printout Flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
    1    4    6    0    0    0    0    0    0    0    0    0    1    9
    5         5    0    0    0    0    0    0    0    0    0    1    9
    6         5    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                     ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each    FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit     possible  exit
             *  *  *  *    *  *  *  *  *        *  *  *  *  *        ***
    1        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    2        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    3        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    4        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
    5        0  1  0  0    4  5  0  0  0        0  0  0  0  0      2  2  2  2  2
    6        0  0  0  0    4  0  0  0  0        0  0  0  0  0      2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2
    RCHRES                                                                  ***
    # -  #    FTABNO       LEN      DELTH      STCOR        KS       DB50     ***
  <------><--------><--------><--------><--------><--------><-------->      ***
    1             1   0.360                                0.5
    2             2   0.455                                0.5
    3             3   0.360                                0.5
    4             4   0.455                                0.5
    5             5   0.360                                0.5
    6             6   0.455                                0.5
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                        ***
    # -  # ***   VCL     Initial  value  of COLIND    Initial  value  of OUTDGT
           *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1     0.01            4.0
    2     0.01            4.0
    3     0.01            4.0
    4     0.01            4.0
    5     1640.0          4.0  5.0
```

```
   6      0.01              4.0
  END HYDR-INIT
END RCHRES
                                                                                ***
FTABLES
  FTABLE       1
 ROWS COLS     CROSS-SECTION 33A: ASSUME FLOW REMAINS IN CHANNEL          ***
   10    4
     DEPTH       AREA    VOLUME  OUTFLOW1                                 ***
      (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                                ***
        .0        .00       .00      0.00
        .5        .17       .06      4.55
       1.0        .21       .15     20.18
       1.5        .25       .27     44.98
       2.0        .31       .40     79.09
       2.5        .37       .57    122.89
       3.0        .44       .78    176.99
       3.5        .50      1.01    242.05
       4.0        .56      1.28    318.68
       4.1        .58      1.33    335.45
  END FTABLE   1
  FTABLE       2
 ROWS COLS          CROSS-SECTION:   31B (PINE LAKE)                      ***
    7    4
     DEPTH       AREA    VOLUME  OUTFLOW1                                 ***
      (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                                ***
        .0        .00       .00      0.00
        .5        .82       .20      4.77
       1.0       1.26       .76     32.70
       1.5       1.45      1.44     86.01
       2.0       1.65      2.21    160.41
       2.5       1.84      3.08    255.09
       3.0       2.04      4.05    369.83
  END FTABLE   2
  FTABLE       3
 ROWS COLS          CROSS-SECTION:   32A (PINE LAKE)                      ***
    7    4
     DEPTH       AREA    VOLUME  OUTFLOW1                                 ***
      (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                                ***
        .0        .00       .00      0.00
        .5       1.18       .29      4.31
       1.0       1.78      1.03     27.19
       1.5       2.13      2.04     74.70
       2.0       2.30      3.14    145.45
       2.5       2.48      4.34    235.40
       3.0       2.66      5.62    343.53
  END FTABLE   3
  FTABLE       4
 ROWS COLS          CROSS-SECTION:   30A (PINE LAKE)                      ***
    7    4
     DEPTH       AREA    VOLUME  OUTFLOW1                                 ***
      (FT)    (ACRES) (ACRE-FT)   ( FT3/S)                                ***
        .0        .00       .00      0.00
        .5        .05       .01       .64
       1.0        .09       .05      4.04
       1.5        .14       .10     11.92
       2.0        .18       .18     25.66
       2.5        .23       .28     46.53
       2.6        .35       .31     52.19
  END FTABLE   4
```

```
  FTABLE       5
 ROWS COLS         REACH 5: PINE LAKE - USGS FLOW MEASUREMENT          ***
   10    5
     DEPTH      AREA    VOLUME  OUTFLOW1  OUTFLOW2                     ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)   (FT3/S)                     ***
        .0        .0       .00       .00       .28
      19.0     86.00    442.40       .00       .28
      29.0     86.00    979.95       .00       .28
      38.7     86.00   1690.00       .00       .28
