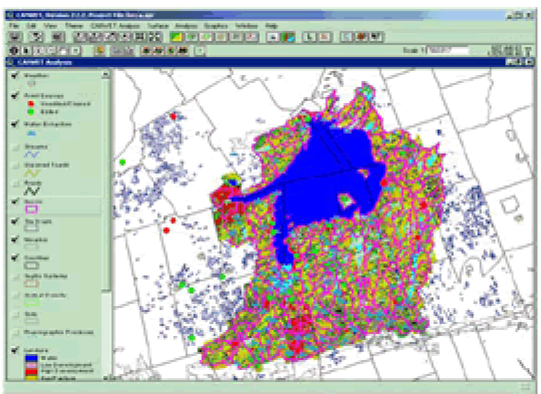
Welcome to the Canadian Nutrient and Water Evaluation Tool CANWET™ Version 3.6

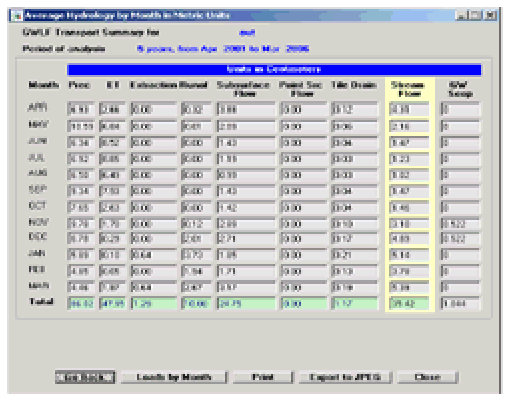
INTRODUCTION

CANWET™ (v 3.6) is a GIS-based nutrient and water budget management tool. Its relative ease of use and ability to take advantage of commonly available spatial data makes it a solid choice over more complex models with greater input requirements. CANWET™ has been successfully used for Assimilative Capacity Studies; Watershed and Sub-watershed Studies; Master Drainage Plans; and, Source Water Protection Studies.

CANWET™ (v 3.6)

CANWET™ (v 3.6) provides the user with increased water budget modeling flexibility over previous versions. This is the first version to allow the user to incorporate the affects of inter-basin and groundwater flux. See water budget enhancements brochure for details on specific enhancements.





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CANWET™ (v 3.6) currently consists of four (4) modules that operate from within an ArcView 3.x GIS environment including:

The Four CANWET™ Modules:

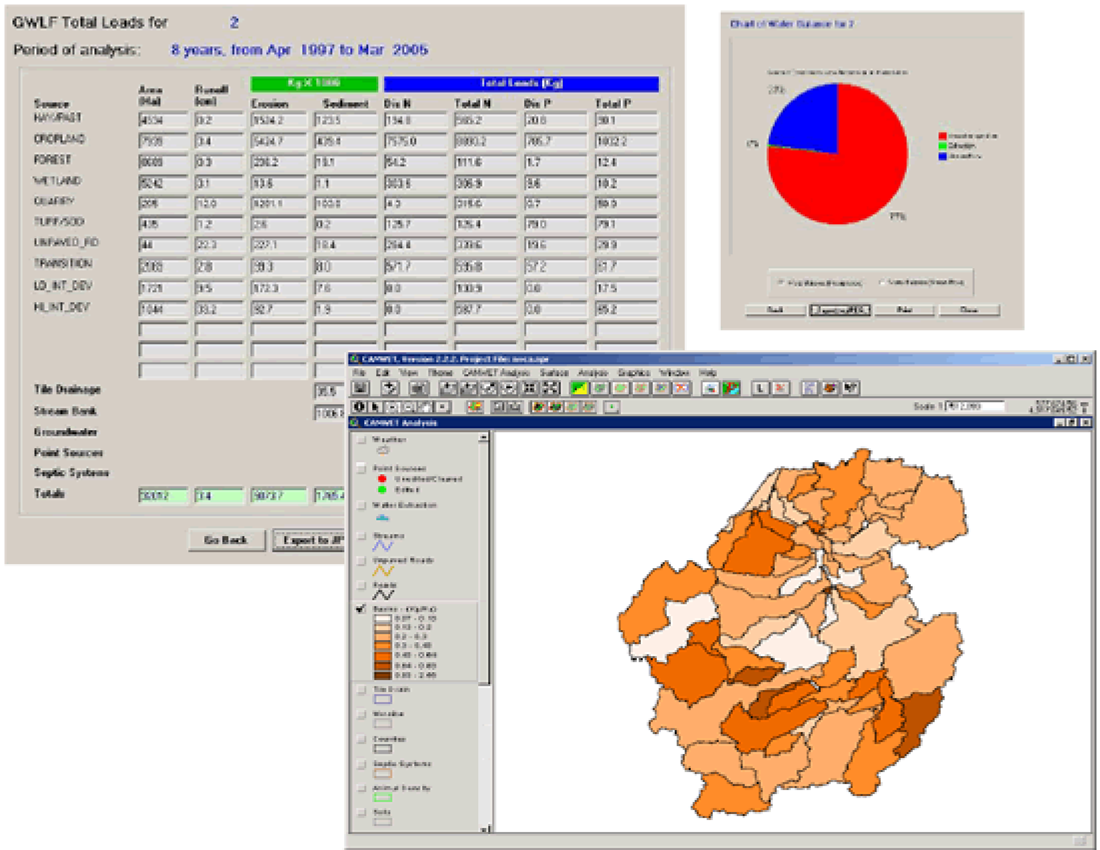
- **Clipping Routines** for populating input files
- **GWLF** (Generalized Watershed Loading Function) Hydrology and Nutrient Loading Module
- **PRedICT** (Pollution Reduction Impact Comparison Tool) Best Management Practice Module
- **STREAMPLAN** (Spreadsheet Tool for River Environmental Assessment Management and Planning) routes In-Stream Concentrations and Flows

