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COMPREHENSIVE FLOOD PLAIN STUDIES USING SPATIAL DATA MANAGEMENT TECHNIQUES[1]

Darryl W. Davis[2]

ABSTRACT: A pilot study undertaken to develop and test analytical methodologies for application in comprehensive flood plain information studies is described. The methodology permits and encourages comprehensive, systematic, practical assessments of present and alternative future basin-wide development patterns as reflected by alternative land use patterns and physical works in terms of flood hazard, economic damage potential and selected environmental consequences. The analysis methodologies are centered about integrated use of computerized spatial, gridded geographic and resource data files. A family of special purpose utility computer programs access the data file and extract appropriate variables and interpret and format the data into specific analytical parameters that are subsequently formatted for input to traditional modeling computer programs. An example application to Trail Creek in Clarke County, Georgia, is described.
(KEY TERMS: planning; flood plain management; computer modeling; spatial analysis; data management; flood damages; environmental assessments; urban hydrology.)

INTRODUCTION

Comprehensive flood plain studies undertaken by the Corps of Engineers in recent pilot studies require systematic evaluation of present and alternative future basinwide development patterns that are characterized by alternative land use patterns and physical works. The evaluation is needed for assessing present and possible future flood hazards, economic damage potential, and environmental consequences so that conscious choices may be made by local governmental agencies among possible future development patterns. Spatial data management techniques are employed within a traditional analysis framework to permit and encourage the comprehensive systematic assessments that are needed. This paper provides an overview of the data management and other specific analytic techniques developed, and presents selected results from a test application.

OVERVIEW

The general analytical strategy is to 1) assemble and catalogue basic geographic and resource information into a computer data bank; 2) cooperatively, with local agencies,

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forecast and place into the data bank selected alternative future development patterns; 3) perform comprehensive assessments of the selected alternative futures by use of the data bank and supporting computer programs; and 4) document the assessment for study by the general public and community officials. Subsequent assessment services would be provided by the Corps on a continuing basis at local agency request. Specific development proposals would be assessed, land use development policies analyzed and informed technical guidance provided by the Corps to the local officials.

The analytical techniques developed center on integrated use of computerized spatial, gridded geographic and resource data files. Data such as existing and alternative future land use patterns, topographic elevation and slope, soil properties, hydrologic subbasins and environmental habitats are encoded and placed in a permanent computerized grid cell data file. A family of special purpose utility computer programs access the files, select, coordinate and interpret the data for selected variables into specific parameters that are subsequently formatted for input to traditionally used computer modeling programs. The utility and modeling programs perform the comprehensive analysis.

A basic concept is to use traditional analysis methods where possible and provide for automation of analysis and displays where appropriate, while providing the capability to perform consistent analysis over a very broad range of detail. For instance, one might wish for a general assessment of an entire urban watershed unit of 20 sq. miles for an alternative future land use pattern, and desire to have the analysis with a minimum of prior data preparation, i.e., essentially only have available the proposed land use pattern. In a different situation, one might wish a specific assessment of a portion of a tributary area of say one sq. mile of the 20 sq. miles where a 300-acre shopping center with attendant surface drainage works such as channel straightening and lining and detention storage are proposed. These extreme levels of detail are accommodated by providing the capability for automated computer analysis that can be interrupted at a number of stages during the computations and more detailed specifically tailored data substituted for the automatically generated data.

Flood hazard evaluations involve computation of flow rates for events of interest (e.g., several events ranging from the 5- to 100-year exceedance interval magnitude) for designated control points, and the corresponding water surface elevations and flooded area delineation. The modeling programs that perform the analysis are the traditional Corps of Engineers hydrologic engineering programs. The hydrologic modeling program parameters are determined automatically from the computerized data files.

The economic damage potential is characterized by selected event (such as the 100-year exceedance interval event) damage potential and expected annual damage at designated control points. The analysis develops elevation damage relationships by automated analysis of land use and topographic data from the grid data file that is subsequently input to a traditional hydrologic engineering computer program that performs the damage assessments.

The environmental assessment consists of tabulating land use/environmental habitat coincidents, computation of urban stormwater runoff (quantity and quality), land surface erosion and in-stream water quality using other Corps of Engineers computer programs. The data and parameters for the analysis are automatically generated from the computerized data files.

The methods were applied to a small test area of a larger pilot study (U.S. Army Engineer District, Savannah, 1975) for the purpose of testing, debugging, and concept refinement. The pilot study is projected for completion in early 1977. The test area for which results are shown is the Trail Creek watershed which occupies about 12 sq. miles of the pilot study area of 300 sq. miles and includes a portion of the city of Athens, Georgia. The test area is presently about 10 percent urban and expected to grow to 20 to 30 percent urban by 1990. The data bank created for Trail Creek included the 15 data variables shown in Figure 1 at a grid size of approximately 1.1 acres (Hydrologic Engineering Center, Trail Creek, 1975).

HEC-SAM

The HEC-SAM system, assembled to perform these studies, is comprised of a family of data management and analysis computer programs that service the full range of comprehensive assessments. Figure 1 presents a functional flow diagram of the analysis process and input and output results. About 1/3 of the links shown on the diagram for the Interface and Analysis programs are presently automated and these links are intended to be highly automated in the near future.

The system has three distinct functional elements: Data Bank Management, Data Bank Processing Interface, and Comprehensive Analysis. The data bank management element is comprised of the subfamily of computer programs required to process raw map or other type data into the grid cell format that becomes the general data bank. This includes a program that permits displaying data digitized in the grid cell format (GRID, Harvard, 1971), a program that displays data digitized in the polygon format and generates grid cell data from polygon format data (AUTOMAP II, Environmental Systems Research Institute), special-purpose programs to create grid topographic data from digitized contour lines (TOPO, LINES), and programs to properly register polygon data to the base grid coordinates (REGISTER) and place the grid data into the general data bank (BANK).