      38.8     86.00   1700.00       .00       .28
      39.3     86.00   1743.00      2.28       .28
      39.8     86.00   1786.00      7.24       .28
      40.8     86.00   1872.00     23.00       .28
      41.8     86.00   1958.00     45.20       .28
      42.8     86.00   2044.00     73.00       .28
  END FTABLE   5
  FTABLE       6
 ROWS COLS         CROSS-SECTION:   WETLAND 30  REACH 6                ***
   12    4
     DEPTH      AREA    VOLUME  OUTFLOW1                               ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                               ***
        .0       .04       .00       .00
        .5       .20       .05       .08
       1.0       .40       .20       .50
       1.5       .60       .45      1.46
       2.0      1.30       .90      3.60
       2.5      2.13      1.76      7.73
       3.0      6.90      3.82     16.46
       3.5     12.66      8.71     36.72
       3.8     68.70     12.88     58.32
       3.9     68.70     19.75     67.73
       4.0     68.70     26.62     77.85
       4.1     68.70     33.49     88.66
  END FTABLE   6
END FTABLES
                                                                      ***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply--->  <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1         PINE LK CR SIMQ (IN)9/18B  SUM     0    2    6    1    3    6    9
    2         PINE SIMPEAKS (CFS) 9/18B  MAX     0    2    6    1    2    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

Appendix A10. Final version of the HSPF input file used for the Inglewood Creek Basin

```
RUN
GLOBAL
  INGLEWOOD CREEK -10/29A - FINAL VALIDATION RUN
  START       1986/10/01 00:00  END    1988/09/30 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1 TSSFL    15 WDMSFL   16
END GLOBAL
OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      11
      PERLND      15
      PERLND      17
      PERLND      21
      PERLND      25
      PERLND      27
      PERLND      51
      PERLND      31
      PERLND      41
      IMPLND      11
      RCHRES       7
      RCHRES      12
      RCHRES       6
      RCHRES      16
      RCHRES       5
      RCHRES       4
      RCHRES       3
      RCHRES       2
      RCHRES       1
      DISPLY       1
      DISPLY       2
      DISPLY       3
      DISPLY       4
      DISPLY       5
      DISPLY       6
    END INGRP
END OPN SEQUENCE
                                                                       ***
PERLND
  GEN-INFO
    <PLS >       Name            NBLKS   Unit-systems   Printer           ***
    # -  #                            User  t-series Engl Metr            ***
                                              in  out                     ***
   11       TF/MILD               1    1    1    1    6    0
   15       TF/MODERATE           1    1    1    1    6    0
   17       TF/STEEP              1    1    1    1    6    0
   21       TG/MILD               1    1    1    1    6    0
   25       TG/MODERATE           1    1    1    1    6    0
   27       TG/STEEP              1    1    1    1    6    0
   31       OF/MILD               1    1    1    1    6    0
   41       OG/MILD               1    1    1    1    6    0
   51       WETLANDS              1    1    1    1    6    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC      ***
   11   51    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
```

```
  <PLS > ******************** Print-flags ************************ PIVL  PYR
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
 11   51    0    0    5    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > **************** Flags ******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                      ***
 11   51    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 11           0.75    4.5000    0.0800    400.00    0.0500    0.5000    0.9960
 15           0.75    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
 17           0.75    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
 21           0.05    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
 25           0.05    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
 27           0.05    4.5000    0.0300    200.00    0.2000    0.5000    0.9960
 31           0.75    5.0000    2.0000    400.00    0.0500    0.3000    0.9960
 41           0.05    5.0000    0.8000    400.00    0.0500    0.3000    0.9960
 51           0.75    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 11                             3.5000    2.0000      1.00        0.        0.
 15                             2.0000    2.0000      1.00        0.        0.
 17                             1.5000    2.0000      1.00        0.        0.
 21                             3.5000    2.0000      1.00        0.        0.
 25                             2.0000    2.0000      1.00        0.        0.
 27                             1.5000    2.0000      1.00        0.        0.
 31                             2.0000    2.0000       .00        0.        0.
 41                             2.0000    2.0000       .00        0.        0.