Clipping Routines

Clipping Routines in CANWET™ allow the user to quickly and easily populate input data files needed to run other modules in the suite. Data is clipped from Geographic Information System (GIS) vector and grid maps (approximately twenty (20) layers in total). The clipping routines can be used to generate input files for single or multiple basin analyses.

GWLF

GWLF, is a continuous, combined distributed/lumped parameter model based on land use categories. It simulates stream flow, sediment, and nutrient (nitrogen and phosphorous) loadings from a catchment, given variable-size source areas (i.e. agricultural, forested, and developed land). The model also calculates a continuous water balance over the period of the simulation.



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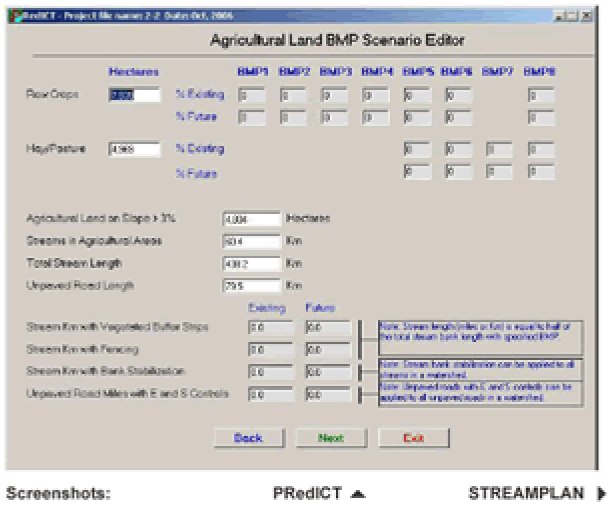
PRedICT

PRedICT evaluates the performance of best management practices (BMPs) for existing and future scenarios by applying area-weighted loading rate reductions for phosphorous, nitrogen and sediment for both rural and urban lands. It also calculates estimated costs for typical BMP applications based on unit-costing.

STREAMPLAN

STREAMPLAN calculates continuous constituent concentrations by reach for use in total maximum monthly load studies where simulated stream concentrations are evaluated against target concentrations. STREAMPLAN uses non-point source flows and loads from GWLF to route concentrations and flows through river networks.



OTHER FEATURES AND FUNCTIONS

- algorithms to correct for nutrient and sediment loss/retention/addition from reservoirs and wetlands;
- Loading estimates consider septic system and livestock contributions;
- Algorithms to estimate load contribution from point source discharge;
- Built-in cost information for an assessment of pollution mitigation techniques, and;
- GIS-based output of sub-catchment loading results in addition to tables and charts.
- Universal Soil Loss Equation (USLE) based calculations consider variation in soil type and topography.

APPLICATION EXAMPLE

Although the original GWLF module has been successfully used world-wide, the initial version of CANWET™ was developed for a pilot nutrient management project led by the Lake Simcoe Region Conservation Authority in 2004. It has been continuously upgraded for Canadian conditions since this initial application in Ontario. The Assimilative Capacity Studies for the Lake Simcoe and Nottawasaga River Basins illustrates the successful use of CANWET™ for two large watersheds.

In this project, CANWET™ was used to quantify point- and non-point sources of nutrients and sediment from sub-watersheds within the Lake Simcoe and Nottawasaga River Basins. Agricultural Best Management Practices and urban mitigative measures were applied to determine loading rates under improved management conditions and to assist in setting water quality targets for annual sub-watershed loads.

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HYDROLOGICAL SIMULATION PROGRAM - FORTRAN
USER'S MANUAL FOR RELEASE 11

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4.2(1).7 Simulate Quality Constituents Using Simple Relationships with Sediment and Water Yield (Section PQUAL of Module PERLND)

Purpose

The PQUAL module section simulates water quality constituents or pollutants in the outflows from a pervious land segment using simple relationships with water and/or sediment yield. Any constituent can be simulated by this module section. The user supplies the name, units and parameter values appropriate to each of the constituents that are needed in the simulation. However, more detailed methods of simulating sediment, heat, dissolved oxygen, dissolved carbon dioxide, nitrogen, phosphorus, soluble tracers, and pesticide removal from a pervious land segment are available, in other module sections.

Approach

The basic algorithms used to simulate quality constituents are a synthesis of those used in the NPS Model (Donigian and Crawford, 1976b) and HSP QUALITY (Hydrocomp, 1977). However, some options and combinations are unique to HSPF.

Figure 4.2(1).7-1 shows schematically the fluxes and storages represented in module section PQUAL. The occurrence of a water quality constituent in both surface and subsurface outflow can be simulated. The behavior of a constituent in surface outflow is considered more complex and dynamic than the behavior in subsurface flow. A constituent on the surface can be affected greatly by adhesion to the soil and by temperature, light, wind, atmospheric deposition, and direct human influences. Section PQUAL is able to represent these processes in a general fashion. It allows quantities in the surface outflow to be simulated by two methods. One approach is to simulate the constituent by association with sediment removal. The other approach is to simulate it using atmospheric deposition and/or basic accumulation and depletion rates together with depletion by washoff; that is, constituent outflow from the surface is a function of the water flow and the constituent in storage. A combination of the two methods may be used in which the individual outfluxes are added to obtain the total surface outflow. These approaches will be discussed further in the descriptions of the corresponding subroutines. Concentrations of quality constituents in the subsurface flows of interflow and active groundwater are specified by the user. The concentration may be linearly interpolated to obtain daily values from input monthly values.

The user has the option of simulating the constituents by any combination of these surface and subsurface outflow pathways. The outflux from the combination of the pathways simulated will be the total outflow from the land segment. In addition, the user is able to select the units to be associated with the fluxes. These options provide considerable flexibility. For example, a user may wish to simulate coliforms in units of organisms/ac by association with sediment in the surface runoff and use a concentration in the groundwater which varies seasonally. Or a user may want to simulate total dissolved salts in pounds per acre by direct association with overland flow and a constant concentration in interflow and groundwater flow.

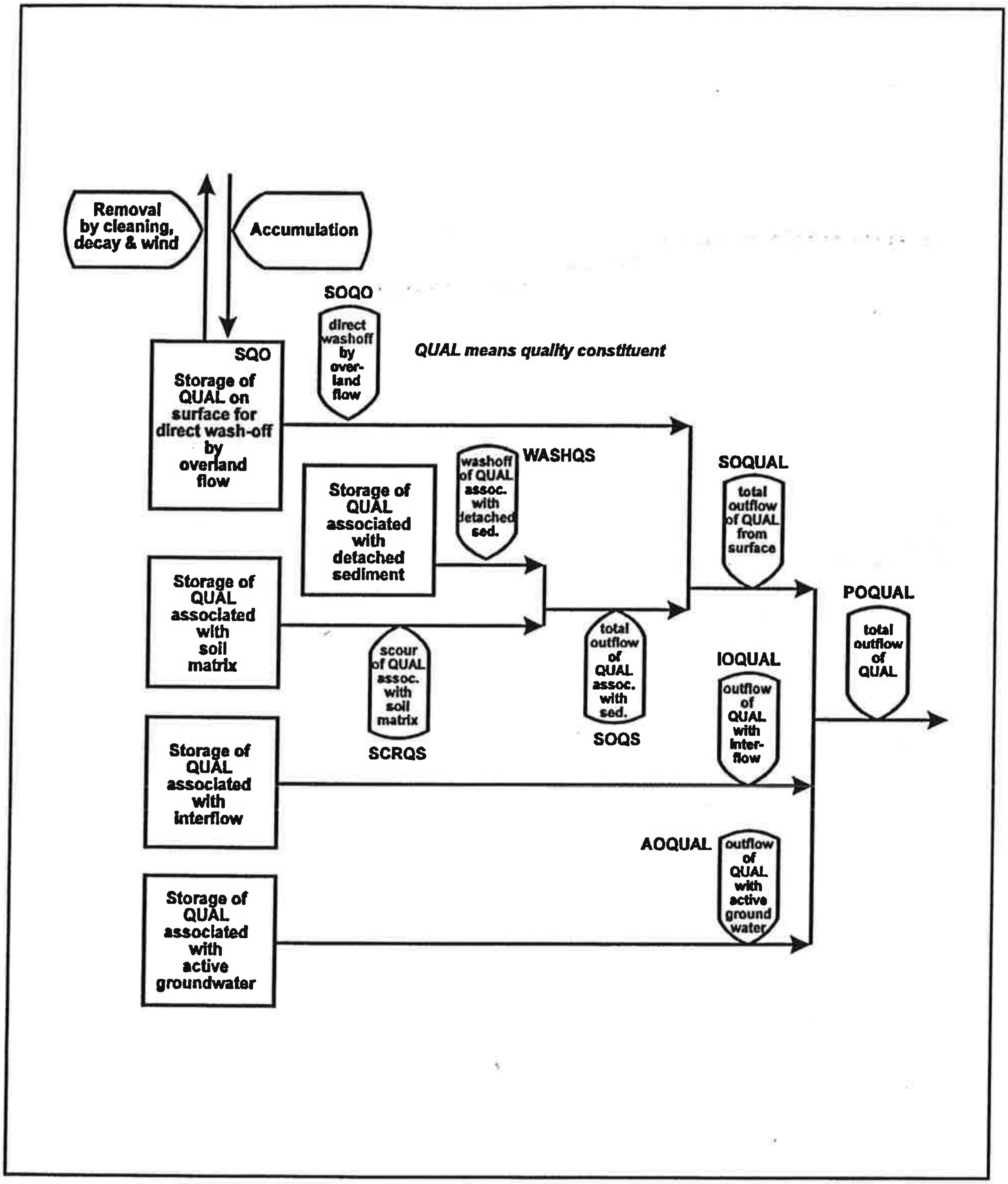

Figure 4.2(1).7-1 Flow diagram for PQUAL section of the PERLND Application Module

