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CIRSS Vertical Data Integration - San Bernardino Study

William Hodson
Jerrold Christenson
Russel Michel

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William Hodson
Jerrold Christenson
Russel Michel
Environmental Systems Research Institute,
380 New York St, Redlands, CA 92373

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Ames Research Center
Moffett Field, California 94035

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CIRSS
Vertical Data Integration - San Bernardino Study
Phase 2
NAS 2-10741

Ames Research Center

PREFACE

Several new challenges have resulted from the adoption of automated geographic information systems over the past decade. These challenges result from the automation of two or more geographic data bases which encompass portions of the same or adjacent physical areas. The automated systems contain data of differing classification, resolution and file structure. For example, local government agencies typically have automated at least portions of their parcel records in an address or parcel-based data file. Automated census data are available for the same area at several levels of aggregation. Public utilities frequently automate service facility networks in addition to maintaining address-based use and billing records. In addition, a variety of aggregated environmental characteristics may have been automated for use in local or regional environmental analysis and planning. Superimposed on these automated systems, LANDSAT data are available for all areas of the United States.

The California Integrated Remote Sensing System (CIRSS) task force, comprised of representatives of NASA, State agencies, and private industry, was established to study the methods whereby access to geographic data throughout the State could be integrated through a central facility. Further, the CIRSS task force established a pilot study in the San Bernardino Valley and Mountain areas to investigate methods for vertically integrating data bases in that subregion of the State.

The San Bernardino study area was selected for the following features:

- Several automated data bases were known to exist in the area. Table I-1 lists those used in the project.

- Two of the data bases were of land use captured in 1974 and updated in 1979.

- Parcel-based land use change data were available through San Bernardino County's growth monitoring data base.

- Potential users of an integrated data base include the San Bernardino National Forest staff and the San Bernardino County Planning Department.

This report describes the creation (Phase 1) and use (Phase 2) of a vertically integrated data base, including LANDSAT data, for local planning purposes in a portion of San Bernardino County, California. The project illustrates that a vertically integrated approach can benefit local users, can be used to identify and rectify discrepancies in various data sources, and that the LANDSAT component can be effectively used to identify change, perform initial capability/suitability modeling, update existing data, and refine existing data in a geographic information system. Local analyses were developed which produced data of value to planners in the San Bernardino County Planning Department and the San Bernardino National Forest staff.

FINAL REPORT
Vertical Data Integration - San Bernardino County

I. INTRODUCTION

The San Bernardino County Vertical Data Integration Study is one of four approaches to LANDSAT data integration being studied by the California Integrated Remote Sensing System (CIRSS) Task Force. The general objective of the San Bernardino study is to examine the capability and effectiveness of using private industry to aid local governments in their efforts to integrate geographic data. Other approaches to local geographic data integration which are being studied by the CIRSS Task force include the evolution of vertical data integration within a major State agency (California Department of Forestry), establishment of a network integrated data base in the context of a regional authority (Association of Bay Area Governments), and the development of an integrated data base to meet a newly identified State/County need (Prime Agriculture - University of California at Santa Barbara).

A. Purpose

These studies have evolved to establish an effective solution to several geographic data problems:

- Geographic data for a given area are often incomplete in terms of spatial coverage and data content. Gathering new data by traditional means is generally expensive and time consuming.

- Many local and regional agencies have established extensive data bases of specific geographic information types within their district boundaries. These data bases generally are not used by other agencies even though their districts overlap. This results from incomplete or incompatible data needs in some cases, and lack of interagency communication in many cases.

- Geographic data bases for an area often exist in different computer formats (e.g., DIME, polygon, raster, etc.) which require efforts to transform into another system.

- LANDSAT data have not been used by a large segment of local, regional or State agencies. Reasons given by the agencies include scale, resolution and lack of familiarity with the technology. However, most agencies agree that they would benefit from timely updating of existing data.

This report presents the methods used to integrate data sets for a geographic area in San Bernardino County for which these problems existed, and for which a specific geographic analysis was desired. Automated geographic data types covering portions of the area were available from

Federal, State, County and private sources. Table I-1 lists the data bases integrated for the study. In addition, 1979 aerial photographic (1:24,000 B&W) and classified LANDSAT data from 1976 and 1979 were obtained to extend the geographic data to those areas not covered by existing GIS data. The concept of assembling a single data base for a single area from data bases which exist at several administrative levels is referred to as VERTICAL DATA INTEGRATION*. Coincidentally, the data bases used in this project were obtained from data sensed at several elevations: ground level parcel-based data; low elevation aerial photography; high elevation aerial photography; and LANDSAT raster digital data.

Major goals of the project were to involve several organizations in the construction of an integrated data base, involve these same organizations in use of the data base, and demonstrate to them the use of LANDSAT technology as a means of efficiently updating an agency data needs.

B. Participants

The San Bernardino Vertical Data Integration effort involved both public and private participants as identified in Table I-2. Responsibilities included administrative (CIRSS, ARL, EDC), provision of data and data bases (ARL, USFS, SBC, SCE, ESRI), and participation in the design and application of the integrated data base (USFS, SBC, ESRI). Communication between the participants was facilitated by several conferences and workshops sponsored by ARL and CIRSS. A major initial difficulty was the identification of a single administrative person to provide overall management of the project. This role was filled by several individuals during the course of the project.

C. Area of Application

The area of application is illustrated in Figure I-1. The following criteria were used during the selection process:

- Several geographically adjacent automated GIS systems are represented within the area. This allows a test of methods designed to integrate GIS data prepared for separate users.

- Several GIS files were prepared at different times for the same area to identify change in land use. These were prepared from interpreted aerial photos, census data, and development monitoring records. These provide for an analysis of LANDSAT change detection output.

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*The CIRSS task force has also defined vertical data integration as the general compatibility of data formats, classifictaion methods, and encoding routines whereby data collected within a geographic area by one agency or level of government can be selectively incorporated into the geobased information systems of many other agencies or levels of government with minimal data manipulation and reformatting.

TABLE I-1: Data Sets Incorporated

Owner	Date	Data Set Description	Geographic Area
SCE	1974	Land Use Communities - Polyogns	East Valley and Mountains
SCE	1979	Land Use Update - Polygons	East Valley
USFS	1976-77	Terrain Units (Slope. vegetation, landform, geology) - Polygons	San Bernardino National Forest
SBC	1979	Parcel Ownership File - Address	Yucaipa 7½' Quad
SBC	varies	General plan support data	East Valley and Mountains
SBC	current	GBF/DIME (geo-coded address and census geographic unit matching system)	Urbanized portions of County
SCE	1980	Census Tracts - Polygons	Urbanized portions of County

New data set created for this project:

	1979	Terrain Units	East Valley/Yucaipa Quad

TABLE I-2
Participants

Public

1. CIRSS Task Force (CIRSS)

   University of California at Berkeley
   University of California at Santa Barbara
   Humboldt State University
   California Department of Conservation
   California Department of Forestry
   California Department of Food and Agriculture
   California State Assembly
   US Geological Survey
   US Forest Service
   Industry Advisory Panel

2. NASA-Ames Research Laboratory (ARL)

3. US Forest Service (USFS)

4. California Environmental Data Center (EDC)

5. San Bernardino County Planning Department (SBC)

Private

6. Southern California Edison Company (SCE)

7. Environmental Systems Research Institute (ESRI)

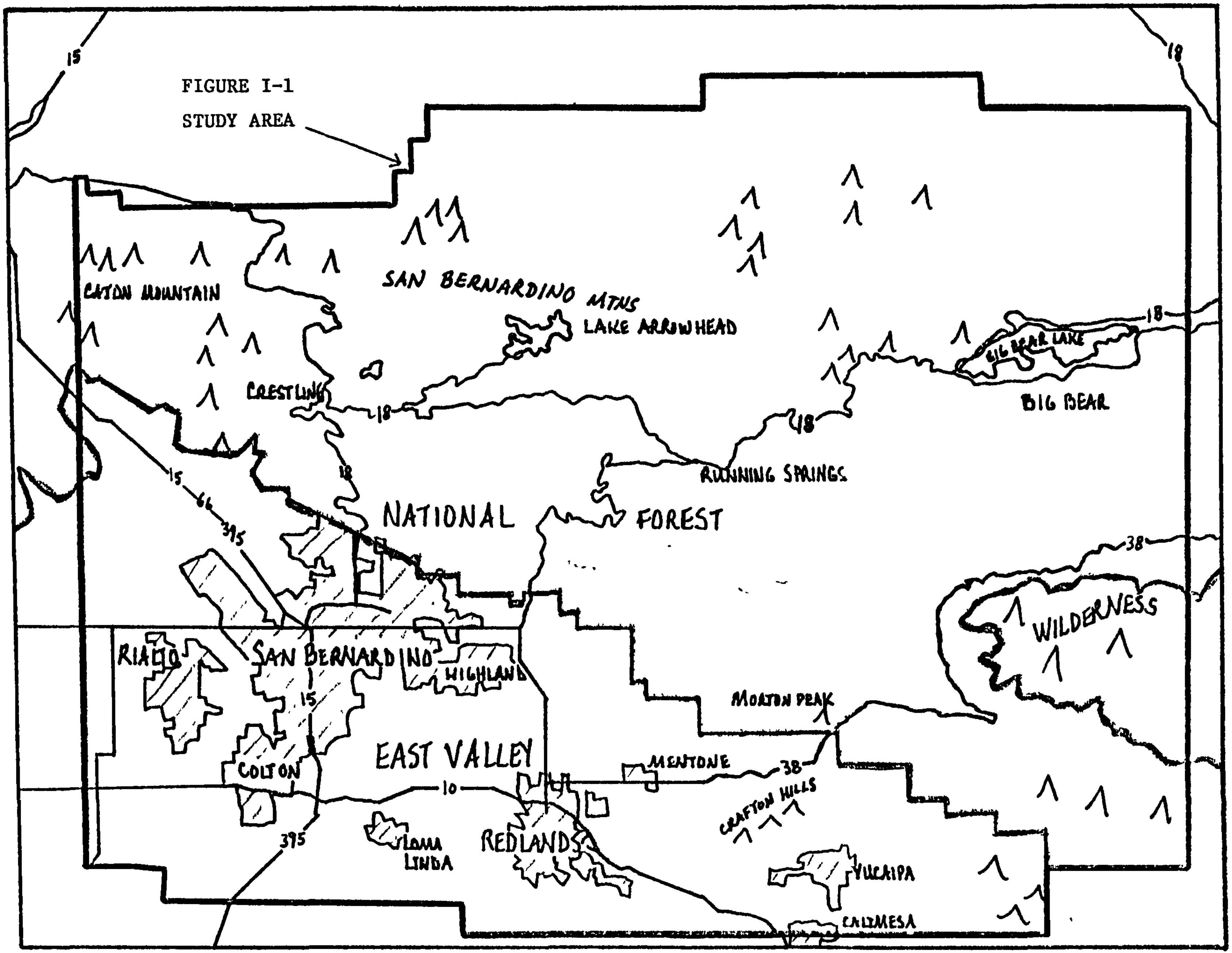


FIGURE I-1

STUDY AREA

- The GIS prepared for the San Bernardino National Forest excluded the designated Wilderness area within the forest. This provided an opportunity to test the use of LANDSAT data to infill or extend an existing GIS data base into adjacent lands which, although similar in land cover, were not included in the original study.

- Both the US Forest Service, San Bernardino National Forest, and the San Bernardino County Planning Department offered to provide significant input and personnel time for participation in this effort.

Roughly bisected by the San Andreas earthquake fault, the area selected includes a range of observable ground cover types and encompasses both mountainous and alluvial valley landforms. Portions of the mountains are undisturbed wilderness, while much of the valley has experienced rapid development of residential and commercial properties. Natural land cover varies from valley grassland to hillside chaparral to mountain coniferous forests.

Special characteristics of the study area include geologic hazards related to ground shaking and steep slopes, fire fuel growth on lower slopes, significant erosion (particularly after wildfires), and flooding in the valley. Both the valley and mountain communities of the study area experience strong cultural pressure for urban development, particularly residential development. This pressure results from the proximity of major commercial and industrial centers, good transportation, available resources, and the aesthetic appeal of the east valley/mountain configuration. Land costs have historically been lower than in areas closer to the Los Angeles metropolitan center to the west.

For these reasons, application of the integrated data base was focused on its utility for projecting and monitoring urban development and for identifying constraints and opportunities with respect to proposed development patterns. Specifically, the San Bernardino County Planning application was a test of methods for identifying specific types of change, correlating these changes with observable characteristics of the land, and projecting those areas likely to develop in the near future. The US Forest Service application (Phase II) is a test of the use of an integrated data base to identify appropriate sites for designation as a greenbelt, and subsequently, project the impacts of such designation on the fire fuel, hydrologic and erosion characteristics of the identified sites.

Integration of the Data Base

Each of the data bases used in the project was registered to State Plane coordinates and converted to a grid-based data file at a resolution of 4 acres and used to create a multi-variable data base for the entire study area. To this data base was added classified LANDSAT data from 1976 and 1979. The resulting data base thus integrated in a uniform format all of the separately automated data within the study area. Except for LANDSAT data, none of the data bases covered the entire area, nor were all prepared at the same time. Within the Valley subarea, data from 1974, 1976, and 1979 were available to illustrate temporal change. Within the National Forest subarea, both photo-interpreted terrain units and classified LANDSAT land cover data were available for comparison.

Use of Integrated Data Base

A primary function of the vertically integrated data base was to test several possible interactions between existing geocoded data bases and LANDSAT data:

- Using LANDSAT data to update a GIS and monitor changes in land cover/land use through time.

- Using LANDSAT data to extend existing GIS data over a larger area.

- Determining whether new data types such as capability/suitability for urban development can be modeled at a useful scale and resolution using LANDSAT data.

- Using a GIS to identify classes resulting from an unsupervised LANDSAT classification.

Figure I-2 illustrates the use of a GIS to supervise the classification of LANDSAT data by means of an automated comparison of the two data types. This method is useful when the imagery is being used to extend the GIS coverage beyond its original boundaries. In the present study, the U.S. Forest Service data base included all National Forest lands except those declared "Wilderness Area". The classified LANDSAT data were reinterpreted using the USFS portion of the integrated data base to extend coverage into the Wilderness Area in the study area. A fire hazard model was then applied to the area and compared with a similar model previously run only on the non-wilderness areas. Figure I-3 illustrates an alternative use of a GIS to interpret and code a LANDSAT image processed through an unsupervised classification.

Phase 2 Studies

The use of LANDSAT to update an existing data base was tested using the SCE 1974 - 1979 land use data in the integrated data base for a small portion of the San Bernardino Valley. The land use change data was compared to the LANDSAT change detection model run on the same geographic area. Areas of inconsistency between the two analyses were compared with the County Assessor's development tracking data and a statistical analysis of the accuracy and resolution of the LANDSAT change detection model developed. The model logic screens change data using the County General Plan and the existing urban land use data planes of the GIS. The logic eliminates erroneous or improbable types of change. Thus changes from developed land use type to agriculture are blocked by the screen. LANDSAT change detection techniques used during this study are reported in detail by Likens and Maw

FIGURE I-2
VERTICAL INTEGRATION APPLICATIONS
- Use GIS to classify Landsat-Digital
Image & extend area

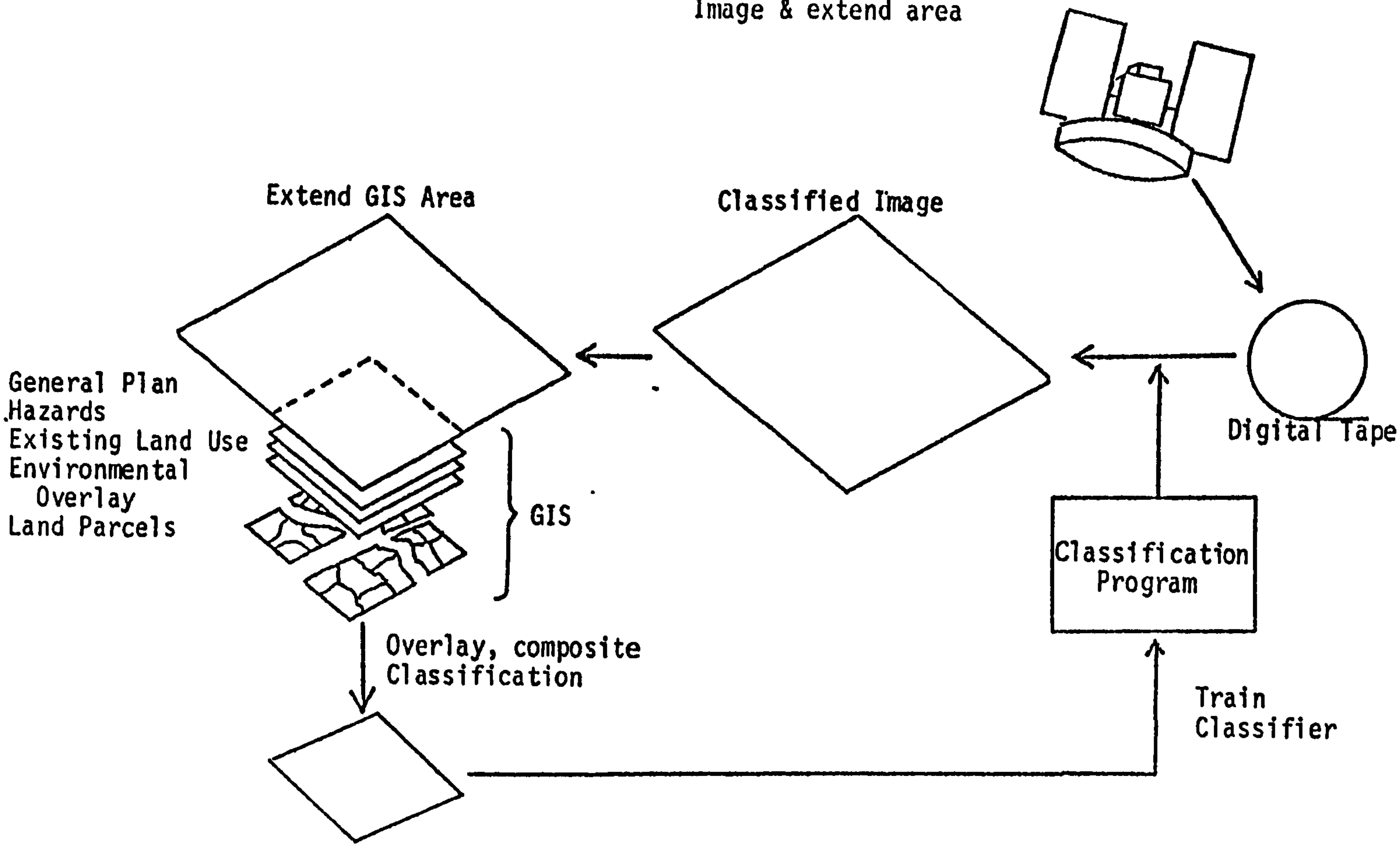
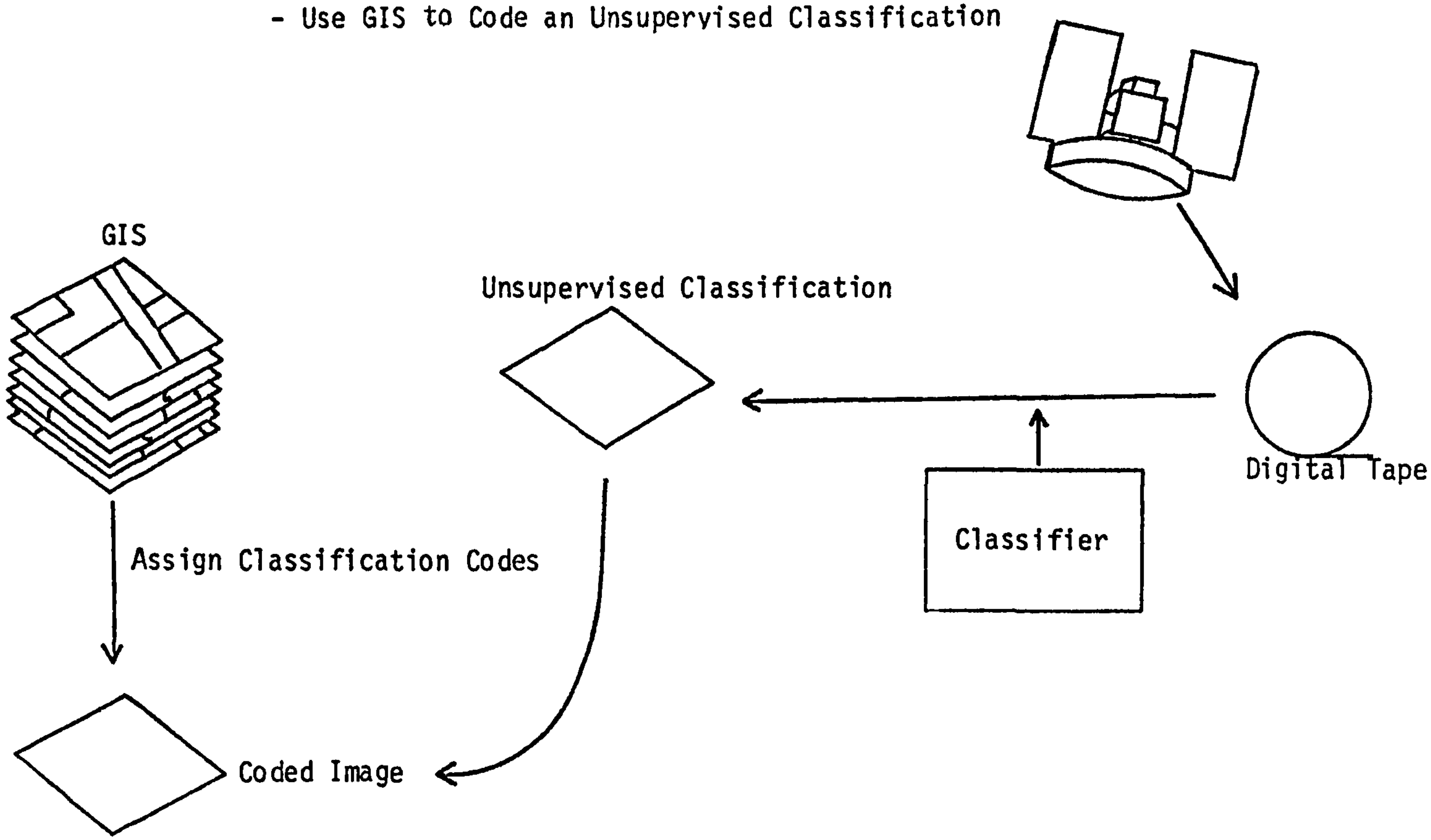


FIGURE I-3
VERTICAL INTEGRATION APPLICATIONS
- Use GIS to Code an Unsupervised Classification



1982.

Figures I-4 and I-5 show two possible methods of using a screen during the change detection modeling. The method illustrated by Figure I-4 illustrates the use of a screen after change detection has taken place. Clustering algorithms of the image classifier were found to produce many erroneous indications of change where no change had actually taken place. Use of the screen eliminated this "noise", but only in areas removed from consideration. Another change detection methodology which evolved during this effort, involving the use of a screen prior to LANDSAT change detection, is depicted in Figure I-5. The original 1976 data is screened using the GIS, so only developable areas are examined for change. If no change is observed, the 1976 classification is retained. If change is detected, the 1979 classification replaces the 1976 data for that pixel. The original 1976 data and the updated 1976 data (now including 1979 codes for specific changed areas) can now be analyzed by the change detection model. The result is a change detection output which a) is focused on specifically defined areas of concern, and b) contains no "noise" produced by the clustering algorithm.

During the second phase of the Vertical Data Integration Study, specific user applications was performed using two small subareas of the data base: one an area expected to experience pressure for development and the other an area under consideration as a fire-retardant greenbelt. The small area studies demonstrate the potential for using a vertically integrated data base for local analyses.

Figure I-6 illustrates the San Bernardino County Planning application studied in Phase II. A small area data base was windowed from the integrated data base and gridded at a resolution of one acre. This data base was used to develop a urbanization capability/suitability model which was compared to both the Assessor's development data and actual development in the field in an effort to determine which characteristics can be reasonably correlated with development activity. Several resolutions of known information were evaluated against the LANDSAT analysis. The refined model was then be applied to the 1979 land cover data. The resulting analysis is suggestive of the potential pressure for future development in the area.

Figure I-7 illustrates the U.S. Forest Service application being studied. It also consists of evaluation of a small area data base at a resolution of one acre. The area is in the foothill region, which is being exposed to development pressures while at the same time supporting significant fire, flooding, and erosion hazards. The small area data base has been analyzed using a greenbelt siting model to identify the most appropriate areas which could be declared fire buffer greenbelts. Because such designation would limit urban development and promote agriculture, an agricultural suitability/capability model was applied to the designated areas. The entire small area data base was also modeled to project future urban development, given existing designations and constraints.

The two scenarios which result from the modeling reflect policies of

FIGURE I-4
VERTICAL INTEGRATION APPLICATIONS
Screen Noise from Change Detection Model

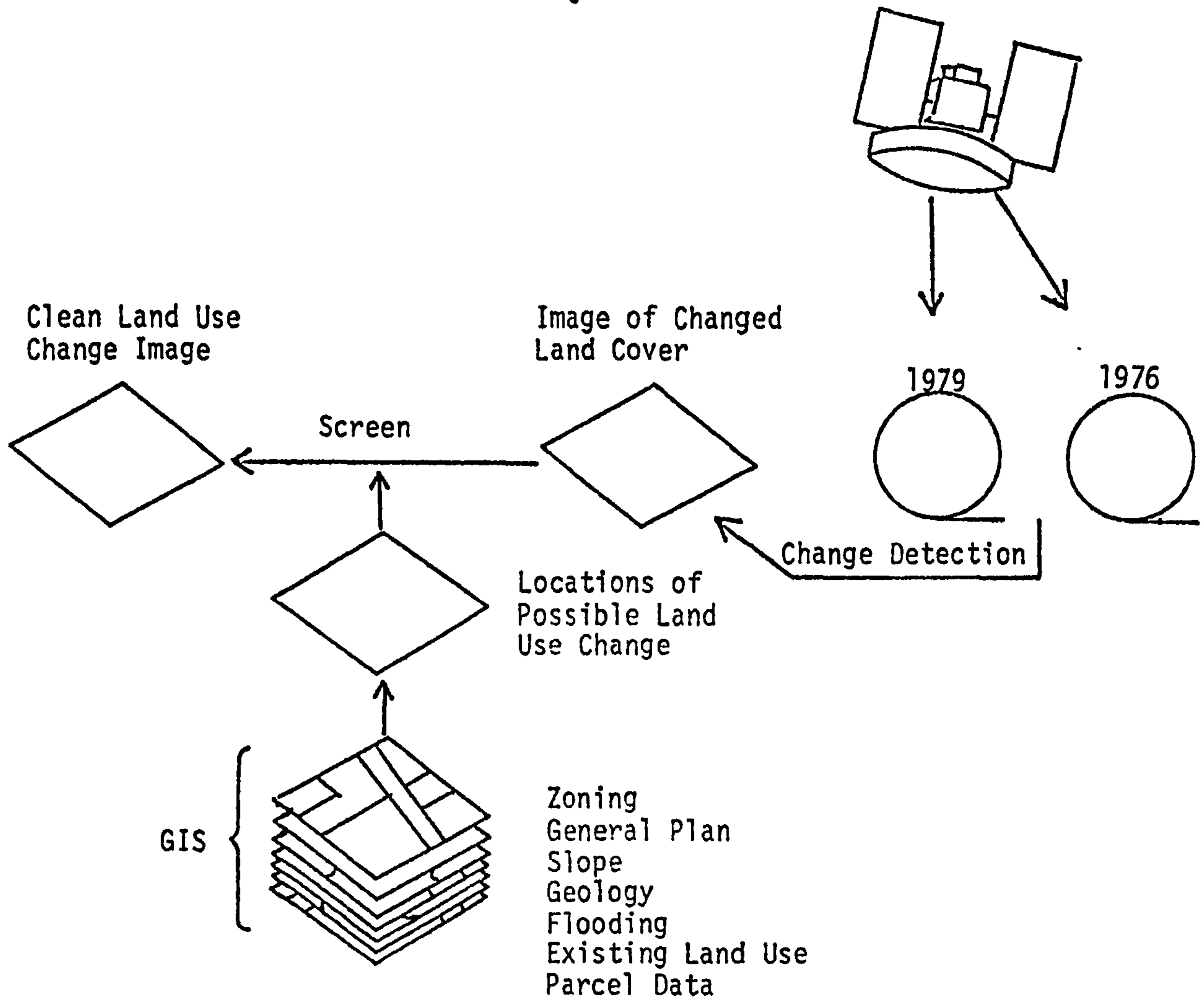


FIGURE I-5
VERTICAL INTEGRATION APPLICATIONS
Update Image using Specified Change Factors

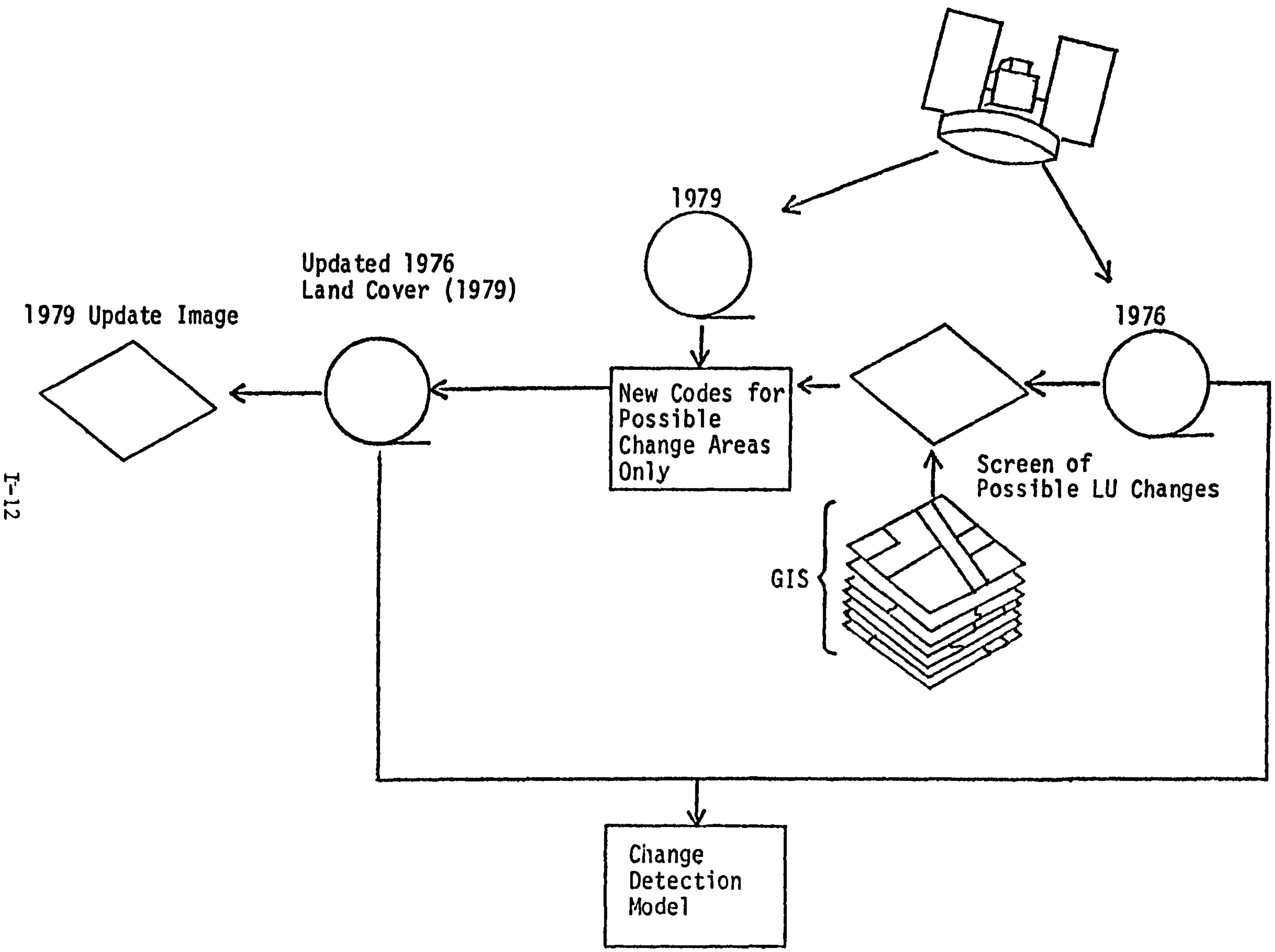


FIGURE I-6

COUNTY PLANNING APPLICATIONS STUDY

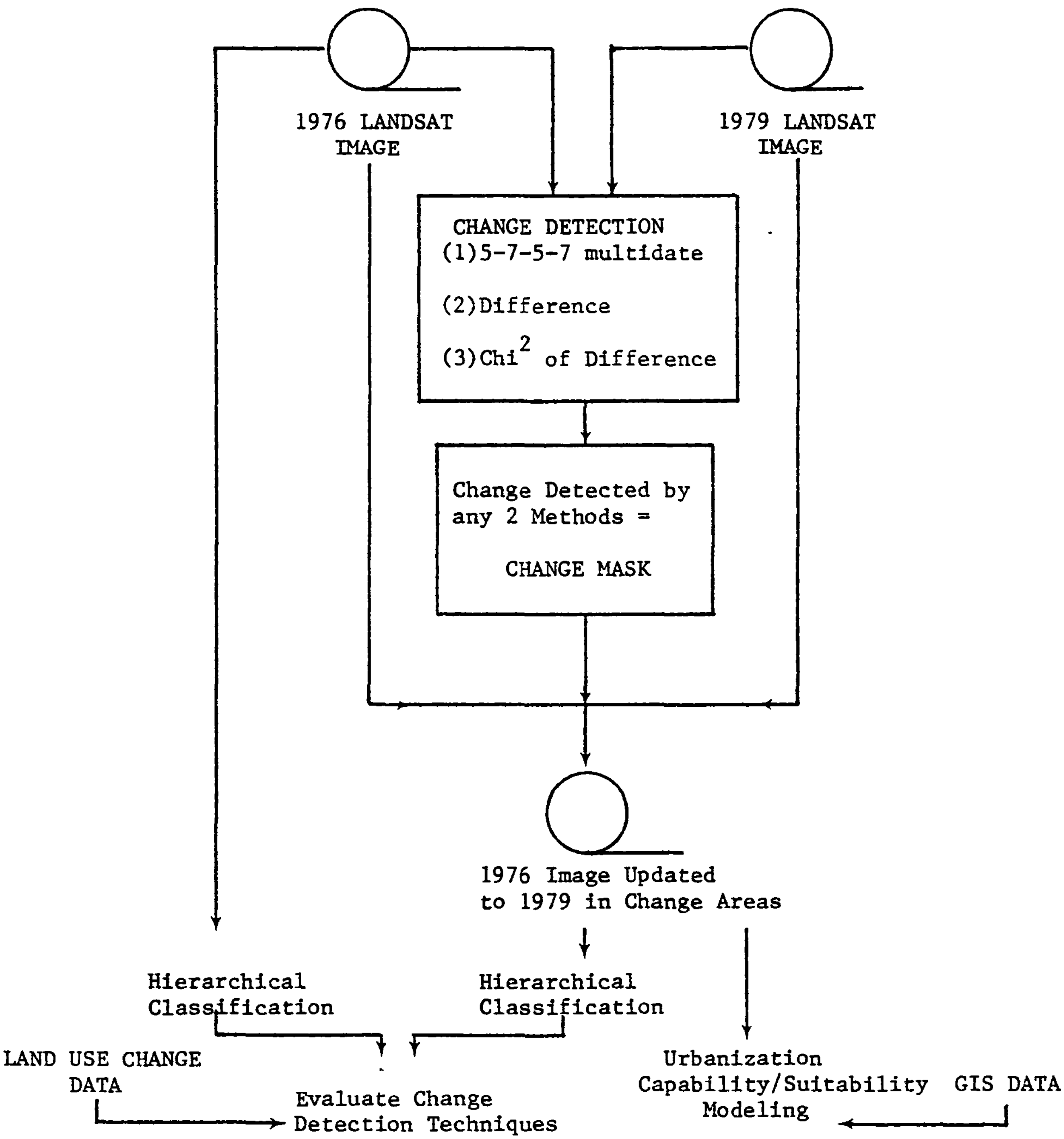
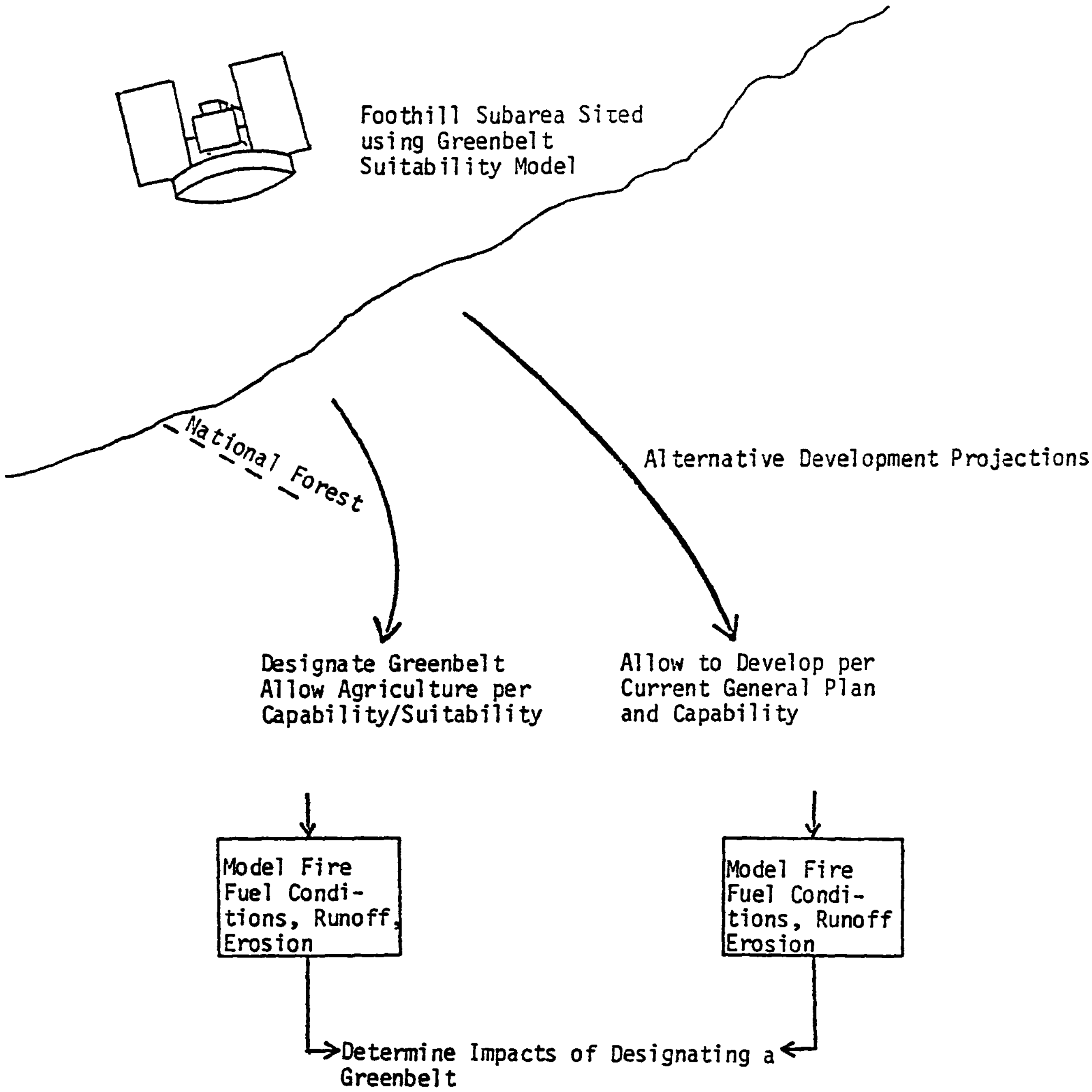


FIGURE I-7
FOREST SERVICE APPLICATION STUDY



designating a greenbelt or allowing development to proceed. Each scenario was analyzed by models which evaluate fire hazards, changes in runoff rates and locations, and erosion potential. Output from these analyses can be used to evaluate the impacts of designating the greenbelt or not designating it in the modeled area, and are useful input to the greenbelt siting process.