The Data Bank Processing Interface element is comprised of the subfamily of computer programs that compile and reformat geographic and resource data retrieved from the data bank into a form processable by the general analysis computer programs. The programs service the functional analysis areas of flood hazard, flood damage and environmental status. HYDPAR links the data bank to the flood hazard analysis by retrieving the data variables of hydrologic subbasins, slope, soil group and land use to generate the modeling parameters required to simulate storm runoff. HYDPAR also provides links to the environmental analysis by retrieving land use, soil and subbasin data from the data bank and generating modeling parameters required to simulate the quality of urban storm runoff and land surface erosion. The link between the data bank through HYDPAR to the analysis program STORM is completely automated. DAMCAL links the data bank to the flood damage analysis by retrieving the data variables of damage reach, land use, topography and reference flood to generate elevation-damage tables by land use category and damage index location for subsequent integrated analysis. ATODTA also serves the flood damage analysis by restructuring the DAMCAL generated data, interfacing it with hydraulic and hydrologic probability data and providing an automated link to the general hydrologic and damage analysis program HEC-1. The linkage from the data bank through DAMCAL and ATODTA to the analysis program is completely automated.

The Comprehensive Analysis element is comprised of the general simulation and analysis computer programs that perform the detailed technical assessments that compare the existing condition to the development condition of interest. In most instances the final analysis computer programs are standard Corps of Engineers analytical tools that have

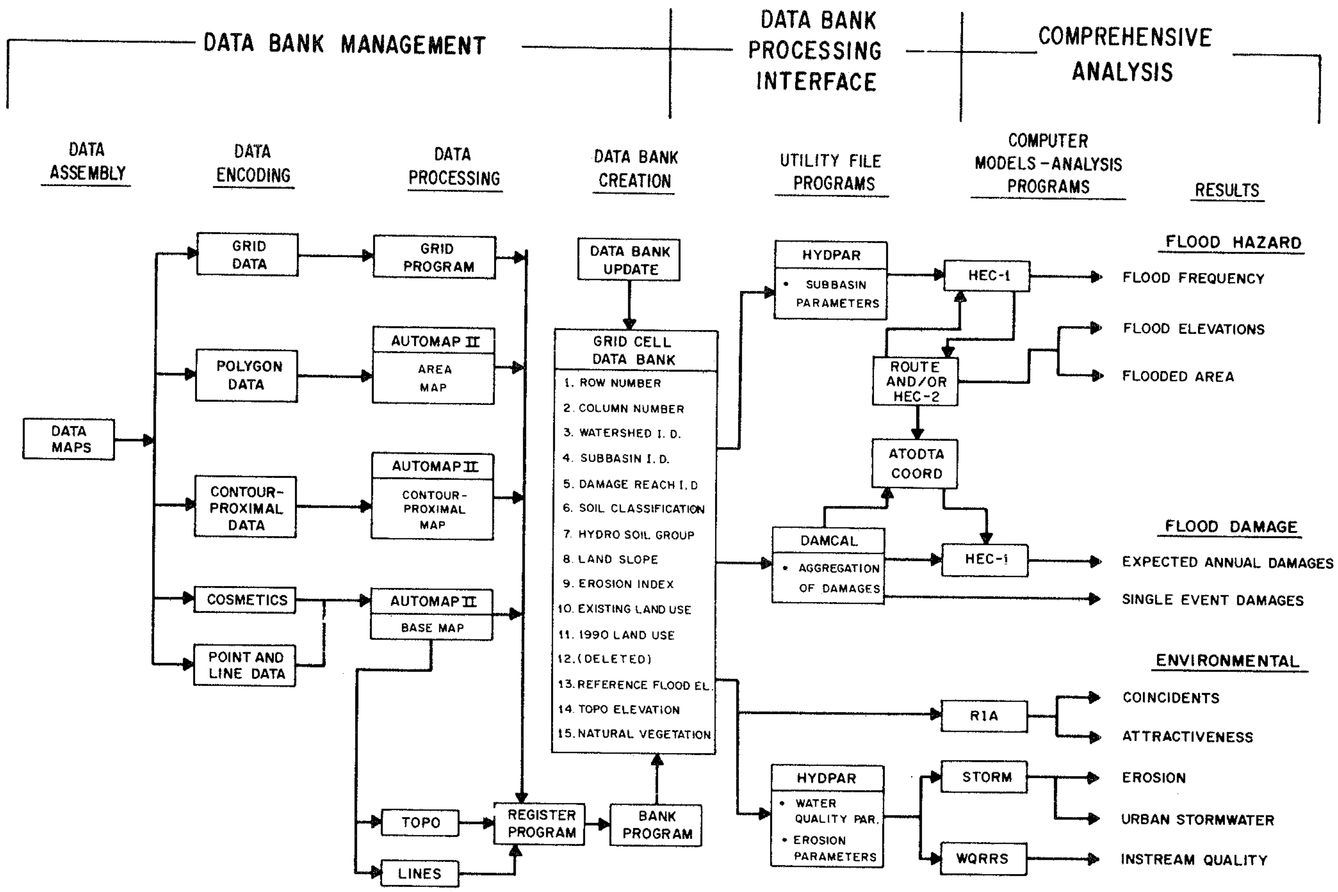


Figure 1. Spatial Data Management and Comprehensive Analysis System (HEC-SAM).