PQUAL allows the user to simulate up to 10 quality constituents at a time. Each of the 10 constituents may be defined as one or a combination of the following types: QUALSD, QUALOF, QUALIF, and/or QUALGW. If a constituent is considered to be associated with sediment, it is called a QUALSD. The corresponding terms for constituents associated with overland flow, interflow, and groundwater flow are QUALOF, QUALIF, and QUALGW, respectively. Note that only a QUALOF may receive atmospheric deposition, since it is the only type to maintain a storage. However, no more than seven of any one of the constituent types (QUALSD, QUALOF, QUALIF, or QUALGW) may be simulated in one operation. The program uses a set of flag pointers to keep track of these associations. For example, QSDFP(3) = 0 means that the third constituent is not associated with sediment, whereas QSDFP(6) = 4 means that the sixth constituent is the fourth sediment associated constituent (QUALSD). Similar flag pointer arrays are used to indicate whether or not a quality constituent is a QUALOF, QUALIF, or QUALGW.

4.2(1).7.1 Remove by Association with Sediment (subroutine QUALSD)

Purpose

QUALSD simulates the removal of a quality constituent from a pervious land surface by association with the sediment removal determined in module section SEDMNT.

Method

This approach assumes that the particular quality constituent removed from the land surface is in proportion to the sediment removal. The relation is specified with user-input "potency factors." Potency factors indicate the constituent strength relative to the sediment removed from the surface. Various quality constituents such as iron, lead, and strongly adsorbed toxicants are actually attached to the sediment being removed from the land surface. Some other pollutants such as ammonia, organics, pathogens, and BOD may not be extensively adsorbed, but can be considered highly correlated to sediment yield.

For each quality constituent associated with sediment, the user supplies separate potency factors for association with washed off and scoured sediment (WSSD and SCRSD). Typically, the washoff potency factor would be larger than the scour potency factor because washed off sediment is usually finer than the scoured material and thus has a higher adsorption capacity. Organic nitrogen would be a common example of such a constituent. The user is also able to supply monthly potency factors for constituents that vary somewhat consistently during the year. For instance, constituents that are associated with spring and fall fertilization may require such monthly input values.

Removal of the sediment associated constituent by detached sediment washoff is simulated by:

$$WASHQS = WSSD*POTFW \qquad (1)$$

where:

WASHQS = flux of quality constituent associated with detached sediment washoff (quantity/ac per interval)
WSSD = washoff of detached sediment (tons/ac per interval)
POTFW = washoff potency factor (quantity/ton)

Removal of constituents by scouring of the soil matrix is similar:

$$SCRQS = SCRSD*POTFS \qquad (2)$$

where:

SCRQS = flux of quality constituent associated with scouring of the matrix soil (quantity/ac per interval)
SCRSD = scour of matrix soil (tons/ac per interval)
POTFS = scour potency factor (quantity/ton)

WASHQS and SCRQS are combined to give the total sediment associated flux of the constituent from the land segment, SOQS.

The unit "quantity" refers to mass units (pounds or tons in the English system) or some other quantity, such as number of organisms for coliforms. The unit is user-specified.

4.2(1).7.2 Accumulate and Remove by a Constant Unit Rate and by Overland Flow (subroutine QUALOF)

Purpose

QUALOF simulates the accumulation of a quality constituent on the pervious land surface and its removal by a constant unit rate and by overland flow.

Method

This subroutine differs from the others in module section PQUAL in that the storage of the quality constituent on the land surface is simulated. The constituent can be accumulated and removed by processes which are independent of storm events such as cleaning, decay, and wind erosion and deposition, or it can be washed off by overland flow. The accumulation and removal rates can have monthly values to account for seasonal fluctuations. A pollution indicator such as fecal coliform from range land is an example of a constituent with accumulation and removal rates which may need to vary throughout the year. The concentration of the coliform in the surface runoff may fluctuate with the seasonal grazing density, and the weather.

The constituent may, alternatively or additionally, receive atmospheric deposition. Atmospheric deposition inputs can be specified in two possible ways depending on the form of the available data. If the deposition is in the form of a flux (mass per area per time), then it is considered "dry deposition". If the deposition is in the form of a concentration in rainfall, then it is considered "wet deposition", and the program automatically combines it with the input rainfall time series to compute the resulting flux. Either type of deposition data can be input as a time series, which covers the entire simulation period, or as a set of monthly values that is used for each year of the simulation. The specific atmospheric deposition time series are documented in the EXTNL table of the Time Series Catalog for PERLND, and are specified in the EXT SOURCES block of the UCI. The monthly values are input in the MONTH-DATA block in the UCI.