II. USER NEEDS - DATA TYPES

The types of geographic data required by the San Bernardino County Planning Department and the San Bernardino National Forest staff were determined by interviewing staff members, evaluating existing data and reviewing the components of the integrated data base with the participants (see ESRI, 1981. "Inventory of Available Data Elements for the San Bernardino, California Region"). Of special concern were the data types not normally observable, such as parcel boundaries and permitted use. These data are important to the users and must originate from a source other than imagery or photo-interpretation. The types, scale and resolution of data needed reflect the levels of decisions that each agency must make.

For example, SBC Planning Department is responsible for site-specific analysis of proposed development. To accomplish this task a variety of data types must be explored and evaluated to determine whether or not a proposed land use change meets the criteria set forth in the Consolidated General Plan, Development Code and environmental impact regulations. Thus, the geographic data must be detailed enough to evaluate specific projects. In addition, development in the County must be tracked such that accurate records are kept for service agencies, auditing agencies, and the Planning Department staff.

The SB National Forest staff is responsible for proposing, evaluating and managing uses of the National forest lands. Data required to perform these functions vary from general planning criteria to site-specific engineering constraints.

The general data types regularly used by these agencies are presented by the following matrix.

Based on the needs of potential users of the system, the data types shown in Table II-1 were included in the integrated data base. These data types were derived from existing geographic information system files already automated for the area, LANDSAT digital data, and some additional data mapped and automated specifically for this study. Section III elaborates on the specific methods used to integrate the data and identifies the specific data in the data base.

SAN BERNARDINO COUNTY DATA TYPES USED

DATA TYPE	PLANNING	ENVIRONMENTAL ANALYSIS	APPLICATION PROCESSING	CENSUS/ ASSESSOR	
CURRENT LAND USE	Map 1:24,000	Air Photos Map $\leq$1:10,000 Parcels	Parcel Map, Parcel Record	Parcel Map, Parcel Record	
DESIGNATED LAND USE	General Plan Map 1:24,000	Maps $\leq$1:10,000 Parcel	Parcel Record	Parcel Record	
PROPOSED LAND USE	Tentative Map $\leq$1:10,000	Tentative, Parcel Map	Parcel Map, Record	---	
ENVIRONMENTAL CONDITIONS	Air Photos Map 1:24,000	Air Photos Maps $\leq$1:10,000 Parcel	---	---	

SAN BERNARDINO NATIONAL FOREST
DATA TYPES USED

	PLANNING	MANAGEMENT	CONSTRUCTION	FIRE CONTROL	
CURRENT LAND USE	Air Photos Map 1:24,000	Map 1:24,000	Forest Plan Parcel Record	Map 1:24,000	
DESIGNATED LAND USE	Map 1:24,000	Forest Plan Map 1:24,000	Ownership, Parcel Map	---	
ENVIRONMENTAL CONDITIONS	Map 1:24,000 Larger Scale	Map 1:24,000	Maps $\leq$1:10,000 Parcel	Map 1:24,000	

TABLE II-1
Data Incorporated

Date Types	Potential User
1974 Land Use	SBC, SBNF
1979 Land Use Update	SBC
1976-77 Terrain Units	SBNF
1979 Terrain Units	SBC
1976-77 Recreation Inventory	SBNF
1979 Parcel Ownership	SBC
1979 Consolidated General Plan Designations	SBC
1979 Growth Monitoring Data	SBC
1980 Census Tracts	SBC
1976, 1979 LANDSAT	SBC, SBNF

III. DATA MAPPING, COMPILATION, AND AUTOMATION - VERTICALLY INTEGRATED DATA BASE

A. Introduction

The emphasis of the mapping phase of this project is the superimposition and rectification of various data sets to create an integrated data base. These computerized data sets have been developed and are maintained by several public agencies and private concerns, in addition to data generated expressly for this study. These are then combined with LANDSAT-derived data, to produce the vertically integrated data base. This process may be defined as follows:

> Vertical Data Integration refers to the general compatibility of data formats, classification methods, and encoding routines whereby data collected within a geographic area by one agency or level of government can be selectively incorporated into the geobased information systems of many other agencies or levels of government with minimal data manipulation and reformatting.

Most of the data incorporated into the Integrated Data Base were originally contained within independently constructed and maintained data bases which were individually utilized by a variety of public and private data users. These data bases are listed below:

Owner	Date	Data Set Description	Geographic Area
SCE	1974	Land Use Communities	East Valley & Mountains
SCE	1979	Land Use Update	East Valley
USFS	1976-77	Terrain Units (Slope, Vegetation, Landform, Geology)	San Bernardino National Forest
SBC	1979	Parcel Ownership File	Yucaipa 7 1/2´ Quad
SBC	Varies	General Plan Support Data	East Valley & Mountains
SBC	Current	GBF/DIME (Geo-coded Address and Census Geographic Unit Matching System)	Urbanized Portions of County
SCE	1980	Census Tracts	Urbanized Portions of County

In addition, the USFS terrain unit data base was supplemented by mapping done in conjunction with this project. This extended the terrain unit information into the Valley area, which was not originally included in the Forest Service's data base.

LANDSAT-derived data were also compiled into the vertically integrated data base. These data were "classified", meaning that the image scanned by the LANDSAT satellite had been computer-processed and the spectral class of each pixel assigned to a class of land cover. Processed, classified LANDSAT data for both 1976 and 1979* were incorporated into the data base to allow comparisons of land cover, and particularly to detect changes in urban land use. The LANDSAT classification used in this study is attached as Appendix A.

B. Data Base Components

Each of the data base components integrated into the complete data base for the project study area has unique attributes in terms of its format, content, coverage, validity, accuracy and resolution, and capture date, as well as the data classification system used for each. The preliminary, pre-automation mapping procedures utilized in preparation of each of the data base components selected for the study are described below, as are the reasons for incorporating each into the integrated data base.

Data Set Number 1 - SCE 1974 Land Use. This data base was compiled for the Land Division of Southern California Edison Company in 1974. It contains automated polygon data for land use at the community level at a scale of 1:24,000, covering the East San Bernardino Valley area and adjoining mountain communities. Mapping was done by photo-interpretation of black and white aerial photos, with a resolution of 5 acres for rural land use and 3.5 acres for urban land use.

The actual mapping process involved a number of steps. The first of these was the preparation of suitable base maps on a stable-base material and the establishment of tic points for coordinate referencing. USGS 7.5' topographic maps at a scale of 1:24,000 (2000 feet to the inch) were chosen as base maps. Mylar copies of these maps were then overlaid onto black and white aerial imagery at the same scale. This topo sheet/photo imagery combination enabled definition of the true geographic position and spatial extent of land uses. The streets, canals, railways, and other linear features on the topo maps were used as locational references to ensure that the final pattern was planimetric (i.e., that all areas drafted on any portion of the mylar mapping material would have true areal size relative to all other areas on the map). The land use patterns were then interpreted and drafted a onto mylar overlay. A minimum size of 3.5 acres was the normal

*The 1976 data were classified by ARC. The 1979 data were classified by ESRI, using a classification model provided by ARC.

convention used to define polygons for urban areas. This was overriden in some cases in order to ensure the inclusion of pertinent data. A minimum size of five acres was the normal convention used to define polygons for rural areas. This, too, was overridden when necessary to include significant data. These minimum polygon mapping unit areas were a part of the working definition of the classifications. Land use patterns less than these minimums were normally absorbed into more predominant land use patterns for an area and classified according to the predominant occurrence.

As a check on the photo-interpretations made, bluelines of the manuscript maps thus produced were taken to the field for an on-site evaluation of interpreted boundaries and classifications. This process was used to clarify both areas of confusion as to proper interpretation of land use and as random spot checks for accuracy throughout the study area. Any corrections noted were then transferred to the manuscript maps.

Mapped data comprises the following general types of land use:

Residential

Commercial and Services

Industrial

Transportation and Utilities

Public

Open Space

Agriculture

Water

Undeveloped and Forest

Within each of these categories are specific densities and types expressing greater detail about the specific land use throughout the study area. These specific data classes are shown in the Data Set 1 Data Classification System included in Appendix C. The purpose of the land use study initially was to provide SCE with current urbanization patterns and to provide a starting point or base for subsequent change detection efforts. This change detection capability was also a primary reason for including this data base in the vertical integration project. It provided a control to be used in conjunction with the 1979 Update (see below) for evaluation of LANDSAT change detection techniques.

Data Set Number 2 - SCE 1979 Land Use Update. This data base is essentially the same as the 1974 Land Use study in terms of format, coverage, resolution, content, and, with minor adjustments, data classification. The process of producing this data base involved examining the information within the 1974 study, updating it to account for new development in the region, and then creating a new land use data base including the updated information. This process actually involved a number of discrete steps. The first was to replot the 1974 land use maps utilizing revised coding and coordinate referencing procedures. This involved aggregating certain polygon codes and reassigning others based on the new classification system. Polygon coordinates were in certain instances redefined to reflect software revisions, and previously undetected errors were corrected. Study area boundaries were also changed in a few locations. Polygons whose new land use code could not be determined precisely from the original files were specifically designated on the plots so that they could be later identified. The polygon land use plots were subsequently overlaid on newly interpreted land use data and compared to relevant collateral data. This second phase involved reformatting photo-based land use delineations to match the 1974 plots. These delineations were then compared to the plotted maps to discover land use changes that had taken place in the intervening five years. Two types of land use changes were observed in this process. Some of the originally-mapped polygons had changed in land use throughout their entire areas to a new land use type. Such polygons required a change of land use code, but the polygons themselves remained unchanged in terms of their configuration. Other polygons changed in only a portion of their areas and/or a number of land uses were now present within the original polygon. An example is the encroachment of residential and other types of development into an area previously designated as Agriculture/Orchard. New polygons, as well as codes, were created to address these areas. This process was also utilized for areas not previously mapped, including non-urban areas within Riverside County contained within the 1979 Update study (but not included in this Vertical Integration effort). Finally, as the third part of the Update mapping, new polygon sequence numbers and codes were created consistent with the numbering and coding scheme utilized initially. Codes contained descriptors for both the old land use (using the revised land use codes) and the updated land use. Appendix C contains a complete description of the code listing format and the data classification system developed for the update study.

As noted above, the Update Land Use study was designed for use in conjunction with the original 1974 Land Use mapping. Actually, since the newly automated data base contained much of the data from the 1974 work, it could be used independently by SCE and County planners to evaluate land use patterns and trends throughout the region. This was conceived as an on-going process to involve periodic updates of land use. In this study, the material is of particular value not only as a component of County application studies and the preparation of models For hazard/resource and suitability evaluations. It also has utility as a ground and air photo based check for LANDSAT change detection programs and as a means for evaluating such systems and for enhancing the reliability of LANDSAT-derived data.

Data Set Number 3 - USFS Terrain Units. This data set, prepared for the San Bernardino National Forest, U.S. Forest Service, incorporates a mapping methodology known as integrated terrain unit mapping. This method, which involves the resolution of a range of environmental data to a single polygon map, is discussed in greater detail below. The data base was developed from materials compiled in 1976 and 1977, and was current as of September, 1978. It covers the 334,000 hectare (825,000 acre) area of the public lands within the San Bernardino National Forest, exclusive of wilderness areas, at a scale of 1:62,500 (approximately one mile to the inch). Basic geographic data related to the phenomena of landform, geology, slope, and vegetation were mapped using USGS 15′ topographic maps and U-2 color infrared imagery as well as collateral data sources. These data were integrated into a final manuscript map based on a minimum mapping unit of 50 acres. As part of the USFS study, seven other categories of data were compiled and mapped, including circulation patterns, recreation sites, land ownership, land use, administrative districts, water courses, and other special features. Although these could be included at a later date, at present the terrain unit component is the only part of the USFS computerized data base incorporated into the vertically integrated data base.

As noted above, this data set utilized a mapping procedure termed Integrated Terrain Unit Mapping (ITUM), which resolves interdependent environmental variables to a single polygon map. Since the boundaries of many natural features are normally coincident, these boundaries can accurately be represented by a single line. Where discrepancies exist between boundaries of various natural features on different maps, these frequently are the result of cartographic inaccuracies or slight differences in interpretation, rather than a real difference between, for example, the boundary of a soil unit and that of a vegetation unit. The process of Integrated Terrain Unit Mapping, then, involves the manual overlay of maps of the various data elements at a common planimetric scale and the drafting of a manuscript map containing all the lines on those overlays, integrated to common lines where appropriate according to imagery and base maps.

The actual mapping procedure used for the USFS terrain unit data set involved the same initial step as for the SCE Land Use study: the selection of suitable base maps. For this study, USGS 15′ topographic maps at a scale of 1:62,500 were chosen. Imagery used with base maps included U-2 color infrared (CIR) photos. Four categories of data were included within this data set: landform, geology, slope, and land cover (vegetation and land use).

Land cover was mapped from aerial photos and from Forest Service timber maps showing location and type of commercial timber within the publicly-owned areas of the Forest. Vegetation patterns were delineated on the photos and then, through the use of an enlarging/reducing projector, these delineations were rescaled and rectified to match the USGS base maps. An overlay to the base map showing vegetation and land use resulted.

Geologic type was mapped using detailed USGS and California Division of Mines and Geology geologic maps. The detail expressed on these collateral source maps generally exceeded the needs of the study, so the information was generalized to the mapping resolution of 50 acres. Where necessary, maps were rescaled to create an overlay to the 1:62,500 base maps.

Slope classes were delineated directly on the USGS maps based on contour line density to produce the slope overlay. Again, the 50 acre minimum polygon size was observed.

Landforms were interpreted using both aerial photos, as with vegetation mapping, and topographic maps, as with slope. All landform interpretations were rectified where necessary to create the landform overlay to the base maps.

These four overlays were then integrated to form the terrain unit file. As descibed above, each overlay contributed lines to the final manuscript, but these lines were cross-compared and checked against the imagery to resolve multiple lines to single common polygon boundaries. The resulting polygon map thus delineated areas which were homogeneous throughout, with respect to the data variables being integrated and the classification system being used. Each of the polygons was then assigned a unique sequence number. This number in turn referenced a code string which numerically described the characteristics of each polygon. The data classification used and the code structure necessary to describe the polygons are listed in Appendix B.

This terrain unit file was one of eight components to the USFS Wildland Recreation Study data base. Its purpose was to contribute to modeling processes for evaluation of the suitability of public Forest lands for identified recreation activities. It has been included in the Vertical Data Integration study to provide a data base for Forest Service application studies and for evaluation and training of LANDSAT land cover classification processes, particularly in the Wilderness Areas not originally mapped.

Data Set Number 4 - San Bernardino County Parcel Ownership File. This data set consists of an automated ownership record of parcels within the Yucaipa 7.5 minute topographic quadrangle, maintained by the San Bernardino County Assessor's Office. This file is currently updated through 1979. However, the actual mapped parcel data is not automated at this time. The County Planning Department's Growth Monitoring system is designed to read this address file and assign data to geographic coordinates enabling conversion of the address data to mapped data. This conversion will be included for a small area of the data base during the Phase II applications study of the project.

Data Set Number 5 - San Bernardino County General Plan Support Data. The East Valley portion of the Land Use Element map of the San Bernardino County Consolidated General Plan, adopted in June 1979, comprises this data set. It designates classes of permitted land use and portrays land uses projected for the next five to twenty years. Originally prepared by the County Planning Department, the designations were remapped and rectified to the standard USGS base maps as part of this study. It was prepared as manuscript 3 for Data Set #9, including the Integrated Terrain Unit Map, as a component of this study. The complete data classification system is included in Appendix B. It is important to note that this map, while being incorporated into the integrated data base for reference and comparison purposes regarding future development trends, is designed to be used in conjunction with the text of the Consolidated General Plan.

Data Set Number 6 - San Bernardino County GBF/DIME. The GBF/DIME file comprising this data set consists of an automated file for spatial cross-reference between many types of urban census data within San Bernardino County. That portion of the file within the urbanized East Valley/Foothill area has been windowed out for inclusion in the data base. The file was created by a GBF/DIME data process that matches geo-coded non-polygon address information that has been previously automated with census geographical units. The resulting structure has a record layout containing 300 characters expressing such information as street names, types, and directions; left and right-hand side addresses; block, tract, and other geographic codes; ZIP codes; and node numbers and latitude and longitude coordinates. Thus census data can be referenced by a variety of geographic indicators. Preliminary 1980 Census data is now available and will be available to this level of detail in the near future. This data set thus will include housing and population counts compiled by block group and census tract.

This system was initially devised to provide a ready geographic display of census-derived data. It was included in the integrated data base for comparison to land use and to community and regional plans to identify potential growth areas and the existence of possible development opportunities.

Data Set Number 7 - Census Bureau's Census Tracts. This data set consists of census tract boundaries, which have been mapped and automated for Southern California Edison Company, Land Division, based on the Bureau of the Census' 1:24,000 Metropolitan Map Series. These polygon data are computer automated x,y coordinate data files, similar to the polygon files for land use and terrain units.

Mapping was done by overlaying the Census Bureau maps on standard

USGS quadrangles and drafting the tract boundary using observable features on both the ground and the topo base maps. Preliminary 1980 adjustments to this information were made in the mapping process. Since census tract boundaries are in urban areas tied to cultural features and since the size of even the smallest tracts may be accurately represented on a 1:24,000 scale map, these polygons are considered highly accurate and reliable. Tracts were mapped for the entire study area, resulting in a total of 65 census tracts automated and included in the vertically integrated data base. Each polygon has a unique census tract number associated with it instead of a sequence number and expansion codes.

Census tract maps, particularly when used in conjunction with Census attribute data (see Data Set Number 6), are a major framework utilized by the County for purposes of identifying population and housing statistics, since tracts represent the basic compilation unit for most census information. In the context of the vertical data integration study, this data set and the GBF/DIME file provided additional input to environmental models to provide a broader picture of the region of study.

Data Set Number 8 - Digital Terrain Data. This data set, prepared for NASA-Ames by the Jet Propulsion Laboratory (JPL), contains automated information concerning elevation contours. The area covered by this data set includes the San Bernardino East and West 1^{o} quadrangles, with elevation data from the California Division of Forestry. The digital terrain files were originally prepared by the Defense Mapping Agency in cooperation with the National Cartographic Information Center (DMA/NCIC). This process involved recording the elevation of numerous pre-selected and coordinate-identified points. The JPL data were derived from these files with some additional resampling and the use of an algorithm to interpolate elevation data. This resulted finally in a grid-based file containing information by cell on elevation, slope gradient, and aspect, stratified into 40-foot vertical quanta. This interval was considered adequate for the statewide mapping done with the original LANDSAT scene, but presented problems in this project for modeling in smaller-area analyses.

This information supplements Forest and Valley slope information. More importantly, it coincides in area with the LANDSAT scene so it can be used in direct conjunction with LANDSAT data for mapping and modeling.

Data Set Number 9 - Integrated Terrain Unit Map for the Valley. This data set, unlike the other eight, does not consist of a previously developed and automated data base prepared for or by another user. Instead it was constructed specifically for this study primarily to provide terrain information for the Valley areas not included in the U.S. Forest Service data base (Data Set Number 3). It is similar to that study in that it utilizes the Integrated Terrain Unit Mapping concept. As described earlier, this is a method which allows the resolution of all related environmental data to a single manuscript map. In addition to this integrated terrain unit map, three other manuscript map types were prepared for this study: a surface hydrology and faults map, consisting of lines; a transportation map, also consisting of lines; and a land use map, consisting of polygons. The land use map is the rectified general plan land use map described in Data Set Number 5 above, so will not be discussed any further here.

Appendix B documents, in detail, the methods used and data codes assigned during Terrain Unit Mapping. All of the maps produced were prepared using as base maps USGS topographic sheets at a scale of 1:62,500. These were compiled from 7.5 minute maps at 1:24,000 scale photographically reduced to 1:62,500.

Much of the data was in a format which either required rescaling, adjustment to imagery, or both before it was in a form amenable to integration into a manuscript map. To rescale data to the working scale a combination optical/manual procedure was followed. This method involved the use of an optical pantograph; for this study the device used was a Kargl reflecting projector, with a rated distortion factor of less than 0.01%. In use, the collateral material (a map, for example) is placed on a platform, and its image is optically projected upward onto a glass surface. Enlargement or reduction of the original collateral material occurs when collateral-to-lens ratio is changed. Fastening a mylar copy of the topographic basemap onto the projection glass allowed the collateral to be reformatted to the basemap scale of 1:62,500.

After the information was adjusted to the 1:62,500 scale, it was manually transferred onto the drafting film. Care was taken that all information was transferred accurately, and that no transposition of information codes occurred. An edit check of the hand-drawn map compared it to the original data.

The physical characteristics and interpretive values of the phenomena mapped for this project were derived partially from the collateral documents used; this capitalized on the detailed field and laboratory observations which were made in order to create the collateral. Image interpretation was used to verify, rectify, and clarify the distribution and areal extent of the phenomena mapped from the collateral. Patterns were adjusted to match the imagery and the base maps. The imagery and base maps thus acted as geographic "controls" for the reformatting, eliminating cartographic inconsistencies between the various data variables mapped.

In the instances where no reliable collateral information could be found, limited field investigations were conducted on the ground and from the air to verify the mapped units which had been photo-interpreted.

As noted above, mapping was done using both polygons and lines. In creating polygon maps the study area was divided into smaller, discrete areas, each bounded by a closed line, called a polygon. The term polygon derives from the fact that these areas are initially digitized as a series of vertices which are connected by line segments. The discrete area inside each polygon is homogeneous with respect to the variable or variables to which the particular polygon designation refers.

For purposes of identification and description, the individual polygons on a manuscript map were given sequential identification numbers. Each polygon's sequential identifier was then used to associate the polygon with a set of attribute codes that also includes the sequential identifier. This code set describes the polygon's attributes in terms of the variable or variables portrayed on the manuscript map of which the polygon is a part.

Line maps were used to portray specific linear features, as opposed to polygon maps, used to portray areal data. On these maps, linear features were drawn as either lines or line segments. Coded values for lines were either applied directly to the manuscript map, or they were referenced from a separate code file to the map by the use of sequential identification numbers, as with polygons.

The four individual manuscripts prepared for each of the modules, or base maps, within the Vertical Integration study area are listed below, along with the specific data variables mapped for each. As noted, Manuscript #3 is discussed separately earlier in this section as Data Set Number 5.

Manuscript #1 - Integrated Terrain Unit Map

Land Cover
Geologic Type
Percent Slope
Landform
Soils
Surface Configuration
Geologic Hazards
    Alquist-Priolo Special Studies Zones
    Landslide Susceptibility
Depth to Groundwater
Flood-Prone Areas

Manuscript #2 - Surface Hydrology and Fault Map

Stream Order
Flow Characteristics
Channelization
Faults

Manuscript #3 - General Plan Land Use Map

Designated Land Use

Manuscript #4 - Transportation

Responsible Agency
Roads Classified by Intensity of Use Grouping
Roads Classified by General Surface Qualities
Scenic Roads
Railroads

Following are detailed descriptions of the considerations involved in mapping each of these data variables. The complete data classification system is contained in Appendix B.

Manuscript #1 - Integrated Terrain Unit Map

Manuscript #1 is a polygon map composed of nine data variables - land cover, geologic type, percent slope, landforms, soils, surface configuration, geologic hazards, depth to groundwater, and flood prone areas. Each variable is divided into a number of data classes. In some instances, these classes were defined by the collateral used; in other cases, the variables were divided into classes which had been applied to similar projects or which were needed to reflect particular aspects of the planning process.

In the integration process, lines representing certain data variables were considered very reliable, and so were not shifted or adjusted. These are called "hard" lines. At the other extreme were lines which were only generally defined and thus could be moved considerably in the integration process. These are called "soft" lines. The relative certainty for each of the data variables may be ranked from high to low as follows:

1. Flood prone areas (where available from collateral)
2. Geologic Hazards
3. Geologic Type
4. Landform (supersedes geology in areas of alluvium)
5. Vegetation (photo-interpreted to match other natural features)
6. Soils
7. Percent Slope
8. Surface Configuration
9. Depth to Groundwater

Each of these data variables is described below:

Flood Prone Areas. Flood prone areas were mapped to show areas subject to catastrophic floods. This variable is used to avoid development on areas where flooding is likely to be extensive.

The collateral consisted of U.S.G.S. Flood-Prone Area maps published at a scale of 1:24,000. These data were photographically reduced to 1:62,500 and were held closely to the pattern shown. Slight adjustments were made to reflect a 10 acre mapping resolution.

Geologic Hazards. Two types of special concern for geologic hazards were mapped - Alquist-Priolo Special Studies Zones and landslide susceptibility. These data were included to allow consideration of known or suspected geologic hazards when evaluating the geologic hazards potential of an area.

The collateral was in each case larger than 1:62,500, so photographic reductions were used. Delineations were closely held but were generalized to a 10-acre resolution.

Geologic Type. Geologic types were mapped by rock type and age. This variable provides the basis for a variety of interpretations through the use of an extended geologic interpretation matrix in which mapped units are given interpretive values for strength, generalized hazards, mineral potential, available groundwater, ease of excavation, and so on.

The collateral was at a scale of 1:48,000 and required photo reduction. Among the data classes portrayed were formation, age, and rock type. These data were resolved to the air photos and base maps at a scale of 1:62,500 to resolve dynamic boundaries such as floodplains. Minor changes were made to effect integration with other map variables.

Landforms. Landforms are a descriptive classification based upon structure, genesis, and material. These data provide a description of the general environmental setting while serving a variety of modeling needs, for example habitat, visual characteristics, and landscape dynamics.

Landforms were interpreted by a process which involved visual inspection of stereo pairs of high altitude air photos while delineating the actual pattern on a corresponding chronoflex enlargement at a scale of 1:62,500.

Vegetation. Vegetation was mapped using a system developed specifically for Southern California by the U.S. Forest Service. These data are essential to the environmental assessment process, serving a wide variety of modeling needs including potential fire hazard, mudflow, habitat, visual quality, noise, and recreation.

The vegetation pattern was photo-interpreted using the process described for landforms. In the highly urbanized areas, vegetation classes which represent the vegetation found on vacant properties were used and assigned to the entire urban sector. Overlay of the land use information from the land use file can be used to identify the actual land cover in the built-up part of these urban areas. This technique eliminated the necessity of drafting numerous "urban" polygons and helped to lower the cost of automation without sacrificing detail.

Soils. Soil series were mapped by series name. This allowed assignment of any of the soil interpretations or characteristics normally used by the Soil Conservation Service through the use of an interpretive matrix.

Soils were mapped from the SCS soil survey at a scale of 1:24,000 by a process of photo-reduction followed by visual comparison to the recent air photos to resolve conflicts with other data planes and to account to recent geomorphic events such as changes in river channels.

Percent Slope. The average percent slope was mapped to provide an input to development capability and suitability ratings. The classes chosen represent those normally used by planners to establish different types and densities of land use patterns.

The slope classes were interpreted by inspection of the contour line densities on the USGS topographic base maps. These classes, therefore, reflect overall slope rather than site specific conditions.

Surface Configuration. Surface configuration was included to provide an overall assessment of micro-relief. It is useful for a variety of aesthetic interpretations and assessments of land use suitability.

These data were interpreted by comparison of air photo stereo views with the crenulation of contour lines on the USGS topographic sheet base maps.

Depth to Groundwater. The average depth to groundwater was mapped to allow identification of potential liquefaction or structural problems associated with high water tables. This data is highly generalized and subject to wide seasonal variations. It should be noted that another source of groundwater information is found on the soil survey matrix of interpretations. Groundwater information was taken from a generalized 1960 map of groundwater at a scale of 1:48,000. These data were photographically reduced to 1:62,500 and integrated with the other data plains.

Manuscript #2 - Surface Hydrology and Faults

Manuscript #2 is the surface hydrology and faults manuscript, which includes two types of data: 1) stream course lines and 2) geologic fault lines.

The surface hydrology map locates and classifies major streams and most of the minor streams in the study area. These data can be used to identify water courses, possible pollution problems, critical habitats, and construction constraint areas (for example, those areas that may require bridges or stream culverts). The faults map locates and classfies known and suspected earthquake faults. These data can be used to screen areas for geologic hazards associated with ground motion and ground rupture and can be used in conjunction with the Alquist-Priolo Special Studies Zones mapped on Manuscript #1.

Surface Hydrology. Stream course lines were the first feature to be mapped for the manuscript. The stream courses were mapped from the base maps registered to their corresponding photo images. Each stream was not traced exactly as it appeared on the imagery or the base map; short, straight line segments were used instead. This process allows the stream lines to be digitized and displayed for a much lower cost than if the streams were digitized directly as they appear (continuously curving lines). These short line segments at no time represent a stream more than 0.2 cm (0.075 inches) from its actual location on the map.

Each stream course map was then rechecked against the imagery. If there were discrepancies between the base map data and imagery, the streams were adjusted to the imagery.

Stream values were given in the form of stream order and flow (perenniality). Stream order is described by the first code number in a numeric code value assigned to each stream segment. Flow characteristic was determined by either use of the legend of the base map and/or interpretation from imagery.

Photo-interpretation was used to establish where stream segments are channelized.

Faults. Fault lines, known or suspected, were mapped by registering photo-reduced collateral maps to the USGS base maps and manually transferring the lines. Dotted or dashed lines on the data source maps were represented as solid lines on the manuscript.

No photo-interpretation was done for faults.

Manuscript #4 - Transportation

This manuscript consists of lines. Variables included in this manuscript are data for roads classified by responsible agency, intensity of use, surface quality, and scenic qualities. Railroads and airports are shown on the land use update maps (Data Set No. 2).

Road data were collected from the topographic base maps, published road maps, and imagery at a scale of 1:62,500. The data were first mapped directly from the base maps onto a mylar overlay. The road maps were then used to supplement that data. All additional information was optically/manually reduced and transcribed to the 1:62,500 working scale. Each road was then image verified and coded.

Railroads were mapped from the topographic maps. The same procedures used for mapping roads were used here.

C. LANDSAT Component

A component of the vertical integration data base separate and distinct from the individual data sets described above is processed information provided by LANDSAT, a satellite-based system for acquiring land cover and resource data. This information, classified according to land cover and encoded in digital form on tape, was capable of direct incorporation into the data base through a series of aggregation and coordinate referencing procedures. The data were recorded as pixels of 1-acre grid-cell size.

The LANDSAT data utilized for this study were two unsupervised classifications covering the study area and additional area beyond the borders. One scene dated from 1976 and the other from 1979. The two scenes were included to allow for the application of change detection models, registration and extension of mapped data, and examination of LANDSAT performance in a GIS environment. Both scenes cover the entire study area, unlike many of the data base components, and were rectified and adjusted to match each other as closely as possible. The spectral classes were assigned to land cover classes through a series of iterations based on reassignments of spectral values for each pixel. Initially these data were grouped into broad classes or strata with subsequent refinement of the strata made using a color CRT and information contained within land use and land cover data bases. A total of 48 land cover classes were ultimately identified. A relabelling model was then developed that would assign each cluster of pixels to one of the designated classes based on its spectral value. This information was provided in both tape and photographic products. A complete description of the methodology utilized for the development of the classification system and the use of a hierarchical model for the creation of the classified LANDSAT scene is contained in a separate document (Likens & Maw, 1982). The classification system and a description of the codes is contained in Appendix A. The classes represented by this system are necessarily somewhat different than the classes used in the land use data base components. This is because LANDSAT classification utilizes spectral values for assignment, whereas the data base elements relied on a variety of photo-interpretive clues from lower altitude photography and on ground-truthing surveys. This does not diminish the validity or reliability of the LANDSAT data. It simply means that classes of vegetation or especially land use are differentiated on different bases. For example, LANDSAT classification groups together most non-residential urban land use as "structures" whereas commercial, office, industrial, and other uses can be distinguished with conventional approaches. On the other hand, LANDSAT provides an indication of the relative vigor of vineyards and orchards, and whether they are under cultivation, which cannot be reliably determined from other sources.

The 1979 LANDSAT image was initially prepared using the same classification steps as those used for the 1976 image. Because the two years had different rainfall patterns (1976 followed several drought years, while 1979 was extremely wet), the two images contained signficant differences caused by vegetation change and by standing water in 1979. In addition, the MSS sensors responses varied between the two scenes. This resulted in an image-subtraction change product containing indications of change not related to urban development - the principle change type of interest for this project. Several other change detection techniques were performed, including classification of a two-band difference image, and a Chi-square analysis of original image spectral clusters (see Likens et al, 1982). Ultimately, workshops were held and members of the San Bernardino County Planning staff aided in determining the procedures for identifying areas that had actually changed in land cover/use. The final decision was to identify as changed any area that was identified as change by two or more of these detection methods. These pixels were then identified on the 1976 image and the information associated with them was replaced by their classfication on the 1979 image. Thus, the 1979 image is identical to the 1976 image except in areas which were identified by the change detection procedure outlined here.

The format of the LANDSAT data, like the content, differs significantly from that of the data base components. Although pixels may be seen to be analogous to grid cells, they are conceptually quite different. Grid cells for the data base are based on data mapped originally as polygons. As such, they reflect previous interpretive decisions regarding the unit mapped, its area, its boundary with neighboring units, and mapping minimum conventions. Pixels represent basic data, albeit processed, without this layer of interpretive decisions. Thus, they are not subject to interpretive biases, but may also represent a degree of extraneous information. From a technical processing standpoint the format of the LANDSAT data does not match other data forms, but once they are accurately referenced to planimetrically accurate geographic coordinates the data can be re-adjusted to provide an exact fit.

This relates to one of the primary purposes of incorporating LANDSAT into the vertical data integration effort - to provide an accurate geographic standard for the rectification of the other component data bases. By this process, the compatibility of all the components could be ensured (this is discussed further in Section D. - Automation). As described in the Introduction to this report, and as is evident from the modeling done and the conclusions reached, LANDSAT is an essential factor in this study. The existing mapped data were used to train the LANDSAT data to extend terrain unit-type information into areas not originally mapped, notably the wilderness areas in the National Forest. These data also served as a test to determine if first-cut capability/suitability modeling was possible using only LANDSAT data in combination with digital terrain data (which generates slope, aspect, and elevation). Finally, the incorporation of LANDSAT into the integrated data base provided the basis for evaluating the reliability and utility of this process to County-scale planning needs.

D. Automation

The utility of the vertically integrated data base with its multiple components and LANDSAT-derived data is due to the automation of the entire system. This central fact allowed for the organization of numerous data planes over a wide geographic area, the comparison, checking, and rectification of several independently structured data bases, and the development of complex weighted models for systematic evaluation of land resources. System automation took place in two distinct phases. Most, but not all, of the information incorporated into this study had been previously automated; many of these data bases were in fully compatible formats. That portion of the study which was mapped specifically for this project was subsequently automated to match the previously automated portion. The LANDSAT and digital terrain information are by their nature in an automated form. Thus, each part of the vertically integrated data base was automated. The second phase of the automation effort centered on creating a single, coherent geographic information system out of those multiple components. This section of this report deals with these two phases separately, as Map Automation and Data Base Integration.

Map Automation. The SCE land use and land use update, the USFS terrain units, the General Plan support data, census tracts, and the Valley terrain units (Data Sets Number 1, 2, 3, 5, 7 and 9) were all automated using an identical automation method involving digitizing the polygons, lines, and points on the map, and keypunching the numeric codes describing the attributes of each. Digitizing is a process of converting lines to a series of x,y coordinates, connected by straight lines, that can be stored in the computer. Each polygon, point, and line has a unique sequence number that is keypunched into the computer directly with the attribute codes to be associated in later processing with the identically numbered mapped unit. This process was done independently for each of the component data bases.

The technical process involved in transferring geographic data from the manuscript maps and associated codes to the automated data files can be divided into four major tasks. These can be described as follows:

- Manuscript Map Preparation for Digitizing
- Digitizing
- Editing of Digitized Files
- Final File Creation

1. Manuscript Map Preparation for Digitizing

Before any manuscript is automated, it is carefully checked for errors and prepared for actual digitizing. The checking includes examination for missing polygons or codes, extraneous lines, or problems which might cause confusion during digitizing.

Then a unique number is assigned to each of the maps and the map files created to distinguish each module manuscript from all other files for that data base. Certain of these manuscripts were further subdivided into variable files during processing, reflecting the different type of data included on these maps.

Next, each manuscript map is "prepped" by first numbering the geographic reference points (tic marks) on each map in sequence from north to south. Then, each polygon, point, and line is assigned a unique sequence number which is recorded on the map. These numbers are used to indicate an order in which to enter the data and for identification purposes during subsequent file editing.

2. Digitizing

Using a process called "digitizing", all data recorded on the manuscript map is converted to machine readable form. The machine used to make this conversion is a digitizer, a backlighted drafting table to which is attached a movable cursor. As the cursor is moved horizontally and vertically over a manuscript map mounted on the digitizer table, electronic devices translate these movements into digital measurements in units of one thousandth of an inch. The numbered tic marks are digitized (recorded) first. The cursor is moved to each tic mark and, by pressing a key, a record is sent to a mini-computer for storage. After all tic marks are digitized, each polygon, point, and line on the map is similarly recorded and stored. The digitized record indicates the precise location (x,y coordinates) of all mapped information with respect to the tic marks. The tic marks represent known points of latitude and longitude so that all of the maps can be referenced to each other. The latitude and longitude coordinates can be transformed into State Plane Coordinates or UTM coordinates.

Data digitizing and all subsequent data automation processes for the specified components utilized Polygon Information Overlay System (PIOS) software. PIOS was initially developed by ESRI in 1970 and is now in its fifth version.

The digitizing process involves systematically recording data according to a standard set of procedures. For polygon data, this involves selecting and recording a string of x,y coordinates (vertices) where a change in direction occurs along the border of each polygon. Curves are approximated by short straight line segments. The polygons are digitized in a specific order, which is determined by sequence numbers before the digitizing begins. When a set of donut polygons occurs, the innermost polygons are digitized first. Digitizing then proceeds to the polygon which contains the previously digitized polygon(s). In no case is a polygon digitized before all the polygons contained within that polygon are digitized. PIOS software resolves the hierarchy to produce accurate area calculations.

Lines are digitized in a similar way, but unlike polygons the strings of x,y coordinates are not required to close. Point features are represented by a single x,y coordinate. Since no area calculations are involved, digitizing is more straightforward.

3. Editing of Digitized Files

After the manuscript map is digitized, the stored record is transferred from the digitizer's mini-computer to a large computer for further processing. The first step in the edit process is to shift and scale the coordinates of each file relative to "tic" marks which provide geographic reference. From this step, lists are generated which allow tic identification numbers, tic coordinates, sequence numbers, donut level identifiers, and code numbers to be checked. Because of machine errors during digitizing, it is sometimes necessary to redigitize a polygon or a series of polygons. After these editing steps are completed, changes are made and the revised files are stored. At this stage, all information stored in the file is numerically accurate.

After these machine edits, plots of each variable map ("droplines") are generated. These maps are used to visually check the accuracy of the digitized and machine edited x,y coordinates. Graphically editing polygons is the simplest and least costly method currently available. If each of the plots from the automated file visually matches the original map within acceptable limits, the file is assumed to be sufficiently accurate.

The visual edit is an overlay process whereby the boundaries on the plotted information for each variable are visually compared with the boundaries on the manuscript maps that were used for digitizing. This quality control step of overlaying digitized maps and manuscript maps allows identification of missing polygons, duplicated po50gons, unacceptable polygons, code errors, and code offsets (for legibility).

Data errors discovered in this process are relatively easy to correct. PIOS edit software allows code corrections, point changes, etc. In more complex cases, such as missed polygons, the entire polygon is redigitized. This involves remounting the original manuscript map and redigitizing the entire polygon in error. This redigitized information is readily merged with the previous information because the tic marks are also redigitized, insuring perfect alignment when the new data are merged with the existing file.

