Computer Techniques in Environmental Studies IV

Editor: P. Zannetti, Failure Analysis Associates, Inc., California, USA

Computational Mechanics Publications
Southampton Boston

Co-published with

Elsevier Applied Science
London New York

Application of a Graphics Data Base Management System: Computerized Master Plan of Drainage

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Abstract

A Graphics Data Base Management System is developed for use with computerized Master Plans of Drainage. The Master Plans are prepared according to Agency specifications involving multiple hydrologic and hydraulic modeling options, integrated into a single software package. Data bases are prepared for graphical representation of streets, land uses, hydrologic soil groups, rainfall, master plan system elements, topographic, and other data, as well as computational results developed from the Master Plan of Drainage computer model. Two applications are available; an integrated package enabling editing and upgrading of the Master Plan, and another package designed to publish and distribute the Graphics and the Master Plan of Drainage data bases to the public in an access-only data base retrieval environment. The opportunities provided by such public information programs are significant, in that the entire Master Plan becomes available to the public in an easy-to-read and easy-to-use environment. The public therefore becomes an integral and important member of the Master Plan team, exchanging input and easing the way for acceptance of the project.

INTRODUCTION

An integrated hydrology/hydraulics/planning/deficiency-analysis Master Plan of Drainage computer model is developed which performs several master planning and engineering analysis tasks simultaneously. The computer modeling approach evaluates each link of the Master Plan of Drainage for deficiencies with respect to several defined street flow criteria, and determines mitigation measures of parallel and replacement systems. Because different hydraulic systems have different flow velocity characteristics, hydrology estimates are recomputed as the master plan is developed. Although small areas (less than about one square mile) are modeled by a rational method technique, the computer model integrates the small area hydrology techniques with the unit hydrograph technique for areas greater than one square mile.

The entire Master Plan is represented by a HydroGraphics Management System (or HMS) which allows for rapid communication of master plan data and estimates in graphical form. Two applications are developed:

Application 1: Graphical representation of data, and access to a data base retrieval system, which is noneditable, and which can be published and distributed to the public.

Application 2: Graphical database storage, and editing via an AutoCAD environment, wherein hydrologic, planning, topographic, and geographic data are accessible for processing in AutoCAD, and thence transferable to the Master Plan of Drainage computer model, with access to a data base retrieval system.

In the following, each major element of the above described HMS will be discussed. An application of HMS to an example Master Plan of Drainage will be used to demonstrate graphical display opportunities.

COMPUTERIZED MASTER PLAN OF DRAINAGE AND GRAPHICS DATA BASE MANAGEMENT SYSTEM

The total Master Plan of Drainage software package and data base system contains numerous elements and components that span several technical fields including data base management, geographic information systems (or GIS), hydrologic/hydraulic computer modeling, graphical data base management, flood control engineering and planning, among others. In the following is provided a brief survey of the key elements of the total software package.

Coupled Hydrologic Modeling Technique

Most flood control agencies at city, county or state leve specific procedures for the calculation of flood flow q Often the procedure may involve the use of two or more depending on conditions such as watershed size. In California, several county flood control districts require the u floodflow estimation techniques dependent on catchm namely, the rational method for areas smaller than a square mile, and the design storm unit hydrograph me areas larger than about one square mile. The transition techniques has been coupled into an integrated comp Master Plan of Drainage model, enabling the developmen first time, of an integrated hydrologic computer model pass of the analysis, rather than two separate studies. As a coupling hydrologic techniques into just one computer single system analysis is available for use in preparing Mas of Drainage and upgrading the master plan, thereby greatly the complexity, review process and cost involved.

Additionally, the new software enables all files to be that an entire Master Plan of Drainage may be updated in minutes after the proper changes have been made. This means that new peak flows, tributary areas, and even cost and drainage fee assessments can be easily updated to re changes that occur to the study area.

The Master Plan of Drainage software contains editing and computational elements that involve 152 hydr hydrologic submodels and global modeling commanc software enables analysis of an integrated open channel conduit flood control system on a study-wide basis.

Graphical Data Base

Several data base layers will be required to complete any h study. These layers will be created individually, however, be viewed simultaneously to show any hydrologic inf desired. These layers include:

1) Base Map consisting of contours and streets right-of-v
2) Watershed Boundary to define study boundaries.
3) Drainage Reservations to define alignments.
4) Existing Facilities to define alignments.
5) Street Flow to determine existing flows.
6) Alignments defined by layers 3, 4, and 5.
7) Subarea Boundaries defined by layers 5 and 6.
8) Overall Mapping Divides for Final Report.
9) Land Use Map.
10) Hydrologic Soil Group Map.

11) Rainfall Isohyetal Map.
12) Hydrologic Nodal Points defined by layers 6 and 7.
13) Hydrologic Element Type to define routing parameters.

Some layers, such as the base map, drainage reservations, existing facilities, land use, hydrologic soil group, and rainfall isohyetal maps may be available in digital form. If these layers are not available in digital form then they can either be digitized or scanned. The layers specifically related to the development of a Master Plan of Drainage can either be digitized from a marked up hard copy or directly drafted using AutoCAD.

Primary hydrologic parameters used in the Master Plan of Drainage computer model are land use, hydrologic soil group, rainfall, and hydrologic subarea topographic data such as area, length of water course, and elevation. In general, a study is discretized into subareas that are 10 to 20 acres in size. These subareas require definition as to each of the parameters listed above. Additionally, maps are needed in order to communicate these data. By obtaining in digital form or actually digitizing the land use maps, hydrologic soil group maps, rainfall maps, and subarea maps, not only is a digital/graphical representation available for display, but the data can then be processed by a "polygon processor" in order to partition the subareas into the intersection of all of the graphical layers. Geographic location is provided by use of street layout layers, right-of-way maps and freeway maps. The graphics data base is used to prepare hard-copy maps for reports, as well as graphical layers for display on the computer monitor. Figures 1 and 2 show hard copies of example graphical layers for a Master Plan of Drainage. Figure 1 depicts the land use map and Figure 2 depicts the hydrologic soil group map.

An acceptable base map is chosen and information such as subarea boundaries, alignments, and node numbers are added. This information is entered on a watershed basis. Once all this information is added, any desired layers are overlaid to create a hydrology map. Since these maps are created using AutoCAD, they can be reproduced at any scale. Additionally, each hydrology map becomes a "mapview" of the HMS, and thus, serves two purposes.

From each watershed map, the boundary is taken and overlaid with other watershed boundaries to create quadrant maps. These quadrant maps along with an index map are the navigational tools by which the user can locate any specific location in the study area.

There are also several by-products that are crea updated throughout the entire duration of the MPD dev process or prepared in advance.

1. Drawing database file (.DWG type) - used to create t of the index map and quadrants. It contain information and outlines of all individual watersh their corresponding numbers, and project boundary.

2. Drawing database file (.DWG type) - containing hy land use information; color-coded with uniqu patterns for every land use type.

3. Drawing database file (.DWG type) - containing hy soil group information; color-coded with uniqu patterns for every soil group.

4. Drawing database file (.DWG type) - containing i rainfall information used in the hydrologic software. an option which is not necessary in all projects.

5. "Polygon Processor" output files (.OUT type) - f watershed processed by this program. It includes inf on every subarea in the watershed, in easy to rea efficient, tabulated form.

Polygon Processor

The use of geographic information systems (GIS) has widespread in many facets of engineering and planning, other fields. A key element of a GIS is the ability to graphical layers so that the several forms of informa resolved into "cells" wherein all parameters are constant. depicts the resolution of several graphical layers of informa homogeneous cells.

In the Master Plan of Drainage, each subarea definition of land use, hydrologic soil group, and rainfall, proportions of each within the subarea. The polygon p performs this important task, and then develops a data bas in the Master Plan of Drainage computer model. The suba are stored in tabled formats, on a subarea basis, indexed acco subarea number. Thus, the retrieval of a specific subarea will access these several data, automatically developed polygon processor. This GIS related processing is base software developed for this application, and is part HydroGraphics Management System; that is, anoth proprietary package is not required.

copy print-outs. Similarly, report technical appendices can be prepared using the Master Plan of Drainage data base.

Application to Sewer, Water and Environmental Systems

Extension of the Graphics Data Base Management System to use in sewer, water, and environmental systems is straightforward and has been accomplished in several applications in Orange County, California. Both Applications 1 and 2 follow the procedural steps described for Master Plans of Drainage. A key element to use with other systems is the availability of an integrated processing model -- such as readily available integrated sewer and water system models. In the application described herein, the development of an integrated Master Plan of Drainage computer model was a crucial step in the evolution of the Graphics Data Base Management System approach for Master Plans of Drainage.

CONCLUSIONS

A graphics data base management system for computerized Master Plans of Drainage is developed. Two applications are prepared which enables the agency to upgrade the Master Plan in the future, and to publish the Master Plan in computer graphics form for distribution to the public. Because of the ease of communication opportunities afforded by this approach, the utility in Agency public information programs may be significant.

REFERENCES

1. Hromadka II, T.V., 1983, Computer Methods in Urban Hydrology, Rational Methods and Unit Hydrograph Methods, Lighthouse Publications.

2. Hromadka II, T.V., Durbin, T.J., and DeVries, J.J., 1985, Computer Methods in Water Resources, Lighthouse Publications.

3. Hromadka II. T.V., McCuen, R.H., and Yen, C.C., 1987, Computational Hydrology in Flood Control Design and Planning, Lighthouse Publications.

4. Hromadka II, T.V., 1988, Computational Hydraulics of Irregular Channels, Lighthouse Publications, 270 pgs.

5. Hromadka II, T.V., Durbin, T.J., DeVries, and J.J., 1990, Computer Methods in Water Resources and Environmental Engineering, Lighthouse Publications, 450 pgs (in-press).

APPENDIX A
HYDROGRAPHICS GENERAL APPROACH SUMMA
APPLICATIONS 1 & 2

1. REQUIRED IMAGE LAYERS
   - A. STREET - DIGITAL DATA BASE
   - B. LAND USE - DIGITIZED
   - C. HYDROLOGIC SOIL TYPE - DIGITIZED
   - D. RAINFALL ISOHYETAL - DIGITIZED
   - E. SUBAREA - DIGITIZED
   - F. ALIGNMENT - DIGITIZED

2. STEPS FOR GRAPHICS BASE MAP PREPARATION
   - A. TRANSFER DATA BASE FROM VAX TO PC (ALL LAYERS
   - B. CHECK ALIGNMENT OF LAYERS AND SCALE (ALL LAY
   - C. CHOOSE COLORS FOR LAYERS
   - D. CLOSE LAYERS IN COUNTERCLOCKWISE DIRECTION

3. STEPS FOR CREATING A GRAPHICS WATERSHED MAP
   - A. OUTLINE WATERSHED MAP
   - B. CHOOSE FRAME LOCATION
   - C. TRIM WATERSHED FROM GRAPHICS BASE MAP

4. STEPS FOR PREPARING GRAPHICS WATERSHED MAP
   - A. CLOSE SUBAREAS IN COUNTERCLOCKWISE DIRECTIC
   - B. ADD NODE NUMBERS
   - C. ADJUST DRAINAGE ALIGNMENT
   - D. INSERT STREET NAMES
   - E. POLYGON PROCESSING

5. STEPS FOR MODIFYING DATA BASE FORMAT
   - A. DESIGN DATA BANK TO AGENCY REQUIREMENTS
   - B. CUSTOMIZE PROGRAM FOR SPECIFIC MAPS AND DAT/
   - D. ASSEMBLE DATA BANK FROM MASTER PLAN SOFTWA

6. STEPS FOR MAKING GRAPHICS WATERSHED MAP SLIDES
   - A. MERGE APPROPRIATE LAYERS (SELECTED BY AGENCY
   - B. ADD GRAPHICS WATERSHED NUMBERS

7. STEPS FOR MAKING DATA BANK NAVIGATION MAPS
   - A. MERGE GRAPHICS WATERSHED MAP BOUNDARY ANI LAYER
   - B. ADD GRAPHICS WATERSHED NUMBERS
   - C. MAKE SLIDE OF PRODUCT

8. STEPS FOR MAKING OVERALL DATA BANK INDEX MAP
   - A. MERGE STUDY BOUNDARY AND STREET LAYER
   - B. ADD QUADRANT NUMBERS
   - C. MAKE SLIDE OF ENTIRE STUDY AREA

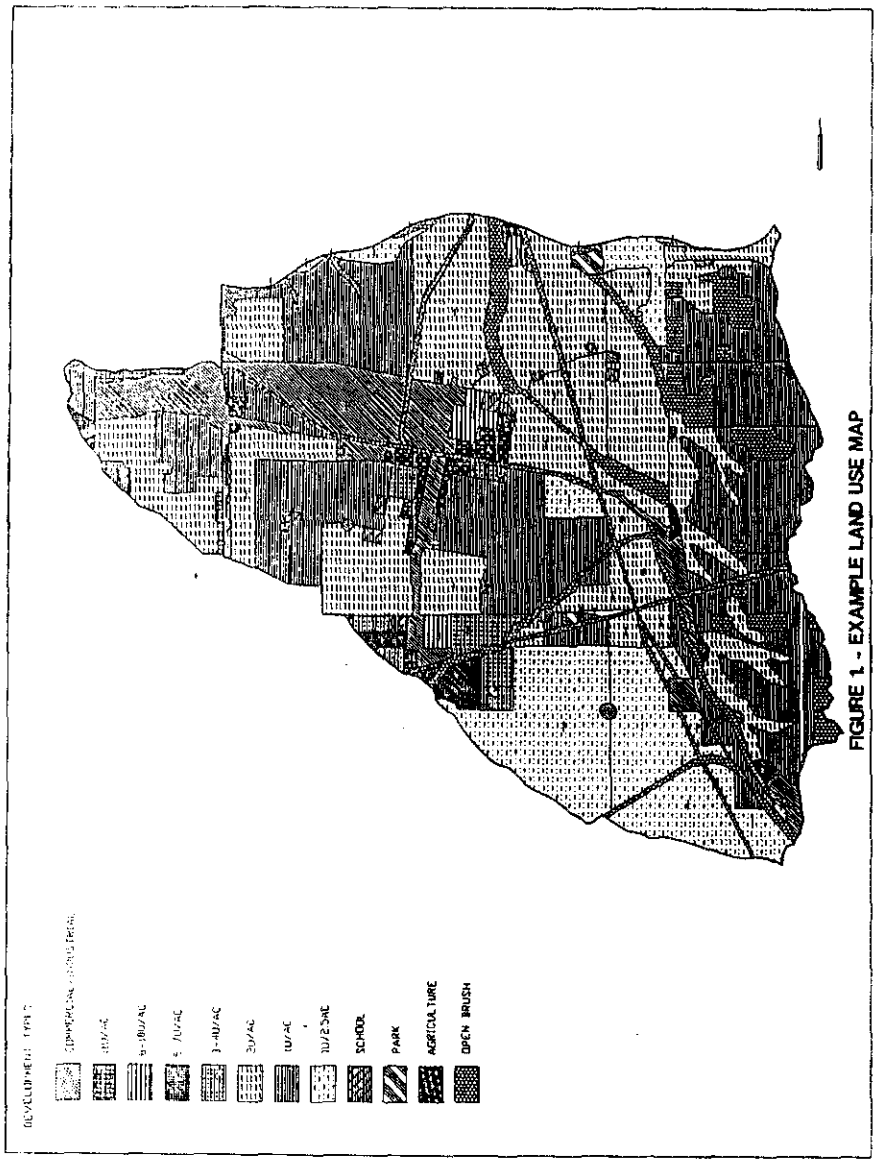
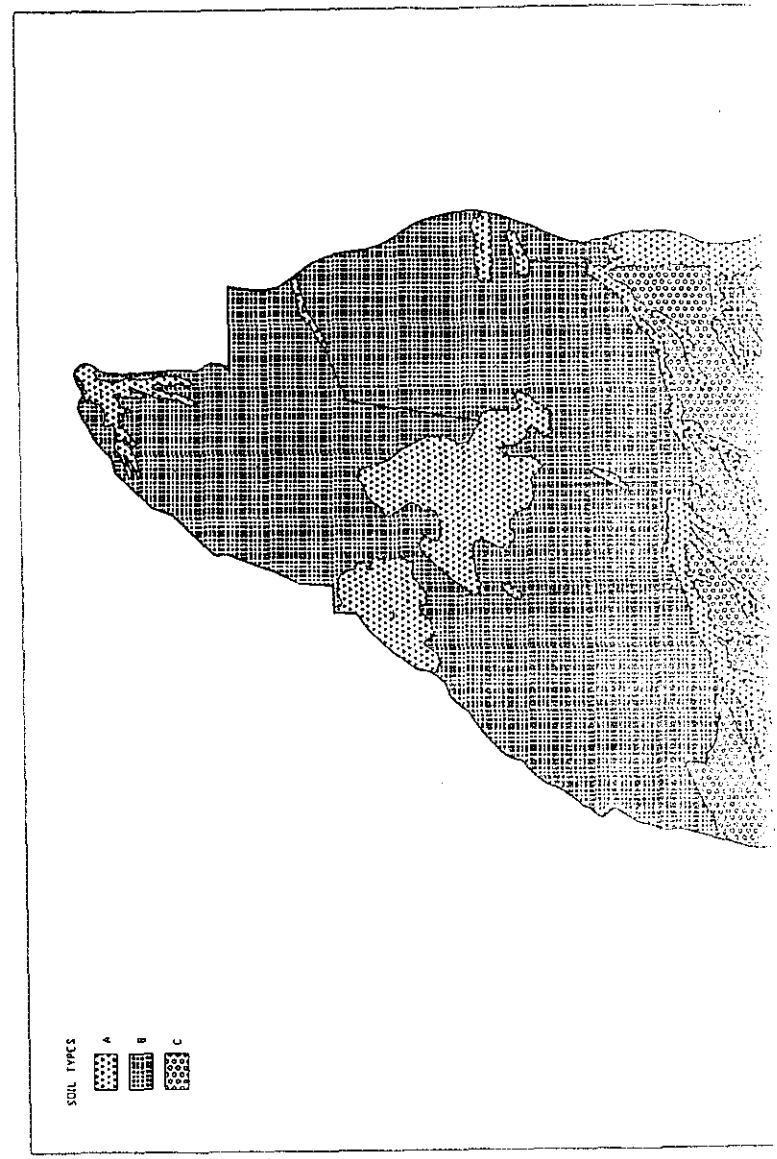