If atmospheric deposition data are input to the model, the storage of qual is updated as follows:

```
SQO = SQO + ADFX + PREC*ADCN                                        (3)
```

where:

```
SQO  = storage of available quality constituent on the surface (mass/area)
ADFX = dry or total atmospheric deposition flux (mass/area per interval)
PREC = precipitation depth
ADCN = concentration for wet atmospheric deposition (mass/volume)
```

When there is surface outflow and some quality constituent is in storage, washoff is simulated using the commonly used relationship:

```
SOQO = SQO*(1.0 - EXP(-SURO*WSFAC))                                 (4)
```

where:

```
SOQO  = washoff of the quality constituent from the land
        surface (quantity/ac per interval)
SQO   = storage of available quality constituent on the surface (quantity/ac)
SURO  = surface outflow of water (in/interval)
WSFAC = susceptibility of the quality constituent to washoff (/in)
EXP   = exponential function
```

The storage is updated once a day to account for accumulation and removal which occurs independent of runoff by the equation:

```
SQO = ACQOP + SQOS*(1.0 - REMQOP)                                   (5)
```

where:

```
ACQOP  = accumulation rate of the constituent (quantity/ac per day)
SQOS   = SQO at the start of the interval
REMQOP = unit removal rate of the stored constituent (per day)
```

The Run Interpreter computes REMQOP and WSFAC for this subroutine according to:

```
REMQOP = ACQOP/SQOLIM                                               (6)
```

where:

```
SQOLIM = asymptotic limit for SQO as time approaches infinity
         (quantity/ac), if no washoff occurs
```

and

```
WSFAC = 2.30/WSQOP                                                  (7)
```

where:

WSQOP = rate of surface runoff that results in 90 percent washoff in one hour (in/hr)

Since the unit removal rate of the stored constituent (REMQOP) is computed from two other parameters, it does not have to be supplied by the user.

4.2(1).7.3 Simulate by Association with Interflow Outflow (subroutine QUALIF)

Purpose

QUALIF is designed to permit the user to simulate the occurrence of a constituent in interflow.

Method

The user specifies a concentration for each constituent which is a QUALIF. Optionally, one can specify 12 monthly values, to account for seasonal variation. In this case, the system interpolates a new value each day.

4.2(1).7.4 Simulate by Association with Active Groundwater Outflow (subroutine QUALGW)

Purpose

QUALGW is designed to permit the user to simulate the occurrence of a constituent in groundwater outflow.

Method

The method is identical to that for QUALIF.

20.8 WATER QUALITY

20.8.1 Introduction

Simulation of urban runoff quality is very inexact. The many difficulties of simulation of urban runoff quality are discussed by Huber (1985, 1986). Very large uncertainties arise both in the representation of the physical, chemical and biological processes and in the acquisition of data and parameters for model algorithms. For instance, subsequent sections discuss the concept of "buildup" of pollutants on land surfaces and "washoff" during storm events. The true mechanisms of buildup involve factors such as wind, traffic, atmospheric fallout, land surface activities, erosion, street cleaning and other imponderables. Although efforts have been made to include such factors in physically-based equations (James and Boregowda, 1985), it is unrealistic to assume that they can be represented with enough accuracy to determine *a priori* the amount of pollutants on the surface at the beginning of the storm. Equally naive is the idea that empirical washoff equations truly represent the complex hydrodynamic (and chemical and biological) processes that occur while overland flow moves in random patterns over the land surface.

Such uncertainties can be dealt with in two ways. The first option is to collect enough calibration and verification data to calibrate the model equations used for quality simulation. Given sufficient data, the equations used in SWMM can usually be manipulated to reproduce observed concentrations and loads. This is essentially the option discussed at length in the following sections. The second option is to abandon the notion of detailed quality simulation altogether and use either (a) a constant concentration applied to quantity predictions (i.e., obtain storm loads by multiplying predicted volumes by an assumed concentration) (Johansen et al., 1984) or (b) a statistical method (Hydroscience, 1979; Driscoll and Assoc., 1981; EPA, 1983b; DiToro, 1984). Two ways in which constant concentrations can be simulated in SWMM are by using a rating curve (equation 20-114) with an exponent of 1.0 or by assigning a concentration to rainfall. Statistical methods are based in part upon strong evidence that storm event mean concentrations (EMCs) are lognormally distributed (Driscoll, 1986). The statistical methods recognize the frustrations of physically-based modeling and move directly to a stochastic result (e.g. a frequency distribution of EMCs), but they are even more dependent on available data than methods such as those found in SWMM. That is, statistical parameters such as mean, median and variance must be available from other studies in order to use the statistical methods. Furthermore, it is harder to study the effect of controls and catchment modifications using statistical methods.

The main point is that there are alternatives to the approaches used in SWMM; the latter can involve extensive effort at parameter estimation and model calibration to produce quality predictions that may vary greatly from an unknown "reality." Before delving into the arcane methods incorporated in

SWMM and other urban runoff quality simulation models, you should try to determine whether or not the effort will be worth it in view of the uncertainties of the process and whether or not simpler alternative methods might suffice. The discussions that follow provide a comprehensive view of the options available in SWMM, which are more than in almost any other comparable model in the public domain, but the extent of the discussion should not be interpreted as a guarantee of success in applying the methods.

Overview of Quality Procedures

For most SWMM applications, the RUNOFF Module is the origin of water quality constituents. Although effects of dry-weather flow and scour and deposition may be included in the TRANSport module, (dry-weather flow quality may also be included in the STORAGe/treatment Module), the generation of quality constituents (e.g., pollutants) in the storm water itself can only be included in the RUNOFF Module.