been in use a number of years and are thus familiar to potential Corps users. Some programs have been slightly modified to interface with data being generated from the data bank rather than in their usual formats. In a few instances basic modifications were made to the programs to permit or encourage a more systematic analysis process (than traditional) to take advantage of the opportunities offered by ready access to a comprehensive data bank. HEC-2 (The Hydrologic Engineering Center, 1976) has served the Corps many years in performing river hydraulic analysis and is used in its traditional form. HEC-1 (The Hydrologic Engineering Center, 1976) serves the double duty of general hydrologic simulation to forecast the hydrologic effects of development proposals and also integration of the hydrologic with economic damage data to provide the assessment of the expected value of annual damages (average annual damages) resulting from development alternatives. The RIA program operates by direct link to the data bank and performs coincident, attractiveness and vulnerability analysis, and general grid mapping. The program is adapted from work by Harvard (Honey Hill, IRW Report 71-9), and makes use of a modified version of the general grid plot program GRID. STORM and WQRRS (The Hydrologic Engineering Center, 1976) are recently developed Hydrologic Engineering Center computer programs that forecast urban storm water quality and dynamic instream water quality response to waste loadings from treatment plants and urban storm runoff.

The system envisions that the data normally used during comprehensive planning studies would be encoded and processed onto a computer storage device (such as tape or disc) by application of the various Data Bank Management programs. The specific programs used would depend on the form in which the digitized data is received; either point, grid, contour or polygon, the form being dependent upon the nature of the variable and the relative advantages and disadvantages of alternative encoding methods. The initial input data are the basic resource maps that are encoded and placed into the data bank. Analysis would be performed for a selected development condition (alternative future, e.g., a projected land use pattern with a certain flood hazard zoning policy) by processing the development into the data bank as a new variable and successively executing the Interface and Comprehensive Analysis programs. The specific executions that are performed would be dependent upon the specific nature of the alternative future that is assessed.

The comprehensive assessments require specific input data such as the hydrologic structure of the area, stream geometry, calibrated storms, relationships between land use and runoff, damage potential, storm pollutant washoff, etc. The initial modeling calibration data is prepared conventionally based on observed data supplemented by parameters generated from the data bank and then the calibration data is used as the mechanism for forecasting the change in modeling data that would be caused by development alternatives.

The system output includes 1) grid map graphic displays of the data variables, attractiveness, and impact analysis results; and 2) detailed numeric printout of runoff hydrographs, flow exceedance frequency relationships, expected annual damages, storm pollutographs and time traces of erosion and a range of water quality parameters for existing and the selected alternative future development patterns. The output corresponds to the complete range of technical output of comprehensive flood plain assessments.

LAND USE

Land use is a key factor in the analysis. It is used as the primary indicator of development status and analytical methods key on it to forecast the hydrologic, economic, and environmental consequences of existing and alternative future development patterns.

The development and use of a reasonable set of land use categories received special attention because of the critical land use focus of the techniques. The criteria applied to determine a rational set of land use categories included compatibility with local agency classification systems, potential for automatic classification by use of remote sensing technology, and responsiveness to technical requirements needed to perform hydrologic, economic, and environmental analysis.

Table 1 defines the describes the characteristics of each of the ten categories adopted for the test studies. The pilot study and consequent studies have made use of as many as 22 categories. Ideally, the existing and alternative future land use patterns will be available from local planning agencies and used for analysis. In most instances, however, future patterns will be developed by the local agency and the study staff working together. Figure 2 displays computer-printer plots of the Trail Creek existing 1975 land use and a selected alternative future 1990 projected land use patterns. The distribution of land use within Trail Creek for these land use patterns is tabulated in Table 1.

FLOOD HAZARD EVALUATION

The objective of the flood hazard evaluation that is the usual product of flood plain information studies are the spatial and elevation description of specific hydrologic events such as the 100-year exceedance interval flood. The analysis normally consists of hydrologic studies to define flows and exceedance frequencies, hydraulic studies to relate flow to stage and thus develop water surface elevation profiles, and mapping studies to relate the water surface elevation profiles to flooded area, usually presented as outlines of flooded area.

The methods of analysis developed for the pilot study are consistent with the objectives and the methods that have been used in past studies, but several tasks associated with obtaining basic hydrologic modeling data have been substantially automated so that large scale, relatively rapid analysis of future land use patterns is possible. The 'flood hazard' portion of Figure 1 depicts the overall flood hazard evaluation process developed for the pilot study.

Hydrologic Studies

The basic strategy is to generate hydrologic simulation program HEC-1 model parameters automatically from the grid cell data bank, develop routing criteria from a special utility program, and execute HEC-1 for a range of synthetic events (such as the 100-year event) using the generated model parameters to develop flow frequency curves, and convert selected flows at selected control points to stage and area flooded by conventional analysis using stream profile program HEC-2, and topographic map analysis to delineate flooded areas.