FIGURE 1 - EXAMPLE LAND USE MAP



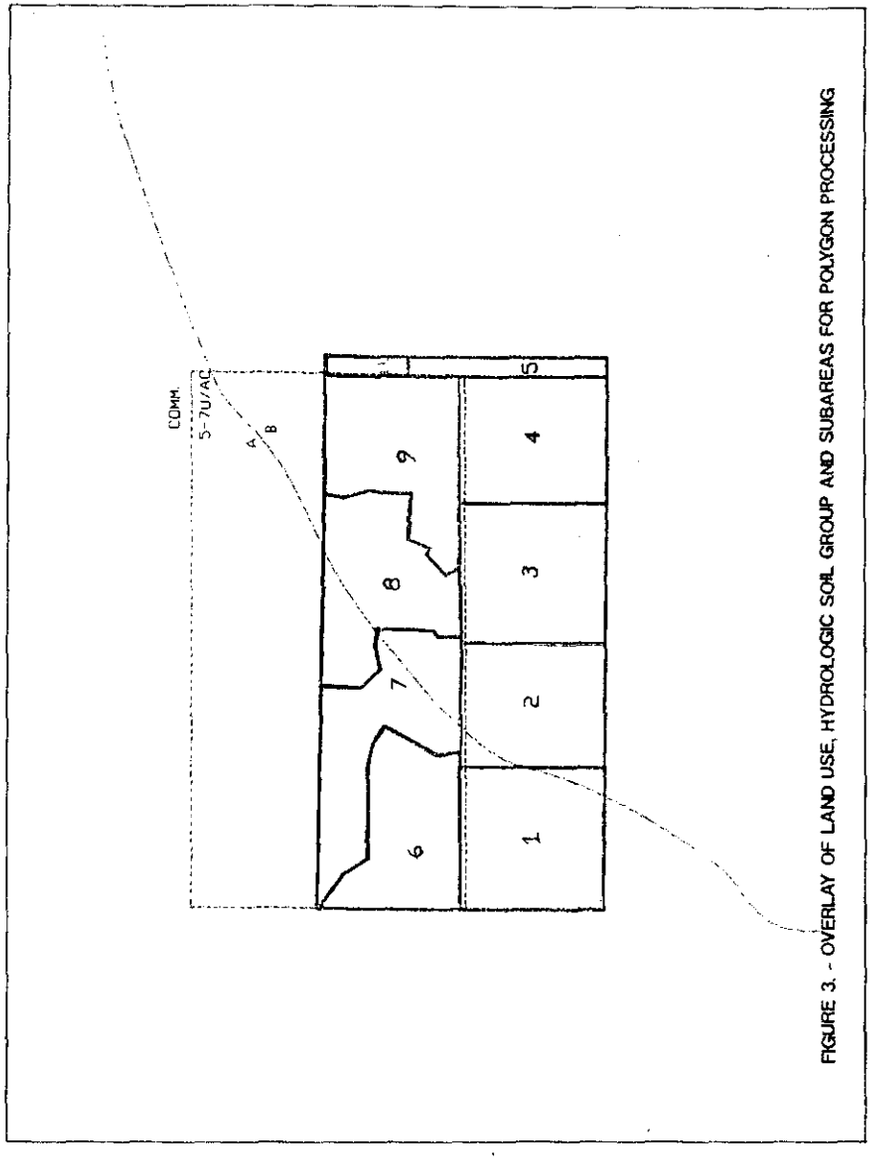


FIGURE 3. - OVERLAY OF LAND USE, HYDROLOGIC SOIL GROUP AND SUBAREAS FOR POLYGON PROCESSING