Methods for prediction of urban runoff quality constituents are reviewed extensively by Huber (1985, 1986). Several mechanisms constitute the genesis of stormwater quality, most notably buildup and washoff. In an impervious urban area, it is usually assumed that a supply of constituents is built up on the land surface during dry weather preceding a storm. Such a buildup may or may not be a function of time and factors such as traffic flow, dry fallout and street sweeping (James and Boregowda, 1985). With the storm the material is then washed off into the drainage system. The physics of the washoff may involve rainfall energy, as in some erosion calculations, or may be a function of bottom shear stress in the flow as in sediment transport theory. Most often, however, washoff is treated by an empirical equation with slight physical justification. As an alternative to the use of a buildup-washoff formulation, quality loads (i.e., mass/time) may be generated by a rating curve approach in which loads are proportional to flow raised to some power.

Another pollutant source is catchbasins. These are treated in SWMM as a reservoir of constituents in each subcatchment available to be flushed out during the storm.

Erosion of "solids" may be simulated directly be the Universal Soil Loss Equation (USLE). Since it was developed for long term predictions (e.g. seasonal or annual loads), its use during a storm event in SWMM is questionable. But it is convenient since many data are available to support it.

A final source of constituents is in the precipitation itself. Much more monitoring exists of precipitation quality at present than in the past, and precipitation can contain surprisingly high concentrations of many parameters. This is treated in SWMM by permitting a constant concentration of constituents in precipitation.

Many constituents can appear in either dissolved or solid forms (e.g. BOD, nitrogen, phosphorus) and may be adsorbed onto other constituents (e.g.

pesticides onto "solids") and thus be generated as a portion of such other constituents. To treat this situation, any constituent may be computed as a fraction ("potency factor") of another. For instance, five percent of the suspended solids load could be added to the (soluble) BOD load. Or several particle size - specific gravity ranges could be generated, with other constituents consisting of fractions of each.

Up to ten quality constituents may be simulated in the RUNOFF Module. All are user-supplied, with appropriate parameters for each. All are transferred to the interface file for transmittal to subsequent SWMM modules, but not all may be used by the modules; see the documentation for each module.

Up to five user-supplied land uses may be entered to characterize different subcatchments. Street sweeping is a function of land use, and individual constituents. Constituent buildup may be a function of land use or else fixed for each constituent. Considerable flexibility thus exists.

When channel/pipes (links) are included, quality constituents are routed through them assuming complete mixing within each gutter/pipe (link) at each time step. No scour, deposition or decay-interaction during routing is simulated in the RUNOFF Module.

Output consists of pollutographs (concentrations versus time) at desired locations along with total loads, and flow-weighted concentration means and standard deviations. In addition, summaries are printed for each constituent describing its overall mass balance for the simulation for the total catchment, i.e., sources, removals, etc. These summaries are the most useful output for continuous simulation runs.

In the following material, the processes described above are discussed in more detail.

Quality Simulation Credibility

Although the conceptualization of the quality processes is not difficult, the reliability and credibility of quality parameter simulation is very difficult to establish. In fact, quality predictions by SWMM or almost any other surface RUNOFF model are almost useless without local data for calibration and validation. If such data are lacking, results may still be used to compare relative effects of changes, but parameter magnitudes (e.g. predicted concentrations) will forever be in doubt. This is in marked contrast to quantity prediction for which reasonable estimates of hydrographs may be made in advance of calibration.

Moreover, there is disagreement in the literature as to what are the important and appropriate physical and chemical mechanisms that should be included in a model to generate surface runoff quality. The objective in the RUNOFF Module has been to provide flexibility in mechanisms and the opportunity for calibration. But this places a considerable burden on you to obtain adequate data for model usage and to be familiar with quality

mechanisms that may apply to the catchment being studied. This burden is all too often ignored, leading ultimately to model results being discredited.

In the end then, there is no substitute for local data, that is, observed rain, flow and concentrations, with which to calibrate and verify the quality predictions. Without such data, little reliability can be placed in the predicted magnitudes of quality parameters.

Required Degree of Temporal Detail

Early quality modeling efforts with SWMM emphasized generation of detailed pollutographs, in which concentrations versus time were generated for short time increments during a storm event (e.g. Metcalf and Eddy et al., 1971b). In most applications, such detail is entirely unnecessary because the receiving waters cannot respond to such rapid changes in concentration or loads. Instead, only the total storm event load is necessary for most studies of receiving water quality. Time scales for the response of various receiving waters are presented in Table 20-17 (Driscoll, 1979; Hydroscience, 1979). Concentration transients occurring within a storm event are unlikely to affect any common quality parameter within the receiving water, with the possible exception of bacteria. The only time that detailed temporal concentration variations might be needed within a storm event is when they will affect control alternatives. For example, a storage device may need to trap the "first flush" of pollutants.

Table 20-17 Required Temporal Detail for Receiving Water Analysis. (after Driscoll, 1979 and Hydroscience, 1979)

Type of Receiving Water	Key Constituents	Response Time
Lakes, Bays	Nutrients	Weeks – Years
Estuaries	Nutrients, DO(?)	Days – Weeks
Large Rivers	DO, Nitrogen	Days
Streams	DO, Nitrogen	Hours – Days
	Bacteria	Hours
Ponds	DO, Nutrients	Hours – Weeks
Beaches	Bacteria	Hours

The significant point is that calibration and verification ordinarily need only be performed on total storm event loads, or on event mean concentrations. This is a much easier task than trying to match detailed concentration transients within a storm event.

