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Project Summary

Storm Water Management Model User's Manual Version III

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A description is given of the third update of a user's manual for the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM). The manual should be used with Addendum I to run the Extran block (detailed hydrologic flow routing). The SWMM is a comprehensive mathematical model developed for both continuous and single event simulation of urban runoff quantity and quality in storm and combined sewer systems. All aspects of the urban hydrologic and quality cycles are simulated, including surface runoff, transport through the drainage network, storage and treatment, and receiving water effects. (The latter component is currently under revision by EPA.)

Detailed descriptions are provided in the User's Manual for all blocks except the Receiving Water Block. Blocks include Runoff, Transport, Storage/Treatment, Combine, Statistics, and Graph. The latter three are service blocks, and the first three are the principal computation blocks. In addition, extensive documentation of new procedures is provided in the text and in several appendices.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, 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

Urban runoff quantity and quality have long posed problems for cities who have for many years assumed the responsibility of controlling stormwater flooding and treating point sources of wastewater (e.g., municipal sewage). Within the past two decades, the severe pollution potential of urban nonpoint sources (principally combined sewer overflows and stormwater discharges) has been recognized, and Federal control legislation has been enacted. The advent of modern, high-speed computers has led to the development of complex, sophisticated tools for analyzing both the quantity and quality of nonpoint pollution. The EPA's SWMM was developed between 1969 and 1971 and was one of the first such models; it is by no means the only one, however. Since its original development, it has been continually maintained and updated, and it is perhaps the best known and most widely used of the several available urban runoff quantity and quality models.

In its original form, the SWMM was strictly a design model oriented toward the detailed simulation of a single storm event; it used relatively short time steps and included as much catchment and drainage detail as necessary. The model is now routinely used in a planning context as well as for an overall assessment of the urban runoff problem and proposed abatement options. This mode is typified by continuous simulation for several years using long (e.g., hourly) time steps and minimum detail in the catchment scheme. The SWMM follows the Corps of Engineers STORM model in this capability for urban hydrology.

Continuous simulation may also be used to identify hydrologic events that may be of special interest for design or other purposes. For example, event magnitudes (such as flow volumes or peaks and pollutant loads) of a desired frequency or return period can be obtained from the Statistics Block of the SWMM. These events may then be analyzed in detail if desired.

Before a commitment is made to any large computer program, screening models may be used to provide a first estimate of the magnitude of urban runoff quantity and quality problems. Such models require no computers.

Overall SWMM Description

Overview

An overview of the model structure appears in Figure 1. In simplest terms, the program is constructed in the form of blocks, as follows:

1. The input sources. The Runoff Block generates surface runoff based on arbitrary rainfall hyetographs, antecedent conditions, land use, topography, etc. Dry-weather flow and infiltration into the sewer system may be optionally generated using the Transport Block.

2. The central core. The Transport and Extended Transport Blocks combine and route the inputs through the drainage system. The user's manual and documentation for the Extended Transport Block has been prepared as an addendum to the Version III User's Manual and is available as a separate document. (Roesner, L.A., Shubinski, R.P., and Aldrich, J.A., "Storm Water Management Model User's Manual Version III: Addendum I, EXTRAN," EPA-600/2-84-109b, U.S. Environmental Protection Agency, Cincinnati, Ohio.

3. The correctional devices. The Storage/Treatment Block characterizes the effects of control devices on flow and quality. The simulation is conceptual and may be adapted to most wet- and dry-weather control devices. Elementary cost computations are also made.

4. The effect (receiving waters). The Receiving Block routes hydrographs and pollutographs through the receiving waters, which may consist of a stream, river, lake, estuary, or bay. This block is currently undergoing extensive revisions at the EPA Environmental Research Laboratory in Athens, Georgia, and is not presently included in the SWMM Version III.

Since the program objectives are directed toward analyzing both detailed time and spatial effects and also gross effects such as total pounds of pollutant discharged in a given storm, it is considered essential to work with both continuous output (magnitude versus time), referred to as hydrographs and pollutographs, and with daily, monthly, annual, and total simulation summaries (for continuous simulation). Such summaries may be augmented using the frequency analysis of the Statistics Block.