4. **Final File Generation**

This process combines the error-free digitized files of polygon boundaries, based on lines and intersections, and the codes for each polygon. Two preliminary steps are required for completion of both files. The first step is to convert the digitized tic coordinates (referenced in inches from a single point of origin) to a "real world" geographic coordinate referencing system; State Plane Coordinates were used for this study. The next step required is to merge the individual files created for each map module into a single file for the entire study area. At the completion of this step, these files are in their final polygon format.

Each of these steps was followed for the six data bases listed above. It should be noted that the land use studies, the Forest Service maps, and the Census Tracts (Data Base Numbers 1, 2, 3, and 7) were automated separately from this study. The Land Use Element of the County Plan (Data Base No. 5), although prepared independently, was automated specifically for this study. Data base Number 4, Parcel Ownership File, is an automated address file not involving map automation. Data Base Number 6, GBF/DIME, is based on a different system which automatically converts side-of-street information to a polygon system and matches it to census units and real world geographic coordinates. The data was automated separately, but then converted to polygon form for this project. Digital terrain information (Data Set Number 8) had been previously automated in a digital grid format. Finally, the Valley Terrain Units (Data Base No. 9) were mapped and automated for the vertical integration data base.

Data Base Integration. At this point, each of the data bases was independent of the others, although referenced to the same set of geographic coordinates; with the exception of Digital Terrain Data and LANDSAT data sets, each was in a polygon format. Two steps were necessary from this point to create the vertically integrated data base. The first was the conversion of the files within each of the distinct data bases to a grid format. The second step was the merging of all the files into an inclusive grid Multi-Variable File (MVF).

The individual grid files were created using a series of ESRI computer programs (GRIPS - Gridded Information from Polygons). The first step in this process was the merging of all of the map modules into one unit for the data base, and assigning new polygon numbers numbered sequentially for the entire study area (TUNGEN numbers). (At this point, the files for each of the manuscripts within each data base still existed separately.) Then a single variable file was created in grid format from the new terrain unit polygon numbers. In effect, a grid with a cell size of 4 acre was superimposed over the polygon maps as automated, and each cell was assigned a code corresponding to the polygon in which it was located. This was done in two steps. Initially, a one-acre grid was overlaid on the data and values assigned using the GRIPS program. After a series of sort and edit procedures were completed, a second program (GRDPST) converted 2 x 2 cell groups into 4-acre cell groups, considering their primary, secondary, and tertiary values. This allowed a more accurate capture of the original polygon data than a simple 4-acre overlay would have.

The northwestern corner of the LANDSAT data was designated as the first row and column of the grid. Knowing the State Plane Coordinates of each tic mark for each data base, the row and column numbers for each were calculated. The GRIPS program was used to create gridded data files for each data base which were thus registered by means of row/column numbers to the LANDSAT image. Figure III-3 illustrates this registration concept. Next, the codes for the polygons were added into this file to create a multi-variable file. Non-polygon format data variables were also added to the grid file for the Valley terrain units. In some cases, an identifier sequence number was merged into the file and then the coded variables added as described above; in others, the codes were merged in directly from the code files. Also added was an expansion matrix for soils mapped as part of the Valley terrain units. This matrix provided a series of coded interpretations for each soil mapped, such as stability, suitability for building, and agricultural capability, that could themselves be used for modeling.

The creation of the individual grid files allowed the development of the grid Multi-Variable File encompassing all of the information mapped within the study area. This was done by the same process used to add individual variables to the files for each of the data bases - layers of information comprising each component were successively added to the original file. The proper registration of all the components was achieved as described above by designating a known geographic reference point as the upper-left corner of the gridded study area (row 1, column 1). Since the true geographic location of each data base was known, they could be accurately positioned relative to this point. As each data plane was added to the multi-variable file, its northwest corner cell was assigned to the correct grid cell location to insure proper registration. The terrain unit data planes (Forest and Valley) were used to define the limits of the data base, thus truncating all cells outside the study area, but included in the LANDSAT image. In the case of information that originally existed in a grid form (the Digital Terrain Data and the LANDSAT data), these cells were processed in the computer to match precisely the location and configuration of the grid structure used for this study. The GRDPST program was used to aggregate the data bases compiled at a 1-acre resolution to the 4-acre resolution chosen for the integrated data base. This process if illustrated in Figure III-1.

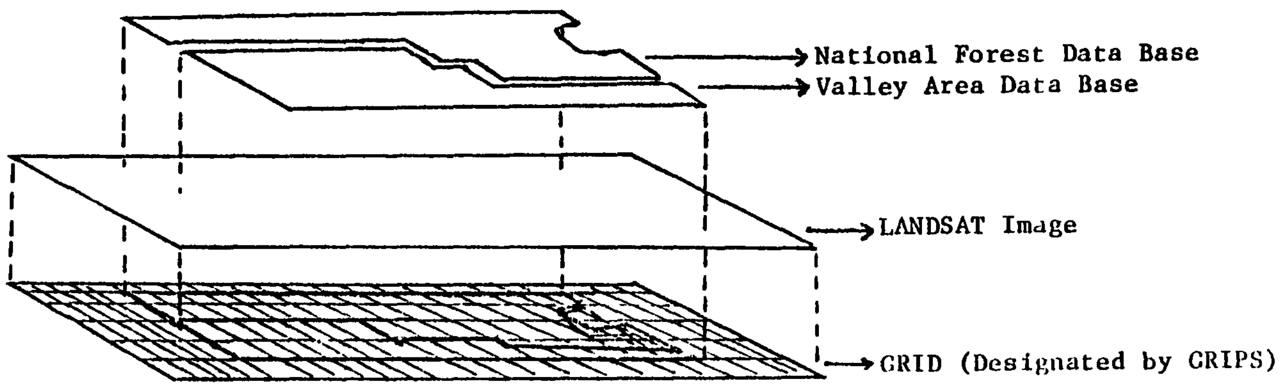


FIGURE III-1

Data Base/LANDSAT Registration

Assignment of codes to the aggregated cells for all of the data bases was made by one of three optional methods described in Table III-I. The result of this was the Integrated Data Base, in a form suitable for various analysis and modeling procedures relying on an extensive range of environmental characteristics. The complete contents of the MVF for the data base are shown below:

MULTIVARIABLE FILE

The Vertically Integrated MVF contains 39 data planes which are identified below. The study area is comprised of 343 rows x 552 columns. The area containing data includes 160,498 grid cells, each encompassing 4 acres. Appendices following identify the specific data values employed as well as the methods of data acquisition.

Variable	Data	Variable	Data
1.	Row	26.	Valley Roads
2.	Column	27.	Valley Railroads
3.	Subarea	28.	Valley Streams (3)
4.	Valley Terrain Unique Number	29.	Valley Fault Lines
5.	SBNF Terrain Unique Number	30.	1976 CDF Landsat
6.	Valley Map Module Number	31.	Elevation (DMA)
7.	Valley Terrain Unit Sequence Number	32.	Slope Aspect (from elevation)
8.	Valley Land Cover	33.	Slope (from elevation)
9.	Valley Geologic Type	34.	1976 Classified Landsat
10.	Valley Slope	35.	Change Mask (Landsat)
11.	Valley Landform	36.	1979 Spectral Classes (Landsat)
12.	Valley Soils	37.	1979 Classified Landsat
13.	Valley Surface Config., Geo. Hazards	38.	Valley Soil Interpretations (3)
14.	Valley Flood Prone Areas	39.	Valley Soils K Value
15.	Valley Groundwater		
16.	SBNF Map Module Number		
17.	SBNF Terrain Unit Sequence Number		
18.	SBNF Land Cover		
19.	SBNF Geology		
20.	SBNF Slope		
21.	SBNF Landform		
22.	1974 Land Use		
23.	1979 Land Use		
24.	General Plan		
25.	Census Tracts		

LECRL = 39x2 = 78

Blocking Factor = 50

Blksize = 3900

TABLE III-1
GRDPST
Method of assigning values to Grid cells

DATA BASE	METHOD
1976 LANDSAT	-aggregated from 1 acre to 4 acre grid cell based on frequency option
1979 LANDSAT	-aggregated from 1 acre to 4 acre grid cell based on frequency option
Digital Terrain Data	-aggregated from 1 acre to 4 acre grid cell based on frequency option
1974 Land Use	-aggregated from 1 acre to 4 acre grid cell based on frequency option
1979 Land Use	-aggregated from 1 acre to 4 acre grid cell based on frequency option
Forest Service Terrain Units	-aggregated from 1 acre to 4 acre grid cell based on frequency option
Valley Terrain Units	-aggregated from 1 acre to 4 acre grid cell based on frequency option
General Plan	-aggregated from 1 acre to 4 acre grid cell based on frequency option
Roads	
Calculation and scenic designation	-aggregated from 1 acre to 4 acre grid with descending option: highest value code takes precedence
Use, surface qualities	-aggregated from 1 acre to 4 acre grid with ascending option: lowest value code take precedence
Streams	
Order, flow characteristics channelization	-aggregated from 1 acre to 4 acre grid with descending option: highest value code takes precedence
Faults	-ascending option: low value code takes precedence
Railroads -	-frequency

BASIC DATA MAP LEGENDS

The following pages are derived from analysis of the data categories in several of the basic data files and the amount of the study area which is encompassed by each class of data. Some data variables contain a large number of different class types, while others contain relatively few different classes. For visual clarity of output maps some classes have been aggregated into more general classes (e.g., Residential comprised for residential subclasses). Total area of each class was calculated from the output listing from the GRDMDL used to create the map output file.

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
1974 LAND USE

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Open space/recreation 125, 171 - 174	A	1045.71	1.67%
Vacant 175, 231 - 235	C	24180.78	38.50%
Agriculture 210 - 216	F	12771.88	20.33%
Residential 111 - 114	M	13306.06	21.29%
Other committed 150 - 155, 167	P	3009.24	4.79%
Industrial/extractive 130 - 132, 140	S	1576.66	2.51%
Public/institutional 160 - 166, 168	X	1265.86	2.02%
Commercial 120 - 124, 126 - 127	Z	1754.72	2.79%
Water 221 - 223	Blank	3893.08	6.20%

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
1979 LAND USE

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Open space/recreation 171 - 172	A	1071.61	1.71%
Vacant 231 - 233	C	26481.01	42.15%
Agriculture 210 - 216	F	8508.11	13.55%
Residential 110 - 114	M	14894.05	23.72%
Other committed 151 - 153	P	3012.48	4.80%
Industrial 131 - 133	S	1689.97	2.69%
Public/institutional 161 - 162	X	1364.60	2.17%
Commercial 121 - 123	Z	1809.75	2.88%
Water 154	Blank	3972.39	6.33%

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
LANDCOVER

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Urban 110 - 162, 151 - 153	A	26440.54	10.83%
Barren 31	D	7193.69	2.95%
Agriculture 210 - 216	F	8100.19	3.32%
Grass 30	K	10437.65	4.27%
Brush 24 - 25, 29	M	10643.23	4.36%
Chaparral 19 - 22	P	62161.33	25.46%
Joshua tree forest 18	C	1249.67	0.53%
Dry forest 12, 23	S	27065.38	11.09%
Hardwood forest 16 - 17, 26 - 28, 34	T	17699.33	7.25%
Coniferous forest 1 - 11, 15	Z	56913.37	23.31%
Water/wilderness 33	Blank	14594.58	6.63%

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
GENERAL SLOPE

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
0 - 8%	A	63550.21	26.03%
8 - 15%	D	17660.48	7.23%
15 - 30%	F	26961.78	11.04%
30 - 50%	M	37142.05	15.22%
GT 50%	T	82549.40	33.83%
Wilderness	Z	13754.46	5.63%
Water	Blank	2499.34	1.02%

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
GENERAL PLAN LAND USE

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Rural conservation	Blank	8988.88	14.44%
Rural living	K	6699.98	11.14%
Agriculture	F	2591.61	4.31%
Residential			
1 - 2 units/acre	A	6350.33	10.56%
3 - 5 units/acre	D	7080.38	11.77%
6 - 10 units/acre	F	9663.89	16.06%
GT 10 units/acre	M	6275.86	10.43%
Commercial	S	2910.50	4.84%
Industrial	T	6597.99	10.97%
Public	Z	2997.91	4.98%

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
1976 LANDCOVER - LANDSAT

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Residential/urban 23 - 24, 27 - 33	A	18401.87	7.10%
Other committed 18 - 22	C	581.13	0.22%
Cleared/bare 1 - 2, 26	D	12138.95	4.69%
Agriculture 17	F	1155.78	0.45%
Grass 15 - 16	K	31401.99	12.12%
Orchard/vineyard 6 - 12, 34	M	6526.77	2.52%
Brush, Chaparral 3 - 5, 44 - 49	P	7409.02	45.33%
Woodland forest/chaparral 13 - 14, 37, 40	S	31505.59	12.16%
Hardwood forest 41	T	260.62	0.10%
Coniferous forest 35 - 36, 38 - 39, 42 - 43	Z	38247.65	14.76%
Water 25	Blank	1426.11	0.55%

VERTICAL INTEGRATION
BASIC DATA MAP LEGEND/STATISTICS
1979 LANDCOVER - LANDSAT

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Residential/urban 23 - 24, 27 - 33	A	19764.85	7.63%
Other committed 18 - 22	C	587.60	0.23%
Cleared/bare/snow 1 - 2, 26	D	12036.97	4.64%
Agriculture 17	F	969.63	0.37%
Grass 15 - 16	K	30226.78	11.67%
Orchard/vineyard 6 - 12, 34	M	6050.86	2.34%
Brush/chaparral 3 - 5, 44 - 49	P	117750.57	45.45%
Woodland/forest - chaparral 13 - 14, 37, 40	S	16229.51	6.26%
Hardwood forest 41	T	233.10	0.09%
Coniferous forest 35 - 36, 38 - 39, 42 - 43	Z	53030.01	20.48%
Water 25	Blank	2175.59	0.84%

IV. USER NEEDS - ANALYSIS TYPES

The County of San Bernardino has recently adopted a Consolidated General Plan and Implementation System to control the location and types of development throughout the County unincorporated areas. In order to monitor the results of the General Plan and Implementation System, the Planning Department must track a variety of data types generated by local jurisdictions, by County agencies and by State agencies. A vertically integrated data base with the capability of using LANDSAT temporal monitoring data in concert with other geographic data types can be instrumental in the evaluation of many time-consuming data gathering and analysis tasks. These tasks, which must be dealt with daily by planners, include the following:

1. Determine the amount of land in a given area that is now committed to urban uses. To rural uses.

2. Determine the amount of land converted from rural to urban use in a given time period. From undisturbed vegetation to agricultural and/or urban use.

3. Identify the location and chief characteristics of environmentally sensitive land types in an area.

4. Identify the location and condition of agricultural and other land resources. Project the impact of land conversions on these resources.

5. Identify what land resources have been converted in a given time frame. To what? At what specific locations?

6. Determine the development characteristics of the newly urbanized areas (e.g., concentrated - scattered; infill - fringe).

7. Identify consistency and inconsistency between actual development patterns and the County's Consolidated General Plan.

8. Using environmental constraint data, determine the effective population capacities of the various regions in the Consolidated General Plan.

9. Determine what land areas are most capable of supporting urban growth.

10. Identify which areas are most likely to experience growth demand, considering all environmental, capability and resource values.

The data base designed for this study contains available data elements which can be used to perform these tasks in a rapid, efficient and cost-effective manner. The Phase 1 data base was designed to cover both County and National forest lands at a resolution of 4-acres. This data base was subsequently subdivided (windowed) to create two 1-acre resolution small-area data bases in order to test the application of the vertically integrated data base and its LANDSAT component to large-scale detailed analyses.

The National forest staff is responsible for managing a large area of land for a variety of uses including wilderness recreation, forestry, mineral extraction, and others. Much of the forest is maintained in its native shrub and forest land cover and is susceptible to periodic wildfire - a major control and planning function for the staff. Planning decisions deal primarily with the appropriate use designations within the forest lands and the intensity of use permitted. These decisions require evaluation of the capability of natural resources to support - or tolerate - given uses as well as legal mandates for multiple forest uses. Objective and well-documented decisions must be made and clearly presented, as the San Bernardino National Forest is among the most intensively used areas controlled by the US Forest Service.

Vertical integration in a given region was conceived as a method of providing flexibility of data types as described in Section II and also as a means of providing efficient analyses of these data types. The following paragraphs describe the basic type of analysis which are routinely undertaken by the users.

Hazard Analysis: Both the Planning Department and National Forest staff determine the location, extent and probababllity of occurrence of various hazards. These analyses are basic input to planning studies and use designations. The major hazards evaluated are fire hazard, landslide/soil stability, earthquake fault zones (Alquist - Priolo Special Study Zones) and flooding. Each of these analyses requires a geographic location and a quantitative hazard rating.

Soil Suitability/Potential: Soils present at a given site are analyzed with respect to their suitability to support construction, waste discharge, and/or agriculture. This analysis involves locational and interpretive data, and is used by both agencies to aid in determining the most appropriate use of a given land area.

Impact Sensitivity: This analysis is a composite of the impacts expected to result from a given project or a general intensity of use. Impacts of activity or construction on natural resources are considered, as are impacts of natural characteristics on a proposed activity. The analysis includes both locational and intensity (sensitivity) parameters.

Service District Extension Capability: This analysis is used primarily by SBC to determine whether or not a proposed land use will be serviced by public (and private) services. This analysis requires locational data regarding the total area served by the utility (service district), the capacity of the utility to absorb the proposed new demand, and the ability of the service to extend a new line or route to the site of the proposed land use change.

General Plan and Zoning Designations: This analysis is performed by SBC to determine whether or not a proposed land use change is compatible with the general plan for development in the region. If compatible, a project application is processed by the staff to insure that the County ordinances and development code criteria are met. If not compatible, the applicant must request amendment of the zone or General Plan designation. The amendment process is discretionary and requires public notification and hearings. Only after the appropriate designation has been assigned can an application for a land use change be submitted. This analysis is primarily locational, although intensity of use is reflected by the General Plan designations.

Conversion Rates, Building Rates: This analysis is done primarily by SBC to keep an accounting of all building activity in the County, as well as tracking the status of each parcel. In addition to aiding the Planning Department as it processes applications, this analysis provides data which can be used to verify census records and State Department of Finance records. These records are used to allot tax monies to the County and also to apportion representative districts. The development status of each parcel is an important criterion used by the County Assessor to value the property for tax purposes. These data are primarily statistical, although they are geocoded according to address, parcel number, blocks, block groups and census tracts.

The following chapter describes how the data in the integrated data base were used to perform some of these analyses over the integrated study area. Assembly of several data banks into a unified format facilitated their analysis and allowed two or more analyses to be locationally related. In addition, an integrated data base makes it possible to output graphic representations of integrated data types such as administrative designations along with slope, vegetation, flood zones, etc. This allows comparison of development patterns with any and all of the geographic, environmental and planning data which are also contained in the data base.

V. DATA MODELING & MAPPING

A. Introduction

As a demonstration of the utility of the data base, specific studies have been conducted related to identified County applications. The models were designed to test and illustrate the use of the integrated GIS for urban and agricultural capability modeling, comparison with the use of LANDSAT data for "first-cut" urban capability modeling, and use of the LANDSAT data to extend a geographic model into a previously unmapped mapped area. These techniques were then refined and applied to the small-area analysis data bases developed for the second phase of this project. Phase 1 applications are associated with general planning and growth monitoring efforts within the San Bernardino County Planning Department and fire control planning for the National forest. In general, they are directed by the analysis needs described in the previous section and rely on the outlined models which are responsive to those needs. These models manipulate the automated environmental data contained within the system to produce maps delineating hazards and resources and the suitability of land for various types of development. Conceptually, the models are a means of examining multiple environmental factors simultaneously, weighting the relative importance of those factors, and adding in additional environmental interpretations related to the characteristics and locations of mapped units. These examinations are based on a set of assumptions, developed by the study team in association with agency personnel, regarding the positive or negative significance of particular feature of the landscape to the relevant factor. The sources for the mapped data were also considered in the modeling process. A parallel fire hazard model was developed to ascertain the value of LANDSAT derived data to extend an existing GIS data base in the San Bernardino National Forest.

B. Models

The specific models employed for this study are of two sequential types: interpretive opportunity/constraint models and land capability/suitability models. The former assess general environmental patterns and processes. They focus on identifying general conditions which pose an opportunity or constraint to development or which represent hazards or resources for identified land use activities. The latter models, which build upon both the basic data in the GIS and data developed through the process of interpretive modeling, focus on the evaluation of land capability and land suitability for select types of uses. For purposes of this study, land capability was conceptualized as the inherent capacity of the total complex of land to sustain development or support specific activities, taking into account natural constraining factors. More specifically, it refers to the inherent capacity of the total complex of land-based environmental patterns and processes to sustain a specific type of land use without bringing about excessive environmental degradation or exposing people or investment to hazards or unusual costs. Land suitability means the appropriateness of land for a specific use, taking into account social, economic, and political considerations. It refers to such considerations as compatibility with existing development, proximity to existing infrastructure, and the existence of or proximity to valuable resources.

The interpetive models developed for this study were specifically designed to reflect current County analysis needs and to demonstrate the utility of the integrated data base. The ten models employed are listed below:

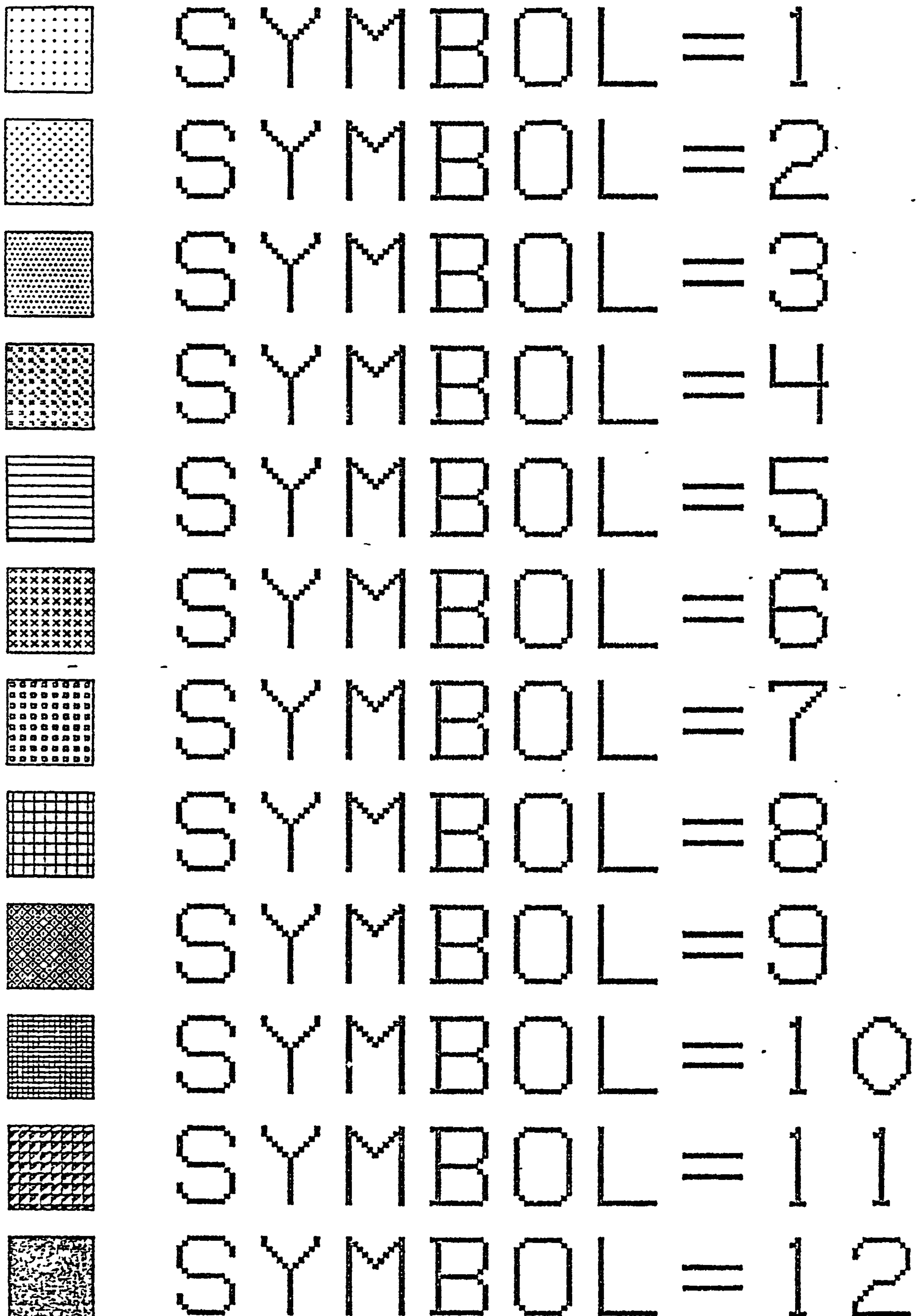
- o Slope Stability
- o Geologic/Seismic Hazards
- o Flood Hazards
- o Soil Resources
- o Erosion Potential
- o Ecological Impact Potential
- o Fire Hazard Rating

In addition to the interpretive models, models were constructed to evaluate Agricultural Capability and Urban Development Capability/Suitability. These models utilized results of many of the interpretive models, as well as other information obtained directly from the data base. They represent a composite evaluation of environmental hazards and resources and their significance for the ability of land to support agriculture and general urban development.

C. Map Outputs

Three types of maps were produced for the County Application Studies: basic data, interpretive, and capability/suitability maps. As noted earlier, maps were produced for specific basic data elements: geology, slope, vegetation, groundwater, general plan, existing urban and rural, 1976 and 1979 LANDSAT, 1976-79 change mask, and 1974 and 1979 land use. Basic data types selected for mapping were chosen for their utility to County planners and their balance of legibility and usable detail. LANDSAT maps were output for purposes of comparision and as a point of reference for discussions of LANDSAT utility. Each of the models also resulted in a map output displaying the environmental hazard or resource or the capability/suitability considerations. These maps, both basic data and model outputs, are in a gray-tone grid format at a scale of 1:62,500. Each class or level of mapped data is represented by a symbol (Figure V -1). When viewed from a distance, these grade from white through shades of gray to black. Since maps can display up to twelve levels of data, these levels typically represent aggregations of data derived by prescribed summation rules. For example, these rules might dictate for a particular model that final values of 1 to 12 would be in Class I - very low, 12-25 in Class II - Low, and so forth. In other instances, data were not ranked, but more than 12 individual classes of information were coded. This was especially common for the basic data planes. For these, similar types would be aggregated into a single class; for example, chaparral, coastal sage scrub, and other "bushy" vegetation communities would all be classified into a single scrub vegetation class.

FIGURE V-1


SYMBOL=1
SYMBOL=2
SYMBOL=3
SYMBOL=4
SYMBOL=5
SYMBOL=6
SYMBOL=7
SYMBOL=8
SYMBOL=9
SYMBOL=10
SYMBOL=11
SYMBOL=12

For certain of the maps, there were fewer than 12 separate classes of information, either basic or modeled data, so they were displayed directly without modification. Thus, the basic concept underlying the classes represented by the map symbols differed significantly on various maps. Therefore, legends for each of the maps are presented later in this section, indicating the type of grouping used for each.

To summarize, grid gray-tone maps have been produced for each of the following considerations:

Basic Data Maps

- o Geologic Type
- o Slope
- o Vegetation
- o Depth to Groundwater
- o General Plan
- o Existing Urban
- o Existing Rural
- o 76 Classified LANDSAT
- o 79 Classified LANDSAT
- o 76-79 Change Mask
- o 74 Land Use
- o 79 Land Use

Interpretive Maps

- o Slope Stability
- o Geologic/Seismic Hazards
- o Flood Hazards
- o Soil Resources
- o Erosion Potential
- o Ecological Impact Potential
- o Fire Hazard Rating

Capability/Suitability Maps

- o General Urban Development Capability/Suitability
- o Agricultural Capability

D. County Applications Products

Grid map legends for each of the basic data maps are shown on the following pages. For each, the meaning of each symbol, and the type of aggregation utilized, where appropriate, is shown. The total acreage and the percentage of the study area within each class is also listed.

Each of the interpretive models is described in detail. For each, the specific data base(s) within the integrated system which is (are) the source(s) for the required information, the general characteristics of the environmental hazard or resource, its spatial distribution within the study area, and its significance to County planning efforts are identified. Following the description of each conceptual model is an outline of the model indicating the weighting of each of the environmental variables used. This in turn is followed by a summary of the legend for the associated grid map, indicating the classes used on the map and the acreage for each class.

Slope Stability. The information utilized for this model is contained within the Integrated Terrain Unit data base, as prepared originally for this project for the Valley portion and as supplied by the Forest Service for the National Forest portion of the study area. Three factors are considered in this model: the presence or absence of known landslides, the geologic susceptibility of an area to landslides, and slope. Known landslides and landslide susceptibility were coded into the data base directly from collateral data sources (Morton, 1974) with necessary map/photo rectification and integration with other data sources; slope was interpreted from topographic maps. This type of information is used within the County Planning Department both for long-range comprehensive planning and determinations of overall development suitability of an area, and for evaluation of specific sites and projects when the data are of sufficient detail and resolution. The planning staff requires a special geologic hazard study for projects located in areas suspected of landslide activity. This model also functions as a sub-model for the Urban Development Capability/Suitability model described later in this section. The slope stability model is outlined on the following page.

SLOPE STABILITY
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
General Consideration	Water	SKIP	
Landslide Suscepti-bility	Known Landslide	50	
	Moderate-High	40	
	Low-Moderate	20	
	Generally Devoid, Not a known landslide	10	
Percent Slope	GT 30%	4	
	15-30%	3	
	8-15%	2	
	0-8%	1	

MODEL SUMMATION RULES

Rating	Value
Known Landslide	GE 50
Landslide Susceptibility Rating	
Moderate to High	40-44
Low to Moderate	
GT 30% Slope	24
15-30% Slope	23
8-15% Slope	22
0-8% Slope	21
Generally Devoid	
GT 30% Slope	14
15-30% Slope	13
8-15% Slope	12
0-8% Slope	11

SLOPE STABILITY
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Known landslide	Z	84.17	0.14%
Landslide susceptability Rating			
Moderate to High	X	119.79	0.20%
Low to Moderate			
Greater than 30% slope	S	7038.29	11.83%
15 - 30% slope	P	1419.64	2.39%
8 - 15% slope	O	1838.89	3.09%
0 - 8% slope	M	1400.21	2.35%
Generally devoid			
Greater than 30% slope	K	828.80	1.39%
15 - 30% slope	F	228.24	0.38%
8 - 15% slope	D	767.28	1.29%
0 - 8% slope	C	45701.96	76.83%
Water	Blank	67.99	0.11%

Geologic/Seismic Hazards. Geologic and seismic hazards have also been modeled from information contained within the integrated terrain unit data base. The model describes the potential for hazards due to seismic conditions based on the existence and proximity of faults, the general geologic type of the area, and depth to groundwater. It also refers to the existence of Alquist-Priolo Special Studies Zones. These are areas delineated by the California Department of Mines and Geology as zones which contain a known or suspected geologic fault. Any development within a Special Studies zone must be preceded by a field investigation, including trenching, to determine the exact location of any fault. All of these data items were coded into the data base directly from collateral materials. As with the slope stability map, the model displays the aggregated information classes rather than ranking the factors and displaying hazard ratings (such as high, moderate, low). The classes used are described on the model outline on the next page; the map legend follows.

The mapped information is essential to County Planning efforts, if only because of State requirements regarding Alquist-Priolo Special Studies Zones. In addition, fault rupture and groundshaking potential can be inferred from the displayed information for purposes of evaluating seismic hazards and suggesting appropriate mitigation measures in accordance with the Seismic Safety Element of the County's Consolidated General Plan. The map's primary geographic feature is the San Andreas Fault Zone trending northwesterly-southeasterly across the south-central portion of the study area. Based on this and additional fault lines, geologic type and depth to groundwater suggest high groundshaking potential in the area of Cajon Pass and along the base of the San Bernardino Range.

GEOLOGIC/SEISMIC HAZARDS
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Faults	Known, Concealed or Inferred Fault	200	
Geologic Hazards	Alquist Priolo Fault Zone	100	
Proximity to Fault	Known, Concealed or Inferred, Fault		
	LE 2 Miles Distance		70
	2-5 Miles Distance		50
	GT 5 Miles Distance		30
Geologic Type	Unconsolidated Deposits*	20	
	Consolidated Deposits	10	
Depth to Groundwater	Groundwater LT 100 ft.	5	
	Groundwater GE 100 ft.	0	

MODEL SUMMATION RULES

Rating	Value
Known, Concealed or Inferred Fault	GE 200
Alquist Priolo Special Study Zone	100-195
Proximity to Fault	
LT 2 Miles from a Fault	
Unconsolidated Deposit	
LT 100 ft. Groundwater	95
GT 100 ft. Groundwater	80 - 85
* Consolidated Deposit	
2-5 Miles from a Fault	
Unconsolidated Deposit	
LT 100 ft. Groundwater	75
GT 100 ft. Groundwater	70
Consolidated Deposit	60 - 65
GT 5 Miles from a Fault	
Unconsolidated Deposit	
LT 100 ft. Groundwater	55
GT 100 ft. Groundwater	50
Consolidated Deposit	40 - 45

SPECIAL NOTES
*Unconsolidated Deposits. Following Geology Codes: 01-05, 13, and 15-26

GEOLOGIC/SEISMIC HAZARDS
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Known, concealed, or inferred fault	Z	3460.87	5.82%
Alquist Priolo special study zone	X	4725.11	7.94%
Proximity to faults			
Less than 2 miles from a fault			
- Groundwater less than 100 ft. deep	S	2920.21	4.91%
- Groundwater greater than 100' deep	P	32473.59	54.57%
Consolidated deposit	O	5199.40	8.74%
2 - 5 miles from a fault			
Unconsolidated deposit			
- Groundwater less than 100 ft. deep	M	687.97	1.16%
- Groundwater greater than 100' deep	K	8378.61	14.08%
Consolidated deposit	F	312.42	0.53%
Greater than 5 miles from a fault			
Unconsolidated deposit			
- Groundwater less than 100 feet deep	D	92.27	0.16%
- Groundwater greater than 100' deep	C	1076.46	1.81%
Consolidated deposit	A	100.36	0.17%
Water	Blank	67.99	0.11%

Flood Hazards. Flood prone areas have been defined by this model based on several independently-derived criteria. Documented flood zones were defined by the USGS Flood Prone Area Maps, and mapped as part of the integrated terrain unit component of the data base. This information has been amplified by the use of active stream wash designations for landforms and by stream characteristics identified on the automated map of surface hydrology. As shown on the attached model outline, discrete classes of information are displayed on the map, corresponding to different types of flood prone areas and different bases for that information. This map indicates the existence of significant flood prone areas along streams flowing out of the San Gabriel and San Bernardino Mountains, notably Lytle Creek and the Santa Ana River. This information provides planners with an indication of where future development should be restricted or special engineering required. It also provides a context for the evaluation of proposed flood control projects. As with the previous two models, the data generated by this model is incorporated into the General Urban Development Capability/Suitability model.

FLOOD HAZARDS
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
General Context	Water	SKIP	
Flood Prone Areas	Documented Flood Zone	20	
Landform	Wash-Ephemeral River Channel	10	
Stream Course	Stream Order		
	GE Second Order	5	
Stream Course	Channelization		
	Not Channelized	1	
	Channelized	0	

MODEL SUMMATION SUMMARY

Rating	Values
Documented Flood Zone	
Active Stream Wash	GE 30
Not Active Stream Wash	20-29
Inferred Flood Zone	
Not Channelized	6
Channelized	5
Not Flood Zone	0-1

FLOOD HAZARDS
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Documented Flood Zone			
Active Stream Wash	Z	2235.48	3.76%
Not Active Stream Wash	S	5019.72	8.44%
Inferred Flood Zone			
Not Channelized	M	709.01	1.19%
Channelized	F	1047.33	1.76%
Not Flood Zone	C	50415.74	84.74%
Water	Blank	67.99	0.11%

Soil Resources. This model is designed to express various characteristics related to the condition of soil, including capability class, subclass, and unit, in terms of slope phase. The most direct way of doing this is through the construction of "expansion matrices" containing the various soil interpretations made by the Soil Conservation Service. Soil type is one of the data variables contained within the integrated terrain unit, and is coded by a unique number representing each of the series. This number in turn is referenced to an expanded file which contains a series of coded descriptions of the units. When automated, the computer can model directly from the expansion data, rather than from the usually non-descriptive unit name alone. For example, it can locate soils with poor drainage or those with high agricultural capability. As shown on the following outline, this model examines the expansion interpretations for the USDA soil capability classification assigned by SCS to each of the soil types. The soil resources map indicates areas that have high value for the production of crops based on average capability class for the series and on mapped slope. This information can be used by County and forest planners to identify prime agricultural lands and locations which can be developed without threat of loss of agriculturally productive lands.

SOIL RESOURCES
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
General Context	Water	SKIP	
Soil Interpretive Matrix	Predominant Soil Capability Class		
	Class I	30	
	Class II	20	
	Class III	10	
	Class IV-VIII	0	
Slope Gradient	Average Slope Gradient		
	LE 8%	5	
	GT 8%	0	

MODEL SUMMATION RULES

Rating	Value
Class I	
LT 8% Slope	35
GT 8% Slope	30
Class II	
LT 8% Slope	25
GT 8% Slope	20
Class III	
LT 8% Slope	15
GT 8% Slope	10
Class IV-VIII	0-5
Water	

SOIL RESOURCES
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS
SAN BERNARDINO VERTICAL DATA INTEGRATION (CIRSS)

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Soil Resource Units			
Class I	Z	4032.29	6.78%
Class II			
Less than 8% slope	S	16569.45	27.85%
Greater than 8% slope	P	2730.82	4.59%
Class III			
Less than 8% slope	K	8723.40	14.66%
Greater than 8% slope	D	93.89	0.16%
Other Classes	C	27277.43	45.85%
Water	Blank	67.99	0.11%

Erosion Potential. Erosion potential of a surface is related to the inherent erodibility of the soil comprising that surface and also to the rate at which surface water flows over it. Erodibility of a soil in the field varies with vegetative cover and organic components in the upper soil levels, but the maximum erodibility of the soil without such moderating influences can be determined. The soil descriptions provided by SCS included a K-value, or logarithmic expression of erodibility for each soil. The rate of surface water flow on saturated (or impermeable) soil is a function of its slope gradient. Erodibility (k) factors multiplied by a numeric slope gradient function are used to calculate the maximum erosion potential by the Universal Soil Loss Equation:

Erosion Potential = k factor x slope factor. The result is the maximum expected soil loss (during an average rainfall year) in tons of soil/acre/year.

Unlike the previous models, this one does not display discrete or aggregated data classes, but rather ranks the data into high, moderate, and low erosion potential categories based on the model summation rules shown on the model outline. The map indicates that the areas of highest erosion potential are in the mountain foothills, particularly in the canyons, and the streams below those canyons. This detailed information can be used not only to predict erosion problems, but also to provide a basis for needed erosion control mitigation measures.

EROSION POTENTIAL
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Soil characteristics	K value	N	
Slope gradient	0 - 8%	.6	
	8 - 15%	2.3	
	15 - 30%	5.5	
	30 - 50%	13.0	
	GT 50%	22.0	

Modeling Rules

Soil K values are multiplied to the value for average slope gradient.

Summation Rules

Water	
Very low	60 - 102
Low	103 - 230
Moderate	231 - 1100
High	1101 - 4160
Very high	4161 - 9460

NOTE: Values shown have been multiplied by 1,000

EROSION POTENTIAL
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Very low	A	17474.33	29.36%
Low	C	29394.75	49.41%
Moderate	F	2874.89	4.83%
High	S	4495.25	7.56%
Very high	Z	5179.98	8.71%
Water	Blank	67.99	0.13%

Ecological Impact Potential. This is a complex model based on information in terrain unit and land use data bases incorporating such computer tools as distance searches and counts of surrounding grid cells with specified codes. It relates data describing ecological sensitivity (vegetation, ecotone edge, unimproved streams) to land use data (use type, distance). Ecological sensitivity reflects primarily vegetation type and the proximity of water. Lakes and perennial streams have high ecological value, and decreasing values to a half-mile away. Riparian and forest/woodland vegetation communities also have high ecological value. This decreases as woodland grades to shrub vegetation. Lowest value is assigned to barren and disturbed areas. Since ecological impact is correlated with human interference with natural processes, the potential for significant impact is greater in less disturbed areas. The greater the distance to developed land use, the higher the potential for ecological impact should development occur. Likewise, certain land uses have less potential impact than others. For example, mining, industrial, and commercial operations have greater potential for damaging their surrounding environment than do most recreational or grazing activities.