 51                             10.000    2.0000       .00        0.       0.7
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                             ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 11         0.2000    1.0000    0.3500     3.000    0.7000    0.7000
 15         0.2000    0.5000    0.3500     6.000    0.5000    0.7000
 17         0.2000    0.3000    0.3500     7.000    0.3000    0.7000
 21         0.1000    0.5000    0.2500     3.000    0.7000    0.2500
 25         0.1000    0.2500    0.2500     6.000    0.5000    0.2500
 27         0.1000    0.1500    0.2500     7.000    0.3000    0.2500
 31         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 41         0.1000    0.5000    0.2500     0.000    0.7000    0.2500
 51         0.1000    3.0000    0.5000     1.000    0.7000    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 11             0.        0.    0.0030        0.      .954      0.00      .017
 15             0.        0.    0.0060        0.      .942      0.00      .016
 17             0.        0.    0.0140        0.      .933      0.00      .016
 21             0.        0.    0.1310        0.      2.78      0.00      .095
 25             0.        0.    0.2480        0.      2.47      0.00      .068
 27             0.        0.    0.2220        0.      2.36      0.00      .062
 31             0.        0.    0.0010        0.      .966      4.45      .060
 41             0.        0.    0.0250        0.      4.08      5.45      .070
 51             0.        0.    .66200        0.      3.39      0.19      .162
```

```
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >       Name            Unit-systems   Printer                       ***
    # -  #                    User  t-series Engl Metr                       ***
                                    in   out                                  ***
   11      IMPERVIOUS           1     1    1    6    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   11         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   11         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags          ***                                       ***
    # -  # CSNO RTOP  VRS  VNN RTLI   ***                                     ***
   11         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                    ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                            ***
   11         500.00    0.0100    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                    ***
    # -  #    PETMAX    PETMIN                                                ***
   11
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                            ***
    # -  #      RETS      SURS                                                ***
   11      1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                              ***
EXT SOURCES
                                                                              ***
*** WDM 4 IS PET DATA
*** WDM 7 IS INGLEWOOD CREEK OBSQ DATA
*** WDM10 IS INGLEWOOD CREEK SIMQ DATA
*** WDM 3 IS HOLLYS STABLES PREC DATA
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                              ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      3 PREC     ENGL                   PERLND  11  51 EXTNL  PREC
WDM      3 PREC     ENGL                   IMPLND  11     EXTNL  PREC
WDM      4 PET      ENGL                   PERLND  11  51 EXTNL  PETINP
WDM      4 PET      ENGL                   IMPLND  11     EXTNL  PETINP
END EXT SOURCES
                                                                              ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
```

```
RCHRES    1 HYDR    OVOL    1    48.4      SAME WDM      10 SIMQ      ENGL       REPL
END EXT TARGETS
                                                                                     ***
                                                                                     ***
NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>    #    #        <Name> # #  ***
***
***
*** SUB-BASIN      I1    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          2.1437      RCHRES   1      EXTNL   IVOL
PERLND  15 PWATER PERO          1.2460      RCHRES   1      EXTNL   IVOL
PERLND  17 PWATER PERO          1.2913      RCHRES   1      EXTNL   IVOL
PERLND  21 PWATER PERO          0.3917      RCHRES   1      EXTNL   IVOL
PERLND  25 PWATER PERO          0.4417      RCHRES   1      EXTNL   IVOL
PERLND  27 PWATER PERO          0.2625      RCHRES   1      EXTNL   IVOL
PERLND  31 PWATER SURO          6.7573      RCHRES   1      EXTNL   IVOL
PERLND  41 PWATER SURO          2.1313      RCHRES   1      EXTNL   IVOL
PERLND  31 PWATER AGWI          6.7573      RCHRES   1      EXTNL   IVOL
PERLND  41 PWATER AGWI          2.1313      RCHRES   1      EXTNL   IVOL
IMPLND  11 IWATER SURO          1.0596      RCHRES   1      EXTNL   IVOL
*** SUB-BASIN      I2    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          1.4703      RCHRES   2      EXTNL   IVOL
PERLND  15 PWATER PERO          2.9090      RCHRES   2      EXTNL   IVOL
PERLND  17 PWATER PERO          2.7777      RCHRES   2      EXTNL   IVOL
PERLND  21 PWATER PERO          1.5763      RCHRES   2      EXTNL   IVOL
PERLND  25 PWATER PERO          1.5408      RCHRES   2      EXTNL   IVOL
PERLND  27 PWATER PERO          1.0875      RCHRES   2      EXTNL   IVOL
PERLND  31 PWATER SURO          2.3383      RCHRES   2      EXTNL   IVOL
PERLND  41 PWATER SURO          2.1158      RCHRES   2      EXTNL   IVOL
PERLND  31 PWATER AGWI          2.3383      RCHRES   2      EXTNL   IVOL
PERLND  41 PWATER AGWI          2.1158      RCHRES   2      EXTNL   IVOL
IMPLND  11 IWATER SURO          2.1427      RCHRES   2      EXTNL   IVOL
*** SUB-BASIN      I3    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          3.0943      RCHRES   3      EXTNL   IVOL
PERLND  15 PWATER PERO          3.3587      RCHRES   3      EXTNL   IVOL
PERLND  17 PWATER PERO          1.4807      RCHRES   3      EXTNL   IVOL
PERLND  21 PWATER PERO          2.4697      RCHRES   3      EXTNL   IVOL
PERLND  25 PWATER PERO          1.0019      RCHRES   3      EXTNL   IVOL
PERLND  27 PWATER PERO          2.9944      RCHRES   3      EXTNL   IVOL
PERLND  31 PWATER SURO          3.6693      RCHRES   3      EXTNL   IVOL
PERLND  41 PWATER SURO          1.5792      RCHRES   3      EXTNL   IVOL
PERLND  31 PWATER AGWI          3.6693      RCHRES   3      EXTNL   IVOL
PERLND  41 PWATER AGWI          1.5792      RCHRES   3      EXTNL   IVOL
PERLND  51 PWATER PERO          0.9333      RCHRES   3      EXTNL   IVOL
IMPLND  11 IWATER SURO          1.3518      RCHRES   3      EXTNL   IVOL
*** SUB-BASIN      I4    RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          0.2250      RCHRES   4      EXTNL   IVOL
PERLND  15 PWATER PERO          0.0400      RCHRES   4      EXTNL   IVOL
PERLND  17 PWATER PERO          3.6760      RCHRES   4      EXTNL   IVOL
PERLND  21 PWATER PERO          0.1563      RCHRES   4      EXTNL   IVOL
PERLND  25 PWATER PERO          1.0875      RCHRES   4      EXTNL   IVOL
PERLND  27 PWATER PERO          0.4188      RCHRES   4      EXTNL   IVOL
PERLND  31 PWATER SURO         13.5947      RCHRES   4      EXTNL   IVOL
PERLND  41 PWATER SURO          5.6495      RCHRES   4      EXTNL   IVOL
PERLND  31 PWATER AGWI         13.5947      RCHRES   4      EXTNL   IVOL
PERLND  41 PWATER AGWI          5.6495      RCHRES   4      EXTNL   IVOL
PERLND  51 PWATER PERO          2.2750      RCHRES   4      EXTNL   IVOL
IMPLND  11 IWATER SURO          3.4773      RCHRES   4      EXTNL   IVOL
*** SUB-BASIN      I5    RUNOFF FROM LAND SEGMENTS
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PERLND  11 PWATER PERO          0.0000       RCHRES   5      EXTNL  IVOL
PERLND  15 PWATER PERO          0.2083       RCHRES   5      EXTNL  IVOL
PERLND  25 PWATER PERO          0.0875       RCHRES   5      EXTNL  IVOL
PERLND  31 PWATER PERO          2.4227       RCHRES   5      EXTNL  IVOL
PERLND  41 PWATER PERO          1.3846       RCHRES   5      EXTNL  IVOL
PERLND  51 PWATER PERO          0.9667       RCHRES   5      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.2053       RCHRES   5      EXTNL  IVOL
*** SUB-BASIN      I5A  RUNOFF FROM LAND SEGMENTS
PERLND  17 PWATER PERO          1.7750       RCHRES  15      EXTNL  IVOL
PERLND  31 PWATER PERO          2.4067       RCHRES  15      EXTNL  IVOL
PERLND  41 PWATER PERO          0.3625       RCHRES  15      EXTNL  IVOL
PERLND  51 PWATER PERO          1.3500       RCHRES  15      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.0392       RCHRES  15      EXTNL  IVOL