An HEC-1 model requires precipitation, loss rates, unit hydrographs and routing criteria to be developed. The rainfall-runoff computation methods of the U.S. Soil Conservation Service (SCS) (National Engineering Handbook, U.S. Soil Conservation Service)

TABLE 1. Adopted Land Use Categories, Trail Creek

	Category	Distribution of Land Use (Percent) 1975	1990
1.	NATURAL VEGETATION – Heavy weeds, brush, scrub areas, forest, woods.	52.4	21.9
2.	DEVELOPED OPEN SPACE – Lawns parks, golf courses, cemeteries.	2.6	1.1
3.	LOW DENSITY RESIDENTIAL – Single family: 1 unit per ½ to 3 acres; average 1 unit per 1½ acres. Areal breakdown: 5% structures, 10% pavement, 50% lawns, 37% vegetation.	3.9	4.9
4.	MEDIUM DENSITY RESIDENTIAL – Single family: Typical subdivision lots; 1 unit per 1/5 to 1/2 acre. Average 1 unit per 1/3 acre. Areal breakdown: 10% structures, 15% pavement, 45% lawns, 30% vegetation.	2.3	11.6
5.	HIGH DENSITY RESIDENTIAL – Multi-family: Row houses, apartments, townhouses, etc.; structures on less than 1/5 acre lots; average 1 unit per 1/8 acre. Areal breakdown: 25% structure, 15% pavement, 35% lawns, 25% vegetation.	0.5	4.4
6.	AGRICULTURAL – Cultivated land, row crops, small grain, etc.	28.0	8.6
7.	INDUSTRIAL – Industrial centers and parks, light and heavy industry. Average 1 plant per 8 acres. Areal breakdown: 20% pavement, 50% structures, 30% open space	1.0	12.4
8.	COMMERCIAL – Shopping centers and "strip" commercial areas. Average 3 structures per acre. Areal breakdown: 30% structures, 5% lawns, 10% vegetation, 55% pavement.	1.6	6.1
9.	PASTURE – Livestock grazing areas, ranges, meadow, agricultural open areas, abandoned crop land.	6.8	25.1
10.	WATER BODIES – Lakes, large ponds, major streams, rivers	0.9	3.9

were adopted for the Trail Creek study and incorporated into HEC-1 to form the basic tool for hydrologic computations. The SCS methods were adopted because at present they represent a generally available technique that is responsive to land use considerations and the methods have experienced large scale applications and could be readily automated. Loss rates are characterized by a curve number (CN) which is a function of land cover (land use) and soil characteristics (hydrologic soil group). The subbasin response to

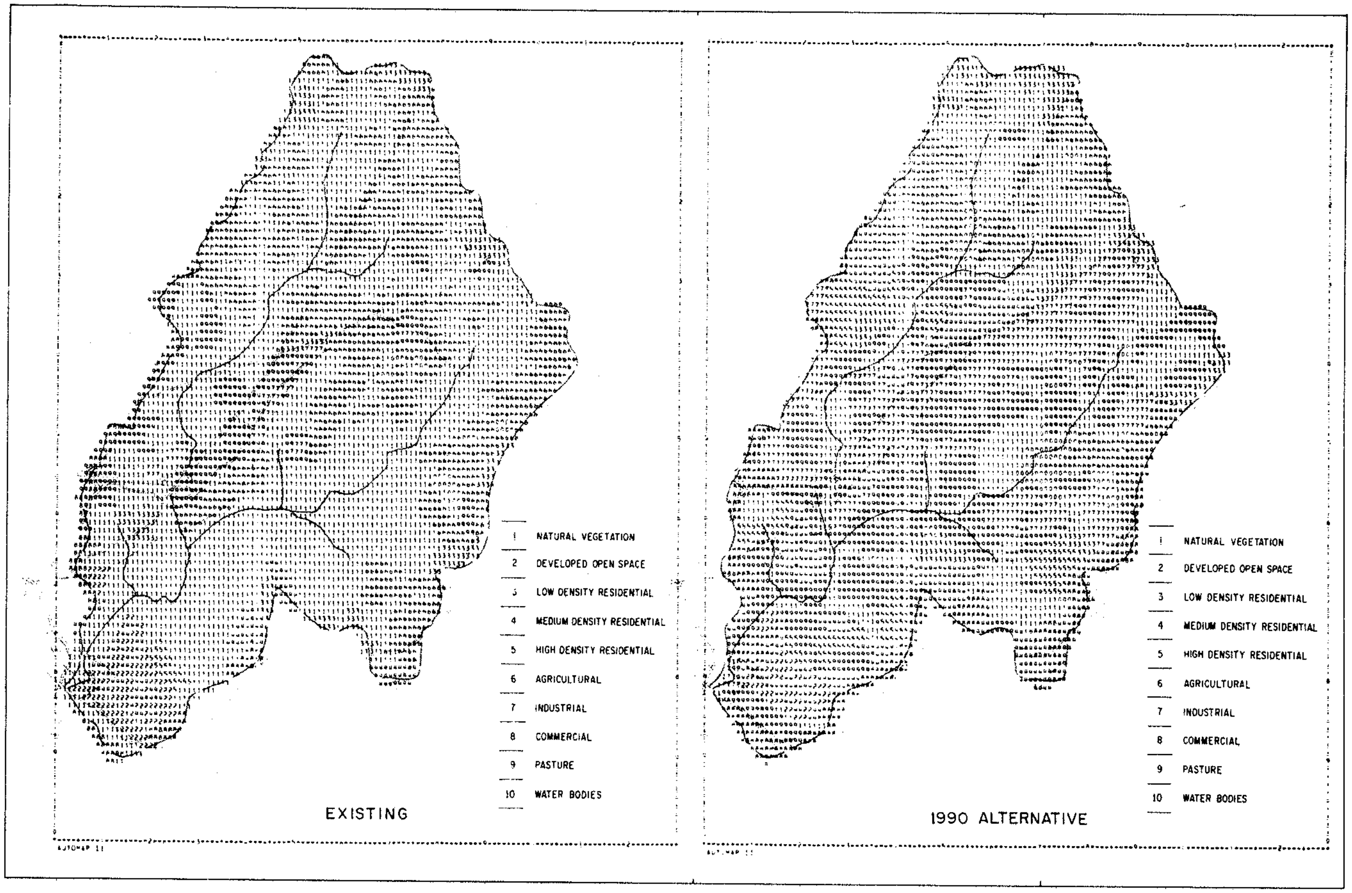


Figure 2. Existing and 1990 Land Use Patterns, Trail Creek.

precipitation excess is characterized by a unit hydrograph which is directly determined from basin "lag" that is computed as a function of the curve number, mean land surface slope within the subbasin and subbasin hydraulic length. Conventional calibration studies are performed to develop the appropriate relationships between land use and the hydrologic parameters (CN and lag).