This model, as with the preceding erosion potential model, ranks data into high to low sensitivity groupings based on model summation rules. These rankings indicate to County planners those areas where new development could significantly impact natural ecological systems.

ECOLOGICAL IMPACT POTENTIAL
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Water	Reservoirs/percolation basins	+4	
	LE 1/4 mile		+2
Streams	Intermittent streams (not channelized)	+6	
	LE 1/4 mile		+3
	1/4 - 1/2 mile		+1
Vegetation	Riparian (3 types)	+10	
	Joshua tree woodland	+ 8	
	Big cone douglas fir	+ 8	
	Deciduous woodland	+ 8	
	Live oak woodland	+ 8	
	Coulter pine	+ 7	
	Ponderosa and jeffrey pine	+ 7	
	Pinon pine	+ 7	
	Juniper-scrub oak-pinon woodland	+ 6	
	Grassland	+ 6	
	White fir	+ 5	
	Incense cedar	+ 5	
	Great basin sage	+ 4	
	Coastal sage	+ 4	
	Desert scrub	+ 4	
	Chaparral (3 types)	+ 3	
	Chamise chaparral	+ 2	
	Barren/urban/agriculture	0	
Vegetation (edge)	One other vegetation group within 1/4 mile		+3
	Two or more other vegetation groups within 1/4 mile		+5
Land use	Urban development* and agriculture		
	GT 1 mile		+3
	1/2 - 1 mile		+2
	1/4 - 1/2 mile		+1
	LE 1/4 mile		0

* Urban development includes the following land uses: residential; commercial; industrial/extractive, public/institutional; and other committed uses (excluding water).

ECOLOGICAL IMPACT POTENTIAL
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

(continued)

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Land use, cont.	Residential	-10	
	Commercial	-10	
	Industrial/Extractive	-10	
	Public/Institutional	-10	
	Open Space/Recreation		
	Irrigated	- 5	
	Non-irrigated	- 2	
	Other Committed Uses		
	Transportation/Communication	-10	
	Utilities	-10	
	Military	-10	
	Water	0	
	Vacant		
	Vacant	0	
	Vacant with Improvements	- 5	
	Agriculture	- 5	

Model Summation Rules

High sensitivity	GE 10
Moderate sensitivity	7 - 9
Marginal sensitivity	1 - 6
Sensitive	LT 1

ECOLOGICAL IMPACT POTENTIAL
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Highly sensitive	Z	4469.35	7.51%
Moderately sensitive	S	9241.40	15.53%
Marginally sensitive	F	16240.84	27.30%
Not sensitive	C	29543.67	49.66%

GIS Urban Capability/Suitability Model

The urban capability/suitability model based on the GIS data was designed to utilize the various opportunity/constraint models developed initially from the basic data types and to correspond generally to locally accepted planning policies and guidelines. The typical GIS capability/suitability planning criteria and modeling methods were used to provide a base from which to compare the first-cut LANDSAT model described later. This model was run on the valley portion of the integrated data base to rate those portions of the valley from very high capability/suitability for development to those portions which are clearly of very low capability/suitability for urban development.

Each input data variable was assigned a numeric weight which reflects a relative penalty against urban capability/suitability. The highest weights (penalties) were assigned to such hazards as active earthquake faults and documented active flood zones. The greatest weights were assigned to flood hazard, slope stability, and geologic/seismic hazards. Reduced weights were assigned to fire hazard, erosion potential and ecological impact potential, as these constraints may often be overcome by careful sight design and treatment.

In several instances, proximity to a hazard was also penalized. This reflects the fact that certain hazard conditions may be initiated at specific locations, but their effect may be felt some distance away. Examples of this phenomenon include proximity to active earthquake faults and proximity to high fire hazard areas. In these cases, the hazard and the penalty decrease with distance from the source. Groundshaking hazard is also modified by foundation support and groundwater depth.

Conversely, distance from existing urban land uses was penalized to reflect both the costs of extending infrastructure into new areas and the County General Plan policies which favor infill development over "leapfrog" development patterns.

The mapped results show the greatest capability/suitability for urban development to exist in the infill parcels, areas adjacent to existing development, and on much of the flatter lands in the valley. The lowest ratings for urban development capability/suitability are associated with seismic faults, flood zones and unstable slopes. The general projected patterns correspond well with the General Plan designations, but are not necessarily identical. Models of this type are useful to planners as they determine objective criteria for setting building density and land use type limits. The vertically integrated data base approach allows rapid access to a variety of objective and interpreted data which must be considered for density designations, land use type designations, and individual development application approvals.

URBAN CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Flood hazard	Documented flood zone		
	Active stream wash	50	
	Not active stream wash	40	
	Inferred flood zone		
	Not channelized	20	
	Channelized	10	
	Not flood zone		
Slope stability	Known landslide	50	
	Landslide susceptibility rating		
	Moderate to high	30	
	Low to moderate		
	GT 30% slope	15	
	15 - 30% slope	5	
	8 - 15% slope	0	
	0 - 8% slope	0	
	Generally devoid		
	GT 30% slope	15	
	15 - 30% slope	5	
	8 - 15% slope	0	
	0 - 8% slope	0	
Geologic/seismic hazards	Known, concealed or inferred fault	50	
	Alquist Priolo special study zone	30	
	Proximity to fault		
	LT 2 miles from a fault		
	Unconsolidated deposit		
	LT 100 ft. groundwater	30	
	GT 100 ft. groundwater	15	
	Consolidated deposit	5	
	2 - 5 miles from a fault		
	Unconsolidated deposit		
	LT 100 ft. groundwater	15	
	GT 100 ft. groundwater	5	
	Consolidated deposit	2	
	GT 5 miles from a fault		
	Unconsolidated deposit		
	LT 100 ft. groundwater	5	
	GT 100 ft. groundwater	2	
	Consolidated deposit	0	

URBAN CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

(continued)

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Fire hazard	Very high	25	
	LT 1/4 mile distance		15
	High	20	
	LT 1/4 mile distance		10
	Moderate	5	
Erosion potential	Very high	15	
	High	10	
	Moderate	5	
	Low	2	
	Very low	0	
Ecological impact potential	Highly sensitive	15	
	Moderately sensitive	8	
	Marginally sensitive	2	
	Not sensitive	0	
Compatible existing land use (GIS)	Existing urban land use (residential, commercial & industrial)		
	LT 1/4 mile distance		0
	1/4 - 1/2 mile distance		+1
	1/2 - 1 mile distance		+3
	GT 1 mile distance		+5

Model Summation Rules

Capability/suitability rating

Very low	GE - 50 - 145	D
Low	35 - 49	F
Moderate	20 - 34	O
High	10 - 19	S
Very high	LT 10	X

Urban/developed/committed	A
Water	Z

URBAN CAPABILITY/SUITABILITY
MAP LEGEND AND STATISTICS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Capability/suitability rating			
Very low	D	17289.79	29.06%
Low	F	3059.42	5.14%
Moderate	O	5631.61	9.47%
High	S	7171.03	12.05%
Very high	X	2750.24	4.62%
Urban/developed/committed	A	23525.19	39.55%
Water	Z	67.99	0.11%

LANDSAT Urban Capability/Suitability Model

The LANDSAT-derived land cover data was utilized to produce a first-cut urban capability/suitability model which would be comparable to the urban development capability/suitability model derived from photointerpreted and ancillary data. In this case, decision rules and weightings were based entirely on the LANDSAT land cover and the DMA digital elevation strata of the data base. Rather than accessing other sources of data, indicators of flood zones (barren, relatively flat slopes) and recent landslides (barren, relatively steep slopes) were derived by combining the two strata. Certain data, such as earthquake faults and legally-defined zones could not be derived directly from the remotely-sensed data and were therefore not included in this model. The following tables list the model inputs and the resulting output legend data.

Examination of the output maps shows that the locational output represents patterns broadly similar in shape and rating to those derived from the photointerpreted GIS model. Notably, the major flood zones are generally similar on both outputs, as are zones rated very highly capable/suitable for urban development. These are the major opportunities and constraints in the study area with respect to urbanization.

Despite the general overall similarity between output models, the resolution of the two data types appears to be quite different when individual grid cells are examined. Within the broad zones of similarity, the LANDSAT-derived output contains scattered individual cells and groups of cells which receive a different rating than do their counterparts on the photointerpreted model output. This results from interaction of three differences between the data:

- The photointerpreted data was "generalized" by a interpreter at a resolution of 10 acres. LANDSAT data was aggregated to 4 acres from a 1.1 acre pixel size and may contain different data for individual cells as a result.

- The LANDSAT model depends heavily on absence of vegetation for assignment of significant weights to floodprone and landslides. The higher resolution of LANDSAT land cover may be emphasized by this characteristic of the model, as pixels in the flood wash areas are classed with vegetation rather than barren.

- The DMA digital elevation data are encoded in 40-foot quanta steps. Calculation of slope from this elevation file results in the smallest non-zero slope being approximately 20%, this being distributed in terraces in relatively flat areas. Because slope gradient plays a significant part in the determination of such indicators as landslides and flood zones, these constraints on development may be identified in locations where they do not in fact occur. Replacement of the 40-foot quanta elevation data with more detailed elevation values or interpreted slope values would eliminate the terracing and allow shallow slopes to contribute to the model.

Because the general patterns and values output by the LANDSAT-based model are similar to those output by the GIS-only model, the capability for first-cut modeling can be demonstrated. Use of this technique would give a rapid, general approximation of which areas of land are most and least suited for urbanization. Use of a more refined slope data file would signficantly increase the similarity of output graphics and relative digital values.

LANDSAT - DMA ELEVATION DATA
URBAN CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Slope gradient (DMA)	GE 50%	30	
	25 - 49%	15	
	12 - 24%	5	
	6 - 11%	0	
	3 - 5%	0	
	0 - 2%	0	
Slope stability/ erosion potential indicator	Barren and GE 50% slope	50	
	Barren and 25 - 49% slope	30	
Fire hazard (LANDSAT)	Very high	25	
	LT 1/4 mile distance		15
	High	20	
	LT 1/4 mile distance		10
	Moderate	5	
Flood hazard indicator (LANDSAT)	Bare		
	0 - 2% slope	50	
	2 - 5% slope	30	
	Sparse brush		
	0 - 5% slope	20	
Ecological impact potential indicator (LANDSAT)	Natural vegetation		
	Spare brush	0	
	Brush	2	
	Thick brush	8	
	Woodland	15	
	Sparse woodland	15	
	Grass	2	
	Dry grass	0	
	Big cone douglas fir	8	
	White fir	15	
	Jeffrey pine mixed community	15	
	Coulter pine mixed forest	8	
	Bracken fern/ceanothus	15	
	Ceanothus/scrub oak	8	
	Chemise	8	
	Chemise/ceanothus	8	
	Coastal sage	8	
	Great Basin Sage	8	

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity,
Compatible Existing Land Use (LANDSAT Land Cover)	Codes 4 - 6	1	
	7 - 13	3	
	Urban, developed, committed	5	

Model Summation Rules

Very Low	21 - 150
Low	17 - 20
Moderate	4 - 16
High	1 - 3
Very High	0

LANDSAT - DMA ELEVATION DATA
URBAN CAPABILITY/SUITABILITY
MAP LEGEND AND STATISTICS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Capability/Suitability rating			
Very low	D	10741.98	18.06%
Low	F	4553.52	7.65%
Moderate	O	11659.80	19.60%
High	S	9429.18	15.85%
Very high	X	12276.54	20.63%
Urban/developed/committed	A	10745.21	18.06%
Water	Z	89.03	0.15%

V-40

Agricultural Capability/Suitability Model

The capability of the San Bernardino Valley to support agricultural uses was modeled using the photointerpreted data base. The model is based on assignment of weights to those parameters correlated with high agricultural productivity (soil capability, slope class, existing agriculture), suitability in terms of conflicting land uses (distance from urbanized land), and socio-legal determinations (General Plan designation, presence of hazards for urban development).

The output map ranks each cell according to its total weighting as determined by the model. The map shows that the areas of highest agricultural capability/suitability are primarily those already in agricultural production. Relatively deep, flat soils containing clay fines are also rated high for agriculture. Steep slopes, sandy, and shallow soils exhibit low values for agricultural use. Near-urban areas are reduced in value, although some areas are rated relatively high due to current agriculture on the site.

This model was produced to demonstrate the value of the integrated data base approach for agricultural capability modeling as well as urbanization. One County planning need is to track agricultural conversion rates and locations. County policy is to maintain productivity agricultural lands. Coincidence of high ratings for both agriculture <u>and</u> urbanization can be identified by the models presented here. This enables planners to identify areas which are sensitive to urban conversion and which may require special studies of agricultural viability before approving construction projects.

AGRICULTURAL CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Soil resources	Class I		
	LT 8% slope	40	
	Class II		
	LT 8% slope	35	
	GT 8% slope	20	
	Class III		
	LT 8% slope	25	
	GT 8% slope	10	
	Class IV		
	LT 8% slope	15	
	GT 8% slope	5	
	Other	0	
Erosion hazard	Very high	-10	
	High	- 5	
	Moderate	- 3	
	Low		
Ecological Impact Potential	High sensitivity	- 5	
	Moderate sensitivity	- 3	
Compatible and conflicting existing land use (GIS)	Existing agriculture (not including range and pasture)	+ 5	
	Existing urban land use (residential, commercial and industrial)		
	LT 1/4 mile distance	- 5	
	1/4 - 1/2 mile distance	- 3	
General plan designation	Designated agriculture	+ 5	
Flood hazard	Documented flood zone		
	Not active stream wash	+ 5	
	Inferred flood zone		
	Not channelized	+ 5	

AGRICULTURAL CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

(continued)

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Geologic/seismic hazard	Known, concealed or inferred fault	+ 5	
	Alquist Priolo special study zone	+ 5	
	Proximity to fault		
	LT 2 miles from a fault		
	Unconsolidated deposits		
	LT 100 ft. groundwater		+ 5
	GT 100 ft. groundwater		+ 3
Fire hazard	Proximity to very high or high fire hazard		
	EL 1/4 mile distance		+ 5

Model Summation Rules

Capability/suitability rating

Very low	LT 10	-17 to -1	D
Low	10 - 19	0 to 19	F
Moderate	20 - 29	20 to 29	O
High	30 - 39	30 to 39	S
Very high	GE 40	40 to 60	X

Urban/developed/committed A

Water Z

AGRICULTURAL CAPABILITY/SUITABILITY
MAP LEGEND AND STATISTICS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Capability/suitability rating			
Very low	D	8160.08	13.72%
Low	F	13382.14	22.49%
Moderate	O	4746.15	7.98%
High	S	5278.72	8.87%
Very high	X	4334.99	7.29%
Urban/developed/committed	A	23525.19	39.54%
Water	Z	67.99	0.11%

Fire Hazard Model - Photointerpreted Data

As a test of the ability of LANDSAT data to support GIS modeling capabilities and to extend modeled criteria into areas not included in a GIS, the fire hazard model created for the U.S. Forest Serivce data base was included in this study. Because the model was originally run using a 40-acre grid cell resolution, the original ITUM data from the Forest Service study was re-gridded at a 4-acre resolution to correspond with other data planes in the Vertical Integration study. The original data did not include the designated Wilderness Area, which is blank on the output maps.

The model assigns hazard ratings to the vegetation components of the study area based on criteria of flammability and rate of fire spread. In addition, steep slope gradients are penalized to reflect both the rate of upslope fire spread and the difficulty of fire control measures on these slopes. One criterion used in the original USFS study - Range Allotments - was not included in this model, because the LANDSAT data with which it is compared do not include range allotments. The following criteria and statistics resulted from this model.

Fire Hazard Model

Class	Specific Phenomenon	Value (Incidence)
Slope	> 50%	+10
	30 - 50%	+ 8
	15 - 30%	+ 4
	8 - 15%	+ 2
Vegetation	Chamise chaparral	+10
	Ceanothus chaparral	+10
	Manzanita chaparral	+10
	Red shank chaparral	+10
	Coastal sage	+ 7
	Juniper-scrub oak-pinon woodland	+ 6
	Pinon pine	+ 6
	Joshua tree woodland	+ 6
	Coulter pine	+ 6
	Big cone douglas fir	+ 6
	Ponderosa and jeffrey pine	+ 5
	Incense cedar	+ 5
	Sugar pine	+ 5
	White fir	+ 5
	Juniper	+ 5
	Lodgepole pine	+ 4
	Limber pine	+ 4
	Live oak woodland	+ 4
	Riparian, live oak	+ 4
	Deciduous woodland	+ 3
	Riparian, sycamore-cottonwood	+ 2
	Riparian, alder-willow-aspen	+ 2
	Great basin sage	+ 2
	Grassland	+ 1
	Desert scrub vegetation	+ 1
	Barren, urban, agriculture	+ 1
	Water	0

Aggregation Decisions

0 - 1 Very low
2 - 7 Low
8 - 11 Moderate
12 - 15 High
16 - 20 Very high

FIRE HAZARDS
MAP LEGEND AND STATISTICS
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Very low hazards	C	44653.01	18.29%
Low hazards	F	29075.85	11.91%
Moderate hazards	M	28175.83	11.54%
High hazards	S	61664.38	25.26%
Very high hazards	Z	66794.17	27.36%
Wilderness	Blank	13754.46	5.64%

Fire Hazard Model - LANDSAT Data

In order to compare the LANDSAT model output with the USFS model, weights were assigned to land cover classes which represent the same fuel types as the vegetation classes used for the GIS fire hazard model. The DMA digital elevation data were used to assign additional penalty weights for steep slope gradients. The resulting model closely resembles that used with the ITUM vegetation data. Similarly, the map output patterns and values closely resemble the ITUM fire hazard model. Some terracing appears to occur throughout the study area, probably due to the 40-foot elevation quanta used to calculate slope gradients. The LANDSAT data include the designated Wilderness Area. Because the Wilderness is not included in the photointerpreted data, this output can be used to visually inspect the ability of LANDSAT analysis to extend modeled information into areas which lack mapped GIS basic data.

The patterning and values around the wilderness area suggest that the LANDSAT model has effectively extended the fire hazard model into the unmapped wilderness area.

The following tables present the model criteria, the legend and data which were output.

SAN BERNARDINO NATIONAL FOREST
FIRE HAZARD MODEL
- LANDSAT DATA -

CODE	CLASS	VALUE (Incidence)
1	Cleared	1
2	Bare	1
3	Sp. Brush	1
4	Brush	2
5	Thick Brush	7
6	Young Orchard	1
7	Moderate Vigor Orchard	1
8	Mature Orchard	1
9	Declining Orchard	2
10	Mod-Vigor Vinyard	1
11	High Vigor Vinyard	1
12	Declining Vinyard	2
13	Woodland	6
14	Sparse Woodland	4
15	Grass	1
16	Dry Grass	1
17	Agriculture	1
18	Asphalt	0
19	Concrete	0
20	Extractive	0
21	Cinder	0
22	Slag	0
23	Structures	Skip
24	Structures Strip	Skip
25	Water	0

SAN BERNARDINO NATIONAL FOREST
FIRE HAZARD MODEL
- LANDSAT DATA -
(cont.)

CODE	CLASS	VALUE (Incidence)
27	Structures W/Brush	10
28	Residential with Trees	Skip
29	Irrigated Newer Residential	Skip
30	Cluster	Skip
31	Large Lot Unirrigated	1
32	Rural/Strip	Skip
33	Mobile Home/High Density	Skip
34	Low Vigor Vinyard	2
35	Big Cone Douglas Fir	6
36	White Fir	5
37	Jeffrey Pine Mixed Community	5
38	Ponderosa Pine	5
39	Lodgepole/Limber Pine	4
40	Pinyon/Juniper	6
41	Canyon Live Oak/Riparian	3
42	Jeffrey Pine/Ceanothus	5
43	Coulter Pine Mixed Forest	6
44	Bracken Fern/Ceanothus	10
45	Ceanothus/Scrub Oak	10
46	Chamise	10
47	Chamise/Ceanothus	10
48	Coastal Sage	7
49	Great Basin Sage	2

LANDSAT WILDERNESS FIRE HAZARD
CONCEPTUAL MODEL OUTLINE
NATURAL OPPORTUNITY/CONSTRAINT ANALYSIS

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Slope	DEM data		
	GT 50%	+10	
	30 - 50%	+ 8	
	15 - 30%	+ 4	
	8 - 15%	+ 2	

<u>Aggregation Decisions</u>

0 - 1	Very low
2 - 7	Low
8 - 11	Moderate
12 - 15	High
16 - 20	Very high

FIRE HAZARDS
LANDSAT/DMA DATA HAZARD MODEL
MAP LEGEND AND DISTRIBUTION

CLASS	SYMBOL	TOTAL AREA (HECTARES)	PERCENTAGE
Very low hazards	C	48879.55	18.81%
Low hazards	F	65775.99	25.32%
Moderate hazards	M	51129.60	19.68%
High hazards	S	62282.74	23.97%
Very high hazards	Z	31737.07	12.22%

Correlation of Data Sets - LANDSAT and PI Data Sets

In order to compare the relative abilities of classified LANDSAT data and manually photointerpreted data, a fire hazard model was designed to run on both data sets. The decision rules employed in the fire hazard model and output from both the photointerpreted data base and the LANDSAT data base are detailed in the previous sections. Visual examination of the output graphics suggests that the major pattern differences are related to the minimum resolution of pixels/grid cells in the LANDSAT classified data compared to the larger minimum resolution used during photointerpretation. Although general similarities of patterns on the two output maps can be recognized, the LANDSAT output includes significant variability within areas which appear homogeneous on the output from the photointerpreted data set.

A contingency analysis was performed on the two output data files to determine the consistency or inconsistency of variation between the two data sets. Figure V-2 is the output of this analysis.

In order to perform the statistical analysis, the LANDSAT model output file was adjusted to the size and shape of the photointerpreted file by eliminating the Wilderness area from the analysis. Each of the remaining cells was examined for its P-I rating and its LANDSAT rating. The contingency analysis resulted in a table which indicates percentage similarity of each P-I rating with each LANDSAT rating.

Examination of the table indicates relatively high similarity (70 - 75%) between the two data bases when assigning the Low Hazard rating. A high similarity (62%) is also noted between the assignment of Very High hazard rating by the LANDSAT model and the same rating assigned by the P-I model. However, the P-I model also assigned (33% similarity) the Very High rating to cells rated High hazard by LANDSAT. Examination of the mid-range ratings of Low, Moderate, and High hazards indicates relatively low similarity between assignments by the two models, although the assignments are clustered within $\pm$ one rating value.

FIGURE V-2

FIRE HAZARD MODELS
CORRELATION MATRIX

LANDSAT/DMA*

PHOTOINTERPRET GIS	Non Study Area	Very Low Hazards	Low Hazards	Moderate Hazards	High Hazards	Very High Hazards	Wilderness	ALL CELLS
Non Study Area	9691	0	0	0	0	0	0	9691
	100.00	--	--	--	--	--	--	100.00
	100.00	--	--	--	--	--	--	6.04
	6.04	--	--	--	--	--	--	6.04
Very Low Hazards	0	19270	7133	780	381	21	0	27585
	--	69.86	25.86	2.83	1.38	.08	--	100.00
	--	76.75	19.42	2.71	1.15	.11	--	17.19
	--	12.01	4.44	.49	.24	.01	--	17.19
Low Hazards	0	3071	9055	3380	2258	198	0	17962
	--	17.10	50.41	18.82	12.57	1.10	--	100.00
	--	12.23	24.65	11.72	6.80	1.07	--	11.19
	--	1.91	5.64	2.11	1.41	.12	--	11.19
Moderate Hazards	0	986	6752	5635	3436	597	0	17406
	--	5.66	38.79	32.37	19.74	3.43	--	100.00
	--	3.93	18.38	19.55	10.35	3.24	--	10.84
	--	.61	4.21	3.51	2.14	.37	--	10.84
High Hazards	0	812	7327	10176	13692	6087	0	38094
	--	2.13	19.23	26.71	35.94	15.98	--	100.00
	--	3.23	19.95	35.30	41.23	33.02	--	23.73
	--	.51	4.57	6.34	8.53	3.79	--	23.73
Very High Hazards	0	969	6464	8858	13439	11533	0	41263
	--	2.35	15.67	21.47	32.57	27.95	--	100.00
	--	3.86	17.60	30.73	40.47	62.56	--	25.71
	--	.60	4.03	5.52	8.37	7.19	--	25.71
Wilderness	0	0	0	0	0	0	8497	8497
	--	--	--	--	--	--	100.00	100.00
	--	--	--	--	--	--	100.00	5.29
	--	--	--	--	--	--	5.29	5.29
ALL CELLS	9691	25108	36731	28829	33206	18436	8497	160498
	6.04	15.64	22.89	17.96	20.69	11.49	5.29	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	6.04	15.64	22.89	17.96	20.69	11.49	5.29	100.00

*Wilderness area reclassified to correspond with GIS Model

Legend: nnnn = Cell Count
n.nn = % of Row
n.nn = % of Column
n.nn = % of Total Cells

A similar analysis was undertaken using the more complex Urban Capability/Suitability models. Figure V-3 is the result of this statistical analysis. In this case, the models were run on the San Bernardino Valley portion of the data base. The GIS model used certain forms of data not directly observable by LANDSAT (e.g., earthquake faults, documented flood zones, known landslides, etc.), while the LANDSAT model was designed to locate indicators of some of these data (e.g., barren + shallow slope = floodplain; barren + steep slope = landslide, etc.).

Examination of the results of the statistical analysis shows excellent agreement between the two data sets in the identification of urbanized areas. The smaller pixel size of the LANDSAT data may be responsible for the assignment of Very High capability for development to 29% of the cells labeled developed by the GIS.

Similarities between the remaining pairs of assignments are relatively low and are scattered about the table. The highest similarity (34% and 55%) is seen with the assignment of Very Low capability by both models. Lower values exist between the other pairs of assignments.

FIGURE V-3

URBAN CAPABILITY/SUITABILITY MODELS
CORRELATION MATRIX

LANDSAT/DMA MODEL

GIS MODEL	Non Study Area	Water	Urban/ Developed	Very Low	Low	Moderate	High	Very High	ALL CELLS
Non Study Area	123744	0	0	0	0	0	0	0	123744
	100.00	--	--	--	--	--	--	--	100.00
	100.00	--	--	--	--	--	--	--	77.10
	77.10	--	--	--	--	--	--	--	77.10
Water	0	7	3	4	2	17	9	0	42
	--	16.67	7.14	9.52	4.76	40.48	21.43	--	100.00
	--	12.73	.05	.06	.07	.24	.15	--	.03
	--	4.361E-3	1.869E-3	2.492E-3	1.246E-3	.01	.01	--	.03
Urban/ Developed	0	1	5821	797	763	1413	1529	4209	14533
	--	.01	40.05	5.48	5.25	9.72	10.52	28.96	100.00
	--	1.82	87.69	12.01	27.12	19.62	26.25	55.50	9.05
	--	6.231E-4	3.63	.50	.48	.88	.95	2.62	9.05
Very Low	0	12	130	3672	966	3335	1712	854	10681
	--	.11	1.22	34.38	9.04	31.22	16.03	8.00	100.00
	--	21.82	1.96	55.33	34.34	46.30	29.39	11.26	6.65
	--	.01	.08	2.29	.60	2.08	1.07	.53	6.65
Low	0	9	62	526	221	495	369	208	1890
	--	.48	3.28	27.83	11.69	26.19	19.52	11.01	100.00
	--	16.36	.93	7.93	7.86	6.87	6.33	2.74	1.18
	--	.01	.04	.33	.14	.31	.23	.13	1.18
Moderate	0	20	131	762	386	895	739	546	3479
	--	.57	3.77	21.90	11.10	25.73	21.24	15.69	100.00
	--	36.36	1.97	11.48	13.72	12.43	12.69	7.20	2.17
	--	.01	.08	.47	.24	.56	.46	.34	2.17
High	0	5	345	615	336	887	1071	1171	4430
	--	.11	7.79	13.88	7.58	20.02	24.18	26.43	100.00
	--	9.09	5.20	9.27	11.94	12.31	18.39	15.44	2.76
	--	3.115E-3	.21	.38	.21	.55	.67	.73	2.76
Very High	0	1	146	260	139	161	396	596	1699
	--	.06	8.59	15.30	8.18	9.48	23.31	35.08	100.00
	--	1.82	2.20	3.92	4.94	2.24	6.80	7.86	1.06
	--	6.231E-4	.09	.16	.09	.10	.25	.37	1.06
ALL CELLS	123744	55	6638	6636	2813	7203	5825	7584	160498
	77.10	.03	4.14	4.13	1.75	4.49	3.63	4.73	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	77.10	.03	4.14	4.13	1.75	4.49	3.63	4.73	100.00

Legends: nnnn = Cell Count
n.nn = % of Row
n.nn = % of Column
n.nn = % of Total Cells

Urban vs. Agriculture Capability/Suitability Models

The contingency analysis was also used to compare the results of the models for urban capability/suitability and agricultural capability/suitability. The resulting table is shown as Figure V-4.

Examination of the output reveals that those cells assigned a rating of Very High capability for urban development agree best (57%) with a Moderate assignment for agricultural capability/suitability. This probably results from the observable pattern of urban development surrounded by current agriculture in the study area. Areas adjacent to existing development received extra weight for urban development, while existing agriculture received additional weight for agricultural capability.

Cells rated Very Low for urban development also obtain ratings of Very Low and Low agricultural capability. A relatively high similarity (46%) is observed between cell rated Highly capable for agriculture and Highly Suitable for urban development. A majority of the cells rate Very High for agricultural capability are rated Very Low (26%), Low (14%), or Moderate (34%) for urban capability/suitability.

FIGURE V-4

GIS CAPABILITY/SUITABILITY MODELS
CORRELATION MATRIX

AGRICULTURE CAPABILITY/SUITABILITY

URBAN CAP/SUIT	Non Study Area	Water	Urban/ Developed	Very Low	Low	Moderate	High	Very High	ALL CELLS
Non Study Area	123744	0	0	0	0	0	0	0	123744
	100.00	--	--	--	--	--	--	--	100.00
	100.00	--	--	--	--	--	--	--	77.10
	77.10	--	--	--	--	--	--	--	77.10
Water	0	42	0	0	0	0	0	0	42
	--	100.00	--	--	--	--	--	--	100.00
	--	100.00	--	--	--	--	--	--	.03
	--	.03	--	--	--	--	--	--	.03
Urban/ Developed	0	0	14533	0	0	0	0	0	14533
	--	--	100.00	--	--	--	--	--	100.00
	--	--	100.00	--	--	--	--	--	9.05
	--	--	9.05	--	--	--	--	--	9.05
Very Low	0	0	0	4131	4805	573	478	694	10681
	--	--	--	38.68	44.99	5.36	4.48	6.50	100.00
	--	--	--	81.95	58.12	19.54	14.66	25.91	6.65
	--	--	--	2.57	2.99	.36	.30	.43	6.65
Low	0	0	0	265	607	280	358	380	1890
	--	--	--	14.02	32.12	14.81	18.94	20.11	100.00
	--	--	--	5.26	7.34	9.55	10.98	14.19	1.18
	--	--	--	.17	.38	.17	.22	.24	1.18
Moderate	0	0	0	385	1033	478	673	910	3479
	--	--	--	11.07	29.69	13.74	19.34	26.16	100.00
	--	--	--	7.64	12.50	16.30	20.64	33.98	2.17
	--	--	--	.24	.64	.30	.42	.57	2.17
High	0	0	0	239	1418	628	1505	640	4430
	--	--	--	5.40	32.01	14.18	33.97	14.45	100.00
	--	--	--	4.74	17.15	21.42	46.15	23.90	2.76
	--	--	--	.15	.88	.39	.94	.40	2.76
Very High	0	0	0	21	404	973	247	54	1699
	--	--	--	1.24	23.78	57.27	14.54	3.18	100.00
	--	--	--	.42	4.89	33.19	7.57	2.02	1.06
	--	--	--	.01	.25	.61	.15	.03	1.06
ALL CELLS	123744	42	14533	5041	8267	2932	3261	2678	160498
	77.10	.03	9.05	3.14	5.15	1.83	2.03	1.67	100.00
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	77.10	.03	9.05	3.14	5.15	1.83	2.03	1.67	100.00

Legend: nnnn = Cell Count
n.nn = % of Row
n.nn = % of Column
n.nn = % of Total Cells

VERTICAL DATA INTEGRATION
San Bernardino Study
Phase 2 - Small Area Analyses

VI. INTRODUCTION

The fundamental purpose of the San Bernardino Vertical Data Integration project was to evaluate a method whereby local agencies could share and utilize geographic data by integrating these into a common data base. Specific user agencies for this data base were the San Bernardino County Planning Department and the San Bernardino National Forest staff. Both agencies had prior experience with the use of automated geographic data and were active participants in the Phase 1 efforts to create the integrated data base. The data base included the types of data used by the planning personnel in these agencies. LANDSAT image data were included in the data base to: 1) provide a common registration for the various data planes; 2) provide a means of subdividing large mapped areas according to the finer resolution of the image; 3) add data types not originally mapped, but sensed by LANDSAT, and 4) test the usefulness of change detection techniques in a small area.

In order to effectively demonstrate the usefulness of the integrated GIS with its LANDSAT component, several example models and tests, based on the types of analysis needed by the local users (see Section IV), were identified and performed to produce both map and statistical results which would be of use to the planners. This second phase of the project was conducted on small areas windowed from the area of the data base created in Phase 1. Specific small area analyses included the following:

A. San Bernardino County Planning Small Area

1. Evaluate LANDSAT land cover data and compare with photointerpreted land use data.

2. Evaluate LANDSAT change detection data, comparing it with photointerpreted land use change data.

3. Model urban capability/suitability for small area using the integrated data base. Evaluate incremental value of LANDSAT land cover when used in a GIS environment.

4. Correlate the influence of each input variable on the raw score output of the urban capability/suitability model.

B. San Bernardino National Forest Small Area

1. Using the integrated GIS, model activities expected to occur if an area of the SB National Forest is designated a fire buffer greenbelt. Model urban development expected to occur in the same

area if it is not designated a fire buffer greenbelt.

2. For each of the future scenarios projected, model the impact on fire hazard, runoff, and erosion potential.

3. Correlate the influence of each input variable on the raw score outputs of the fire hazard, storm runoff, and erosion potential models run against the greenbelt designation future scenario.

This report describes the methods used to conduct the small-area analyses, their results, the usefulness of the vertical data integration approach to the identified user agencies, and methods which may be used to operationalize this approach to small area data analysis.

In order to perform the analyses, the following steps were required:

- Refine the vertically integrated data base created in Phase 1

- Window the small area data bases

- Conduct analyses

- Evaluate products.

The following chapters describe each of these steps in detail. The final chapter presents general evaluations and conclusions regarding the adoption of and use of the vertically integrated data base approach by local agency operations for their analyses.

VII. REFINE PHASE 1 DATA BASE

The vertically integrated data base created in Phase 1 contained all of the basic data types required to conduct the small area analyses. Three refinements to this data base were conducted to increase its utility for the small area size and the types of analyses being conducted. The sequence of refinement is illustrated by Figure VII-1 and the specific refinement tasks are listed below:

1. Land Cover Vegetation classification of the San Bernardino mountain ecological zone was refined based on elevation zones and average annual rainfall data.

2. The grid cell size was reduced from 4 acres (Phase 1) to a 1 acre square.

3. Soils data for the National Forest were digitized for the greenbelt study area and added to the data base.

A. Refine Mountain Vegetation Classification

An evaluation of the land cover which had been classified to produce the Phase 1 integrated data base identified several misclassifications of vegetation in the mountain areas. No such problems were noted in the Valley portion of the data base. These misclassifications appeared to be systematic, and consultation with Jeanine Derby, USFS, (1981, personal communication) indicated that they could be resolved by considering differential rainfall rates, elevation zones, and specific location within the mountain range (i.e., the wetter southwestern front versus the drier northern front). The San Bernardino Range separates the Mediterranean climate (wet mild winter/dry hot summer) of the San Bernardino Valley to the south from the arid climate of the Mojave Desert to the north. The Mojave is a rain shadow desert resulting from orographic airflow which has been dried by precipitation as it was uplifted over the range. Thus, the climate, rainfall, and resulting vegetation types are quite distinct progressing from north to south. Using these criteria, a second model was developed to correctly reclassify the identified errors.

B. Reduce Grid Cell Size

The 4-acre grid cell size used to create the multivariable file of the Phase 1 integrated data base was produced by the Grid-from-Polygon program (GRIPS). The original data had been digitized and stored on tape in x,y coordinate polygon (PIOS) format. LANDSAT land cover data had been aggregated to the 4-acre cell size from a 1-acre classified data file. For purposes of small area analysis, the digitized polygon files for the small area subareas, windowed as described below in Section VIII, were again processed using GRIPS to create a 1-acre multivariable file. The 1-acre LANDSAT land cover file and DMA elevation file were merged to create small area data bases at a grid cell resolution of 1-acre containing all data

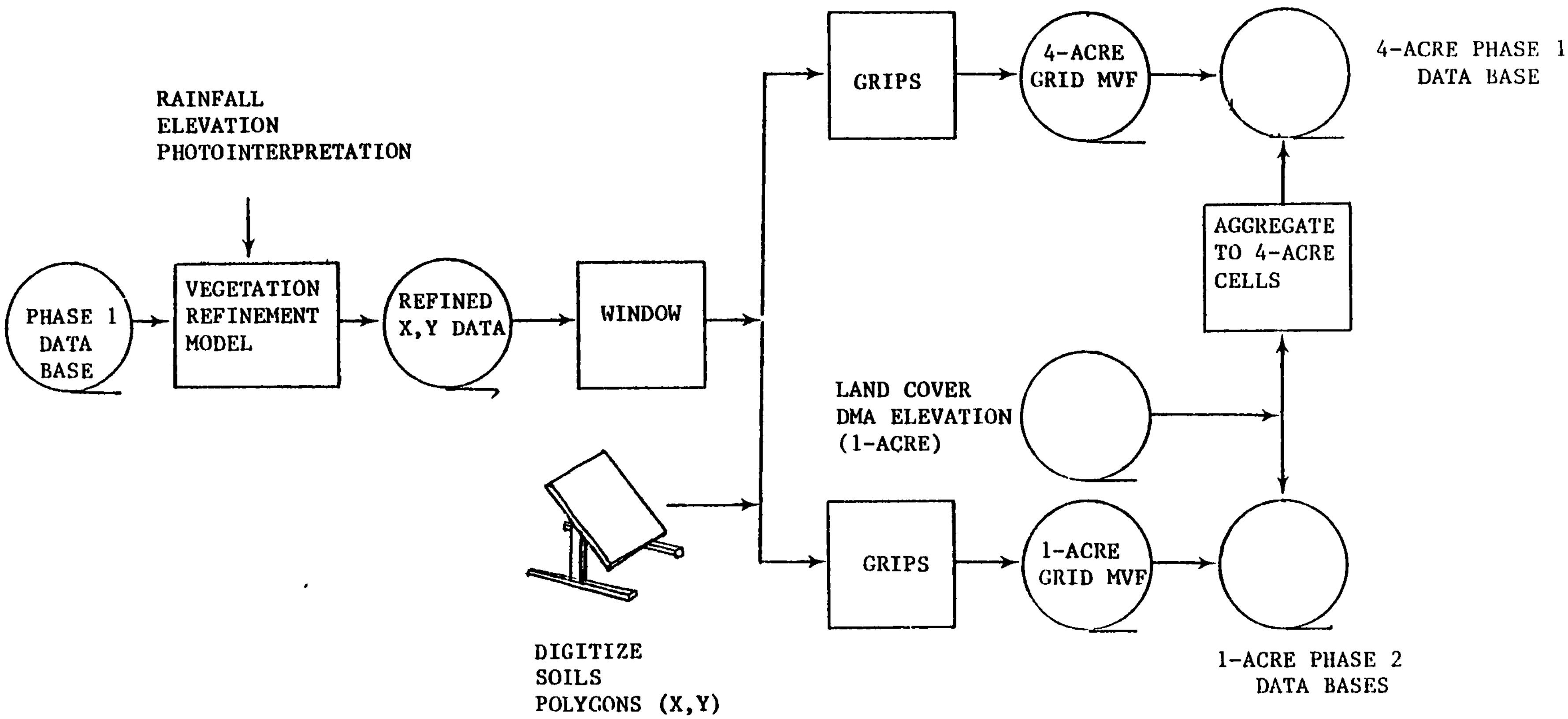


FIGURE VII-1

REFINEMENT AND CREATION OF PHASES 1 & 2 DATA BASES originally entered into the Phase 1 data base. The lower path in Figure VII-1 summarizes the procedure used to create the small area data bases.