*** SUB-BASIN      I6   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          0.3333       RCHRES   6      EXTNL  IVOL
PERLND  15 PWATER PERO          0.9223       RCHRES   6      EXTNL  IVOL
PERLND  17 PWATER PERO          1.2333       RCHRES   6      EXTNL  IVOL
PERLND  21 PWATER PERO          0.1167       RCHRES   6      EXTNL  IVOL
PERLND  27 PWATER PERO          0.2667       RCHRES   6      EXTNL  IVOL
PERLND  31 PWATER PERO          1.2583       RCHRES   6      EXTNL  IVOL
PERLND  41 PWATER PERO          0.5840       RCHRES   6      EXTNL  IVOL
PERLND  51 PWATER PERO          0.0000       RCHRES   6      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.0270       RCHRES   6      EXTNL  IVOL
*** SUB-BASIN      I7   RUNOFF FROM LAND SEGMENTS
PERLND  11 PWATER PERO          7.3277       RCHRES   7      EXTNL  IVOL
PERLND  15 PWATER PERO          6.1510       RCHRES   7      EXTNL  IVOL
PERLND  17 PWATER PERO          7.6997       RCHRES   7      EXTNL  IVOL
PERLND  21 PWATER PERO          0.7708       RCHRES   7      EXTNL  IVOL
PERLND  25 PWATER PERO          0.0688       RCHRES   7      EXTNL  IVOL
PERLND  27 PWATER PERO          0.4104       RCHRES   7      EXTNL  IVOL
PERLND  31 PWATER PERO          3.1003       RCHRES   7      EXTNL  IVOL
PERLND  41 PWATER PERO          0.0000       RCHRES   7      EXTNL  IVOL
PERLND  51 PWATER PERO          1.9583       RCHRES   7      EXTNL  IVOL
IMPLND  11 IWATER SURO          0.2255       RCHRES   7      EXTNL  IVOL
  *** CHANNEL NETWORK LINKAGES ***
RCHRES   7 HYDR   ROVOL  1                   RCHRES  12      EXTNL  IVOL
RCHRES  12 HYDR   ROVOL  1                   RCHRES   6      EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1                   RCHRES   5      EXTNL  IVOL
RCHRES  16 HYDR   ROVOL  1                   RCHRES   5      EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1                   RCHRES   4      EXTNL  IVOL
RCHRES   4 HYDR   OVOL   1                   RCHRES   2      EXTNL  IVOL
RCHRES   4 HYDR   VOL    1                   DISPLY   1      INPUT  TIMSER 1
RCHRES   3 HYDR   OVOL   1                   RCHRES   2      EXTNL  IVOL
RCHRES   3 HYDR   VOL    1                   DISPLY   2      INPUT  TIMSER 1
RCHRES   2 HYDR   OVOL   1                   RCHRES   1      EXTNL  IVOL
RCHRES   2 HYDR   VOL    1                   DISPLY   3      INPUT  TIMSER 1
RCHRES   1 HYDR   VOL    1                   DISPLY   4      INPUT  TIMSER 1
RCHRES   1 HYDR   OVOL   1    .0077118       DISPLY   5      INPUT  TIMSER 1
RCHRES   1 HYDR   O      1                   DISPLY   6      INPUT  TIMSER 1
END NETWORK
                                                                           ***
RCHRES
  GEN-INFO
    RCHRES        Name          Nexits   Unit Systems   Printer            ***
    # -   #<------------------><---> User T-series  Engl Metr LKFG         ***
                                              in  out                      ***
    1      I1                        2    1    1    1    6    0    0
    2      I2                        2    1    1    1    6    0    0
    3      I3                        2    1    1    1    6    0    0
    4      I4                        2    1    1    1    6    0    0
```

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    5       I5/WETLAND 9             1    1    1    1    6    0    0
    6       I6                       1    1    1    1    6    0    0
    7       I7                       1    1    1    1    6    0    0
   12       EXCAVATED POND           1    1    1    1    6    0    0
   16       I5A/WETLAND 9            1    1    1    1    6    0    0
END GEN-INFO
ACTIVITY
  RCHRES *************** Active Sections *****************
  # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                    ***
  1   16    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  RCHRES *************** Printout Flags ***************** PIVL  PYR
  # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
  1    4    6    0    0    0    0    0    0    0    0    0    1    9
  5   16    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
HYDR-PARM1
  RCHRES  Flags for each HYDR Section                                         ***
  # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
          FG FG FG FG  possible  exit  *** possible  exit      possible  exit
           *  *  *  *    *  *  *  *  *        *  *  *  *  *        ***
  1        0  0  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
  2        0  0  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
  3        0  0  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
  4        0  0  0  0    4  5  0  0  0        0  0  0  0  0       2  2  2  2  2
  5        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
  6        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
  7        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
 12        0  1  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
 16        0  0  0  0    4  0  0  0  0        0  0  0  0  0       2  2  2  2  2
END HYDR-PARM1
HYDR-PARM2
  RCHRES                                                                      ***
  # -  #    FTABNO       LEN      DELTH     STCOR         KS       DB50       ***
<------><--------><--------><--------><--------><--------><-------->        ***
  1              1   0.360                                0.0
  2              2   0.455                                0.0
  3              3   0.360                                0.0
  4              4   0.455                                0.0
  5              5   0.360                                0.0
  6              6   0.455                                0.0
  7              7   0.360                                0.0
 12             12   0.360                                0.0
 16             16   0.360                                0.0
END HYDR-PARM2
HYDR-INIT
  RCHRES  Initial conditions for each HYDR section                            ***
  # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
         *** ac-ft     for each possible exit        for each possible exit
<------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  1      1574.           4.0  5.0
  2       792.           4.0  5.0
  3       935.           4.0  5.0
  4      3442.           4.0  5.0
  5      1.20            4.0
  6      0.01            4.0
  7      0.01            4.0
 12      2.10            4.0
 16      1.20            4.0
```

```
  END HYDR-INIT
END RCHRES
                                                                              ***
FTABLES
  FTABLE      1
 ROWS COLS         CROSS-SECTION:   52   (INGLEWOOD)                    ***
   10   4
     DEPTH      AREA     VOLUME  OUTFLOW1                               ***
      (FT)    (ACRES) (ACRE-FT)  ( FT3/S)                               ***
        .0        .40        .00      0.00      0.00
       .07        .40     803.00      0.00      0.00
       .08        .40    1405.00      0.04      0.00
       .09        .40    1505.00      0.08      0.00
        .1        .40    1605.00      0.21      0.00
        .5        .40    1627.00      2.80      0.00
        .6        .40    1631.00      6.00      0.00
       1.0        .79    1638.00     17.76      0.00
       1.5       1.19    1649.00     52.35      0.00
       2.0       1.58    1660.00    112.74      0.00
  END FTABLE  1
  FTABLE      2
 ROWS COLS         CROSS-SECTION:   48A (INGLEWOOD)                     ***
    6    5
     DEPTH      AREA     VOLUME  OUTFLOW1                               ***
      (FT)    (ACRES) (ACRE-FT)  ( FT3/S)                               ***
        .0        .00        .00      0.00      0.00
       .05        .14     790.00      0.03      0.01
        .1        .14     800.00      0.50      0.44
        .5        .14     820.00      5.11      0.44
       1.0        .18     829.00     24.01      0.44
       1.5        .21     842.00     55.76      0.44
  END FTABLE  2
  FTABLE      3
 ROWS COLS         CROSS-SECTION:   44B (INGLEWOOD)                     ***
    7    5
     DEPTH      AREA     VOLUME  OUTFLOW1                               ***
      (FT)    (ACRES) (ACRE-FT)  ( FT3/S)                               ***
        .0        .00        .00      0.00      00.0
       .05        .71     920.00      0.01      0.01
        .1        .71     935.00      0.05      0.55
        .5        .71     972.00      3.94      0.55
       1.0        .94     978.00     14.52      0.55
       1.5       1.17     992.00     31.09      0.55
       1.9       1.35    1000.00     48.72      0.55
  END FTABLE  3
  FTABLE      4
 ROWS COLS         CROSS-SECTION:   44B2 (INGLEWOOD)                    ***
