Chapter 5

BMP Planning Utilizing Knowledge Engineering Techniques

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This chapter explores the possibilities of utilizing dynamic on-line documentation to assist with total catchment planning, which has recently become mandatory both in North America and Australia. The need to plan for improved drainage management for existing and increasing urbanisation, and to improve waterway environments has led to increasing pressures from government agencies through recent environmental legislation.

Since the early 1970s many numerical approaches have been utilized to model urbanising catchments and control structures to contain and manipulate storm drainage and its pollutants. Programs including the US EPA's Stormwater Management Model (SWMM) have been widely applied as primary tools to help researchers and engineers to understand and size required BMPs, channels, pipes and storage structures.

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5.1 Proposed System

The current approach is based on experience gained from a graduate course developed by James, on pollution control planning.

After reviewing a wide range of publications, the authors decided to create a prototype tool based loosely around the Metropolitan Washington Council of Governments publication "Controlling Urban Runoff : A Practical Manual for Planning and Designing Urban BMP's" (Schueler, 1987).

To test the concept a prototype was created using a hypercard approach. The aim of the project was to provide online the principles and outputs of a range of currently available written material together with user interaction capabilities to allow real applications to be incorporated.

BMP PLANNER is a decision support system and knowledge base for stormwater quality management. Although complex simulation tools are currently available in this field, a deficiency exists where first order planning and education is concerned. BMP PLANNER has been developed to satisfy the needs of planners and engineers, new or experienced in this area, to provide strategic planning information when considering optimal watershed management schemes.

BMP PLANNER utilizes a dynamic water quality library to which users may add new elements, enabling even the inexperienced planner or engineer to quickly and easily learn about stormwater quality management in general and dynamically about possible water quality work on the watershed being reviewed. The structure of BMP PLANNER is shown in Figure 5.1.

5.2 System Description

The tool has currently been implemented to run on the Apple Macintosh computer and under Microsoft Windows Version 3.x on the IBM PC and compatible computers. BMP PLANNER takes on the form of a HyperCard stack on the Apple Macintosh, and a PLUS (SPINNAKER, 1992) stack on the IBM-PC. A stack is a collection of information arranged in a certain structured way. One stack is equivalent to one single computer file.

Extensive use of knowledge engineering was utilized to essentially distil information from Schueler (1987). Additionally, the knowledge of many experienced professionals working in the field was included in order to maximize the available knowledge base.

The program utilizes the simple algorithms and procedures proposed by Schueler (1987) to generate Pollutant Loads, BMP Removal Rates as well as to provide a guide to effective control of environmental impacts.

Figure 5.1
Structure of BMP PLANNER

Basic data is input including sub-catchment areas, runoff coefficients, and total rainfall as well as event mean concentration values (EMC's) for the range of pollutants being addressed. Additionally, individual BMP removal efficiencies in percentage terms are input to derive sub-catchment outputs. Outputs from all sub-catchment nodes are added to provide total loads entering the downstream receiving body.

BMP PLANNER additionally calculates construction and maintenance costs following the guidelines provided by Schueler (1987) and then applies present worth analysis based on rate of return and project life inputs.

The planner may analyze the watershed with special regard to pollutant loads, environmental impact, and lifecycle costing of various BMPs. BMP PLANNER embodies a full graphical user interface to enable the user to create a schematic representation of the watershed by using a set of graphical symbols to represent various BMPs and receiving waterbody. The user can easily test different watershed management options by quickly creating and testing many BMP arrangements including porous pavements, ponds, gross pollutant traps, infiltration trenches, grass swales, etc. Figure 5.2 describes the different screen menus.

Figure 5.3 indicates a project catchment showing four typical user input

BMP/nodes and sub-catchment boundaries. The BMPs are selected from the tool strip and moved to appropriate locations within the represented catchment.

All individual node results are ultimately accumulated at the receiving waterbody node at the outlet of the catchment.

At present BMP Planner supports eleven node types representing:

- 1) an extended detention pond,
- 2) a wet pond,
- 3) an infiltration basin,
- 4) an porous pavement,
- 5) a grassed swale,
- 6) a filter strip,
- 7) a water quality inlet,
- 8) a gross pollutant trap,
- 9) the receiving waterbody, and
- 10) a null BMP.

There are ten different BMP screens, one for each type of BMP. The screen in Figure 5.4 shows the four groups of data common to all BMPs.

Each BMP screen presents four groups of features which describe the particular Best Management Practice :

- 1) removal rates,
- 2) environmental impact,
- 3) physical characteristics, and
- 4) cost

With the Sub-Watershed dialogue indicated in Figure 5.5 the individual sub-catchment characteristics are described.