C. Add Soils Data

The original ITUM data base developed for the San Bernardino National Forest, and later included in the vertically integrated data base, did not contain soil survey information. Soil characteristics were required for modeling agricultural capability and for projecting erosion and runoff rates resulting from future scenarios in the greenbelt small area data base.

A recent draft soil resource inventory (Retelas, 1980) provided by the San Bernardino National Forest was used to add needed soils data to the greenbelt study area windowed from the Phase 1 data base as described in Section III. Two operations were required: 1) digitize the soil boundaries and associating each polygon with a unique sequence number and, 2) enter codes descriptive of the soil classes being digitized (e.g., erosion K factors, drainage ratings, agricultural capability class, etc.). These new polygons were registered to the greenbelt MVF by identifying state plane coordinates of known tic marks, gridded to a 1-acre cell size (GRIPS) and merged into the small area data base. This task completed the small area data base creation, providing all data variables needed to conduct the user analyses.

1976 LANDCOVER - LANDSAT

C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

- RESIDENTIAL/URBAN
- COMMITTED USES
- CLEARED/BARE
- AGRICULTURE
- GRASSLAND
- ORCHARD/VINEYARD
- BRUSH/CHAPARRAL
- WOODLAND/FOREST-CHAPARRAL
- HARDWOOD FOREST
- CONIFEROUS FOREST
- WATER

PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)

FIGURE VII-2

1979 LANDCOVER - LANDSAT

C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

- RESIDENTIAL/URBAN
- COMMITTED USES
- CLEARED/BARE/SNOW
- AGRICULTURE
- GRASSLAND
- ORCHARD/VINEYARD
- BRUSH/CHAPARRAL
- WOODLAND/FOREST-CHAPARRAL
- HARDWOOD FOREST
- CONIFEROUS FOREST
- WATER

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FIGURE VII-3

VIII. WINDOW SMALL AREA DATA BASES

Two small areas were selected for the Phase 2 analyses: an area including most of the Yucaipa Community Plan region as designated by the San Bernardino County Planning Department (Craig Gooch, personal communication), and an area described by the fire buffer greenbelt siting criteria developed by the San Bernardino National Forest staff (Bridges, 1981).

A. Yucaipa Data Base

The Yucaipa small area data base was defined by selecting the unincorporated (i.e., County managed) areas of the east San Bernardino Valley, those areas outside the National Forest boundary, and those areas for which the integrated data base has complete records. The latter criterion was not met for one section of land on the eastern border which is within the Yucaipa Community Plan area. The ITUM data layer was drafted as far east as the eastern border of the USGS Yucaipa 7 1/2 minute quadrangle. The additional section lies east of this border and is represented in the Phase 1 data base by LANDSAT land cover data only. Because the analyses focus on the use of LANDSAT data within a comprehensive GIS environment, this section was not included in the small area data base. Figure VIII-1 is a portion of a USGS 15 minute topographic map illustrating the boundary of the Yucaipa study area. This boundary was digitized and used to extract (using the WINDOW program) the data for this area from the Phase 1 data base.

B. Fire Buffer Greenbelt Data Base

The fire buffer greenbelt data base was defined using criteria developed by the Greenbelt Task Force sponsored by the San Bernardino National Forest staff (Bridges, 1981). The Task Force included representatives from San Bernardino County agencies as well as the US Forest Service. Criteria for siting the greenbelt are as follows:

- The buffer zone should be centered at the major slope break at the base of the San Gabriel and San Bernardino Ranges.

- In areas where the slopes have already been urbanized, the buffer zone should be adjusted up-slope.

- The buffer zone should extend 100 to 500 feet both upslope and downslope from the slope break.

In order to accommodate all possible alignments and locations of the potential greenbelt area, the data base was defined to be an area approximately one mile to either side of the slope break. The northern boundary parallels the slope break, while the southern boundary is defined by boundaries of the County General Plan designation polygons. Figure VIII-2 is a portion of a USGS 15 minute quadrangle illustrating the

Figure VIII-1

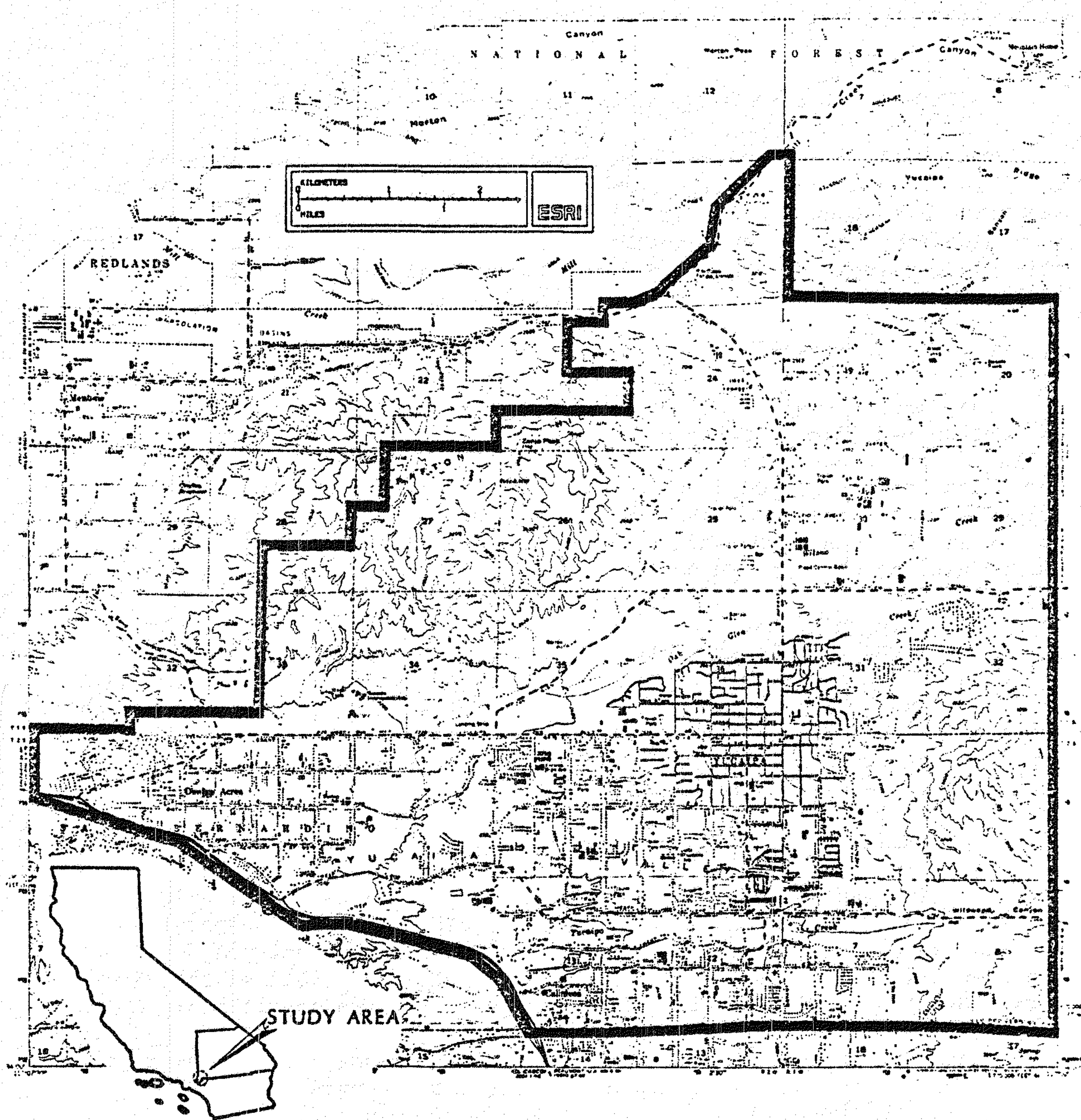
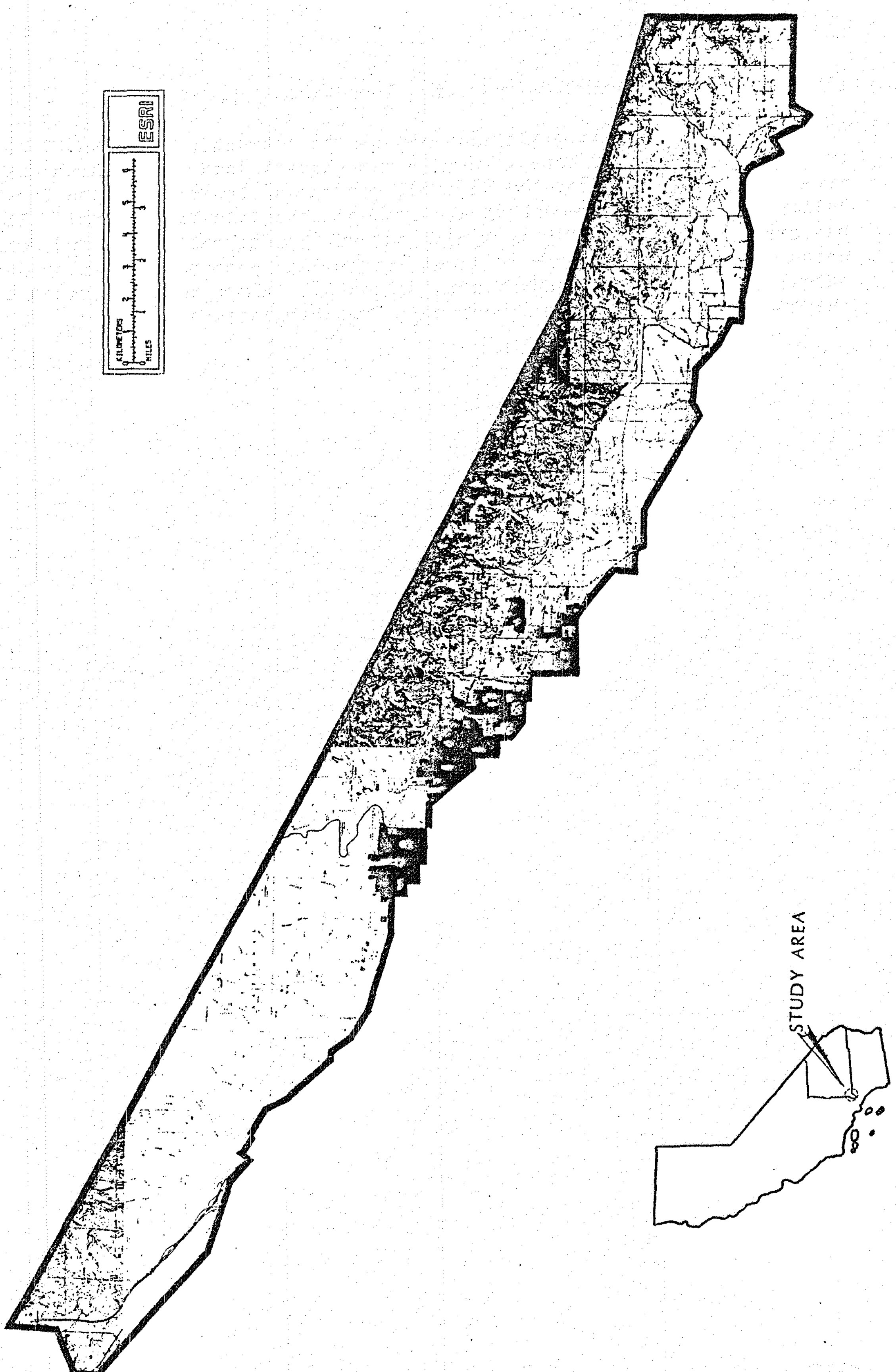


Figure VIII-2



location of the greenbelt study area boundary.

This boundary was digitized and used to extract (using the WINDOW program) the data for this area from the Phase 1 data base. Both the data developed originally for the National Forest and those developed for the Valley are included throughout the area of this data base. Their alignment was evaluated by visually examining stream channel extensions and soil units which cross from the National Forest data base to the Valley data base. The LANDSAT land cover data was output in map form to assure that the two adjacent GIS data layers were properly aligned.

IX. ANALYSIS METHODS

The two small area data bases were analyzed to produce information useful to the local agencies - San Bernardino County Planning Department and the San Bernardino National Forest staff - and to evaluate the behavior of LANDSAT land cover data in a GIS environment. The analyses used ESRI's standard production GIS software for data manipulation and display, and the MINITAB statistical package to evaluate the various output products of the analyses. This section discusses the analyses performed and includes examples of the resulting map output products.

A. County Planning Analyses

Four Analyses were performed using the Yucaipa small area data base. As described earlier in Section IV, these analyses were directed toward actual County Planning Department needs such as comparing methods of acquiring small area data for local agencies, using multitemporal data to detect changes in land status related to County planning functions, using a variety of physical, environmental and agency data to project urban development capability/ suitability, and evaluating the incremental value of the higher-resolution LANDSAT data (including agricultural vigor) when used for small area planning in a GIS environment. The following paragraphs describe the methodology used and the products resulting from each of the analyses.

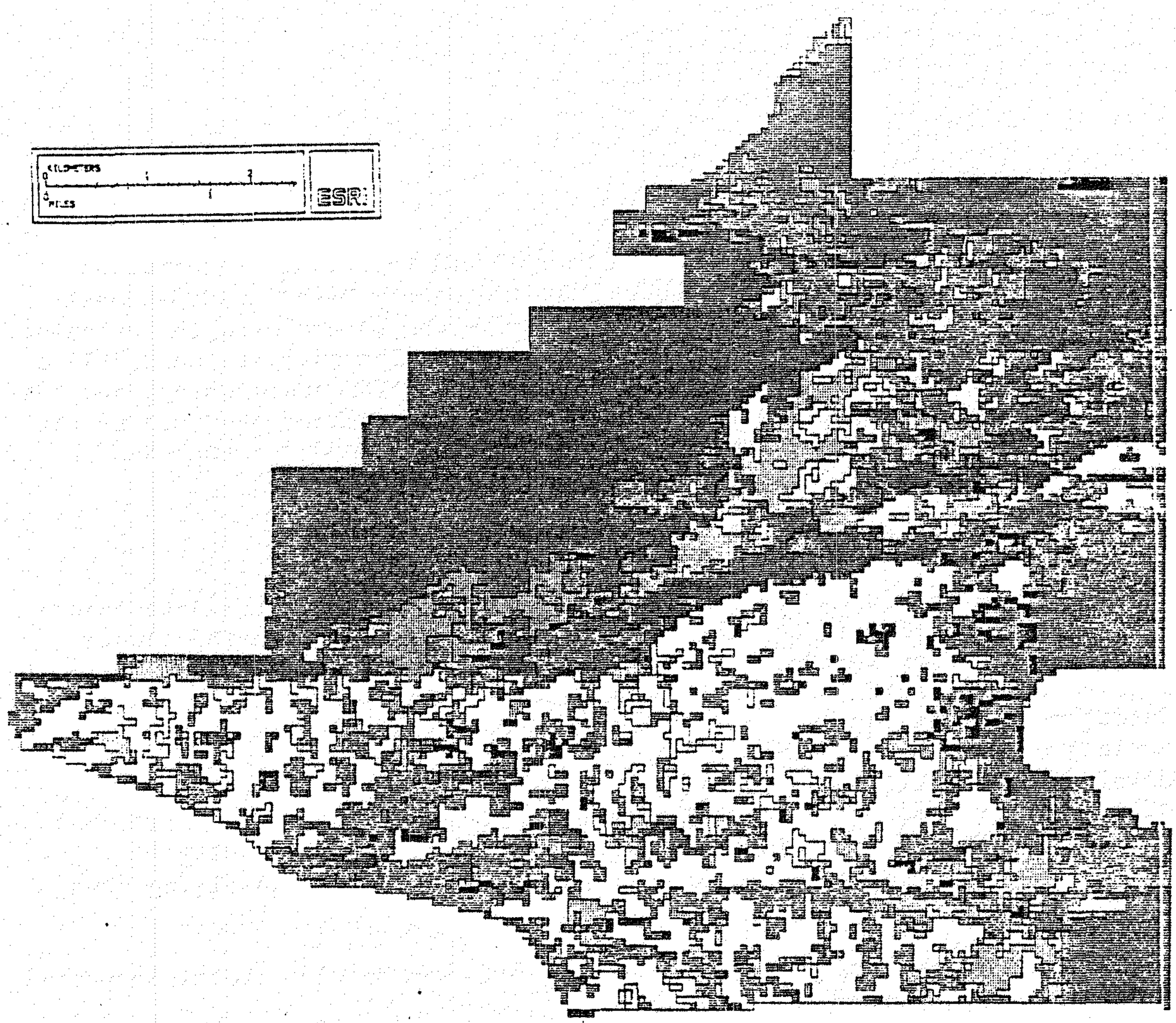
1. Evaluate LANDSAT land cover data and compare with photointerpreted land use data.

   Figure IX-1 and IX-2 are maps showing the 1979 land use and land cover data. Together they illustrate the differences and similarities between the two sets of data. The land use data were mapped by a process of photointerpretation and field verification, while the land cover data were produced from an unsupervised LANDSAT image classification and subsequently aggregated to the classes displayed here. Both sets of data represent conditions in the Yucaipa study area at approximately the same time.

   A general similarity of pattern can be observed on the two scenes for large areas. The large border areas labelled 'Vacant' land use are similar in size and location to the areas labelled 'Brush/Chaparral' land cover. One term represents an interpretation of use; the other defines the actual type of cover. Similarly, the land uses 'Residential', 'Public/Institutional' and 'Commercial' are similar in pattern and extent to the land cover classes 'Residential/Urban' and 'Committed Uses' (primarily parking lots).

   Within this general similarity of pattern, the most noticeable difference between the output maps is the more broken ('salt and pepper') appearance of the land cover data. This results from the

Figure IX-2



1979 LANDCOVER - LANDSAT

C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

- RESIDENTIAL/URBAN
- COMMITTED USES
- CLEARED/BARE/SNOW
- AGRICULTURE
- GRASSLAND
- ORCHARD/VINEYARD
- BRUSH/CHAPARRAL
- WOODLAND/FOREST-CHAPARRAL
- HARDWOOD FOREST
- CONIFEROUS FOREST
- WATER

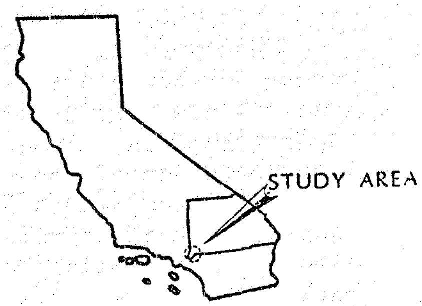


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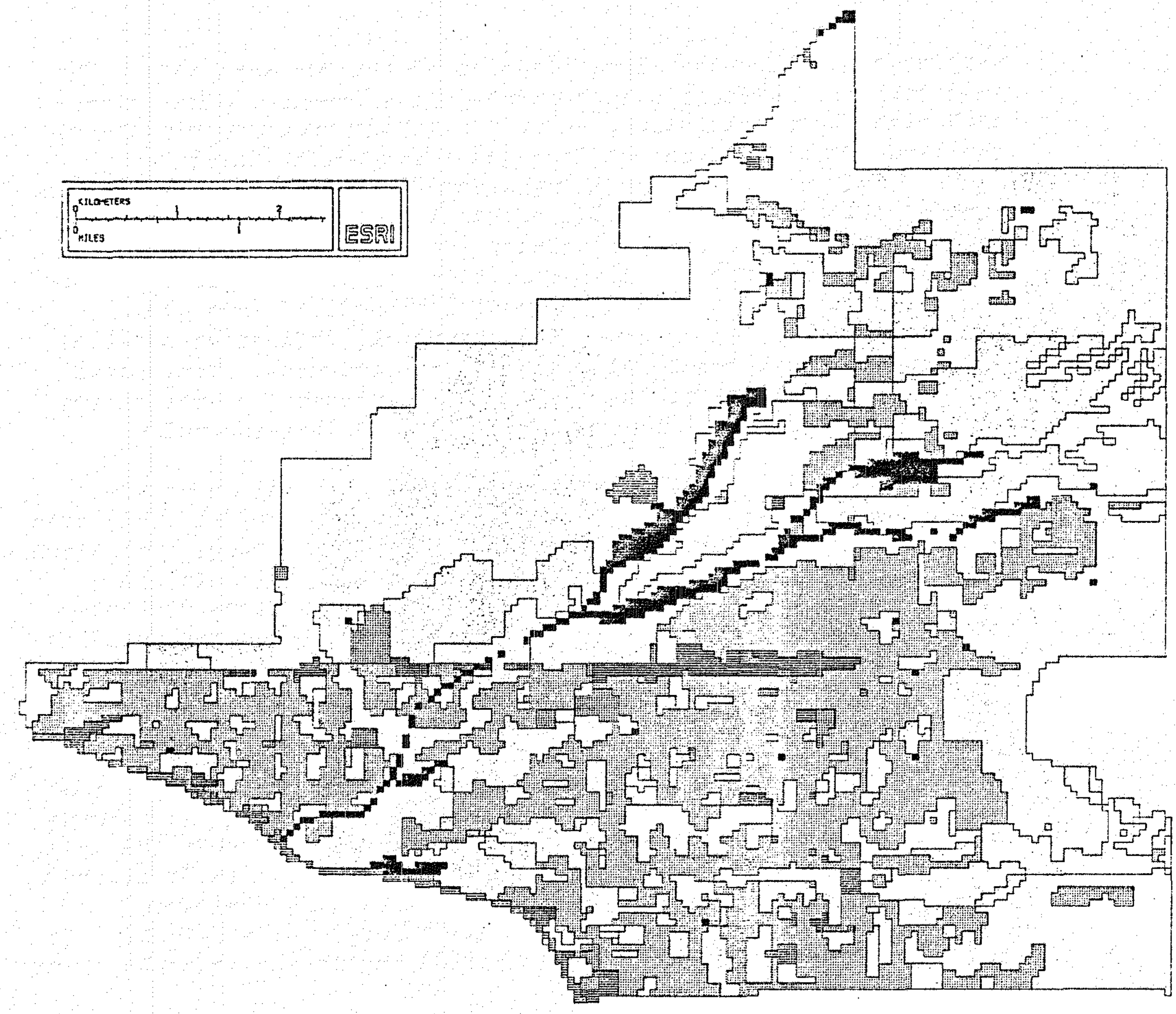
Figure IX-1



1979 LAND USE

C. I. R. S. S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

- OPEN SPACE/RECREATION
- VACANT
- AGRICULTURE
- RESIDENTIAL
- OTHER COMMITTED
- INDUSTRIAL/EXTRACTIVE
- PUBLIC/INSTITUTIONAL
- COMMERCIAL
- WATER

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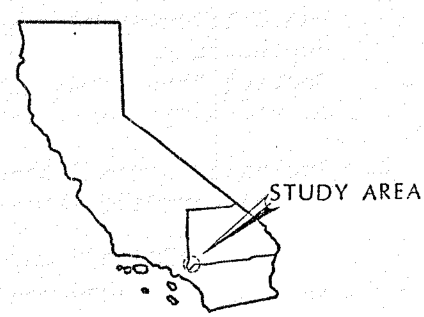


mapping resolution and classification of the two data sets. The land cover classification was created at a one-acre pixel size - each pixel being classified according to its spectral signature. The land use classification included a large-lot 'Rural Residential' category comprising areas five acres and larger. In much of this rural area of San Bernardino County large lots with horse pasturage are the predominant land use. Close examination of the 'salt and pepper' classifications on the land cover output shows that most of the non-residential classifications are agriculture, grassland, brush and chaparral, reflecting spectral signatures from one-acre pixels between structures. These same areas are classified residential on the land use map, reflecting their use within the land use classification decision rules.

Some of the land cover assignments are temporal in nature, such as the large area of 'Water' near the east border. This area is a settling basin and is dry during most of the year. The scene was acquired after a wet season when water was pooled in the basin, where it may remain for several days. The land use data identify the same area as agriculture, because the outer portions of the basin are cultivated during most of the year to reduce erosion. Both assignments are correct, and only appear to be inconsistent.

Other differences are due to classifications made during the land use photointerpretation. For example, the two large merging streams are classified on the land use data as 'Water'. The land cover data shows no water in these same locations. In fact, these streams are normally dry sand-covered washes with scattered shrubs, and contain surface water only briefly during storms. In this instance the 'Water' classification may not be as appropriate as 'Vacant'.

A final and fundamental difference between the two data sets is specifically what they purport to represent. While land cover is often indicative of land use, and land use often controls land cover type, the two are not necessarily related on a one-to-one basis. A grassland land cover could easily be assigned to land use categories of agriculture, vacant, residential, committed (parks), or institutional (school). A residential land cover could likewise be assigned a number of land cover classes depending on lot size, landscaping and presence of parking areas. Bearing this in mind, the two figures demonstrate a large amount of similarity of patterning and consistent use/cover assignment.

2. Evaluate change detection data, comparing LANDSAT with photointerpreted land use change data.

The 1976-1979 multi-temporal scenes were used to generate a land cover change mask for the entire Phase 1 study area as reported by Likens et al. (Likens, Maw and Sinnott, 1982). This procedure resulted in a 1979 classified image which included non-1976 land cover designations only for pixels identified as having a high probability of detecting actual change. Likens et al. (ibid.) report that this procedure was 70-75% accurate for detecting 1979 land cover, total from-to land cover change types (including non-change areas), and Level I land cover change locations (irrespective of change type). They also point out that the accuracy of change type detection is relatively low (about 12% correct detection of type of change). These evaluations were based on samples taken over a 5400 acre area within the San Bernardino Valley portion of the data base, and include a variety of urban, agricultural and undeveloped cover classes.

The integrated data base was used to compare changes detected by the 1976-79 change mask with 1974-79 land use changes which had been encoded by photointerpretation for Southern California Edison Company. Listings were generated to identify the types of land cover and land use changes associated with the grid cells in the Yucaipa small area data base. These listings were used to define an appropriate change type legend which would be useful to the County Planning Department for tracking the development status of land. The following legend was then used for both the land cover and the land use change data:

- Unimproved/Open Space to Agriculture
- Unimproved/Open Space to Urban/Committed
- Agriculture to Urban/Committed
- Other Changes
- No Change

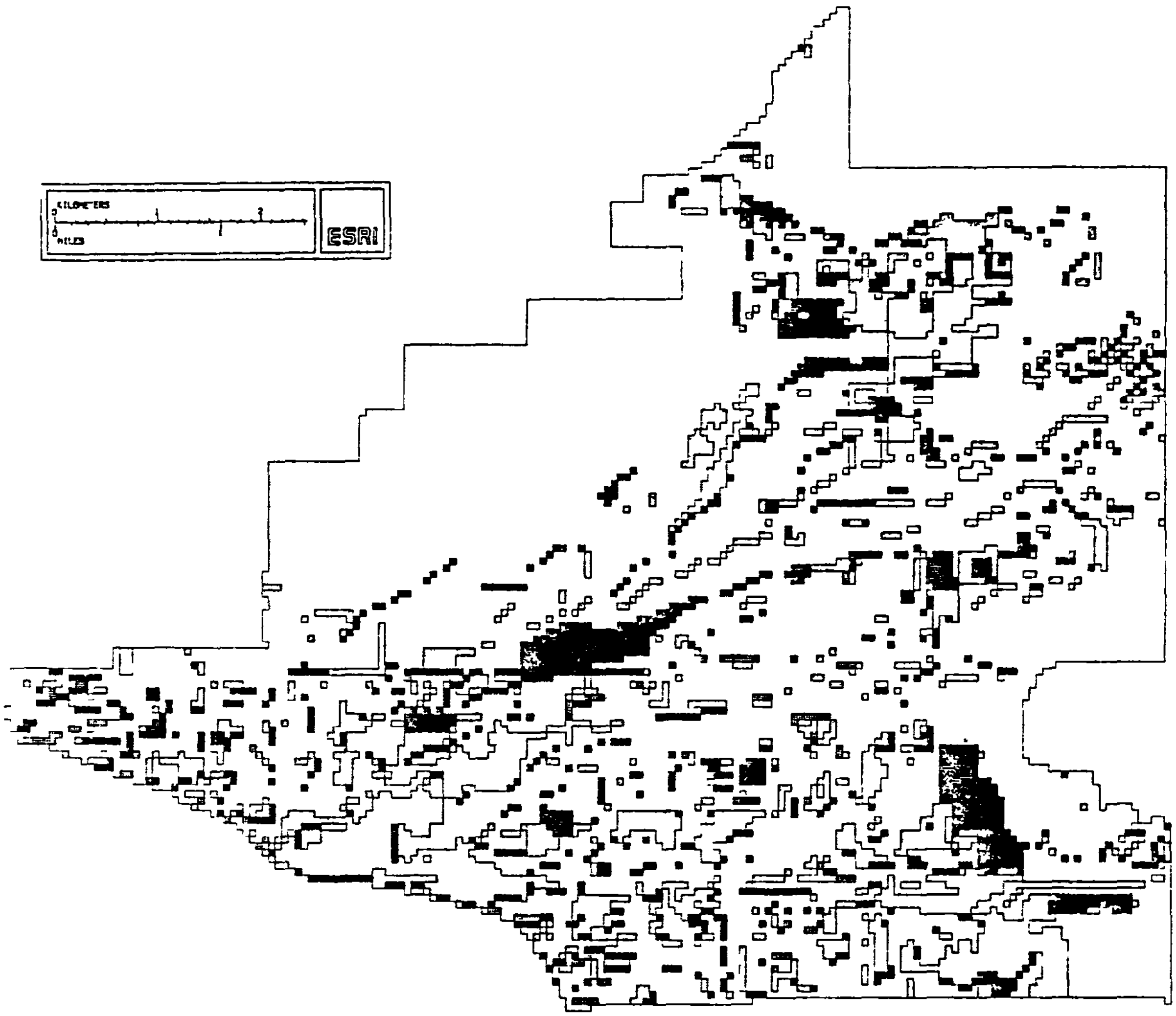
Figure IX-3 and IX-4 are the results of programming a model to generate this analysis of change type by location. Changes detected by LANDSAT are primarily unimproved/open space to urban/committed, some agriculture to urban/committed, and several areas which appear as "other changes". Analysis of these latter areas indicates that they are primarily surface depressions in fields, check dams and percolation/sedimentation basins along drainage courses. These areas were flooded in 1979 and detected by LANDSAT as water. Their unflooded condition during the 1976 drought year was barren or grassland, producing a change type different from the legend types significant to the planning process.

A visual comparison with the County's approved tract maps of those areas designated as change to urbanized uses shows good

Figure IX-3
1974 - 1979 LAND USE CHANGES

CHANGE TYPE	AREA (Acres)
No Change	12,271
Unimproved to Agriculture	443
Unimproved to Urban/Committed	533
Agriculture to Urban/Committed	530
Residential to Other Urban Committed	91
Other Changes	2,223

Figure IX-3



LAND USE CHANGE

C I R S S
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

- UNIMPROVED/OPEN SPACE TO AGRICULTURE
- UNIMPROVED/OPEN SPACE TO URBAN
- AGRICULTURE TO URBAN/COMMITTED
- RESIDENTIAL TO OTHER URBAN/COMMITTED
- OTHER CHANGES
- NO CHANGE

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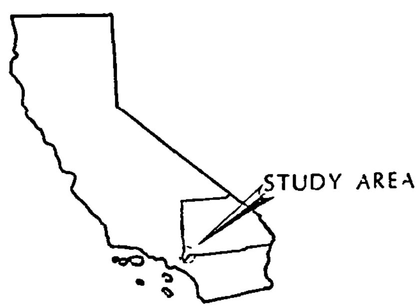
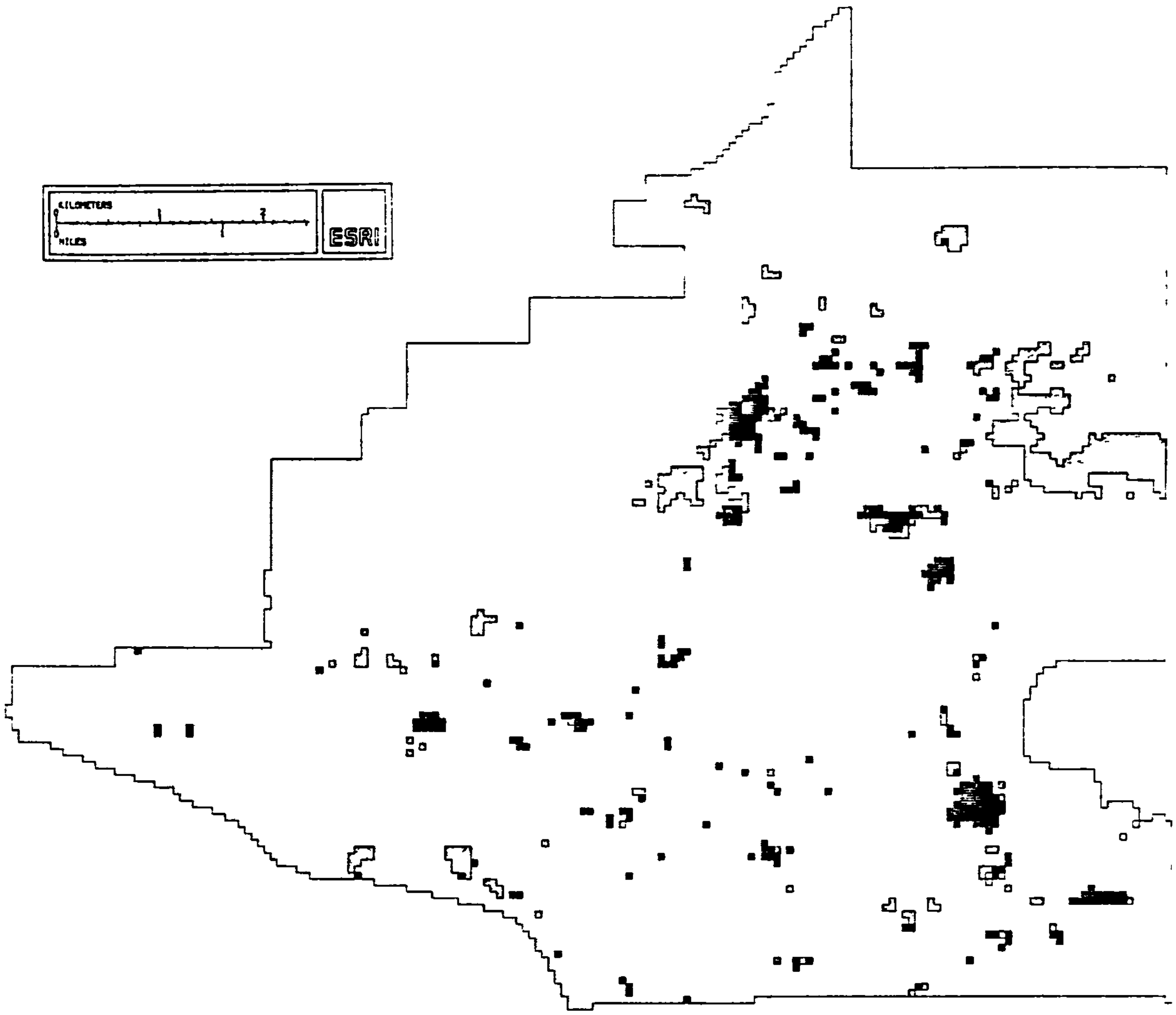


Figure IX-4
1976 - 1979 LANDSAT CHANGE

CHANGE TYPE	AREA (Acres)
No change	15,302
Unimproved to Agriculture	0
Unimproved to Urban/Committed	268
Agriculture to Urban/Committed	72
Residential to Other Urban/Committed	0
Other Changes	449

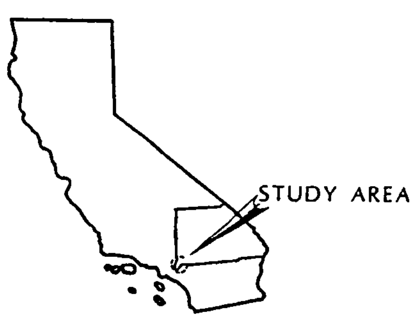
Figure IX-4



LANDSAT CHANGE

C I R S S
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

- UNIMPROVED/OPEN SPACE TO AGRICULTURE
- UNIMPROVED/OPEN SPACE TO URBAN/COMMITTED
- AGRICULTURE TO URBAN/COMMITTED
- RESIDENTIAL TO OTHER URBAN/COMMITTED
- OTHER CHANGES
- NO CHANGE



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locational correspondence with major residential developments during the 1976-79 period. These same tract maps also identify several tracts approved during the same period, but apparently construction was not begun by the date of the second image (July 1979), as no land cover change was detected. It should be noted that the lack of a regional wastewater treatment facility is a major constraint on development density throughout this study area. Except for a few mobile home developments with alternative facilities, large-lot and rural single family residential construction typify the Yucaipa area.

The photointerpreted 1974-1979 land use change output shows considerably more areas of change than does the LANDSAT data. Striking additions include large areas of unimproved/open space to agriculture, and significant areas of "other change". The large areas of new agricultural use are ranches and crop fields developed during the mid-1970's. This example illustrates the difficulty of comparing changes from differing time periods (1974-79 land use versus 1976-79 land cover).

Another difficulty results from the fact that different decision rules were used for the two land use dates, potentially adding change where no change actually occurs. Linear areas identified as change may be related to different boundary decision rules used in the two land use studies. The 1974 land use data base resulted from photointerpretation by Earthsat Corporation, which placed polygon boundaries along one side of a street. The same boundary in the 1979 Aerial Information Services land use data was adjusted to the center of the street (ESRI project files). While the files delivered to SCE included adjustments of these boundaries to the AIS convention, the original unadjusted 1974 land use file was selected for the integrated data base. Thus, unadjusted borders may account for some of the linear change areas, especially those which are adjacent to non-change areas on both sides.

A third characteristic of the two land use dates results in large areas identified as "other change". Examination of the listings indicates these areas to be coded agriculture in 1974 and vacant in 1979. Most of these areas are pasture grasslands used for grazing small numbers of livestock (cattle and horses). Commercial agricultural production in the area has declined over the study period, which may explain these land use codes. However, it is also possible that different classification rules were used to assign codes of agriculture in 1974 and in 1979. Much of the area in question has long been used as horse pasture for both commercial and non-commercial uses (AIS 1979 land use survey). This use may have been coded agriculture in 1974 and then vacant in 1979 by different interpreters.

In order to facilitate comparison of the two change data files, an output file was created to identify locations of agreement and disagreement. Figure IX-5 is the resulting map output from that file. As discussed above, most of the discrepancies result from changes identified in the land use data which are not identified in the land cover data. In this test, LANDSAT appears to be the most accurate means of detecting changes in this area. Approximately 789 acres (4.9%) of the LANDSAT land cover data indicates changes between the 1976 and 1979 images, while the land use data indicate that 4,074 acres (25.32%) of the area changed in use between 1974 and 1975. Further, in locations where the two change files agree that change took place, 20% of the area is coded with similar change direction - all areas of change from unimproved/open space to urban/committed.

Discrepancies between the change data appear to be real in some cases and artifacts of several types in other areas. The following causes can be identified for individual discrepancies:

- Real differences in change/non-change resulting from land use/cover changes between 1974 and the image date of 1976;

- Real differences in land use change without accompanying land cover change (e.g., abandoned commercial agricultural pasture still used for limited equestrian purposes);

- Different rainfall conditions between image dates resulting in some land cover changes (e.g., agriculture to water) not reflected as land use changes;

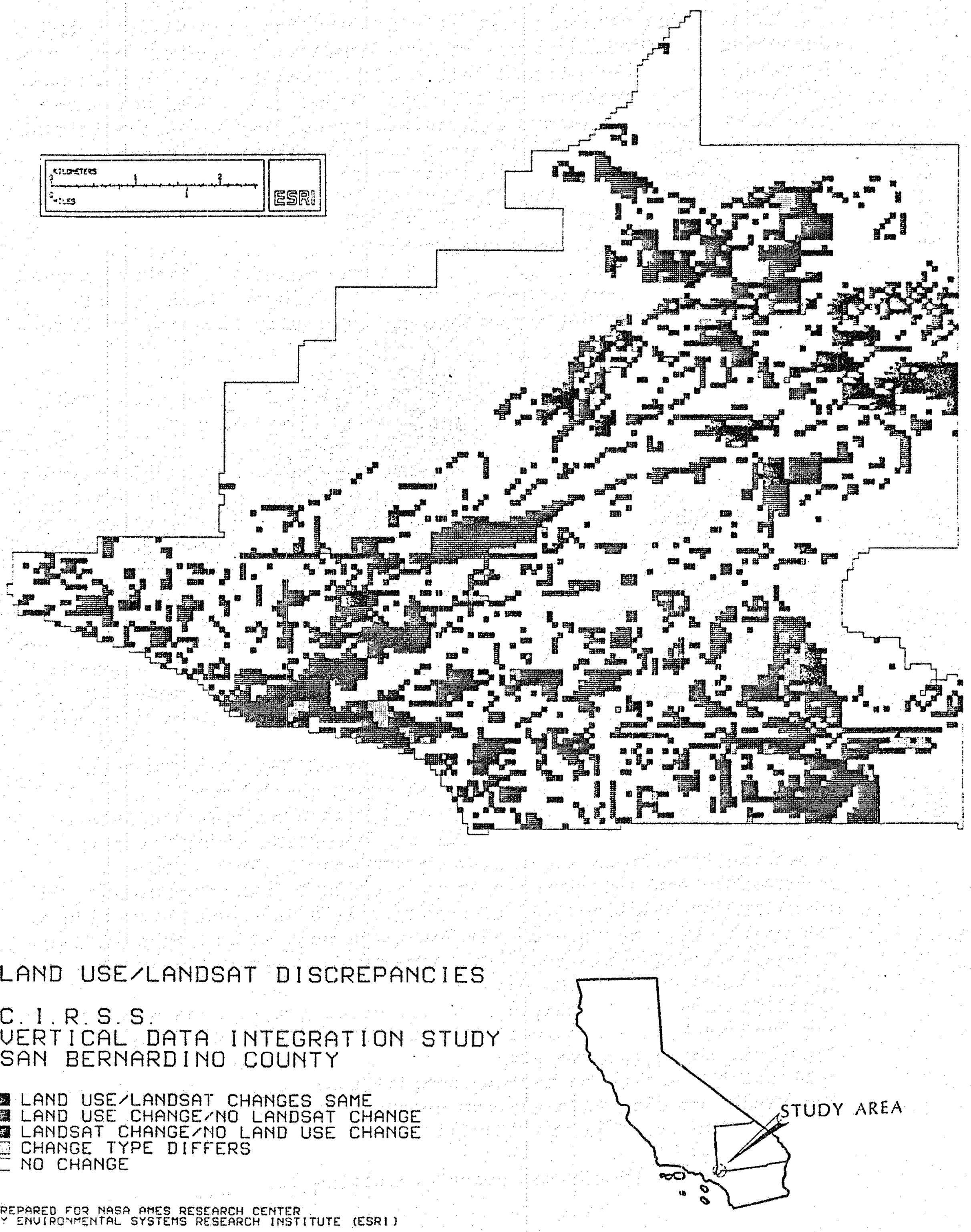
- Possibly different classification decision rules (the land use data were mapped by two independent companies) resulting in land use classification change artifacts (e.g., pasture coded as agriculture and then as unimproved).

The purpose of this project is to investigate benefits and problems associated with vertical integration of existing data sets. The land use/land cover change analysis illustrates both benefits and problems. Problems include the possibility of using data sets which appear to be similar, but which contain internal inconsistencies caused by different mapping methods and decisions. The land use change data included here reflect actual land development in the study area and also reflect both locational and classification inconsistencies. The LANDSAT land cover data reflects actual changes associated with development and also changes associated with climatic differences. The benefit resulting from the integration of these data sets is that the discrepancies become readily apparent and their locations can be identified. This limits the amount of effort required by the user to revise the data sets so that they reflect homogeneous sets of

Figure IX-5
LAND USE/LANDSAT CHANGE DISCREPANCIES

DISCREPANCY	AREA (Acres)
Land Use/LANDSAT Agree	64
Land Use Change/No LANDSAT change	3,517
LANDSAT Change/No Land Use Change	486
Change Type Differs	239
No Change	11,785

Figure IX-5


KILOMETERS
MILES
ESRI
LAND USE/LANDSAT DISCREPANCIES
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
LAND USE/LANDSAT CHANGES SAME
LAND USE CHANGE/NO LANDSAT CHANGE
LANDSAT CHANGE/NO LAND USE CHANGE
CHANGE TYPE DIFFERS
NO CHANGE
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STUDY AREA

information.

This change detection analysis illustrates that LANDSAT change detection can identify areas of developmental change in cover type by relegating non-important change directions to an 'other change' category. Photointerpreted land use change detection, while more closely related to planning classifications, may require extensive field verification to identify or explain change artifacts resulting from inconsistent border and classification rules. The use of multitemporal LANDSAT data, while initially more expensive than existing land use data, may not require as much field verification if the images are properly registered. This would provide County Planning personnel a rapid means of tracking actual building starts over a large area. Such changes which do not coincide with approved projects could be easily flagged for field investigation.

3. Model urban capability/suitability for small area using the integrated data base.

The Yucaipa area is on the relatively rural fringe of the more densely populated east San Bernardino Valley. It is physically separated from the Valley by the brush covered Crafton Hills. The Yucaipa Valley occupies a watershed which drains through Live Oak Canyon and San Timoteo Canyon to the San Bernardino Valley and also through Reservoir Canyon to Redlands. Neither drainage route has been supplied with a waste treatment facility or sewerage, resulting in a dispersed development pattern. Pressure to develop the Yucaipa area more densely has resulted in tentative approval for a waste treatment facility which will allow more dense development as well as conversion of presently unimproved acreage.

In order to determine which portions of the area are more likely to develop in the future, an urban development capability/suitability model was used with the integrated GIS to identify those areas most capable of supporting construction, given the parameters identified in the model. This type of information can aid planners as they project future workloads and identify potential conflicts. Figure IX-6 includes an outline of the model which rates each one-acre grid cell according to a variety of geographic constraints which occur at and near the cell. Major constraints with respect to construction (e.g., flooding) are given greater importance (weight) in the model than are factors wich are more easily mitigated (e.g., soil type). Together, these factors provide a cumulative rating for each grid cell which can then be used to compare that cell to all others. The resulting data file and map output rank each cell according to its relative capability/suitability to support development.

Figure IX-6 is the map output resulting from application of

FIGURE IX-6
SAN BERNARDINO VERTICAL INTEGRATION STUDY
COUNTY PLANNING DEPARTMENT SMALL AREA

1979 URBAN CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Flood Hazard	Documented flood zone		
	Active stream wash	50	
	Not active stream wash	40	
	Inferred flood zone		
	Not channelized	20	
	Channelized	10	
	Not flood zone		
Slope stability	Known landslide	50	
	Landslide susceptibility rating		
	Moderate to high	30	
	Low to moderate		
	GT 30% slope	15	
	15 - 30% slope	5	
	8 - 15% slope	0	
	0 - 8% slope	0	
	Generally devoid		
	GT 30% slope	15	
	15 - 30% slope	5	
	8 - 15% slope	0	
	0 - 8% slope	0	
Geologic/seismic hazards	Known, concealed or inferred fault	50	
	Alquist Priolo special study zone	30	
	Proximity to fault		
	LT 2 miles from a fault		
	Unconsolidated deposit		
	LT 100 ft. groundwater	30	
	GT 100 ft. groundwater	15	
	Consolidated deposit	5	
	2 - 5 miles from a fault		
	Unconsolidated deposit		
	LT 100 ft. groundwater	15	
	GT 100 ft. groundwater	5	
	Consolidated deposit	2	
	GT 5 miles from a fault		
	Unconsolidated deposit		
	LT 100 ft. groundwater	5	
	GT 100 ft. groundwater	2	
	Consolidated deposit	0	

1979 URBAN CAPABILITY/SUITABILITY
CONCEPTUAL MODEL OUTLINE

FIGURE IX-6
(continued)

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Fire hazard	Very high	25	
	LT 1/4 mile distance		15
	High	20	
	LT 1/4 mile distance		10
	Moderate	5	
Erosion potential	Very high	15	
	High	10	
	Moderate	5	
	Low	2	
	Very Low	0	
Ecological impact potential	Highly sensitive	15	
	Moderately sensitive	8	
	Marginally sensitive	2	
	Not sensitive	0	
Compatible existing land use (1979 LU)	Existing urban land use . (residential, commercial & industrial)		
	LT 1/4 mile distance		0
	1/4 - 1/2 mile distance		+1
	1/2 - 1 mile distance		+3
	GT 1 mile distance		+5

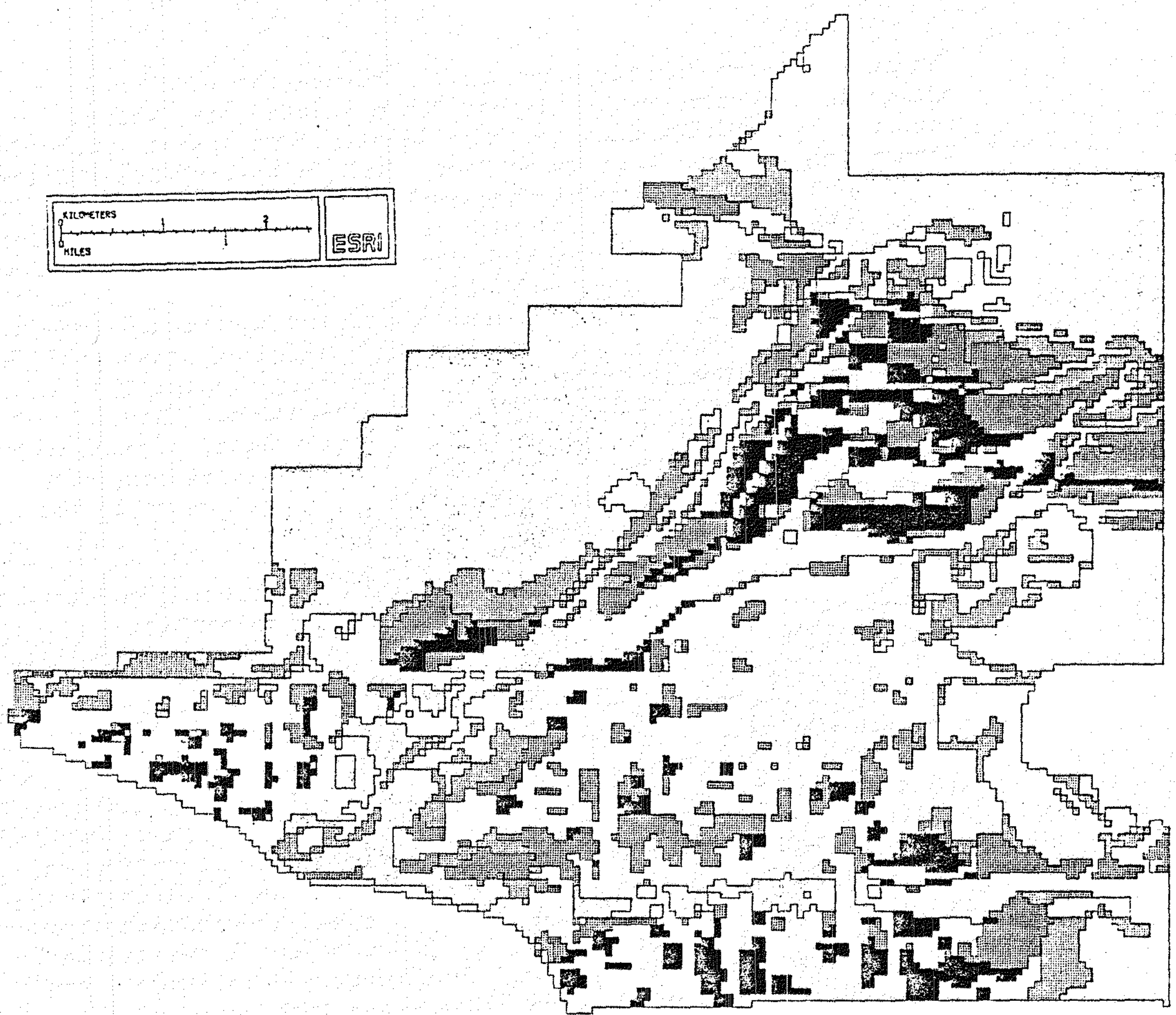
Model Summation Rules

Capability/suitability rating

Very low	GE - 50 - 145	D
Low	35 - 49	F
Moderate	20 - 34	O
High	10 - 19	S
Very high	LT 10	X

Urban/developed/committed	A
Water	Z

Figure IX-6

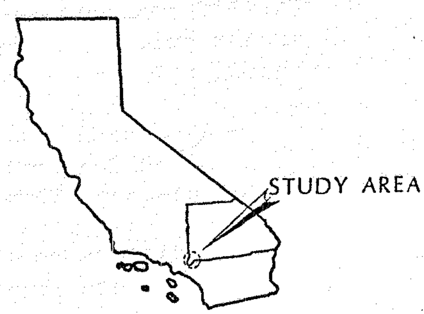


URBAN CAPABILITY/SUITABILITY
GIS MODEL

C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

CAPABILITY/SUITABILITY RATING
- VERY LOW
- LOW
- MODERATE
- HIGH
- VERY HIGH

- URBAN/DEVELOPED/COMMITTED



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the model to the Yucaipa data base. Because the model was originally written for the larger Phase 1 data base, which includes lands designated for high density development in the San Bernardino Valley, no areas of "Very High Capability/Suitability" are calculated by the model when applied to the Yucaipa area. The major geographic constraints such as steep slopes of the Crafton Hills, floodprone areas and high fire hazards are rated very low capability/suitability for urbanization. The presence of existing urban land uses indicates the presence of infrastructure (roads, water service, etc.). Distance from 1979 existing urban land use was therefore used to decrease the suitability of land for development. Areas which the model has designated "High Capability/Suitability" are on gently sloping land, without major constraints, near existing urban uses, and are consistent with those areas designated for moderately dense development by the General Plan.

Likens and Maw (1982) noted problems in developing consistent classifications for intermixed brushland and residential development in the rapidly urbanizing areas of the San Bernardino Valley. Comparison of the LANDSAT image with the generalizations regarding the undeveloped lands made during photointerpretation of the land use data presented apparent classification inconsistencies from one pixel to another. This was found to be the result of intermixed housing and vacant lands. A similar condition exists in the data for the Yucaipa small area. Much of the residential development consists of structures fronting on streets (1/4 to 1/2 mile long) and large acreage of shrubs/grass or pastureland within the residential block. The photointerpreted land use classification for these areas was "rural residential", and includes the entire block of structures and unimproved land. The LANDSAT 1-acre pixel image records the land cover of these same areas as either structures or vacant lands.

Recognizing that these undeveloped lands surrounded by residential development (and associated infrastructure) will be among the most desirable sites for higher density construction should sewerage become available, the LANDSAT land cover data plane was used to add higher resolution information to the urban capability/suitability model in a second analysis. This GIS + LANDSAT analysis added two types of additional information to the original data available to the capability/suitability model:

- A command was included to assign areas encoded grass or shrub land cover and urban/committed land use to the category "Very High" capability/suitability for development.

- Modifiers to the previous values assigned for vegetation, crops and presence of structure were assigned to refine the initial classifications by using the different classification resolution and finer pixel resolution of the LANDSAT based data. The values assigned were selected to allow the same summation rules to be used on this model as in the previous model.

Figure IX-7 is a map output of the urban capability/ suitability model including LANDSAT data. Note that the only difference between this model and the model displayed in Figure IV-6 is the addition of LANDSAT land cover data. The differences thus reflect the incremental difference resulting when LANDSAT data is used in the mode. Figure IV-8 is a flow chart which illustrates the process used to create these two models.

The GIS + LANDSAT model map displays several significant differences when compared to the output of the GIS model. The most apparent difference is the presence of "Very High" capability/suitability assigments on the integrated model. This results from: 1) an assumption that vacant land which is now in urban use or declining agricultural uses will be more suitable for development when appropriate infrastructure is available (sewerage) and; 2) use of the 1-acre LANDSAT resolution of the land cover pixels to distinguish vacant lands from rural development within areas mapped solely as rural development by the land use. One notable artifact illustrates that this technique must be used with care: the Yucaipa land-fill just north of center in the study area, identified as "Very Low" capability/suitability on the GIS model, is increased to a "Very High" rating on the LANDSAT model because it is coded in the the land use file as urban/committed. Its brush land cover causes it to be assigned to the "very high" category as well. While this could have been dealt with in the model, it has been retained here as an illustration of the care with which multi-data layer models must be developed.

Other changes occur in areas coded agricultural use in the 1979 land use file. County policy is to maintain agriculture where it exists and is economically feasible. Agriculture in the area tends to be allowed to decline to an economically unproductive level prior to submitting an application for development. The LANDSAT component of the second model refined the first analysis by adding additional value for urbanization to areas which, although coded agricultural land use, support declining crops indicative of areas about to be removed from production. Several areas in the north-eastern quarter of the study area increase in capability/suitability for development as a result. A recent (1982) ground survey by the author verified that several of these formerly declining vigor croplands and pastures have in fact been converted to single family residential housing and mobile home parks.

FIGURE IX-7
SAN BERNARDINO VERTICAL INTEGRATION STUDY
COUNTY PLANNING DEPARTMENT SMALL AREA

1979 URBAN CAPABILITY/SUITABILITY
+ SEPARATE LANDSAT DATA PLANE

CONSIDERATION	SPECIFIC DATA CLASS		VALUE (Incidence)	VALUE (Proximity)
1979 Urban Capability/ Suitability	Results of GIS model (raw scores)		--	--
1979 LANDSAT Land Cover	Code	Class		
	1	Cleared	-10	
	2	Bare	-10	
	3	Sparse Brush	- 8	
	4	Brush	- 7	
	5	Thick Brush	- 7	
	6	Young Orchard	+ 5	
	7	Moderate Vigor Orchard	+ 2	
	8	Mature Orchard	+ 2	
	9	Declining Orchard	- 7	
	10	Mod-Vigor Vineyard	+ 2	
	11	High Vigor Vineyard	+ 5	
	12	Declining Vineyard	- 7	
	13	Woodland	+10	
	14	Sparse Woodland	0	
	15	Grass	-10	
	16	Dry Grass	-10	
	17	Agriculture	+ 5	
	18	Asphalt	0	
	19	Concrete	0	
	20	Extractive	0	
	21	Cinder	+10	
	22	Slag	+10	
	23	Structures	0	
		Within ¼ Mile		-.5
	24	Strip Structures	0	
		Within ¼ Mile		- 5
	25	Water	0	
	26	Snow		
	27	Structures w/Brush	-10	
	28	Residential w/Trees	0	
		Within ½ Mile		- 5
	29	Irrigated Newer Residential	0	
		Within ½ Mile		- 5
	30	Cluster	0	
		Within ¼ Mile		-10
		¼ to ½ Mile		- 5

1979 URBAN CAPABILITY/SUITABILITY
+ SEPARATE LANDSAT DATA PLANE

FIGURE IX-7
(continued)

CONSIDERATION	SPECIFIC DATA CLASS		VALUE (Incidence)	VALUE (Proximity)
	Code	Class		
	31	Large Lot Unirrigated	- 3	
	32	Rural/Strip	0	
		Within ¼ Mile		- 3
	33	Mobile Home High Density	0	
	34	Low Vigor Vineyard	-10	
	35	Big Cone Douglas Fir	+10	
	36	White Fir	+ 5	
	37	Jeffrey Pine Mixed	+ 5	
	38	Ponderosa Pine	0	
	39	Lodgepole/Limber Pine	0	
	40	Pinyon/Juniper	0	
	41	Canyon Live Oak/Riparian	+ 5	
	42	Jeffrey Pine/Ceanothus	+10	
	43	Coulter Pine Mixed Forest	0	
	44	Bracken Fern/Ceanothus	+10	
	45	Ceanothus/Scrub Oak	+10	
	46	Chamise	+10	
	47	Chamise/Ceanothus	+10	
	48	Coastal Sage	+ 7	
	49	Great Basin Sage	+ 7	
Increased Density on Large Lot Residential	IF Land Use = Residential and Land Cover = grass or shrub		-50	

Model Summation Rules

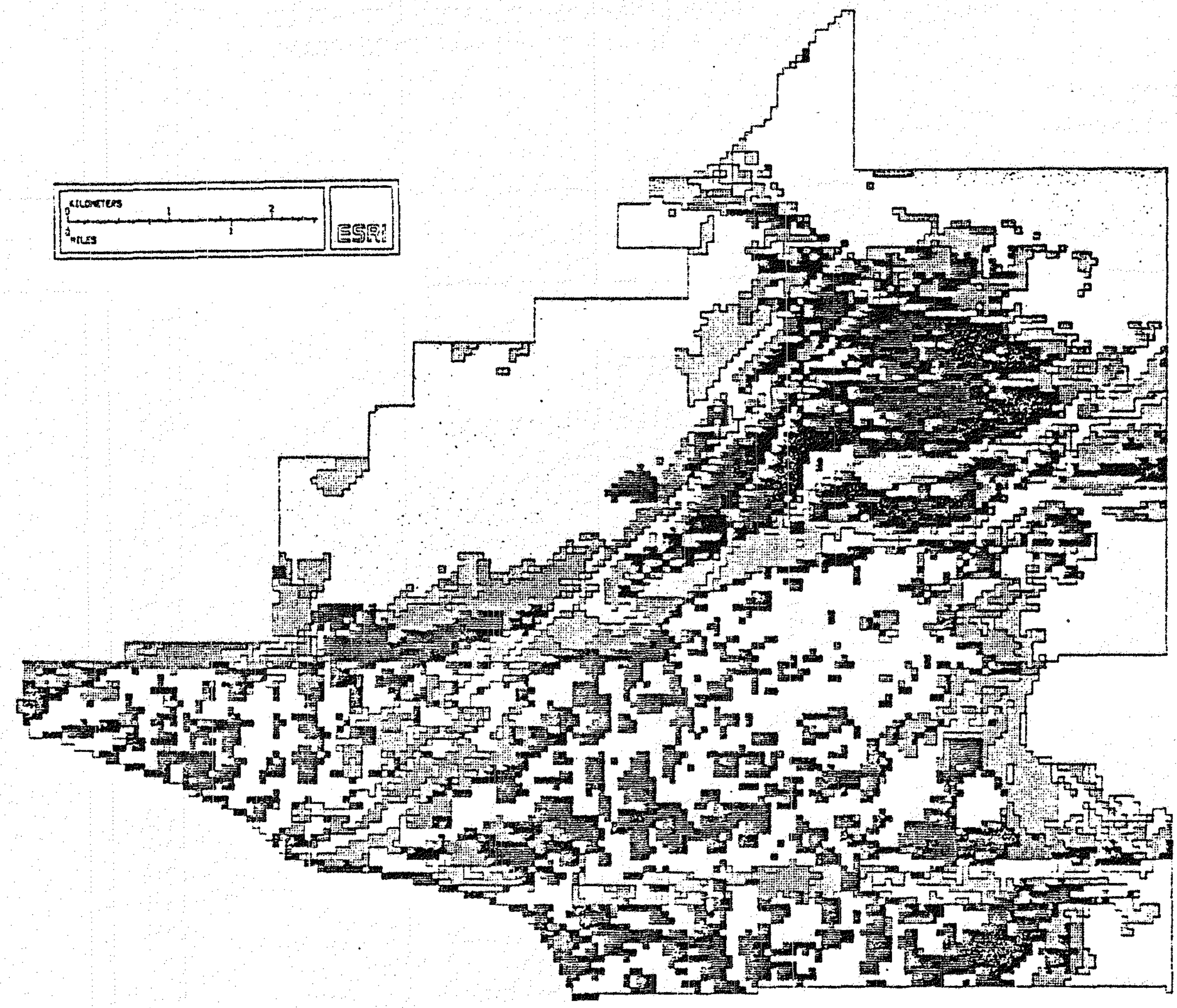
Capability/suitability rating

Very Low	GE - 50 - 145	D
Low	35 - 49	F
Moderate	20 - 34	O
High	10 - 19	S
Very High	LT 10	X

Urban/developed/committed A

Water Z

Figure IX-7



URBAN CAPABILITY/SUITABILITY
GIS + LANDSAT

C. I. R. S. S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY

CAPABILITY/SUITABILITY RATING
- VERY LOW
- LOW
- MODERATE
- HIGH
- VERY HIGH

- URBAN/DEVELOPED/COMMITTED

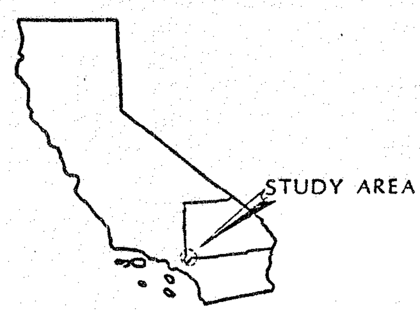


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FIGURE IX-8

INCREMENTAL VALUE OF LANDSAT

URBAN CAPABILITY/SUITABILITY MODELS

Geographic Hazards	Geographic Hazards
Environmental Values	Environmental Values
Administrative Designations	Administrative Designations
Current Land Uses	Current Land Uses
Etc.	Etc.
	LANDSAT Land Cover

Raw Score Output

Raw Score Output

Incremental

Difference

4. Evaluate incremental value of LANDSAT land cover data when used for small area planning in a GIS environment.

    The conceptual value of using LANDSAT land cover data in a GIS modeling context is illustrated by the capability/suitability example described above. In order to quantify the incremental information provided by the LANDSAT data, the raw score outputs of the two models were compared using the MINITAB statistical package. Figure IX-9 is a plot of the generalized values of the two model outputs. The plot shows a tight fit between the output values of the two models, indicating that they are closely related. The overall correlation between the two models is 0.949, thus the incremental numeric value of the LANDSAT land cover data is approximately 10% of the total model value ($1^2 - .949^2$). The numeric significance of this value depends on the correlations of the other data planes input to the model. Table IX-1 identifies the correlation between the GIS model output and the various data layers used as input. The LANDSAT data in the second model is applied primarily to ecological importance, fire hazard, and proximity to urban land use.

    While the 10% incremental value of the LANDSAT data appears to be small in comparison to some of the other input data planes, its importance for planning purposes is significant. The distinction of lands likely to be developed is an extremely important capability for planning, and far outweights the apparently small numeric incremental value of LANDSAT as used in this model. This qualitative value is best illustrated by visual examination of Figures IX-6 and IX-7.

B. National Forest Fire Buffer Analyses

The fire buffer greenbelt small area data base was used to project possible future development scenarios and their impacts on fire hazard, runoff and erosion. This study was done to provide analytic data which will aid the San Bernardino National Forest staff in siting their proposed greenbelt area. The ultimate objective of siting the greenbelt is to reduce the fire, flood and mass erosion processes which become hazards to adjacant urban development. As described in Section IV, these hazards can be catastrophic along the south slopes of the San Bernardino Range.

The San Bernardino National Forest small area data base was used to perform the following analyses:

1. Model fire hazards using the same model used for the Phase 1 data base and compare the results with the output of the 4-acre grid cell Phase 1 output.

2. Model land use/land cover changes expected to result from two

FIGURE IX-9

INCREMENTAL VALUE OF LANDSAT

Correlation between GIS Model and GIS + LANDSAT Model = 0.949

```
               C3
            150.+
                -
                -                                              *
GIS Model       -                                         *  3+
(raw scores)    -                                          ++++
            120.+                                         ++*
                -                                   *** 5++
                -                               +++7+222++
                -                             4+6844 5++
                -                           53*83+   +3
             90.+                          ++++++334+
                -                      * 38+++++8+++
                -                     586++++++9+++
                -                   38+++++++6+++
                -                  +++++++++++++
             60.+                +++++++++++++
                -               88+++++++++++
                -             *8++++++++++5
                -            ++++++++++++*
                -          2++++++++++++
             30.+         9++++++++++++
                -        ++++++++*
                -      ++++++++++***
                -
                -
              0.+
                 +---------+---------+---------+---------+---------+---------+C4
               -40.        0.       40.       80.      120.      160.

                      GIS + LANDSAT Model
                      (raw scores)
```

TABLE IX-1

YUCAIPA SMALL AREA
CORRELATION OF INPUT WITH URBAN
CAPABILITY/SUITABILITY OUTPUT

INPUT	CORRELATION COEFFICIENT (r)	COEFFICIENT OF DETERMINATION OF (R^2)
Flood Hazards	.307	9.42%
Slope Stability	.651	42.38%
Geologic Hazards	.270	7.29%
Erosion Potential	.623	38.81%
Ecological Importance	.523	27.35%
Fire Hazards	.723	52.27%
Proximity to Very High Fire Hazard	-.524	27.46%
Proximity to High Fire Hazard	-.452	20.43%
Proximity to Urban Land Use	.248	6.15%

future scenarios: development if designated a fire buffer greenbelt, or development allowed under present non-designation policies.

3. For each of the future scenarios, model the impacts of expected land use/land cover changes to fire hazard, runoff rates, and erosion potential.

Figure IX-10 illustrates the general processing steps required to produce the final comparative output of impacts expected to result from designation or non-designation as a greenbelt area. This section of the report describes the various analyses conducted using the greenbelt small area data base.

1. Compare fire hazard models

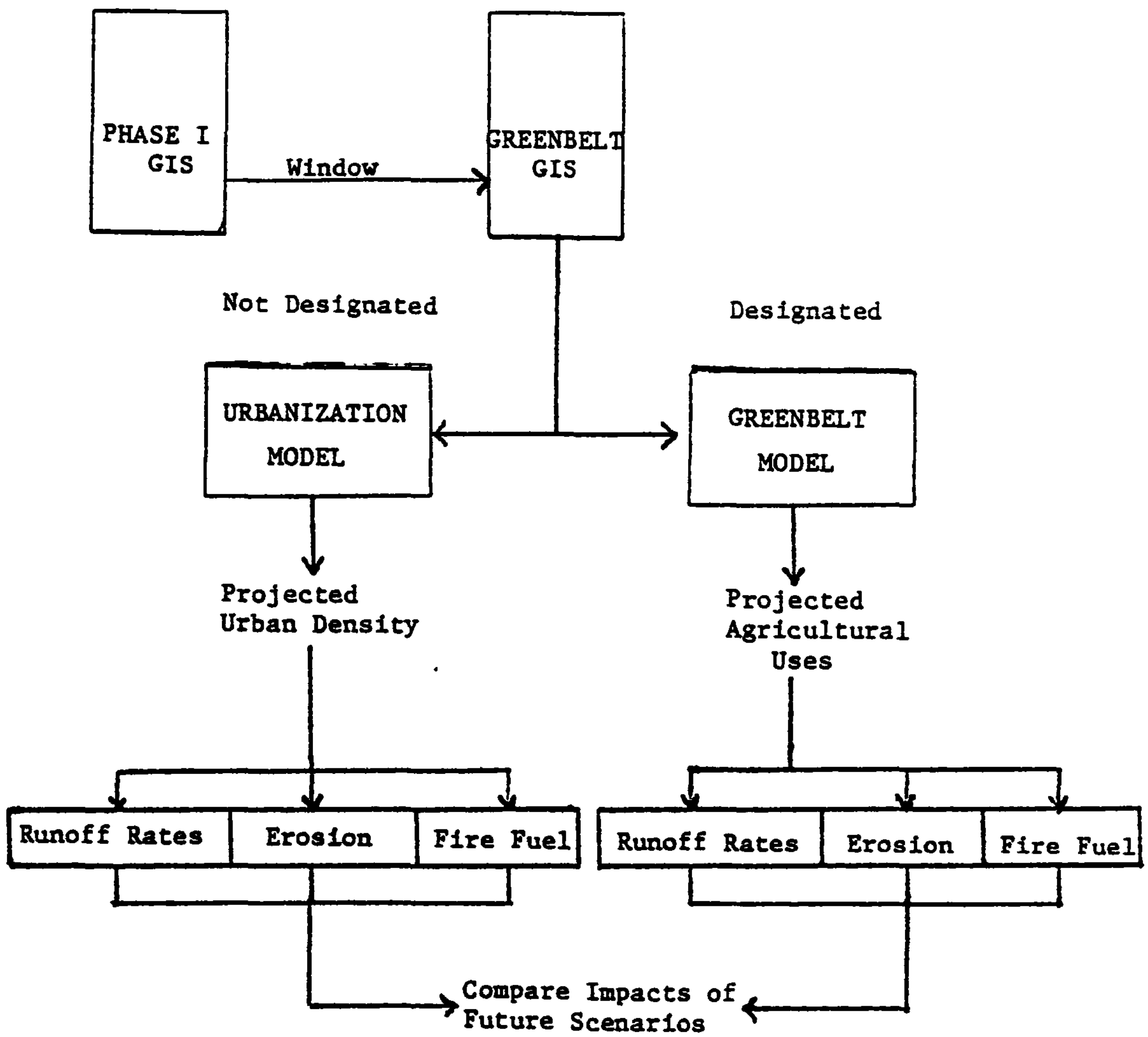
The fire hazard model written for the Phase 1 study utilized vegetation types and slopes as primary indicators of both flammability and rate of fire spread (generally upslope). Slope angle is also a useful indicator of fire suppression methods which could be used in the event of a wildfire.

Both the Phase 1 and Greenbelt fire hazard models used the LANDSAT land cover data as the source of vegetation type. The model assigned numeric weights to the vegetation types based upon an integrated understanding of both flammability and historic damage relationship. Thus, while grassland is highly flammable during the late summer months, it is not associated with high damage costs, and therefore is assigned a lower hazard rating than chaparral, for example. Hazard ratings used in this model were developed for the San Bernardino National Forest staff and reflect the understandings of that agency.

The second major component of the fire hazard rating is slope angle. Topographic slope for the study area was available from two sources in the integrated data base: the DMA Digital Elevation data which were gridded and registered to the scene by Jet Propulsion Laboratories, Pasadena, and polygonal slope gradient classes derived from USGS contour densities and included in the Integrated Terrain Unit Map. The Phase 1 fire hazard model used the gridded DMA data to calculate slope angle between adjacent cells. The interpolation and gridding of the DMA elevation data resulted in 40 foot quanta (40 foot elevation classes), resulting in a minimum slope of about 19% (40/208 foot cell length) between successive elevation classes. This minimum slope characteristic produced a pronounced "terracing" effect on the small area graphic output using 1-acre grid cells, which is illustrated by Figure IX-11. Figure IX-12 is the output resulting from the same model run using the ITUM slope categories instead of slope calculated from the DMA elevation data. The use of slope categories allows

FIGURE IX-10

GREENBELT STUDY



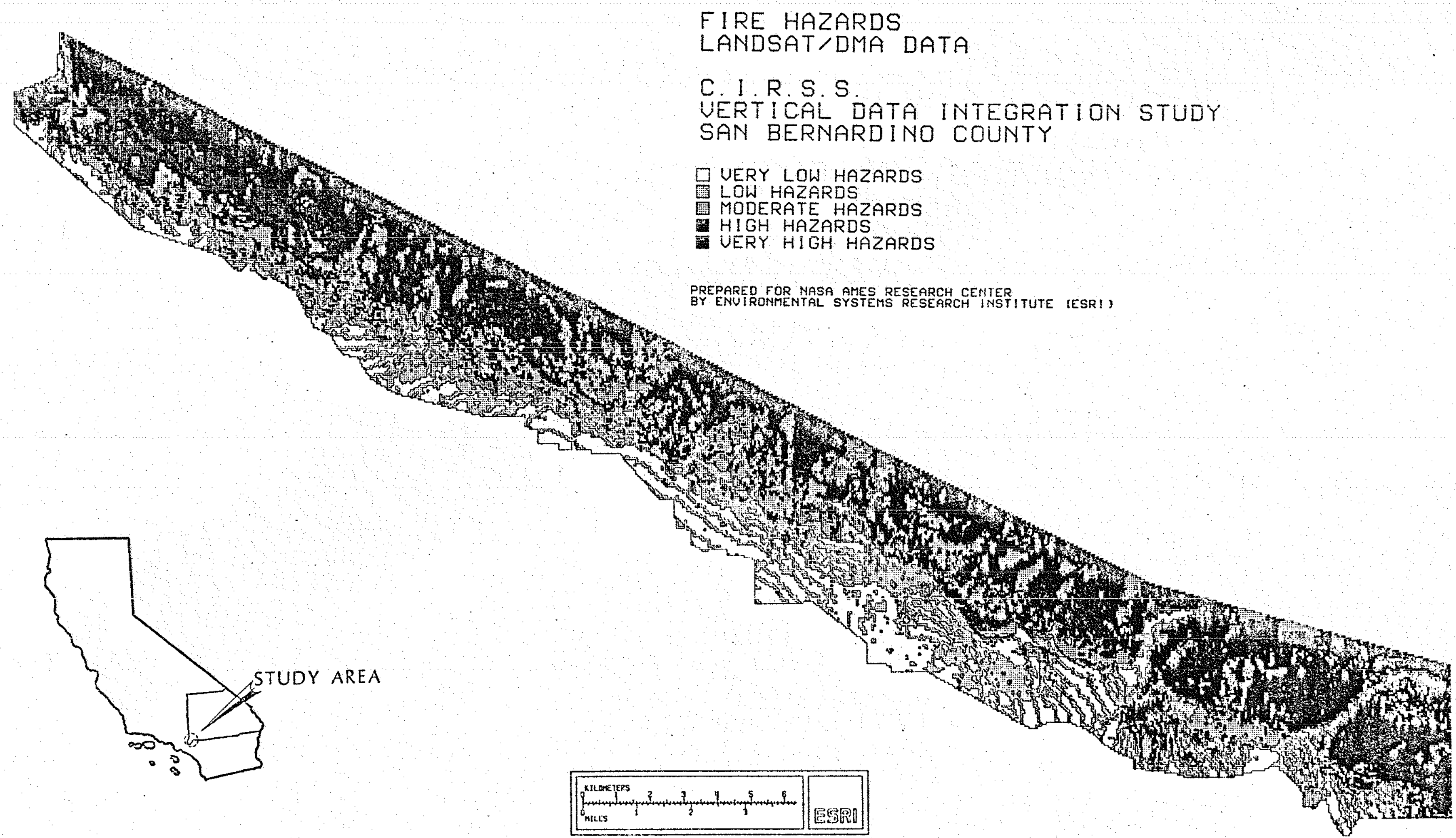

FIRE HAZARDS
LANDSAT/DMA DATA
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
VERY LOW HAZARDS
LOW HAZARDS
MODERATE HAZARDS
HIGH HAZARDS
VERY HIGH HAZARDS
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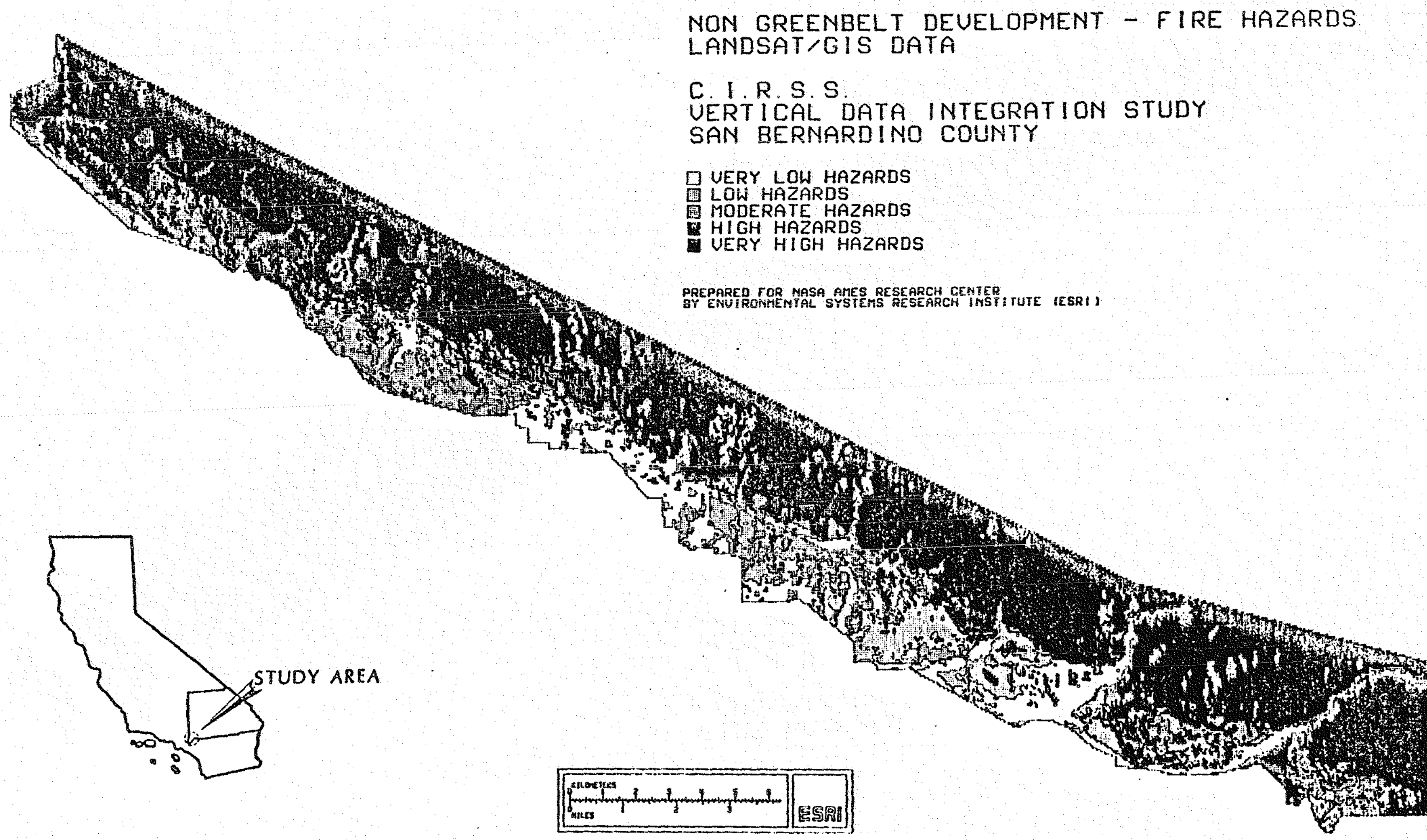
Figure IX-11


NON GREENBELT DEVELOPMENT - FIRE HAZARDS
LANDSAT/GIS DATA
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
VERY LOW HAZARDS
LOW HAZARDS
MODERATE HAZARDS
HIGH HAZARDS
VERY HIGH HAZARDS
PREPARED FOR NASA AMES RESEARCH CENTER
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STUDY AREA
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Figure IX-12

shallower slopes to contribute to the analysis and does not produce steep slope artifacts between adjacent cells.

Because the terracing effect of the DMA elevation data is dependent in part on the size of the grid cell, an exact point to point comparison of the Phase 1 and Phase 2 output plots is not possible. However, visual examination of the general shading patterns indicates an overall similarity of locations of major high and low hazard areas. This result follows from the distinctness of the steeply sloping mountain escarpment and the gently sloping valley floor. These relatively planar surfaces occupy major portions of the greenbelt study area.

Conclusions which may be drawn from this comparison is fire hazard output models are:

- Slope-sensitive nature of the model requires a more accurate source of slope values that generated by the 40-foot elevation quanta derived from DMA elevation data. Terracing is more visually apparent using the 1-acre cell size;

- The intregrated nature of the data base allowed more refined slope data (ITUM slope categories) to be used by the same model, producing results more consistent with the terrain and fire hazard model; and,

- The fire hazard model run using the 1-acre small area data base produces a generally similar spatial product as that produced by the 4-acre Phase 1 data base.

2. Model future scenarios

Figure IX-10 is a flow chart showing the conceptual flow of the future scenario development phase of this task. Potential future land uses were modeled using the following sets of assumptions:

a. No greenbelt designation (urban development model)

- Urban development will occur in the study area based upon its natural capability to support construction.

- Urban development density will be limited by ownership and density designations reflected on the San Bernardino County Comprehensive General Plan map.

- Some consideration (restriction) will be made to reduce density of development in proximity to existing high fire hazard areas.

b. Greenbelt designation

- Existing urban areas in the zone will be maintained.

- Large-scale new urban development will be restricted or prohibited.

- Agricultural uses will occur according to the capability of the land to support such uses. The fire buffer greenbelt will be an active agricultural entity rather than non-maintained open space.

It should be noted that either of these future scenarios would require appropriate market and administrative incentives. This subject is not addressed by the models except indirectly by considering proximity to existing development (with infrastructure) to be more suitable for urbanization than distance from existing development. Economic and administrative considerations are discussed in greater detail by Bridges (1981).

Figure IX-13 shows the pattern of future development projected by the non-designation model. The model uses most of the integrated data base layers, including the 1979 LANDSAT data for vegetation cover and existing development. Significant urbanization densities are projected in relatively flat areas without significant hazards or conflicts. Moderate density (e.g., 5 units/acre) are projected onto the more gentle foothill slopes. Major slopes are considered by the model to be incapable of more than rural development densities (e.g., one dwelling per 5-40 acres). Over 70% of the area is not suitable for urbanization due to steep slopes and ownership considerations (e.g., National Forest). Signficant hazards (flood channels, earthquake faults, known landslides) are avoided by the model by assigning negative value for development.

Figure IX-14 shows the pattern of agricultural land use projected should the area be designated a fire buffer greenbelt. Over 85% of the area is considered capable of supporting some type of agricultural activity. Much of this area is steeply sloping, supports chaparral and brush, and is capable of supporting sparse grazing - probably goats on the steeper slopes and sheep on more gentle terrain. More intensive uses such as grazing or dry-crop farming would be possible on gentle slopes with fertile soils and in low-lying runoff channels. Potential for intensive agriculture is restricted to good soils (SCS class I and II) in flat or gently sloping conditions. In addition, existing agricultural uses (e.g., orchards) and areas designated agriculture on the Comprehensive General Plan are identified in this category. Proximity to existing intensive agriculture was used as an indication of higher value for agricultural potential.

Comparison of the two model output maps shows a high correlation between the locations of areas that are highly capable of development and

Figure IX-13

VERTICAL INTEGRATION
SAN BERNARDINO STUDY
NON-GREENBELT DEVELOPMENT MODEL

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Slope Stability	Known Landslide	50	
	Moderate-High Landslide Potential	30	
	Low-Moderate Landslide Potential		
	GT 30% Slope	15	
	15 - 30% Slope	5	
	Generally Devoid of Landslides		
	GT 30% Slope	15	
	15 - 30% Slope	5	
Geologic/Seismic Hazards	Known Fault	50	
	Alquist-Priolo Study Zone	30	
	Proximity to Fault		
	LT 2 miles distant		
	Unconsolidated Deposit		
	Groundwater LT 100 ft.		30
	Groundwater GT 100 ft.		15
	Consolidated Deposit		5
	2-5 Miles Distant		
	Unconsolidated Deposit		
	Groundwater LT 100 ft.		15
	Groundwater GT 100 ft.		5
	Consolidated Deposit		2
	GT 5 miles distant		
	Unconsolidated Deposit		
	Groundwater LT 100 ft.		5
	Groundwater GT 100 ft.		2
Fire Hazards (Inc. LANDSAT)	Very High Hazard	25	
	- Within 1/4 mile		15
	High Hazard	20	
	- Within 1/2 mile		10
	Moderate Hazard	5	
Flood Zones	Documented Flood Zone		
	- Active Stream Wash	50	
	- Not Active Stream Wash	40	
	Inferred Flood Zone		
	- Not Channelized	20	
	- Channelized	10	

(continued)

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Erosion Potential	Very High	15	
	High	10	
	Moderate	5	
	Low	2	
Ecological Sensitivity (Incl. LANDSAT)	Highly Sensitive	15	
	Moderately Sensitive	8	
	Marginally Sensitive	2	
Existing Land Use (LANDSAT)	Urban/Developed/Committed	SKIP	
	1/4 to 1/2 mile distant		1
	1/2 to 1 mile distant		3
	GT 1 mile distant		5

Model Summation Rules

Class	Value	Acreage
Very Low Density-No Development	50 - 145	39,414
Low Density	35 - 49	3,710
Moderate Density	20 - 34	4,431
High Density	0 - 19	4,630
Urban/Developed/Committed		2,522
Water		63

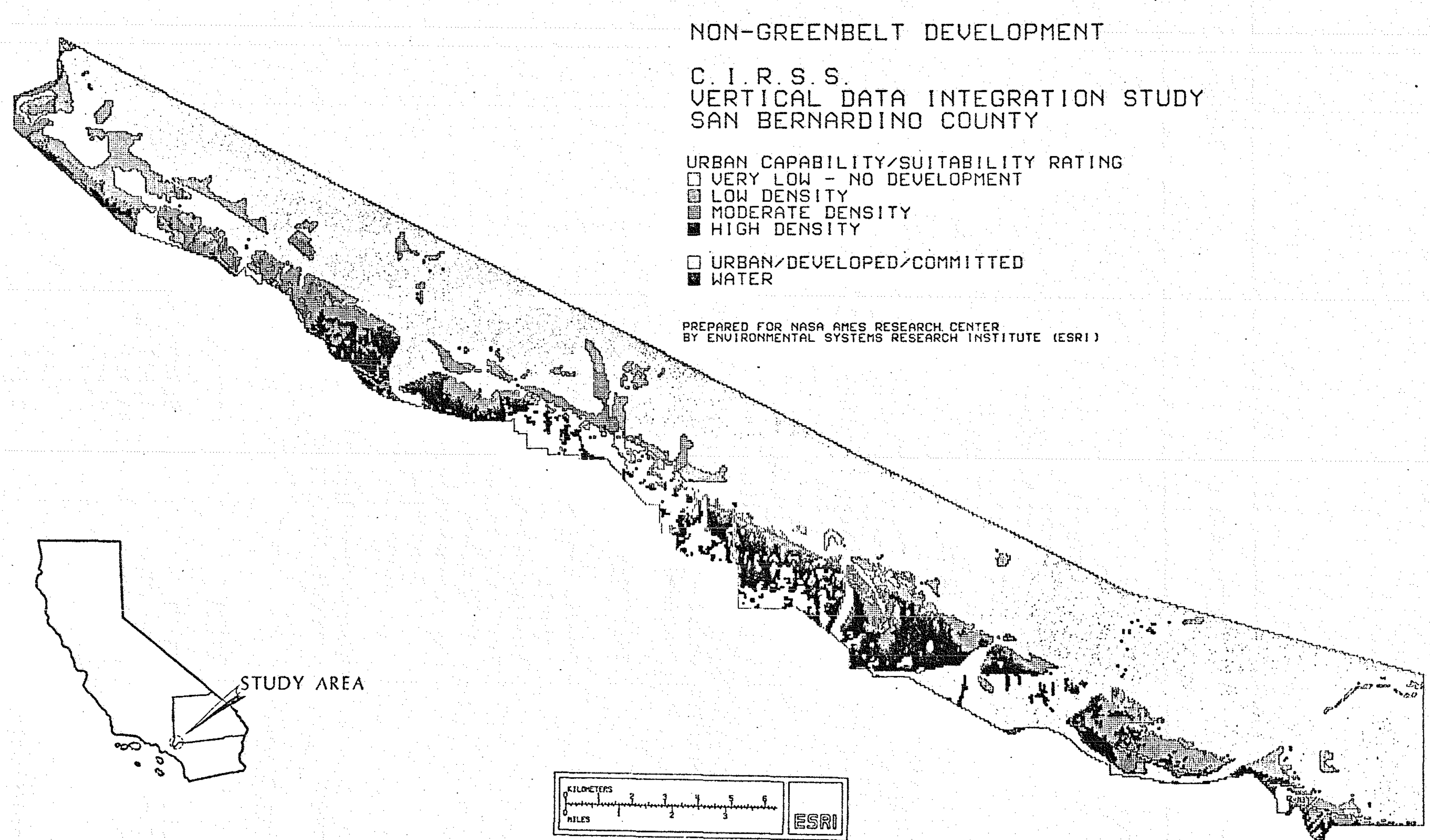
NON-GREENBELT DEVELOPMENT
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
URBAN CAPABILITY/SUITABILITY RATING
VERY LOW - NO DEVELOPMENT
LOW DENSITY
MODERATE DENSITY
HIGH DENSITY
URBAN/DEVELOPED/COMMITTED
WATER
PREPARED FOR NASA AMES RESEARCH CENTER
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Figure IX-13

Figure IX-14

VERTICAL INTEGRATION
SAN BERNARDINO STUDY
GREENBELT DESIGNATION MODEL

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Soil Capability Class/ Slope	Class I	40	
	Class II		
	LT 8% Slope	35	
	GT 8% Slope	20	
	Class III, LT 8% Slope	25	
	GT 8% Slope	10	
	Class IV, LT 8% Slope	15	
	GT 8% Slope	5	
Existing Land Use (LANDSAT)	Orchard, Row Crops	10	
	Other Agriculture	5	
	- Ag Within 1/4 mile		5
	- 1/4 - 1/2 mile		3
	Urban Land Use	-40	
	- Within 1/4 mile		-5
	1/4 - 1/2 mile		-3
General Plan Designation	Designated Agriculture	20	
Flood Hazard	Very High - High Flood Hazard	5	
Geological/Seismic Hazard	Known, Concealed or inferred fault	5	
	Alguist Priolo Study Zone	5	
	Proximity to fault		
	LT 2 miles distant		
	Unconsolidated deposit		
	Groundwater LT 100 ft.		5
	Groundwater GT 100 ft.		3
Fire Hazard (Incl. LANDSAT)	High - Very High Fire Hazard Within 1/4 mile		5

Model Summation Rules

Class	Value	Acreage
Intensive Agriculture	GE 29	6,949
Grazing/Dry Farming	19 - 28	3,638
Sparse Grazing	4 - 18	33,944
Not Suitable	LT 4	7,654
Water		63
Urban/Developed/Committed		2,522

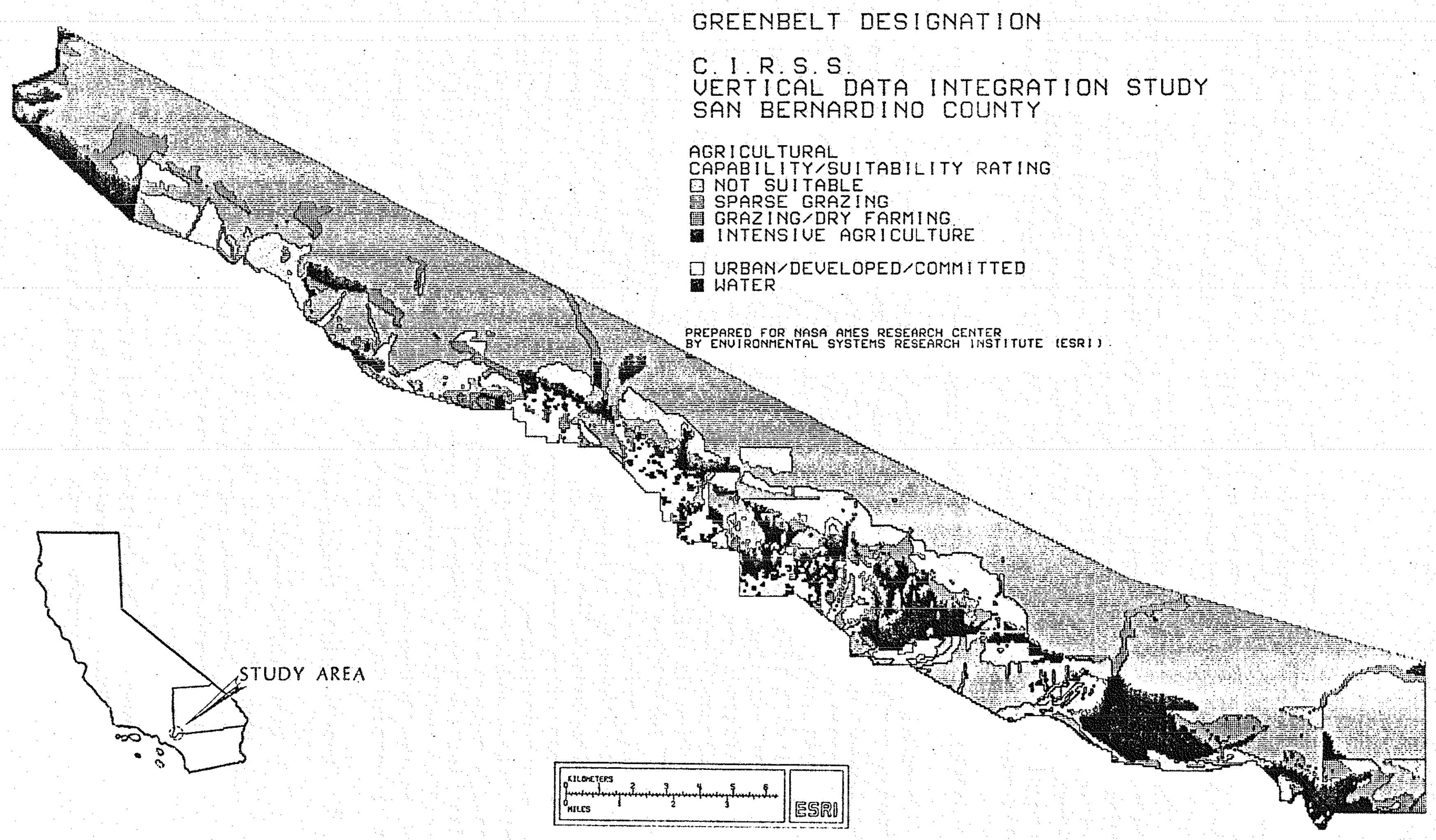
GREENBELT DESIGNATION
C. I. R. S. S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
AGRICULTURAL
CAPABILITY/SUITABILITY RATING
NOT SUITABLE
SPARSE GRAZING
GRAZING/DRY FARMING
INTENSIVE AGRICULTURE
URBAN/DEVELOPED/COMMITTED
WATER
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Figure IX-14

also of agricultural potential. This coincidence of location derives from similar criteria for both agricultural and urban development - gentle slopes and deep workable soils - and indicates the magnitude of the administrative hurdles which will be encountered by proposals to limit urban development if economic incentives are not available.

Together the two model outputs present rational possible future scenarios which can be used to predict the impacts of designation or non-designation as a greenbelt. Because the small area data base is significantly wider than the 200 to 1,000 foot fire fuel break recommended (Bridges, 1981), these analyses and the impact analyses which follow will be useful in the selection of a more specific delineation of the area to be recommended as a fire buffer greenbelt.

3. Modeling the impacts of future scenarios.

In order to evaluate the fire hazard reduction effectiveness of greenbelt designation, and also to project impacts of the future scenario activities on erosion and runoff rates, a series of models was run and modified based on the output of the two scenarios. The original fire hazard model, an in situ storm runoff model, and an erosion potential model (universal soil loss equation = soil K factor X slope factor) were run against the existing small area data base, using the LANDSAT layer to derive vegetation and urban cover data, the ITUM layer for slope and soils (Valley portion), and a separate soils variable digitized for the National Forest portion of the data base. Outputs from these three models were ranked and identified in five levels from very high (=5) to very low (=1) fire hazard, storm runoff rates and erosion potential. An impact matrix was then developed by referring to the San Bernardino County Consolidated General Plan development criteria to indicate increases or decreases in these values which would be expected to occur with the various urban development densities. For example, dense urbanization would increase runoff rates, but associated flood control measures would reduce erosion rates. A separate matrix was developed from information in Bridges, 1982, to describe changes expected to occur with the various agricultural uses. Table IX-2 and IX-3 are reproductions of these matrices. The modifiers are based on the following understandings of the impacts of development on the type of terrain in the study area:

1. Non-Greenbelt Development

   - Impermeable surface cover will increase with increasing urban density. This will increase runoff rates.
   - Urban development will include storm runoff control, such as drains and gutter flow, reducing the erosional rates in the same areas.

   - Lower density development may increase both runoff rates (slightly) and erosion rates (due to unpaved road cuts and storm flows directed toward unprotected soils).

VERTICAL INTEGRATION
SAN BERNARDINO STUDY
STORMWATER RUNOFF MODEL

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Soil Manageability Group (National Forest)	I	10	
	II	20	
	III	30	
	IV	40	
Predominant Capability Class (Valley)	1XX	10	
	2XX	10	
	3XX	20	
	4XX	20	
	5XX	20	
	6XX	30	
	7XX	40	
	8XX	40	
	9XX	50	
Slope (ITUM)	0 - 8%	0	
	8 - 15%	2	
	15 - 30%	4	
	30 - 50%	6	
	LT 50%	8	

Model Summation Rules

Class	Value	Non-Greenbelt Acreage	Greenbelt Acreage
Low Runoff	0 - 21	6,422	11,027
Moderate Runoff	22 - 34	10,859	10,681
High Runoff	35 - 42	11,582	8,123
Very High Runoff	43 - 49	25,829	24,861
Water		78	78

VERTICAL INTEGRATION
SAN BERNARDINO STUDY
EROSION POTENTIAL

CONSIDERATION	SPECIFIC DATA CLASS	VALUE (Incidence)	VALUE (Proximity)
Slope Gradient/Length factor (X100)	Slope Gradient		
	0 - 8%	6	
	8 - 15%	23	
	15 - 30%	55	
	30 - 50%	130	
	GT 50%	220	
Erodibility (K) Factors	By soil classification k-factors = 10 through 43 per SCS and National Forest surveys		

Model Summation Rules

Multiply Slope Gradient/Length Factor X k-factor

Class	Value	Non-Greenbelt Acreage	Greenbelt Acreage
Very Low Potential	1-102	7,668	16,157
Low Potential	103-230	7,442	4,287
Moderate Potential	231-1100	5,329	3,174
High Potential	1101-4160	9,718	7,805
Very High Potential	4160-9460	24,535	23,269
Water	---	78	78

IMPACTS OF FUTURE SCENARIOS

TABLE IX-2 Greenbelt Designation

	Runoff	Erosion	Fire Hazard
Not Suitable	-----------No Changes-------------		
Sparse Grazing	NC	-1	-1
Grazing/Dry Farming	+1	-1	-2
Intensive Agriculture	-2	-2	-2
Urban	NC	NC	NC
Water	NC	NC	NC

TABLE IX-3 Non-Greenbelt Development

	Runoff	Erosion	Fire Hazard
Very Low-No Development	----------No Changes------------		
Low Density	NC	+1	+2
Moderate Density	+1	+1	+1
High Density	+2	NC	+1
Urban	NC	NC	NC
Water	NC	NC	NC

NC = No change

\+ = Increased Hazard or Rate

\- = Decreased Hazard or Rate

- Any development taking place in a fire hazard area will increase that hazard. Low density development will increase the hazard more than higher density development with associated landscaping and recontouring.

2. Greenbelt Designation

- Sparse grazing will have little effect on runoff, but will reduce fire hazard.

- Grazing and dry farming will reduce fire hazard, but may increase runoff and/or erosion rates by compacting or tilling soil.

- Intensive agriculture will substantially reduce runoff, erosion and fire hazard by replacing natural fire fuel with controlled fuel/slope/irrigation conditions.

- Any activity which reduces fuel loading will also reduce potential for massive erosion. The post-burn high erosion rates are in part a result of hydrophobic soil conditions caused by extreme heating (Bridges, 1981).

The following sections describe the output resulting from the automated analyses of the two future scenarios. These analyses can be used by National Forest and County staff to determine the optimum location of a greenbelt in terms of its effectiveness as a fire buffer and its impact on runoff and erosion rates.

3. Fire Hazard

Figure IX-15 and IX-16 are copies of the output of the fire hazard analyses of the future scenarios. As expected from the intent of greenbelt designation application of agricultural uses significantly reduces fire hazards as modeled for the area. The reduction is a consequence of reducing fuel growth and also restricting development of structures in the zone. A few areas of high slope angle remain designated as very high fire hazard. These are areas designated by the greenbelt designation model as unsuitable for agricultural uses because of steep slope, existing urban development, or designated urban development (General Plan). Thus, no reduction of existing fire hazard is calculated, nor is reduction expected to result in these locations unless existing conditions are altered.

Urbanization of the area if no greenbelt buffer is designated will extend fire hazard conditions southward into the valley areas. This results from additional fuel available from structures and landscaping. Urban proximity to the existing chaparral vegetation increases the probability of accidental or

Figures IX-15 and IX-16
Fire Hazard Models: Output Acreage

CLASS	NON-GREENBELT ACREAGE	GREENBELT ACREAGE
Very High Hazard	27,080	2,340
High Hazard	7,747	23,227
Moderate Hazard	6,766	5,400
Low Hazard	7,182	5,665
Very Low Hazard	5,995	18,138

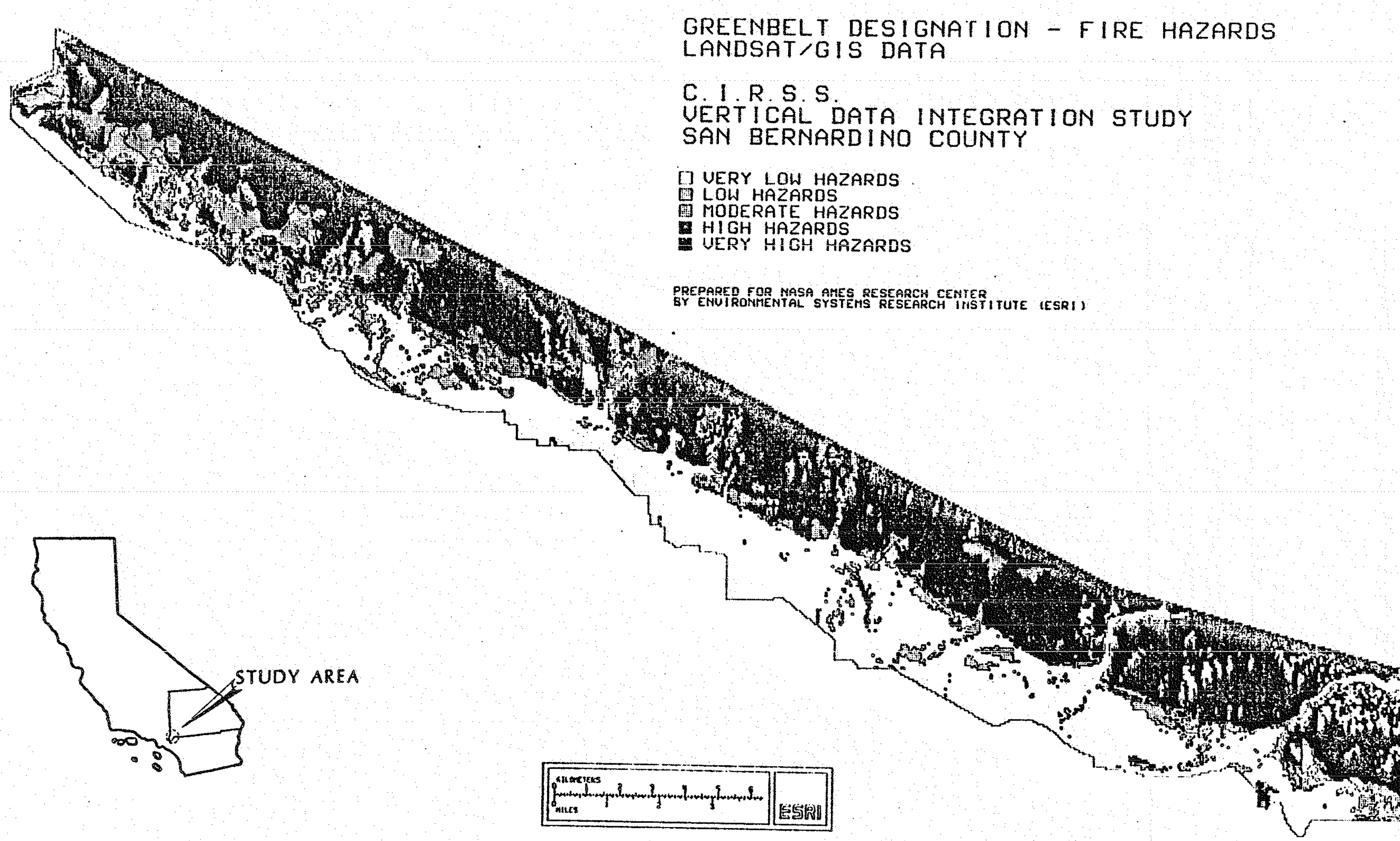
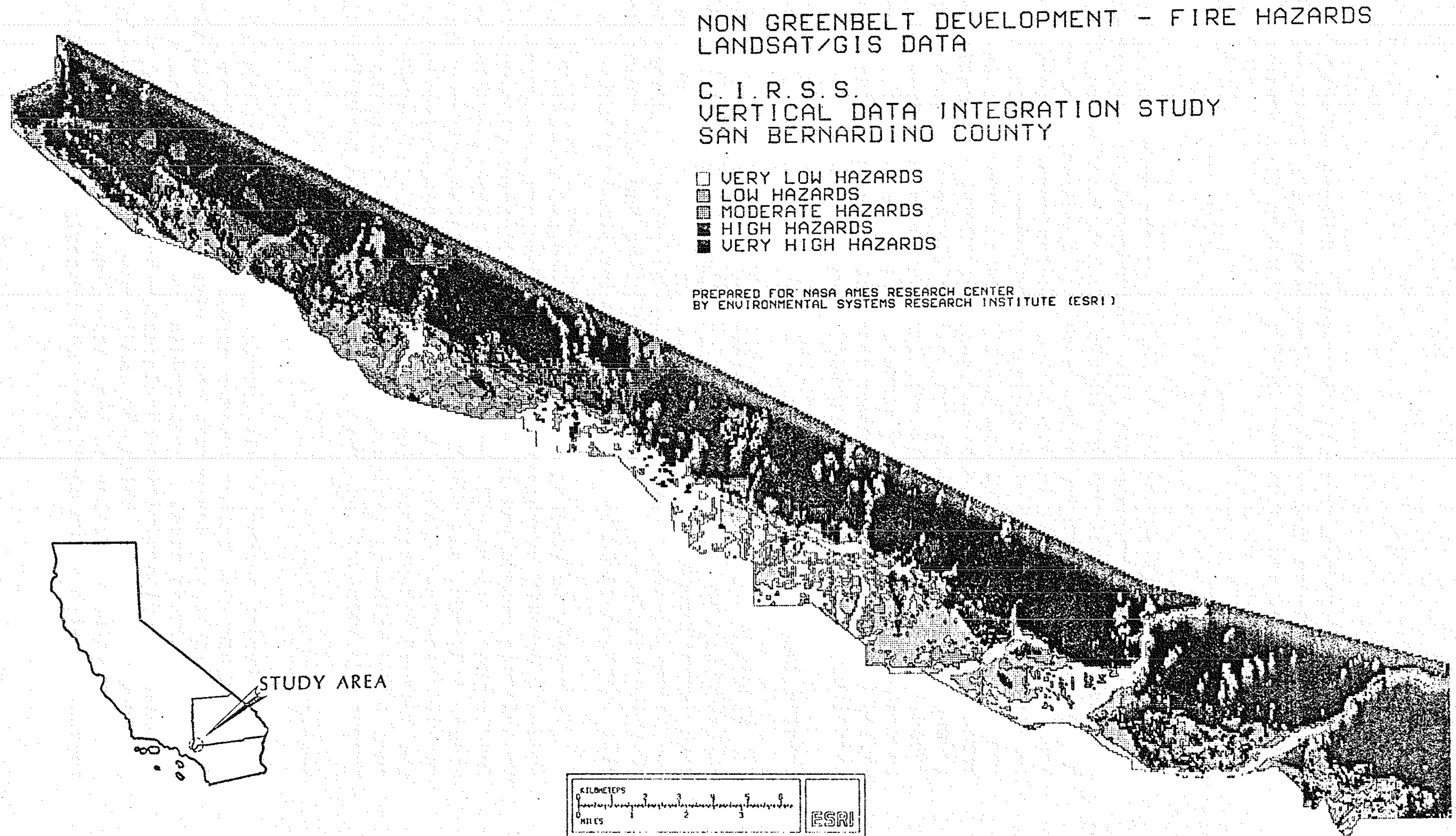

GREENBELT DESIGNATION - FIRE HAZARDS
LANDSAT/GIS DATA
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
VERY LOW HAZARDS
LOW HAZARDS
MODERATE HAZARDS
HIGH HAZARDS
VERY HIGH HAZARDS
PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
STUDY AREA
KILOMETERS
MILES
ESRI

Figure IX-15



NON GREENBELT DEVELOPMENT - FIRE HAZARDS
LANDSAT/GIS DATA
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
VERY LOW HAZARDS
LOW HAZARDS
MODERATE HAZARDS
HIGH HAZARDS
VERY HIGH HAZARDS
PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
KILOMETERS
0
1
2
3
4
5
6
MILES
0
1
2
3
ESRI
STUDY AREA

Figure IX-16

purposeful fire starts along the range. Control of wildfire is then dependent on the speed and direction of air flow, and repetitions of the catastrophic 1980 Panorama fire would not be unexpected.

4. Runoff Rates

Figures IX-17 and IX-18 are copies of the output of the runoff analyses of the future scenarios. As expected, little difference is calculated on the steeper slopes, as these areas are not projected to support dense development. Examination of the scenario maps and the impact maps indicates major differences in runoff are associated with greater development densities on the gently sloping valley and foothill lands as opposed to their potential use for intensive agriculture. Thus, designation of a greenbelt fire buffer along the steeper slopes and to the valley would have little impact on existing runoff rates but could increase runoff on moderate slopes. Urban development of the valley and moderate slope areas would increase runoff in those locations, while agriculture would reduce runoff.

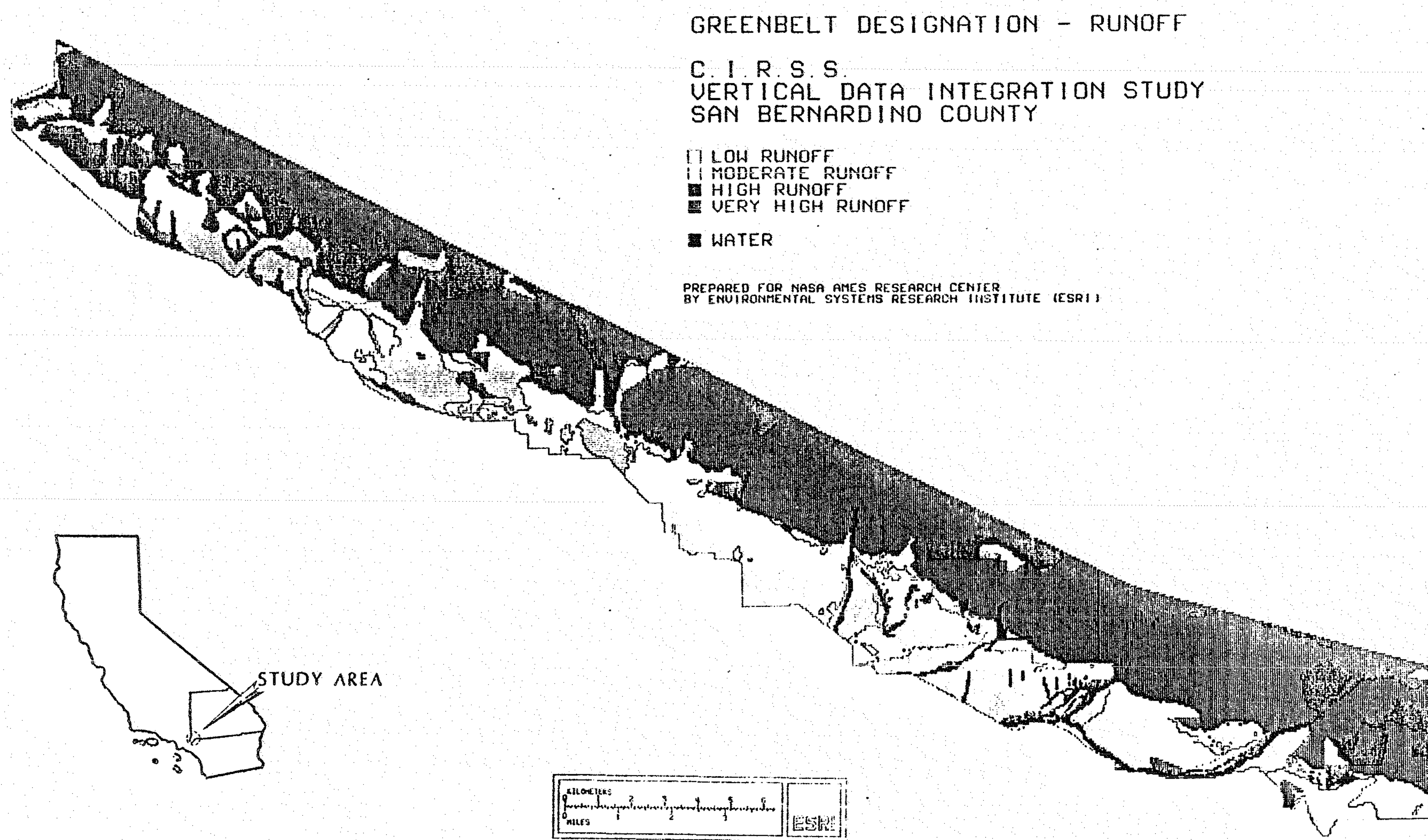
5. Erosion Rates

Figure IX-19 and IX-20 are copies of the output of the erosion analyses of the future scenarios. Much of the area of concern with respect to massive erosion shows little difference when the two scenarios are compared. The steep slopes and erodible soils of the south face of the geologically young San Bernardino range will continue to be highly erodible under either scenario.

Increases in erosion are expected to occur in areas of low and moderate density urbanization. These areas comprise primarily low to moderate slopes and are somewhat removed from existing urban development. Increased erosion presents a control problem in these locations, and could be addressed by appropriate grading and runoff controls. Erosion presents a hazard to development along the base of the steeper slopes where mudflows often occur during even light rainfall following a burn. This hazard could be reduced by locating the greenbelt fire buffer in these locations.