    7    5
     DEPTH      AREA     VOLUME  OUTFLOW1                               ***
      (FT)    (ACRES) (ACRE-FT)  ( FT3/S)                               ***
        .0        .00        .00      0.00      00.0
       .05        .44     3410.0      0.01      0.82
        .1        .44     3465.0      0.10      1.80
        .5        .44     3545.0      1.82      1.80
       1.0        .58     3625.0      6.72      1.80
       1.5        .72     3705.0     14.39      1.80
       1.9        .84     3785.0     22.55      1.80
  END FTABLE  4
  FTABLE      5
 ROWS COLS         WETLAND 9 SUB-BASIN I5 (INGLEWOOD)                     ***
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```
   7    4
     DEPTH      AREA    VOLUME  OUTFLOW1                                   ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                   ***
       0.0     12.40      0.00      0.00
        .1     12.40      2.48      0.00
        .5     12.40     12.40       .91
       1.0     12.40     24.80      6.18
       1.5     12.40     37.20     16.44
       2.0     12.40     49.60     32.29
       2.1     12.40     52.00     36.24
  END FTABLE  5
  FTABLE      6
ROWS COLS         CROSS-SECTION:   41B (INGLEWOOD)                         ***
   7    4
     DEPTH      AREA    VOLUME  OUTFLOW1                                   ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                   ***
        .0      2.51       .00      0.00
        .5      2.51       .90     25.57
       1.0      3.21      2.33    107.21
       1.5      3.90      4.10    242.30
       2.0      4.60      6.23    434.01
       2.5      5.30      8.70    686.43
       2.8      5.71     10.36    868.80
  END FTABLE  6
  FTABLE      7
ROWS COLS         CROSS-SECTION:   41A (INGLEWOOD)                         ***
   5    4
     DEPTH      AREA    VOLUME  OUTFLOW1                                   ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                   ***
        .0      3.00       .00      0.00
        .5      3.09       .77      7.58
       1.0      6.18      3.09     48.12
       1.5      9.77      7.00    152.19
       1.8     12.38     10.33    258.71
  END FTABLE  7
  FTABLE     12
ROWS COLS         EXCAVATED POND I7       (INGLEWOOD)                         ***
   8    4
     DEPTH      AREA    VOLUME  OUTFLOW1                                   ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                   ***
       0.0      0.47      0.00      0.00
       3.0      0.47      1.40      0.00
       4.5      0.47      2.10      0.00
       4.8      0.47      2.20      5.60
       5.0      0.47      2.35     17.70
       5.3      0.47      2.47     27.10
       5.5      0.47      2.59     37.30
       6.0      0.47      2.82     48.30
  END FTABLE 12
  FTABLE     16
ROWS COLS         WETLAND 9 SUB-BASIN I5A (INGLEWOOD)                         ***
   7    4
     DEPTH      AREA    VOLUME  OUTFLOW1                                   ***
      (FT)   (ACRES) (ACRE-FT)  ( FT3/S)                                   ***
       0.0     12.00      0.00      0.00
        .1     12.00      2.40       .00
        .5     12.20     12.20       .91
       1.0     12.20     24.40      6.18
       1.5     12.20     36.60     16.44
       2.0     12.20     48.80     32.29
```

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      2.1      12.20      51.20      36.24
  END FTABLE 16
END FTABLES
                                                                                  ***
DISPLY
  DISPLY-INFO1
    #thru#***<----------Title-------->        <-short-span->
          ***                                 <---disply--->  <annual summary ->
          ***                            TRAN PIVL DIG1 FIL1   PYR DIG2 FIL2 YRND
    1        RCHRES 4 VOL(ACFT) 10/28A   LAST    0    2    6     1    1    6    9
    2        RCHRES 3 VOL(ACFT) 10/28A   LAST    0    2    6     1    1    6    9
    3        RCHRES 2 VOL(ACFT) 10/28A   LAST    0    2    6     1    1    6    9
    4        RCHRES 1 VOL(ACFT) 10/28A   LAST    0    2    6     1    1    6    9
    5        INGLEWOOD SIMQ (IN)10/28A   SUM     0    2    6     1    3    6    9
    6        INGLEWOOD PEAKS    10/28A   MAX     0    2    6     1    3    6    9
  END DISPLY-INFO1
END DISPLY
END RUN
```

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