Values that can be optionally calculated include :

- 1) runoff coefficient,
- 2) runoff volume,
- 3) daily discharge, and
- 4) sediment EMC

The equations used in these calculations are presently based upon Schueler (1987).

The inflow/outflow dialogue shown in Figure 5.6 contains computed inflows as well as outflows based on user input removal rates.

Figure 5.2
BMP PLANNER screen menu.

Figure 5.3
Diagrammatic representation of watershed.

Pond Yarra

Removal Rates

Total Phosphorus	45	%
Total Nitrogen	30	%
Trace Metals	67	%
BOD/COD	45	%
Bacteria	10	%
Sediment	30	%
Overall Removal		low

Physical Characteristics

Max Detention Time	hours
Av Detention Time	hours
Release Duration	hours
Release Rate	ft ³ /sec
Storage Size	acre-feet
Depth	feet
Pond Slopes	: 1 (h : v)
Maintenance Access	feet
Land Requirement	% of site
Min Drainage Area	98.52 acres
Depth to Bedrock	feet
Utility Relocation	
Includes	

Environmental Impact

Low Flow Maintenance	1
Streambank Erosion Control	2
Ground Water Recharge	0
Volume Control	2
Peak Discharge Control	1
Aquatic Habitat Creation	0
Wildlife Habitat Creation	0
No Thermal Enhancement	0
Landscape Enhancement	1
Recreational Benefits	1
Hazard Reduction	2
Aesthetics	1
Community Acceptance	2

Cost

Project Life : 100 Yr

Construction Cost	\$ 72514.50
Maintenance Cost	\$ 98720.0
Total Cost	\$ 171234.5

Inflow/Outflow

Sub Watershed

Maintenance

Schematic

Experience

Figure 5.4
BMP screen.

Sub-Watershed : Pond Yarra

Mean Concentrations

Total P	mg/l
Ortho P	mg/l
Soluble P	0.59 mg/l
Organic P	mg/l
Total N	mg/l
Nitrate N	mg/l
Ammonia N	mg/l
Organic N	mg/l
TKN N	2.72 mg/l
COD	124.0 mg/l
BOD (5 days)	mg/l
ZN	0.380 mg/l
PB	0.550 mg/l
CU	mg/l
Sediment	234.69 mg/l
Hydrocarbon	mg/l

Characteristics

Geography	US Mid At St
Development	Urban Highw
Size	98.52 acres
Imperviousness	50 %
Depth of Rainfall	0.65 in/yr
Correction Factor	0.9
Runoff Coefficient	0.5
Runoff Volume	2.40 acre-feet
Sediment Level	high
Daily Discharge	42.76 ft ³ /sec/day
Time of Concentration	hours
Land Availability	% of site

Experience

Figure 5.5
Sub-watershed dialog.

The following equation is used to estimate of the inflow pollutant load (Schueler, 1987) :

$$L = [(P) (P_j) (R_v) / 12] (C) (A) \tag{1}$$

where:

- P = rainfall depth (inches) over the desired time interval
- P_j = factor that corrects P for storms that produce runoff
- R_v = runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
- C = flow-weight mean concentration of the pollutant in urban runoff (mg/l)
- A = area of the development site (acres)

The outflow loads are inflow loads minus the removed part of pollutants.

Life Cycle project costs are calculated via the Maintenance Dialogue indicated in Figure 5.7 utilising guidelines given by Schueler (1987). Present worth analysis is applied to derive total Watershed Management Costs.

Other attributes include the ability to import or develop schematics of various BMP features as indicated in the Schematic Dialogue in Figure 5.8.

Figure 5.6
Inflow/outflow dialog.

Figure 5.9
Recommend dialog.

A tools palette is available on this screen (a toolbar on the PC version) which provides graphical drawing tools. Like the boundary drawings on the Watershed screen, this graphical representation of the BMP is only indicative.

Other dialogues provide recommendations for a wide range of BMPs either directly imported from the literature or input within experience dialogues via user interaction. Figure 5.9 indicates a typical recommend dialogue.

The Recommendation Screen, which is always accessible, provides suggestions, recommendations and explanations on the different BMPs.

5.3 Conclusions

The BMP PLANNER prototype described here provides a unique first-order planning tool for a wide range of total catchment management applications. Additionally the tool offers considerable scope as a teaching aid for both experienced and non-experienced personnel involved in the planning and design of total catchment management schemes. It is being further developed by Farida Ahmed, a graduate student at the University of Guelph.

References

Schueler, T.R. (1987). Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments.