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Project Summary

Executive Summary for the Hydrological Simulation Program FORTRAN (HSPF)

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This executive summary introduces water resource managers, engineers, and programmers to the Hydrological Simulation Program—FORTRAN (HSPF) and provides them with information that can help them in deciding whether HSPF would be useful and practical for them to use. HSPF uses digital computers to simulate hydrology and water quality in natural and man-made systems. Although data requirements are extensive and running costs are significant, HSPF is thought to be the most accurate and appropriate management tool presently available for the continuous simulation of hydrology and water quality in watersheds.

The executive summary begins with a general overview of the model, how it compares with other models, and how it can be applied. For those more interested in technical details, the executive summary presents detailed information on the model's input requirements, capabilities, innovative features and design criteria. This latter information should be of particular interest to those acquainted with simulation models, who can appreciate the advanced programming techniques used to develop HSPF.

This Project Summary was developed by EPA's Environmental Research Laboratory, Athens, GA, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Hydrological Simulation Program-FORTRAN (HSPF) is a mathematical model designed for use on digital computers to simulate hydrologic and water quality processes in natural and man-made water systems. It is an analytical tool that has application in the planning, design, and operation of water resources systems. The model enables the use of probabilistic analysis in the fields of hydrology and water quality management. To simulate the processes that occur in a watershed, HSPF uses such information as the time history of rainfall, temperature, and solar intensity and the parameters related to land use patterns, soil characteristics, and agricultural practices. The initial result of an HSPF simulation is a time history of the quantity and quality of water transported through various soil zones down to the groundwater aquifers. Runoff flow rate, sediment loads, nutrients, pesticides, toxic chemicals and other quality constituent concentrations can be predicted. The model then takes these results and information about the receiving water channels in the watershed and simulates the processes that occur in these channels This part of the simulation produces a time history of water quantity and quality at any point in the watershed.

HSPF is an extension and improvement of three previously developed models: (1) The Agricultural Runoff Management (ARM) Model, a non-proprietary program written in FORTRAN; (2) The Non-Point Source Runoff (NPS) Model; also a non-proprietary program written in FORTRAN; and (3) The Hydrologic Simulation Program (HSP, including HSP Quality), a Hydrocomp proprietary program written in PL1. The EPA recognized several years ago that the continuous simulation approach contained in these models would be valuable in solving many complex water resource problems. Thus, a fairly large investment was devoted to developing a highly flexible non-proprietary FORTRAN program that contains the capabilities of these three models, plus many extensions. The result of this investment is HSPF. It is geared to the serious user; one who understands continuous simulation modeling, and can make use of the flexibility that it provides.

HSPF Philosophy

Management of water resources involves the commitment of other resources to protect and develop our water. This commitment may range from construction of facilities to the non-use of undeveloped land. Such commitments can only be justified when one knows the benefits or effectiveness of the protection to be achieved. A fundamental question in benefit evaluation is whether an undesirable water quality event occurs once a month, once a year, or once a decade.

Information on hydrologic or water quality events cannot be used effectively for water resources planning unless the probability of occurrence of the events is known. The occurrence of a water quality event is strongly conditioned by antecedent events. As an example, the current population of phytoplankton in a lake is a function of the phytoplankton, zooplankton, and nutrient population yesterday. Likewise, the population of phytoplankton five days ago has a small but finite effect upon the current population of phytoplankton.

Although it is reasonable to assume the physical, chemical, and biological laws that govern interactions in a body of water are invariant, specific reaction rates are determined by what is in the water body and by the stresses imposed upon the water body by inflows. These inflows can be man-caused flows such as wastewater discharges and irrigation return flow, or natural flows such as runoff from rainfall and snowmelt. Natural flows are governed by the climate, soil type, vegetal cover, and other physical features of the watershed. Since vegetal cover (forests, grassland) and human activity (land development, channelization, and reservoirs) can, and often do, change rapidly over short periods of time, they too must be considered variables in water resources planning. Thus, the only constants in water resources planning are the physical, chemical, and biological laws of nature, and the soil types and other fixed physical characteristics of the watershed.

Planners need a method to determine the frequency characteristics of the hydrology and water quality of a watershed under alternative plans for future development. This need led to the development of continuous dynamic simulation, the simulation of extended time periods with various flows and meteorologic conditions. From five to more than one hundred years of data may be required to adequately determine the statistics for streamflow and water quality constituents. Simulation of "critical period" cannot provide the information necessary to determine the probability of water quality events. In fact, the critical period itself might change from one wastewater management scheme to the next. Hence, HSPF simulation deals with the total process, hydrologic and bio-chemical, as a continuous process in time.

Why are continuous models like HSPF an improvement over dynamic event models? The long-term probabilistic character of hydrology and water quality, as discussed earlier, is only available from continuous models. The magnitudes and recurrence intervals of certain harmful events cannot be predicted using event models. One common mistake is that rainfall events of given recurrence intervals are assumed to result in streamflow and flood conditions of the same recurrence interval (i.e., the 25-year rainfall event leads to a 25 year flood). This assumption is erroneous due to factors such as snowmelt and soil water storage, that modify the statistics of rainfall as the water flows on the land and river channels. The use of this invalid assumption in using event models commonly leads to inappropriate planning conclusions.

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The complete report, entitled "Executive Summary for the Hydrological Simulation Program FORTRAN (HSPF)," (Order No. PB 82-231 846; Cost: $10.50, subject to change) will be available only from:
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