Quality constituents for simulation may be arbitrarily chosen for any of the blocks, though the different blocks have different constraints on the number and type of constituents that may be modeled. The Extended Transport Block is the only block that does not simulate water quality.

As indicated in Figure 1, the Transport, Extended Transport and Storage/Treatment Blocks may all use input and provide output to any block, including themselves. The Runoff Block uses input from no other block, and the Receiving Block provides output for no other block.

Service Blocks

In addition to the Runoff, Transport, Extended Transport, Storage/Treatment, and Statistics Blocks mentioned above, the Executive and Combine Blocks are included as service blocks. The Executive Block organizes the sequence of blocks to be executed, manages off-line files, and permits input of measured data for graphing. The Combine Block collects output from previous runs (stored on off-line files) into one file for input to a subsequent run. In this manner, large, complex drainage systems may be partitioned into smaller segments for simulation.

User Requirements

Computer Facilities

A large, high-speed computer is generally required to operate the SWMM. The largest of the blocks (Runoff, with the Executive Block) requires about 90,000

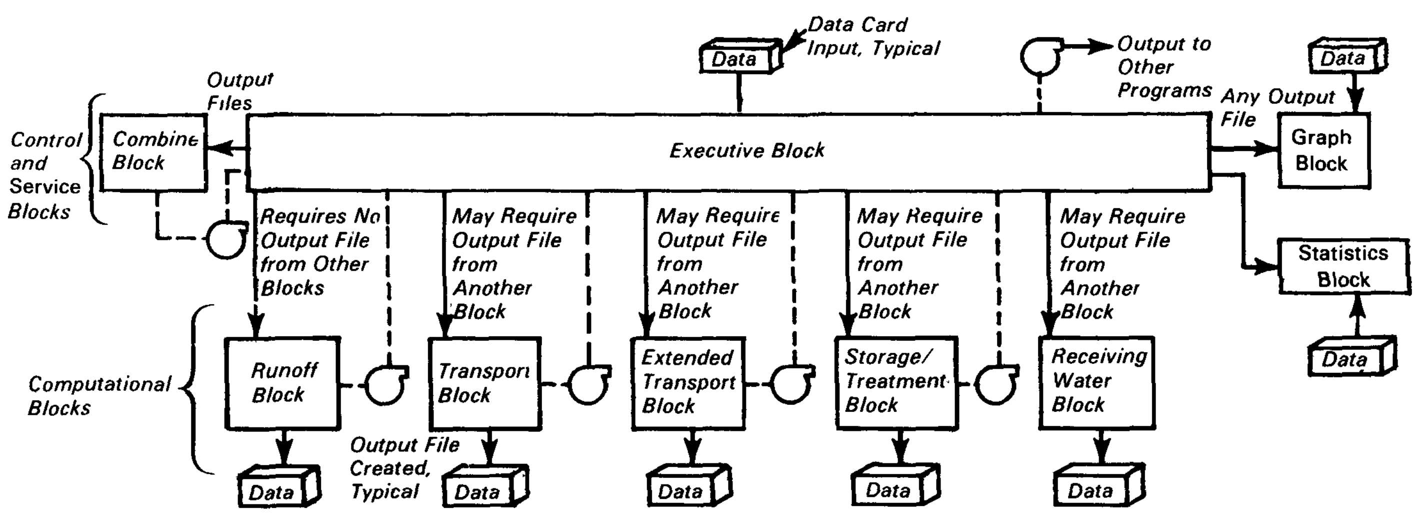

Figure 1. An overview of the SWMM structure.

words of storage with overlay procedures. Examples of machines on which the program has been successfully run include the IBM 370 and 3033,* Amdahl 470, UNIVAC 1108, CDC 6600, CYBER, VAX 11/780, Prime 550, and Burroughs 1900. Execution time and use of off-line storage tend to increase on minicomputers. Typical execution times on an IBM 3033 range from 5 to 20 CPU seconds, with costs of $10 to $20. The most time-consuming blocks tend to be the Runoff Block for a continuous simulation of several years and the Extran Block when it requires a time step of only a few seconds.