Quality Constituents

The number and choice of constituents to be simulated must reflect your needs, potential for treatment and receiving water impacts, etc. Almost any constituent measured by common laboratory or field tests can be included, up to a total of ten. The name and concentration units entered will be passed to subsequent modules and used as column headings for tabular output of concentrations. This heading style is used in both the RUNOFF and TRANSport modules.

Options for concentration units are reasonably broad and broken into three categories, indicated by parameter NDIM. Most constituents are measurable in units of milligrams per liter, mg/l. Although parameters such as metals, phosphorus or trace organics are often given as micrograms per liter, μg/l, the output of concentrations for NDIM = 0 is F10.3 (allowing for three decimal places), and it is expected to be compatible with reported values of such parameters. Thus, the use of mg/l should suffice for all parameters for which the "quantity" of the parameter is measured as a mass (e.g. mg).

A notable exception to the use of mass units is for bacteria, for which constituents such as coliforms, fecal strep etc. are given as a number or count per volume, e.g. MPN/l. Setting NDIM = 1 accounts for these units (or any other type of "quantity" per liter, including mass if desired). Concentration output for these constituents is given an E9.3 format.

A third category covers parameters with specialized concentration-type units such as pH, conductivity (umho), turbidity (JTU), color (PCU), temperature (°C), etc. These are simulated using NDIM = 2. For these parameters, interpretation of concentration results is straightforward, but "total mass" or "buildup" is mostly conceptual. Since loads (e.g. mass/time) are transmitted in terms of concentration times flow rate, whichever concentration units are used, proper continuity of parameters is readily maintained. Of course, simulation of a parameter such as temperature could only be done to the zeroeth approximation in any event since all RUNOFF Module constituents are conservative.

Land Use Data

Each subcatchment must be assigned only one of up to five user-supplied land uses. The number of the land use is used as a program subscript, so at least one land use data must be entered. Street sweeping is a function of land use and constituent (discussed subsequently). Constituent buildup may be a function of land use depending on the type of buildup calculation specified. The buildup parameters DDLIM, DDPOW, and DDFACT are used only when constituent buildup will be a function of "dust and dirt" buildup. This is discussed in detail below.

The land use name, LNAME, will be printed in the output using eight columns. The land use types are completely arbitrary, but they could reflect those for which data are available and, of course, those found in the catchment, or an aggregate thereof.

20.8.2 Buildup

Background

One of the most influential of the early studies of stormwater pollution was conducted in Chicago by the American Public Works Association (1969). As part of this project, street surface accumulation of "dust and dirt" (DD) (anything passing through a quarter inch mesh screen) was measured by sweeping with brooms and vacuum cleaners. The accumulations were measured for different land uses and curb length, and the data were normalized in terms of pounds of dust and dirt per dry day per 100 ft of curb or gutter. These well- known results are shown in Table 20-18 and imply that dust and dirt buildup is a linear function of time. The dust and dirt samples were analyzed chemically, and the fraction of sample consisting of various constituents for each of four land uses was determined, leading to the results shown in Table 20-19.

Table 20-18 Measured Dust and Dirt (DD) Accumulation in Chicago (APWA, 1969).

Type	Land Use	Pounds DD/dry day per 100 ft-curb
1	Single Family Residential	0.7
2	Multi-Family Residential	2.3
3	Commercial	3.3
4	Industrial	4.6
5	Undeveloped or Park	1.5

Table 20-19 Milligrams of Pollutant Per Gram of Dust and Dirt (Parts Per Thousand By Mass) For Four Chicago Land Uses From 1969 APWA Study. (APWA, 1969).

Parameter	Land Use Type: Single Family Residential	Multi-Family Residential	Commercial Industrial	Industrial
BOD5	5.0	3.6	7.7	3.0
COD	40.0	40.0	39.0	40.0
Total Coliforms[a]	1.3×10^6	2.7×10^6	1.7×10^6	1.0×10^6
Total N	0.48	0.61	0.41	0.43
Total PO4 (as PO4)	0.05	0.05	0.07	0.03

[a]Units for coliforms are MPN/gram

From the values shown in Tables 20-18 and 20-19, the buildup of each constituent (also linear with time) can be computed simply by multiplying dust and dirt by the appropriate fraction. Since the APWA study was published during the original SWMM project (1968-1971), it represented the state of the art at

SIMPLIFIED PARTICULATE TRANSPORT MODEL (SIMPTM)

Introduction

Urban stormwater pollution results primarily from the accumulation and transport of contaminated material on paved surfaces such as streets and parking lots. Most street sediment is from local soil erosion; the rest is from automobile track-out and pavement deterioration. The automobile is a major contributor of many toxic pollutants, including heavy metals, and oil and grease. Vegetative litter can be a significant contributor of organic material and nutrients. Feces of pets, livestock and waterfowl are major contributors of bacteriological pollutants. As contaminants accumulate over time, they are removed by wind, traffic, runoff, or street cleaning.

The ability of stormwater runoff to transport sediment and sediment-borne pollutants depends upon many factors such as the distribution of particle size and weight, the intensity and duration of runoff, and the physical characteristics of the urban catchment. Sources farther from the storm drainage system which experience more pervious overland flow have a much smaller impact than do parking lots or street surfaces that are directly connected to the drainage system.

The typical curb and gutter storm sewer design concentrates pollutants in street sediment, and concentrates runoff, resulting in high contaminant transport. Distributing stormwater runoff in grassy swales or other pervious areas can greatly reduce pollutant loads. Cleaning sediment deposits in catchbasin traps and street gutters, and capturing runoff in stormwater treatment facilities also can reduce pollution.

The Simplified Particulate Transport Model (SIMPTM) is an urban stormwater quality model that can simulate the physical processes discussed above. The SIMPTM package is a group of PC-based programs that simulate pollutant loadings transported by urban stormwater on an event-by-event basis (Sutherland and Jelen 1998).

SIMPTM Overview

The Simplified Particulate Transport Model has totally integrated what use to be two different stand alone programs, RAINEV and SIMPTM. RAINEV, the rainfall evaluator, performs the first step in simulating stormwater pollution – rainfall characterization. It groups a continuous hourly precipitation record into significant events and tabulates the starting date and time, duration, depth, time since the last event ended, average intensity and maximum hourly intensity for each one. Monthly and annual averages of these can be grouped into tables either by month, parameter, or year. In addition, RAINEV fits each event rainfall distribution to a rectangle, triangle, and trapezoid – used for SIMPTM. Information for each event is recorded in a log file which can be used by SIMPTM, re-read and re-summarized by RAINEV or easily imported into spreadsheets or databases for further analysis.

RAINEV accepts hourly precipitation data in two formats – that used by the National Weather Service and having 24 hours of data on two lines, and a second one-hour-per-line format used by some automatic recording gages. Output is even more flexible. Summaries can be spreadsheet-ready “numbers” or “quote-delimited” files or simple, easily read ASCII files. The log file, listing information for every significant rainfall event, can be re-read and re-summarized in a different format, saving the time used to identify events from raw data. RAINEV provides valuable information about rainfall events to support not only SIMPTM runs but also NPDES stormwater permitting. Rainfall event characteristics can be tabulated for pollution reduction facility sizing.

SIMPTM simulates event-by-event stormwater discharges and pollutant loadings from developed lands using published, physically-based sediment transport equations. Results are all spreadsheet-ready as "numbers" or "quote-delimited" files for easy post-processing analysis of data. The overall effectiveness of strategies such as street sweeping, sediment trapping catchbasins, and catchbasin cleaning are output by SIMPTM simulations, rather than user-supplied inputs as with most stormwater quality models. SIMPTM uses Pitt's small-storm hydrology work to model initial rainfall losses far better than SCS curve numbers would, and accounts for sediment deposition and re-suspension processes.

For sediment transport, SIMTM uses equations published by Yalin, Einstein and Foster and Meyer and an average trapezoidal hydrograph at a stormwater inlet to simulate the washoff of accumulated sediment from paved areas. This has been shown by Ellis and Sutherland (1979) to be much more accurate than the empirically-based exponential washoff used in EPA's SWMM model. SIMPTM compares the fraction of supply available for transport with the shallow-flow transport capacity from Shield's Diagram and considers the armoring of smaller particles by larger overlying ones.

Many basin-wide planning projects will require simulating unit or per acre runoffs and pollutant washoffs for each of many contributing land uses which must then be combined. Using the spreadsheet-ready output files from SIMPTM this can be easily accomplished in any spreadsheet using matrix multiplication to weigh output results by contributing areas for each of any number of subbasin areas. Thus, subbasin results can be grouped into basin-wide predictions.

Many input parameters can be measured or easily estimated from field survey results, USGS topographic maps, aerial photos, or drainage system inventories. However, others are not well known or have not been measured to a great extent. The Nationwide Urban Runoff Program (NURP) has extensive data from some thirty sites across the country. Two sites in Bellevue, Washington have provided valuable information to calibrate the model for the Pacific Northwest, but other regions might be better served by other sites. The following is suggested in calibrating the model:

1. Match runoff volume by adjusting the effective impervious area and the impervious area variable loss parameters. Establish the relationship between rainfall and runoff durations.

2. Match total solids (TS) or total sediments accumulation and smaller storm washoffs by adjusting the impervious accumulation and availability. Pervious area contributions would be significant only during larger events. Sufficient data of large storm washoffs might support inclusion of pervious runoff which could carry extra pervious area sediment observed to washoff.

3. Match other pollutants in SIMPTM by adjusting their mass-to-mass pollutant strengths for each particle size group. Compare TS-pollutant ratios on paved surfaces with those washing off and in sediment traps.

4. Verify parameters using data from a different period of record.

5. Change parameters to reflect observed differences in land use characteristics between the calibrated and to-be-simulated basins. In the end, good judgement must assess the results.

References

Ellis F.W., and Sutherland, R.C., "An Approach to Urban Pollutant Washoff Modeling." *Proc. Int. Symp. Urban Storm Runoff*, University of Kentucky, Lexington, Kentucky, 1979, 325.

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