The respective subbasin mean curve numbers for an alternative land use pattern are determined automatically by assigning the calibrated curve number to each grid cell within each subbasin depending upon the grid cell hydrologic soil group and grid cell land use, and computing the mean value for each subbasin. The average subbasin land surface slopes are computed in a similar manner. The lag, and thus unit hydrograph is developed from an empirical lag equation containing relationships of curve number, land surface slope, and subbasin hydraulic length. The technique adopted is a modest extension and automation of the method developed for San Diego County (Franzini, *et al.*, 1971).

Trail Creek Test Application

The Trail Creek Watershed was subdivided into the 21 subbasins shown on Figure 3 and HEC-1 model parameters were determined for each. The loss rate functions (CN's) and unit hydrograph lags were determined automatically from the grid cell data file using the calibration data developed and tabulated in Table 2. Table 2 also summarizes the hydrologic parameters for each subbasin that were automatically developed from the grid cell data file by the data processing interface computer program HYDPAR.

Table 3 summarizes the results of evaluating the alternative conditions indicated. Note that the flow rate increases for each of the specified probabilities but at a less proportionate rate for rarer events. Note also that the flow rate change for say the 100-year event is different between control points and that the change in flood elevation is not directly proportional to the change in flow. Study of the table indicates that the hydrologic consequences of land use and engineering works are complex and require careful analysis.

FLOOD DAMAGE ANALYSIS

The objective of the analysis is to evaluate the damage potential of alternative land use patterns and/or specific development proposals. The existing conditions (1975) land use pattern is evaluated with no assumptions as to land development controls (e.g., the development exists). An alternative future land use pattern evaluation requires examination of policy assumptions regarding land use development controls. A method was developed to automatically extract information from the data file and format it for expected annual damage assessments for the alternative land use patterns for alternative land use development policies that consisted of generating damage potential functional relationships from the grid cell data bank. The method constructs a unique elevation-damage relation for each grid cell within the flood plain (based on ground elevation, land use, and damage potential) and aggregates the individual cell damage functions to an index location for each designated damage reach. The technique for aggregating the damage functions is similar to the conventional method of using a reference flood to properly reference each cell to the designated index location. The damage functions are merged with hydrologic (flood frequency) and hydraulic (rating curve) data within the HEC-1 program and expected annual damages for each damage index location, land use category, and evaluation condition is computed.