Data Requirements

The data requirements for the SWMM may be extensive. Data collection from various municipal and other offices within a city is possible to accomplish within a few days, but reducing the data for input to the model is time-consuming and may take up to 3 man-weeks for a large area (e.g., greater than 2000 acres). On an optimistic note, however, most of the data reduction is straightforward--for example, tabulation of slopes, lengths, and diameters of the sewer system. The SWMM is flexible enough to allow different modeling approaches to the same area. A specific, individual modeling decision upstream in the catchment may have little effect on the predicted results at the outfall. Furthermore, many problems lend themselves to a very low level of detail, especially for quality predictions. In such cases input data requirements are greatly reduced.

Metric Units

Use of metric units for input and output (I/O) of data and results is now allowed in the Runoff, Transport, and Storage/Treatment Blocks as an alternative to U.S. customary units. (Metric I/O to the Extran and Receive Blocks may be added in the future.) For the most part, the metric units are used strictly for I/O; all internal quantity calculations are still performed in feet-seconds units.

Calibration and Verification

The SWMM is designed as a deterministic model in that the physics of the processes are simulated sufficiently well to produce accurate results with minimal calibration if all input parameters are accurate. This concept fails in practice because the input data and the numerical methods are not accurate enough for many real applications. Furthermore, many computational procedures within the model are based on limited data themselves, especially surface quality predictions.

As a result, it is essential that local calibration and verification data be available at specific application sites to lend credibility to the predictions of any urban runoff model. These data are usually in the form of measured flows and concentrations at outfalls or combined sewer overflow locations. Although hydrographs may be predicted fairly accurately with only a moderate calibration effort, pollutographs cannot. Thus measured quality data are crucial to establish proper magnitudes of quality predictions.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

An Example of Output

The SWMM output is varied and can be voluminous at the user's option. Output may include echoes of all input data, time-step listings of hydrographs and pollutographs, quantity and quality summaries (including continuity checks), frequency analysis of output, and line printer plots of predicted and measured hydrographs and pollutographs. Such plots are often the most useful form of output from single-event simulations.

The Stormwater and Water Quality Model Users Group

The group was originally the EPA SWMM Users Group and has functioned since 1973 as a forum for discussing all aspects of stormwater quantity and quality modeling. The SWMM program has benefited greatly from user feedback, and the Users Group has been a particularly useful means for disseminating information on SWMM and other models. The group is open to all interested modelers. Semiannual meetings are held in the United States and Canada, and the group also publishes a periodic newsletter. Further information can be obtained from Mr. Thomas O, Barnwell, Center for Water Quality Modeling, Environmental Research Laboratory, USEPA, College Station Road, Athens, Georgia 30613 (Telephone: 404-546-3175).

SWMM Availability

The program and documentation are available from the National Technical Information Service (NTIS) (see last page), the EPA Center for Water Quality Modeling mentioned in the preceding section, and the report authors. Future updates and improvements will be announced through the newsletter of the Stormwater and Water Quality Model Users Group.

Disclaimer

Every attempt has been made to ensure that the SWMM program performs as represented in the documentation, but as with all large computer models, some lingering bugs will persist. The use of the SWMM and interpretation of its output must remain the responsibility of the user. Neither EPA nor the model authors can assume responsibility for decisions made on the basis of the model.

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The complete report consists of two parts:
"Storm Water Management Model User's Manual, Version III," (Order No. PB 84-198 423; Cost: $38.50, subject to change).
"Storm Water Management Model User's Manual, Version III: Addendum I EXTRAN," (authored by Larry A. Roesner, Robert P. Shubinski, and John A. Aldrich who are with Camp Dresser & McKee, Inc., Amadale, VA 22003; Order No. PB 84-198 431; Cost: $20.50, subject to change).
The above reports will be available only from:
National Technical Information Service
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