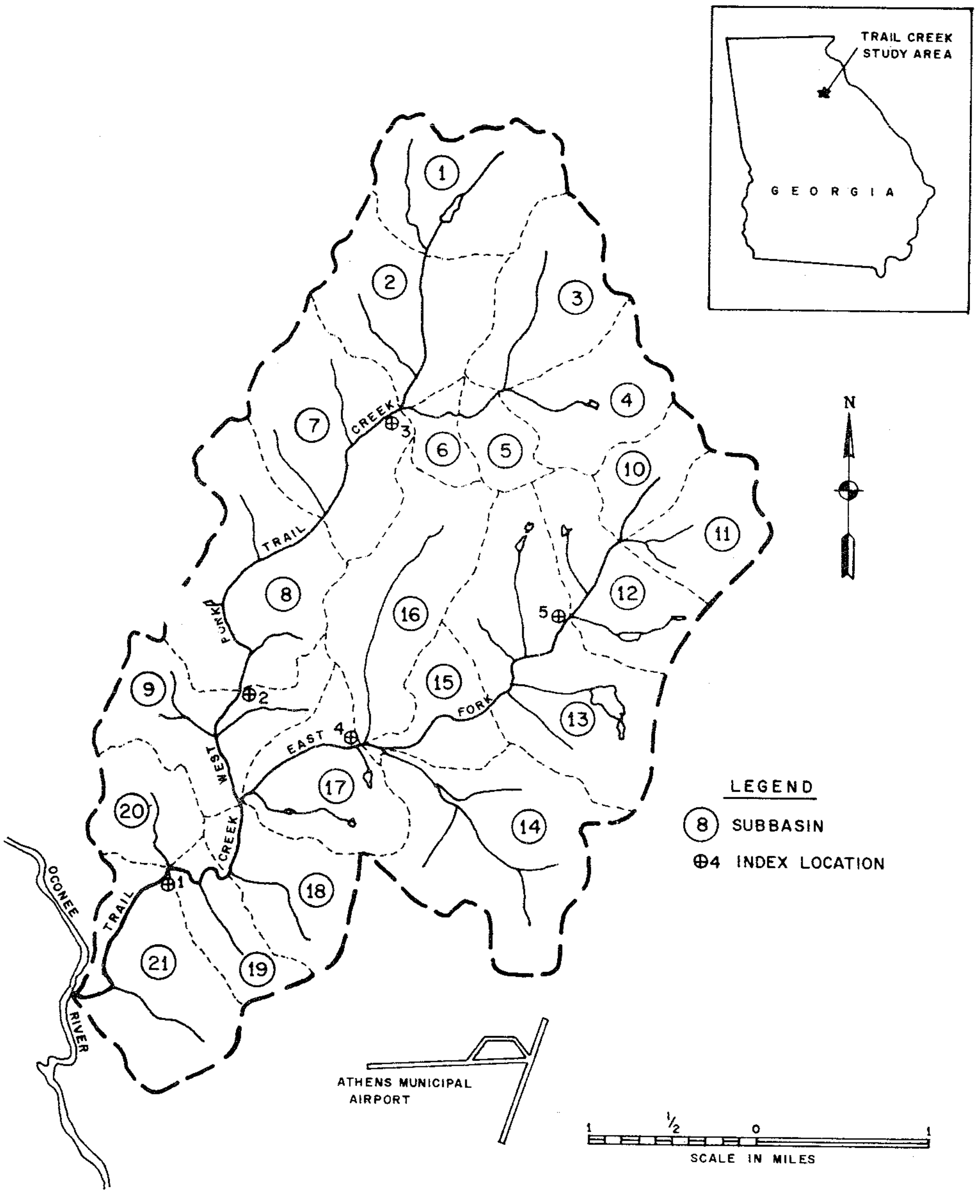


Figure 3. Location Map, Trail Creek.

TABLE 2 Calibration and Model Parameter Summary, Trail Creek

Land Use Category	Title	HYDROLOGIC SOIL GROUP A	B	C	D
1	Natural Vegetation	36	60	73	79
2	Developed Open Space	39	61	74	80
3	Low Density Residential	47	66	77	81
4	Medium Density Residential	61	75	83	87
5	High Density Residential	80	85	90	95
6	Agricultural	67	78	85	89
7	Industrial	83	88	92	96
8	Commercial	95	96	97	98
9	Pasture	49	69	79	84
10	Water Bodies	100	100	100	100

DERIVED PARAMETER SUMMARY
TRAIL CREEK

Subbasin Number	Drainage Area Sq. Mi.	Percent of Watershed	Average CN Exist.	Average CN 1990	Subbasin Lag (Hrs) Exist.	Subbasin Lag (Hrs) 1990
1	0.71	5.58	68.3	65.7	0.63	0.67
2	0.74	5.79	69.6	75.9	0.85	0.71
3	0.58	4.55	73.7	72.8	0.77	0.79
4	0.50	3.90	67.4	74.6	0.79	0.65
5	0.22	1.76	70.6	78.9	0.53	0.42
6	0.16	1.22	73.4	72.7	0.40	0.41
7	0.82	6.44	71.3	73.8	0.80	0.74
8	1.01	7.89	66.9	79.0	1.02	0.73
9	0.66	5.21	66.9	80.7	0.73	0.53
10	0.30	2.32	64.1	70.9	0.67	0.56
11	0.44	3.45	72.0	67.5	0.66	0.74
12	0.57	4.50	72.3	77.0	0.65	0.57
13	1.15	8.97	70.4	78.8	0.86	0.68
14	1.15	8.99	66.2	74.0	1.05	0.85
15	0.30	2.32	62.7	70.3	0.82	0.67
16	0.87	6.82	70.8	76.6	1.04	0.88
17	0.59	4.59	65.8	71.1	0.90	0.77
18	0.51	3.97	64.6	73.8	0.59	0.46
19	0.32	2.47	63.2	74.8	0.79	0.58
20	0.36	2.79	64.6	76.5	0.54	0.39
21	0.82	6.46	66.6	76.9	0.70	0.53

A more general damage analysis than the traditional structure by structure aggregation, and analysis as is normally performed, seems appropriate for assessment of alternative land use patterns. The adopted approach thus was construction of composite damage relationships by land use category rather than by individual structures. A composite damage function, defined as a stage-damage per unit area function, is constructed by averaging structural and content values of sampled field data for each land use category and developing similar data for categories without structures such as for the category developed open space. The composite damage function for the agricultural category was generalized to represent an agricultural enterprise in that the function considered a typical mix of farm structures, crops, farm machinery, livestock, etc.

TABLE 3. Hydrologic Data Summary, Trail Creek.

100-YEAR PEAK FLOW AND ELEVATION

Index Station	Existing Land Use Flow (cfs)	Existing Land Use Elevation	1990 Land Use Flow (cfs)	1990 Land Use Elevation
1	7600	627.1	9400	628.3
2	3450	656.4	3800	656.7
3	2600	711.9	2900	712.2
4	3900	650.3	5100	651.2
5	1600	694.2	1650	694.3

FLOW-EXCEEDANCE INTERVAL DATA
(cfs)

Exceedance Interval (yr)	Index Station 1 Exist	1 1900	2 Exist	2 1990	3 Exist	3 1990	4 Exist	4 1990	5 Exist	5 1990
5	2000	2800	950	1200	800	960	1100	1700	500	570
10	3000	3900	1350	1650	1100	1300	1600	2300	700	780
25	4400	5600	2000	2400	1600	1850	2300	3300	1000	1100
50	5800	7300	2650	3000	2100	2350	3000	4000	1250	1350
100	7600	9400	3400	3800	2700	3000	4000	5200	1600	1700

The composite damage function data is prepared by land use category and the DAMCAL program then accesses the grid data file and computes elevation-damage relations for the land use categories and damage reaches. The damage function aggregation for future land use can be accomplished so that all designated new land use (change from existing) will be placed no lower than a prescribed policy elevation, such as the existing 100-year flood level, and development control policy, such as flood proofing to the ground floor will be accounted for. Alternative land use control policies can thus be easily and quickly evaluated.

Table 4 summarizes selected expected annual damage assessments for a range of conditions and land use control policy sets for damage reaches within the Trail Creek watershed that sustain significant damages.

The results are somewhat surprising and at first glance may be difficult to understand. An initial reaction might be that evaluation condition CODE IV should be similar to

CODE I since the policy of no new development occurring at elevations below the 100-year event is in effect. The table shows a large increase in expected annual damages. This increase is because (1) damage does occur for new basement construction, (2) the 100-year flood for 1990 land use conditions is higher than the 100-year flood for existing land use conditions, and (3) damages are sustained by new development from events that exceed the 100-year event. Several other evaluations that include a number of alternative control and flood proofing policies are included to demonstrate the broad capability of the spatial data management technique as well as present some interesting evaluations of policies designed to manage flood losses. The capabilities of the technique for evaluating a range of nonstructural floodplain management measures is described by (Webb and Burnham, 1976).

TABLE 4. Selected Damage Assessments, Trail Creek.

(Expected Annual Damage in 1000's $) EVALUATION CONDITION			DAMAGE REACH			
Code	Land Use Policy*	Hydrology	1	2	3	Total
I	Existing	(1974) Existing	1.5	1.9	11.9	15.3
X	1990 with no development controls	1990	1033.3	350.0	32.7	1416.0
IV	1990 with new development at at 1975 100-year flood level	1990	19.3	63.8	23.8	106.9
V	1990 w/new devel. @ 1975 100-year and flood proofed to ground floor	1990	16.8	18.9	4.7	40.4
VIII	1990 w/new devel. @ 1990 100-year and flood proofed to ground floor	1990	11.9	16.0	2.8	30.7

*The 1990 land use condition is a projection based on local agency judgment. In some instances, such as Damage Reach No. 3, 1990 urban type development has displaced some present agricultural development.

ENVIRONMENTAL ASSESSMENT

The objective of the environmental assessment is to provide a general description of the environmental status of the watershed areas for alternative land use patterns. The approach taken was to confine the analysis to specific achievable and quantifiable assessments and includes coincident tabulation, locational attractiveness analysis, urban storm water water quality and land surface erosion analysis, and simulation of the dynamic quality response of receiving water to urban storm water runoff and dry weather sanitary loading. The techniques draw heavily upon the grid cell data file for parameter definition, and on spatial analysis techniques for some computations.

Coincident Tabulation

The coincident tabulation is a first level of analysis and is comprised of a data display cataloging of change. The concept is to track changes in watershed land use coincident with an environmental interpretation of the watershed. The coincident analysis may be performed between any pairs of data in the file for any areal subdivision (such as subbasins or damage reaches). Table 5 is a coincident tabulation for the existing and 1990 land use conditions for damage reach No. 2.

TABLE 5. Land Use Coincidents Damage Reach 2, Trail Creek.

		1990 LAND USE – (Acres)										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
EXISTING LAND USE (Acres)	**1**	106	–	–	6	–	–	41	27	92	–	272
	2	–	–	–	–	–	–	–	–	–	–	–
	3	–	–	–	3	–	–	–	–	–	–	–
	4	–	–	–	–	–	–	–	–	–	–	–
	5	–	–	–	–	–	–	–	–	–	–	–
	6	6	–	–	–	–	–	6	–	8	–	20
	7	5	–	–	–	–	–	14	–	4	–	23
	8	–	–	–	–	–	–	–	–	–	–	–
	9	24	–	–	2	–	–	11	9	24	–	70
	10	–	–	–	–	–	–	–	–	–	–	–
	TOTAL	141	–	–	11	–	–	72	36	128	–	

ROW AND COLUMN LEGEND:

1) Natural Vegetation
2) Developed Open Space
3) Low Density Housing
4) Medium Density Housing
5) High Density Housing
6) Agriculture
7) Industrial
8) Commercial
9) Pasture
10) Waterbody

The values displayed in the figure are the number of acres which are coincident with the row and column categories. The diagonal values in the matrix are the number of acres which have not changed land use classification from the existing condition to the 1990 alternative future condition. For example, in row one, 106 acres that were classified as natural vegetation under existing conditions remain so classified under 1990 conditions, 6 acres of land classified as natural vegetation under existing conditions are converted to medium density residential use, etc. The total amount of land classified as natural vegetation under existing conditions is 272 acres while the total amount of land classified as natural vegetation under 1990 conditions is 141 acres.

Locational Attractiveness Analysis

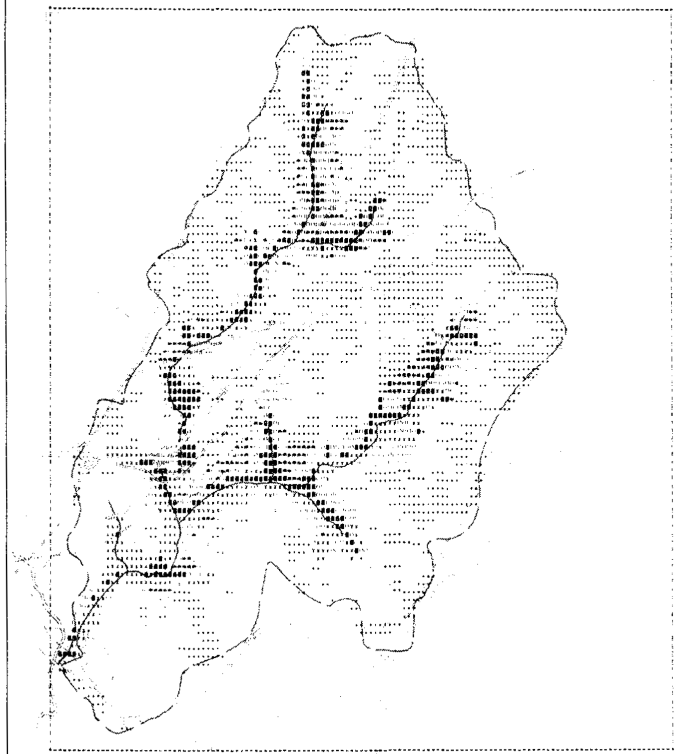
Attractiveness analyses for a number of potential uses within the basin were performed. The output is standard overprint grey shades indicating the relative attributes of each grid cell with respect to the others. The attractiveness display (Figure 4) used to illustrate the capability was for neighborhood park locations. In the display the darker shaded areas are, in a relative sense, more attractive for park development than the lighter shaded areas. The data variables of damage reaches (areas within the flood plain are preferred over areas outside the flood plain), land surface slope (flat and mild slopes are preferred over steep slopes), existing land use (natural vegetation, agriculture and pasture are favored over other categories), and distance to housing (areas near low, medium and high density residential areas are preferred to areas removed and to areas near other land uses) were used in determination.

Water Quality

The water quality analysis planned for the pilot study includes urban storm water quality forecasting and in-stream dynamic water quality simulation of the response of the receiving water to storm water inflows and projected domestic/industrial loading. The quantity and quality of urban storm runoff will be determined for a single synthetic event and for wet weather events during a critical continuous period of historic record that will be used as input to the in-stream dynamic simulation.

The utility computer program HYDPAR accesses the data file and formats the appropriate data (land use, etc.) for operation by the model STORM. STORM is then executed for events of interest generating pollutographs for each watershed (such as Trail Creek) for a single event and wet weather events pollutographs for each watershed for a short continuous period. The pollutograph procedure incorporated into STORM will predict the mass and concentration of five pollutants normally of interest in storm water runoff studies (suspended solids, settleable solids, BOD, total nitrogen, and total orthophosphate). Runoff quantity is computed using the Soil Conservation Service Curve Number technique. Pollutant masses are computed during each time step using an exponential function which represents a "scheduled release" of pollutants from the land use.

In-stream water quality simulation is planned for the main stem Oconee River. The stream will be modeled some distance above the study area to a specified distance beyond the lower boundary of the study area. The input data for the simulation modeling will be very general in nature consistent with the objective of providing a general assessment of alternative land use patterns. The quality simulation, however, will be quite specific and complex and will be performed using the WQRRS model. Model parameters will be determined primarily by transfer of coefficients developed in other studies for nearby areas such as metropolitan Atlanta. Dry weather sanitary, and treated effluent loading will be developed from general relationships that will relate land use as cataloged in the data file to quantity and quality of loadings. Storm water loadings will be computed by STORM as described above.



SUMMARY OF ATTRACTIVENESS MODEL FOR NEIGHBORHOOD PARK SITES

11868 CELLS WERE EVALUATED
0 CELLS WERE REJECTED

VAR ID #	RECODING FOR CLASSES 0 1 2 3 4 5 6 7 8 9	INDEX WEIGHT	VARIABLE NAME
5	0 9 9 9 9 9 0 0 0 0	1.00	FLOOD PLAIN
8	9 9 5 3 1 1 0 0 0 0	1.00	SCS SLOPE CLASSIFICATION
10	0 9 0 0 0 0 9 0 0 9	1.00	EXISTING LAND USE
17	9 9 9 9 9 9 7 7 7 7	1.00	DISTANCE TO HOUSING

ATTRACTIVENESS MAP
FUTURE NEIGHBORHOOD
PARK SITES

LESS ← RELATIVE ATTRACTIVENESS → MORE

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS										
NO. CELLS	8855	1460	0	149	391	529	0	181	0	303
MIN VALUE	0.00	50.00	60.00	65.00	70.00	75.00	80.00	85.00	90.00	95.00
MAX VALUE	50.00	60.00	65.00	70.00	75.00	80.00	85.00	90.00	95.00	100.00
PRCT RANGE	50.00	10.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
PRCT AREA	74.61	12.30	0.00	1.26	3.29	4.46	0.00	1.53	0.00	2.55

Figure 4. Locational Attractiveness – Neighborhood Parks.

Land Erosion and Sedimentation

Two levels of land surface erosion analysis have been developed for application in the pilot study. The basic level is to compute land surface erosion potential for each grid cell within the study area. The data variables of land use, slope and soil erosion index will be automatically retrieved from the data bank and formatted for use in erosion potential calculations. The computations will be performed by the STORM program for alternative land use patterns and the results displayed in computer graphic format. The Soil Conservation Service, Universal Soil Loss Equation technique is used to compute land surface erosion potential.

The second level of erosion analysis will track the movement of sediment eroded from each cell and determine its ultimate deposition location. The erosion computations are performed as above and the material is then transported using a simplified transport model that moves material from cell to cell. The result will be presented as a graphic display of the annual rate of erosion or deposition on a cell-by-cell basis.

SUMMARY

The Corps of Engineers has performed pilot studies that develop flood hazard, flood damage and environmental information for existing and alternative future development patterns as a continuing planning service to local government agencies with land use management responsibilities. Spatial data management techniques have proven to provide the technical capability to perform the comprehensive assessments quickly and systematically. The overall process of data collection and encoding to create a data bank, and processing to interface with modeling computer programs has been found to be rational and achievable although tedious and requiring particular attention to detail. The techniques used are generally modest extensions (although somewhat automated) of traditional analysis methods familiar to most analysts serving the Corps planning function.

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