6. Summary

The impact output models provide graphic illustration of the location and severity of impacts expected to result from designation or non-designation of a fire buffer greenbelt within the mapped study area. These models provide information useful to the planning of activities and location of boundaries of the proposed greenbelt. While the models used are one of several possible methods for impact evaluation, their results are consistent with known conditions and historic concerns within the



GREENBELT DESIGNATION - RUNOFF
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
LOW RUNOFF
MODERATE RUNOFF
HIGH RUNOFF
VERY HIGH RUNOFF
WATER
PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
STUDY AREA
KILOMETERS
MILES
ESRI

Figure IX-17

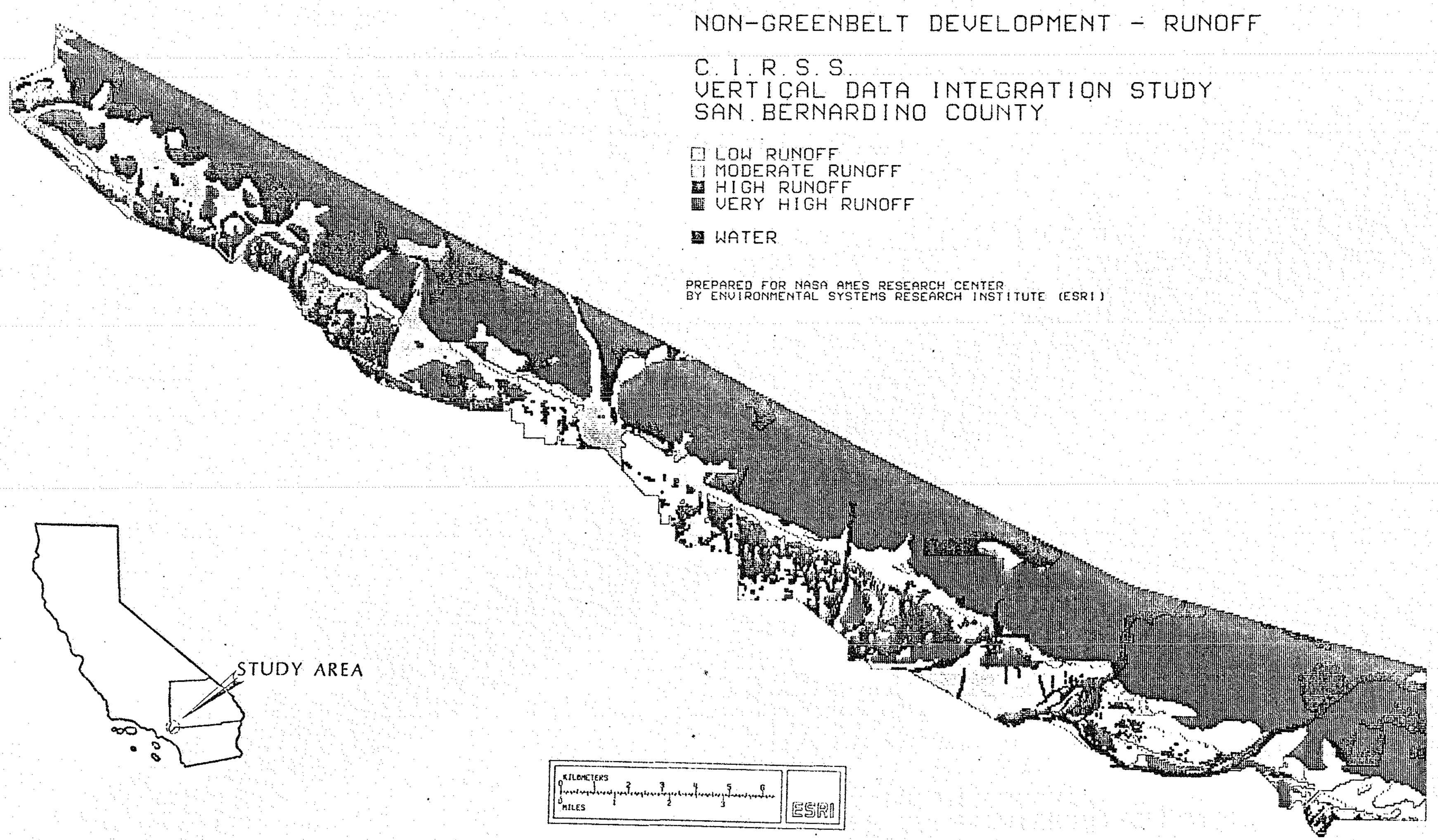

NON-GREENBELT DEVELOPMENT - RUNOFF
C. I. R. S. S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
LOW RUNOFF
MODERATE RUNOFF
HIGH RUNOFF
VERY HIGH RUNOFF
WATER
PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
STUDY AREA
KILOMETERS
MILES
ESRI

Figure IX-18

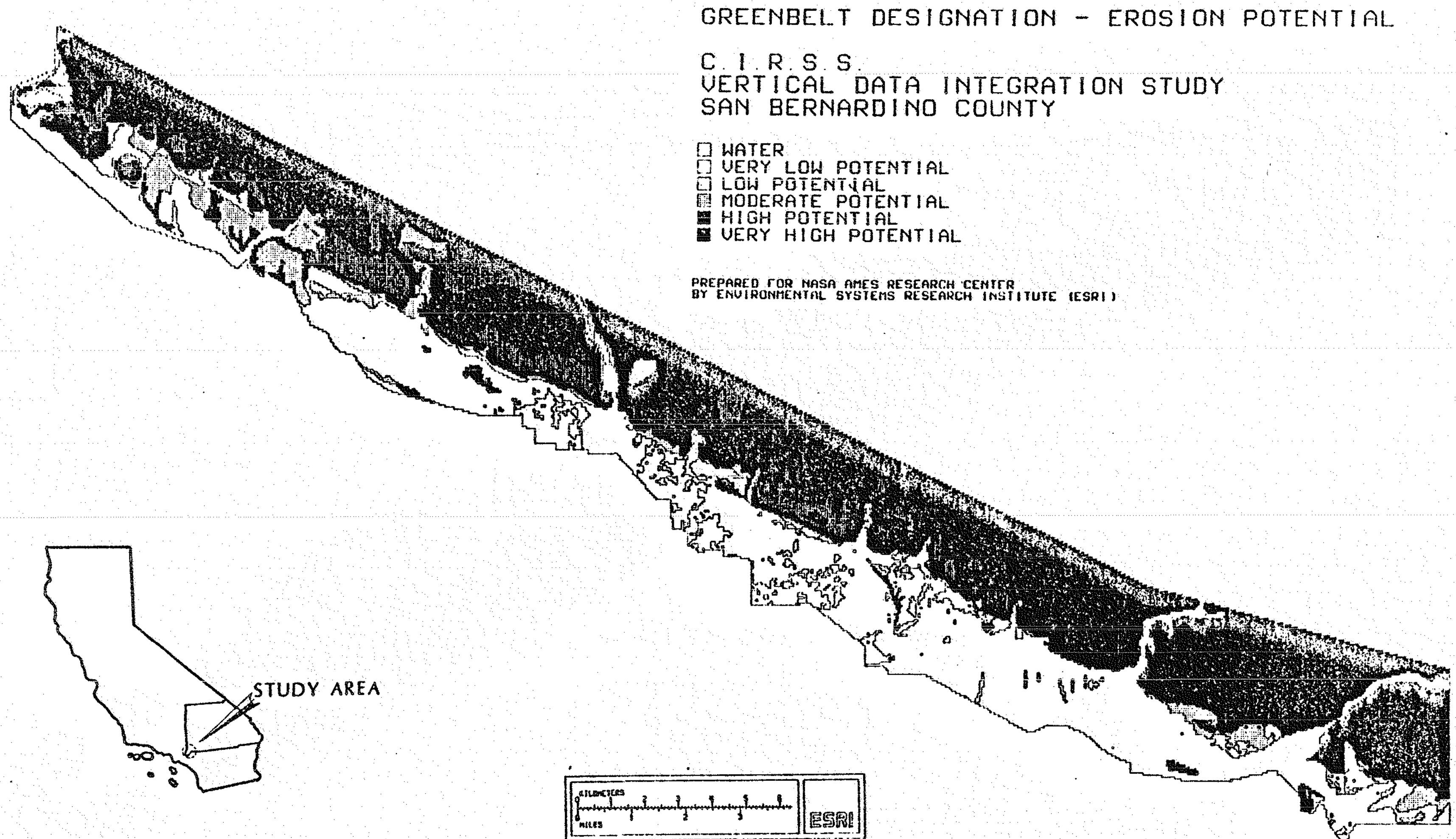

GREENBELT DESIGNATION - EROSION POTENTIAL
C.I.R.S.S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
WATER
VERY LOW POTENTIAL
LOW POTENTIAL
MODERATE POTENTIAL
HIGH POTENTIAL
VERY HIGH POTENTIAL
PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
STUDY AREA
KILOMETERS
MILES
ESRI

Figure IX-19

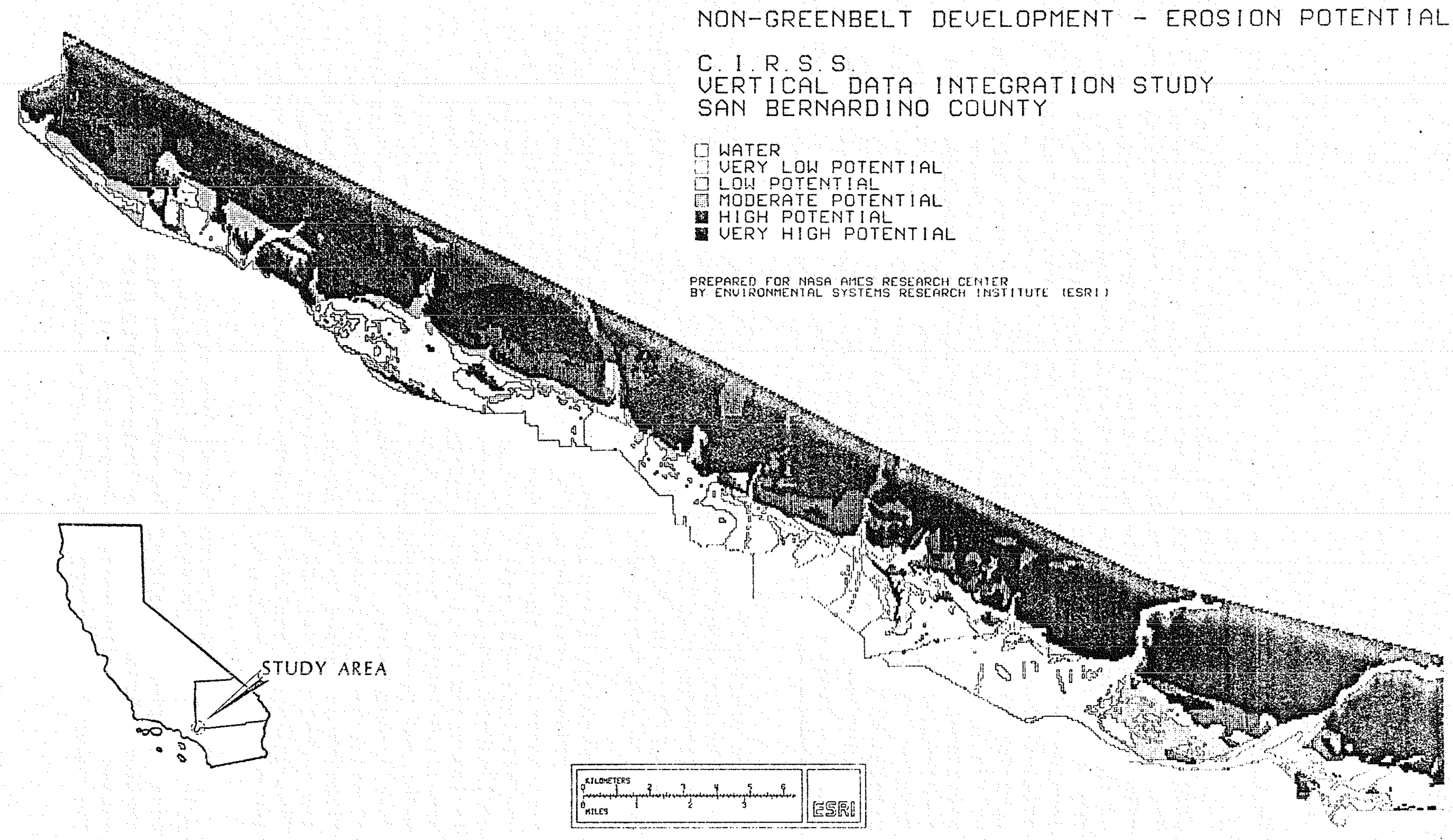

NON-GREENBELT DEVELOPMENT - EROSION POTENTIAL
C. I. R. S. S.
VERTICAL DATA INTEGRATION STUDY
SAN BERNARDINO COUNTY
WATER
VERY LOW POTENTIAL
LOW POTENTIAL
MODERATE POTENTIAL
HIGH POTENTIAL
VERY HIGH POTENTIAL
PREPARED FOR NASA AMES RESEARCH CENTER
BY ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (ESRI)
STUDY AREA
KILOMETERS
MILES
ESRI

Figure IX-20

study area.

7. Evaluation

In order to evaluate the contribution of the various layers of data to the output of the impact models, a series of statistical correlations (Pearson product moment correlation) were performed using the MINITAB statistical software. Table IX-4 is the result of this analysis for the non-greenbelt development model. Because the output of the impact models depends on the results of the development model, the correlation of this model output with its original input variables is also presented. The sign of the correlations varies with the types of numeric data being evaluated by the test. The Pearson correlation assumes a linear relationship between the two data sets being evaluated. This condition may not be met in several cases (such as searches). However, the correlation provides a general indication of the relationship between the values of the row score output data. A principle reason for this evaluation was to help identify the likely sources of output errors which may be noted in subsequent evaluations, as well as contributing useful information.

The coefficient of determination (R^2) has been calculated to indicate the amount of the final output value, assuming a linear relationship, that can be predicted (i.e., accounted for) by knowing the value of the input variable. Thus, the incremental value to the output score of each data layer can be quantified.

The coefficients of determination indicate that the primary determinants of urban development in the study area are existing fire hazard and erosion potential, as presently modeled. These criteria are addressed in the model both directly by weight assignments and also indirectly through use of the General Plan designations which give significant consideration to these hazards. LANDSAT data is a major contributor to the fire hazard model and is the determinant of urban proximity in this urban development model. Slope gradient is the other major determinant of model results in this study area. It should be noted that although addressed by the model, criteria become determinants of the output because the hazard conditions exist in the study area. The same model applied to another area would yield different determination coefficients.

The impact models are based upon slope, soil characteristics and land cover. Of these, slope has the greatest coefficient of determination for all of the models: fire hazard, runoff and erosion. Land cover also correlates well with the fire hazard output, primarily because vegetation type is a major component of the model in the study area, and urban cover types are associated

TABLE IX-4

Input/Output Correlation
Non-Greenbelt Development Scenario

Input Data	Correlation With Output Values: Correlation (r)	Coefficient of Determination (R^2)
Slope stability	.281	7.9%
Geologic Hazards	-.119	1.4%
Fire Hazard (incl. LANDSAT)	.753	56.7%
Proximity to Very High Fire Hazard	-.561	31.5%
Proximity to High Fire Hazard	-.154	2.4%
Flood Hazards	.078	0.6%
Erosion Potential	.720	51.8%
Proximity to Urban Land Use (LANDSAT)	.420	17.6%
Ecological Importance	.320	10.2%

Scenario Non-Greenbelt Impact Models		
- Fire Hazards Impact Model		
Land Cover (LANDSAT)	0.785	61.6%
Slope	0.890	79.2%
- Runoff Impact Model		
Soil Capability Class	0.435	18.9%
Slope	0.842	70.9%
- Erosion Potential Impact Model		
Soil K Value	0.686	47.1%
Slope	0.958	91.8%

with reduced hazards. Soil characteristics have somewhat lower predictive ability in the erosion potential model probably because most of the high erosion soils are similar in erodibility coefficient, differences being due to slope angle. Likewise, soil capability classes throughout the high runoff areas are similar - differences in runoff are primarily due to slope differences - resulting in a low coefficient of determination between soil capability class and runoff.

X. POTENTIAL FOR INSTITUTIONALIZATION

The preceeding sections of this report illustrate that the application of an automated vertically integrated data base can provide information and analysis capabilities useful to local agencies. Combining data vertically increases analysis capability and provides for rapid cross-checking of data types obtained by different methods and at different times. While inconsistencies between data sets are highlighted by vertical integration, this provides an opportunity to identify and correct one or more of the data sets without examining each record within the study area. For sharing, editing and updating data the vertical integration concept appears to be useful to the institutional users involved. Three general requirements must be met before institutionalization of the industry-assisted approach can take place: demonstration of need/cost-benefit, identification of an entity responsible for data base management, and identification of an appropriate industrial source of expertise and assistance.

A. Demonstrate Need

Two criteria can be used to demonstrate need or utility of the industry-assisted development of a vertically integrated data base: increased data/analysis capabilities and increased efficiency of data management/analysis procedures. This report has concentrated on the demonstration and evaluation of capabilities. It has shown that the vertically integrated approach is useful for extending analyses into mapped areas (e.g., fire hazard into Wilderness area), for refining existing sets of data (small area urban capability/suitability analysis), for identifying change and data inconsistencies (change analysis), for rapidly evaluating the impacts of proposed controls (greenbelt analysis) and for first-cut capability/suitability modeling (both Phase 1 and Phase 2 urban and agricultural models). One or more of these tasks is performed or could be usefully employed by each of the cooperating user groups.

A cost-benefit analysis is beyond the scope of this report, but the criteria identified here should be weighed carefully before an agency decides on the appropriate method or contractor.

The economic climate of the 1980's has required public agencies to perform their mandated tasks more efficiently, as work loads increase at a greater rate than do revenues. Thus, the perceived need is to accomplish data acquisition and analysis tasks with less cost per task than has been allotted in the past. The following conditions make the vertically integrated Geographic Information System an attractive alternative in an economic sense:

1. Data sharing - Data gathered and mapped by one agency can be made available to another agency without requiring duplication of effort for similar purposes.

2. Data availability - Using automated access and output, the stored data are readily available to all users, eliminating time required to track down data from other agencies.

3. Documented analyses - Automated analysis must be performed in a logical and well-documented manner. This makes review and public presentation of analyses straightforward and efficient.

4. Repeatability - Once analysis procedures have been developed and used successfully, they can be used repeatedly and efficiently on new sets of data by different analysts.

5. Adaptability - Several analyses can be performed with the time and cost resources now associated with a single analysis. Thus, many alternatives could be examined efficiently.

Although an agency could hire or develop the expertise to create its own vertically integrated GIS, the economic constraints identified above make an industry-associated approach attractive. Experts with experience in data base development can be hired to devote full time to the creation of the GIS and also to the transfer of analysis technology. This is often more easily justified than using existing staff who:

1. must be trained

2. are presently assigned full-time tasks

3. cannot be terminated or transferred easily when the GIS is completed.

In summary, the efficiency of a vertically integrated GIS can be demonstrated in terms of data acquisition and analysis tasks. No less real, though more difficult to assess, is the savings gained by the demonstrable crediblity of this approach for agency analyses and decisions. A clearly presented set of criteria and analyses produced by such a system may provide considerable savings in time and administrative expenses.

B. Identify Responsible Entity

Perhaps the most critical step in the institutionalization of a vertically integrated data base is the identification of an agency or group that will direct its creation and facilitate its employment. Because the various data sets have originally been generated or acquired by several agencies, a large number of groups will be interested in the treatment, classification, resolution and use to which their data are subjected. Cooperation from these groups is necessary for effective understanding of their data. Cooperation is essential if these groups are to share in the ultimate use of the data base or its products. However, the inclusion of all desired criteria from all concerned groups will result in an unwieldy data base which is expensive to construct and maintain, and which contains much data that will be used infrequently, if at all. For this reason, it is critical that the data base be developed under the direction of one agency or a special multi-agency committee empowered to resolve questions and conflicts.

As with most public agency GIS development, an individual agency will probably accept initial responsibility for obtaining interest and agreements from other agencies. The individuals responsible for this development of commitment must be sensitive to the needs of other agencies and, simultaneously, keep in mind the ultimate uses to which the integrated data base will be applied. If a cooperative atmosphere can be created and maintained, the industry-assisted development of the data base itself will be a relatively straightforward task.

C. Identify Source of Expertise

The number of companies specializing in data base development has grown with increasing technological capabilities and increasing awareness of the usefulness of these systems. Costs, system characteristics and company expertise vary considerably. In addition to cost, the following criteria are recommended for consideration during the selection of an industry contractor to develop the integrated GIS.

1. Expertise - The contractor should have demonstrated expertise in creating data bases of a similar type. In addition, the contractor should have expertise in the application of data base technology to production work. This will insure that the contractor is sensitive to agency needs.

2. Track Record - The contractor's previous clients should be contacted and asked about their experience with the contractor and the product.

3. Support - The contractor should agree to provide adequate training to the user agency and follow-on support of the software for some time into the future.

XI. CONCLUSIONS

The San Bernardino Vertical Integration project has investigated the steps and criteria involved in developing a vertically integrated data base for use by a public agency with the assistance of private industry. The product of Phase 1 was an integrated data base which incorporated sets of data from several agencies covering portions of the study area, plus two LANDSAT scenes covering the entire study area. This data base was integrated horizontally and vertically and used to produce first-cut models of agriculture and urban development capability/suitability and to extend a fire hazard model into an area previously unmapped but represented by LANDSAT scenes. Phase 2 used sub-portions of the integrated data base to conduct small area analyses which would yield data needed by local agency users - the San Bernardino County Planning Department and the San Bernardino National Forest staff. The following conclusions can be made as a result of these efforts:

1. Vertical integration allows a variety of data types to be evaluated simultaneously and provides a depth of analysis capability not possible with single data sets. Inconsistencies between data sets become apparent and can be dealt with effectively, producing a more accurate and consistent data base.

2. LANDSAT land cover data serves as a basis for registration of partial coverage data, and for correlating classification assignments.

3. The integrated data base allows a large amount of data to be accessed for analyses such as capability/suitability for prescribed uses and analysis of future impacts.

4. LANDSAT data can be used to refine the spatial resolution of land cover/land use data originally mapped at lower resolution. In one test, LANDSAT added approximately 10% more digital information, virtually all of it in the form of a valuable spatial refinement of existing data.

5. LANDSAT data can be used to refine existing classes of data (e.g., from orchards to young orchards) to provide additional useful information.

6. The industry-assisted approach is a logical alternative to developing expertise within an agency.

7. Agency cooperation and understanding are necessary to the successful development and implementation of an integrated data base.

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APPENDIX A

Vertical Integration Data Base
LANDSAT Land Cover Legend

SBC 1976 and 1979 LANDSAT CLASSIFICATION CODING

0. Background
1. Cleared
2. Bare
3. Sp. Brush
4. Brush
5. Thick Brush
6. Young Orchard
7. Moderate Vigor Orchard
8. Mature Orchard
9. Declining Orchard
10. Mod-Vigor Vineyard
11. High Vigor Vineyard
12. Declining Vineyard
13. Woodland
14. Sparse Woodland
15. Grass
16. Dry Grass
17. Agriculture
18. Asphalt
19. Concrete
20. Extractive
21. Cinder
22. Slag
23. Structures
24. Structures Strip
25. Water
26. Snow
27. Structures W/Brush
28. Residential With Trees
29. Irrigated Newer Residential
30. Cluster
31. Large Lot Unirrigated
32. Rural/Strip
33. Mobile Home/High Density
34. Low Vigor Vineyard
35. Big Cone Douglas Fir
36. White Fir
37. Jeffrey Pine Mixed Community
38. Ponderosa Pine
39. Lodgepole/Limber Pine
40. Pinyon/Juniper
41. Canyon Live Oak/Riparian
42. Jeffrey Pine/Ceanothus
43. Coulter Pine Mixed Forest
44. Bracken Fern/Ceanothus
45. Ceanothus/Scrub Oak
46. Chemise
47. Chemise/Ceanothus
48. Coastal Sage
49. Great Basin Sage

LANDSAT CLASSIFICATION LAND COVER LEGEND

WATER (25) - Lakes, ponds, other standing water.

CLEARED (1) - Vegetation has recently been removed and area is now essentially bare.

BARE (2) - Exposed soil, rock, and snow.

CINDER (21) - Railroad roadbed rock, and other blackened rock.

SLAG (22) - Industrial waste tailings.

EXTRACTIVE (20) - Gravel pits, and other mining resulting in exposed and disturbed soil.

GRASS (15) p Grasses and forbs not differentiated by vigor.

DRY GRASS (16) - Grasses and forbs that have dried and yellowed.

SPARSE BRUSH (3) - Less than 30% brush closure, with grass or exposed soil understory.

BRUSH (4) - 30%-70% brush cover with grass or soil understory.

THICK BRUSH (5) - Over 70% brush cover.

SPARSE WOODLAND (14) - Trees undifferentiated as to type, with between 30% and 50% crown closure.

WOODLAND (13) - Trees undifferentiated as to type, with over 50% crown closure.

HIGH VIGOR VINYARD (11) - Vineyards with bright infrared reflectance.

MODERATE VIGOR VINEYARD (10) - Vineyards with moderate infrared reflectance with some soil and grass, and a few dead vines.

LOW VIGOR VINEYARD (34) - Vineyards with low chlorophyll content, often not presently cultivated.

DECLINING VINEYARD (12) - Poor condition, possibly uncultivated with numerous dead vines.

MATURE ORCHARD (8) - Orchards with over 70% crown closure.

MODERATE VIGOR ORCHARD (7) - Orchards of intermediate age and vigor, with between 45% and 70% crown closure.

YOUNG ORCHARD (6) - New orchards characterized by young small trees with less than 45% crown closure.

DECLINING ORCHARD (9) - Orchards with less than 70% crown closure with large intermittently spaced bare patches indicative of dead trees.

AGRICULTURE (17) - All types of active green agriculture, except orchards and vineyards.

RESIDENTIAL WITH TREES (28) - Wooded residential lots, generally older neighborhoods with established tress.

RESIDENTIAL - NEWER IRRIGATED (29) - New residential neighborhoods without developed large trees, but with well-watered lawns.

RESIDENTIAL-SPARSE CLUSTER (30) - Sparse, generally small, residences occurring in clusters amidst largely undeveloped lands.

RESIDENTIAL-LARGE LOT UNIRRIGATED (31) - Sparsely spaced residences on large lots of dry grass or brush.

RESIDENTIAL- RURAL STRIP (32) - Sparsely spaced residences facing onto roadways, with large vacant brush or grass covered areas to their rear.

MOBILE HOMES/HIGH DENSITY RESIDENTIAL (33) - Trailer parks and apartment complexes with a large amount of roof area.

STRUCTURES (23) - Buildings, predominantly non-residential.

STRUCTURES-STRIP COMMERCIAL (24) - Non-residential buildings sparsely located along highway corridors.

STRUCTURES -WITH BRUSH (27) - Predominantly non-residential buildings surrounded by brush covered lots.

CONCRETE (19) - Concrete parking lots, roofs, some drainage surfaces, and road surfaces.

ASPHALT (18) - Asphalt covered parking lots, roofs, and road surfaces.

COASTAL SAGE (48) - Over 30% vegetative cover of Buckwheat, and other coastal sage types.

CHEMISE (46) - Over 30% crown closure of Chemise dominated chaparral.

CHEMISE/CEANOTHUS (47) - Over 30% crown closure of chaparral co-dominated by Chemise and Ceanothus.

CEANOTHUS/SCRUB OAK (45) - Over 30% crown closure chaparral dominated by either Ceanothus, Scrub Oak, or a mix thereof. Some Manzanita may also be present.

BRACKEN FERN/CEANOTHUS (44) - Over 70% vegetative cover, dominated by a mix of Bracken Fern and Ceanothus.

CANYON LIVE OAK/RIPARIAN MIXED HARDWOODS (41) - Over 30% crown closure of Canyon Live Oak, or other riparian woodland.

BIG CONE DOUGLAS FIR (35) - Over 30% crown closure of Big Cone Douglas Fir.

WHITE FIR (36) - Over 30% forest crown closure, dominated by White Fir.

JEFFREY PINE MIXED COMMUNITY (37) - Over 50% forest crown closure. crown closure dominated by Jeffrey Pine, and mixed with Incense Cedar, Sugar Pine, and Black Oak with Ceanothus understory.

JEFFREY PINE/CEANOTHUS (42) - 30%-50 % Forest crown closure dominated by Jeffrey Pine. Over 50% ceanothus dominated chaparral in understory.

PONDEROSA PINE (38) - Over 30% Ponderosa Pine crown closure, with young Ponderosa and grasses in the understory.

COULTIER PINE MIXED FOREST (43) - Over 30% forest crown closure, dominated by Coultier Pine, and containing varying mixes of Incense Cedar, Sugar Pine, Black Oak, Pinyon, or Juniper.

LODGEPOLE/LIMBER PINE (39) - Over 30% Lodgepole or Limber Pine crown closure.

PINYON/JUNIPER (40) - Over 30% crown closure of either Pinyon Pine, Juniper, or a mix thereof.

GREAT BASIN SAGE (49) - Over 30% great basin Sage vegetative cover.

BACKGROUND (0) - Some areas south of the San Bernardino county line for which no Landsat classification was carried out (principally areas covered by the CDF South Coast Interior Ecozone).

The digital data value representative of each land cover class is noted above in parenthesis.

APPENDIX B

Vertical Integration Data Base
Mapping Methods
and
Data Codes
Photointerpreted GIS Portion
(San Bernardino Valley Portion Only)

VERTICAL INTEGRATED

MAPPING MATERIALS AND METHODS

TABLE OF CONTENTS

DATA MAPPING METHODOLOGY

A. Introduction

The mapping phase of this project involved the aggregation of that data collected which was useful to the analysis into four separate manuscript maps. Each of these manuscripts represents a particular class or format of data that may conveniently and meaningfully be displayed on one map. Some of this information is areal, such as landform or geology, and thus is shown as spatial units called polygons. Other information is in the form of lines: streams, and roads. Both formats of data have been mapped for the study, categorized according to the types of information conveyed. The manuscripts prepared and the format of the data shown are as follows:

Manuscript #	Name	Data Format
1	Integrated Terrain Unit	Polygons
2	Surface Hydrology and Faults	Lines
3	Land Use	Polygons
4	Transportation	Lines

The integrated terrain unit map utilizes a mapping concept which resolves all related environmental data to a single map. Its creation involves the manual overlay and integration of individually interpreted and mapped single-variable overlays onto a base map. Each overlay contributes lines which are drafted onto a manuscript. However, given that boundaries between natural phenomena are often coincidental, the process usually involves the delineation of a single line on the manuscript in place of several different but generally consistent lines which may exist on individual overlay maps. The result of the process is an integrated terrain unit map with up to several thousand polygons each representing areas of homogeneous natural characteristics. Manuscripts #2 and #4 made use of the overlay and manuscript creation steps, but lines were not integrated, or adjusted, during the preparation of these maps.

B. Methodology

The basic concept underlying the preparation of polygon maps such as Manuscript #1 is the Integrated Terrain Unit Mapping (ITUM) approach, used to integrate several kinds of variables into a single polygon map. There are four general principles dealing with the distribution of natural geographic attributes that relate to the ITUM approach.

1. The Principle of Graded Likenesses and Infinite Differences in Natural Areas

No two geographic locations or areas are ever exactly alike, although similarities can be perceived between areas which permit classification of areas into like kinds. The degree of perceived dissimilarity increases directly as the closeness of scrutiny increases. Conversely, similarities become more obvious as observation is less detailed.

2. The Principle of Areal Transitions

Changes in natural geographic characteristics from one area to another are usually gradational. The rate of change along such gradations may vary. Thus the placement of a line drawn to show the separation of any two features is in part a subjective decision. This means that for two or more data variables, different lines can be resolved into a single line, representing the best fit for both features, which can be drafted onto the final ITUM manuscript.

3. The Principles of Continuous Alteration of Areal Characteristics With Time

All the characteristics of any geographic area are changing continuously, although each feature changes at a rate which differs from the rate of change for other features. Since some features change more rapidly than others, the map has some data dealing with rapidly changing features and other data dealing with features which change quite slowly under most circumstances.

4. The Principle of the Functional Interrelatedness of Environmental Elements

As the pattern of any environmental attribute changes, it will have recognizable effect on the patterns of other environmental attributes in the same area. This interrelatedness often means that the various features of an area will respond somewhat as a unit, what might be called an "ecological response unit". The rate of environmental changes are determined by those factors described in Principle 3.

One objective of ITUM mapping is to overcome two major obstacles to computerized handling of spatially defined environmental information: the cost of overlaying variables using the computer, and the problem of what are often called "splinter" polygons.

The cost of overlaying data variable maps with the computer is created by the considerable amount of time required to effectively automate and then overlay a number of maps in the computer. The cost of data base automation is a function of the number of maps to be automated and the complexity of the lines on those maps. If a number of lines are common to every map to be automated, a great saving can be realized by automating these common lines only once rather than for each map. The solution to this problem offered by the ITUM approach is that any line which is common to any two or more data maps is represented on the manuscript map for automation only once.

The second problem is the generation of numerous small "splinter" polygons when computer software is used to overlay individually automated data variable maps. When two or more data maps having common boundaries are automated separately and then overlaid in the computer, these splinter polygons are often formed. The splinters are due to the failure of what should be identically placed lines, lying on the individual maps, to precisely coincide with one another, for example, when the boundary of a river flood plain is shown in different locations on the vegetation map, the soils map, the slope map, etc. Even slight variations in the x,y coordinates of the points which define such lines, occurring from one map to the next, will cause splintering to occur. The splinters will be visible in plotted overlay maps and will also evidence themselves in automated analyses of polygon characteristics, as, for example, when the number of polygons with certain characteristics are tabulated. These splinters are thus confusing to the cartographic display of the data and to the analysis and interpretation of the data as well.

Generally, the cause of the splintering is attributable ultimately either to variations in automation of the lines, or to slight variations in the way a natural boundary line was drafted onto different variable maps (e.g., the case mentioned earlier of the river flood plain boundary represented differently on different variable maps).

It has already been pointed out that the transition from one classification of a natural geographic variable to another is usually gradual, and that for this reason different observers may place the line separating one classification from another in slightly different places. In the present case, working with regional scale maps designed for computer modeling to locate sites within a region, these slight variations in line placement are without geographic significance and only create problems and additional cost. The solution to this splinter problem offered by the ITUM process is the manual adjustment of lines which should naturally follow the same configuration. Adjustment is made so that a single boundary line is formed on the Integrated Terrain Unit Map. This resolution of several lines to a single line eliminates such multiple lines as a cause of splintering.

It is important to point out that where lines on different variable maps do not naturally follow the same course because they represent real geographic differences (e.g., in the case of the river flood plain mentioned above, there is an island of dry soils and different vegetation lying at the periphery of the flood plain) these lines are never eliminated or adjusted.

Such lines, representing real and significant differences, further divide the polygons on the ITUM, showing additional detail. These decisions also take into account that the minimum resolution for polygons is 10 acres.

Much of the data is in a format which either requires rescaling, adjustment to imagery, or both before it is in a form amenable to integration into a manuscript map. To rescale data to the working scale a combination optical/manual procedure is followed. This method involves the use of an optical pantograph; for this study the device used was a Kargl reflecting projector, with a rated distortion factor of less than 0.01%. In use, the collateral material (a map, for example) is placed on a platform and its image is optically projected upward onto a glass surface. Enlargement or reduction of the original collateral material occurs when collateral-to-lens ratio is changed. Fastening a mylar copy of the topographic basemap onto the projection glass allows the collateral to be reformatted to the basemap scale of 1:62,500.

After the information is adjusted to the 1:62,500 scale, it is manually transferred onto the drafting film. Care is taken that all information is transferred accurately, and that no transposition of information codes occurs. An edit check of the hand drawn map compares it to the original data.

The physical characteristics and interpretive values of the phenomena mapped for this project are derived partially from the collateral documents used; this capitalizes on the detailed field and laboratory observations which were made in order to create the collateral. Image interpretation is used to verify, rectify and clarify the distribution and areal extent of the phenomena mapped from the collateral. Patterns are adjusted to match the imagery and the base maps. The imagery and base maps thus act as geographic "controls" for the reformatting, eliminating cartographic inconsistencies between the various data variables mapped.

In the instances where no reliable collateral information could be found, limited field investigations were conducted on the ground and from the air to establish a high degree of confidence in the mapped units which had been photo-interpreted.

Next the polygons or line segments delineated on the data maps were assigned code numbers. These code numbers referred to the different values or characteristics which each such delineations represented. The code numbers were then either applied directly to the manuscript map itself or were referenced, in turn, to sequential numbers applied to the map. In either case the numbers used were related to the polygons or line segments shown on the map being placed within the polygons or immediately adjacent to the lines.

The modules were than edgematched to one another. Edgematching is a process of comparing the adjacent border portions of two map modules which share a common border. Edgematching is done to correct any problems occurring along this hard border due to the two maps having been created independently of one another. Where lines of any kind (polygon borders or linear features) cross from one module into the other these are checked to be sure that they are properly located and that they match (ie., are continuous across the border). A check is also made to be sure that the code assignments along each side of the shared border are correct and are consistent with those across the order in the other module.

As noted above, mapping can be done by polygons or as lines. In creating polygon maps the study area was divided into smaller, discrete areas, each bounded by a closed line, called a polygon. These are so-called because they may be thought of and represented as consisting of a series of vertices which are connected by line segments. The critical point about such polygons is that the discrete area inside each polygon is homogeneous with respect to the variable or variables to which the particular polygon delineation refers.

For purposes of identification and description, the individual polygons on a manuscript map have been given sequential identification numbers. Each polygon's sequential identifier is then used to associate the polygon with an identically numbered set of attribute codes. This code set describes the polygon's attributes in terms of the variable or variables portrayed on the manuscript map of which the polygon is a part.

Assigned to each polygon on a manuscript map is a centroid, a point located in such a way that when the lower left corner of a label is placed on it by computer software, the symbol is centered in the polygon. (When several small polygons are close together, their centroids are located so that the labeling symbols will not overlay yet will clearly indicate to which polygon the label is attached.)

Line maps are frequently used to portray specific features, in contradistinction to polygon maps, used to portray areal data variables. On these maps linear features are drawn as either lines or line segments. Coded values for lines are either applied directly to the manuscript map or they are referenced to the map by the use of sequential identification numbers, as with polygons. Locaters for the labels associated with points or lines are similar to the centroids associated with polygons in that they label for a point or line.

C. Manuscript Maps

In this section, the nature of each kind of manuscript map created for the CIRSS, Verticle Integration Project is discussed in detail. Included are the reasons for incorporating the variable in the data base, the collateral information used to prepare each map, the implications of the source map's scale and resolution, the process used to transfer information from source map to stable base manuscript map, interpretive decisions involved, and the reliability and quality of the information provided by the manuscript map.

Manuscript #1 -Integrated Terrain Unit Maps

Manuscript #1 is a polygon map composed of nine data variables - landcover, geologic type, percent slope, landforms, soils, surface configuration, geologic hazards, depth to ground water and flood prone areas. Each variable is divided into a number of data classes. In some instances, these classes are defined by the collateral used; in other cases, the variables are divided into classes which have been applied to similar projects or which are needed to reflect particular aspects of the planning process.

In the integration process, lines representing certain data variables are considered very reliable, and so are not shifted or adjusted. These are called "hard" lines. At the other extreme are lines which are only generally defined and thus can be moved considerably in the integration process. These are called "soft" lines. The relative certainty for each of the data variables may be ranked from high to low as follows:

1. Flood prone areas (where available from collateral)
2. Geologic Hazards
3. Geologic Type
4. Landform (supersedes geology in areas of alluvium)
5. Vegetation (photo-interpreted to match other natural features)
6. Soils
7. Percent Slope
8. Surface Configuration

9. Depth to Ground Waters

Each of these data variables is described below:

Flood Prone Areas

Flood prone areas were mapped to show areas subject to catastrophic floods. This variable is used to avoid development on areas where flooding is likely to be extensive.

The collateral consisted of U.S.G.S. Flood-Prone Area maps which are published at a scale of 1:24,000. These data were photographically reduced to 1:62,500 and were held closely to the pattern shown. Slight adjustments were made to reflect a 10 acre mapping resolution.

Geologic Hazards

Two types of special concern for geologic hazards were mapped. They are Alquist-Priolo Special Study Zones and landslide susceptibility. This data is included to allow consideration of known or suspected geologic hazards when evaluating the geologic hazards potential of an area.

The collateral was in each case larger than 1:62,500. Photographic reductions were used and delineations closely held but generalized to 10 acre resolution.

Geologic Type

Geologic types were mapped by rock type and age. This variable provides the basis for a variety of interpretations through the use of an extended geologic interpretation matrix where mapped units are given interpretive values for strength, generalized hazards, mineral potential, available ground water, ease of excavation and so on.

The collateral was at a scale of 1:48,000 and required photo reduction. Among the data classes were portrayed formation, age and rock type. These data were resolved to the air photos and base maps at a scale of 1:62,500 to resolve dynamic boundaries such as floodplains. Minor changes were made to effect integration with other map variables.

Landforms

Landforms consisting of a descriptive classification are based upon structure, genesis and material. These data provide a description of the general environmental setting while serving a variety of modeling needs. for example, habitat, visual characteristics, and landscape dynamics.

Landforms were interpreted by a process which involves visual inspection of stereo pairs of high altitude air photos while delineating the actual pattern on a corresponding cronoflex enlargement at a scale of 1:62,500.

Vegetation

Vegetation was mapped using a system developed specifically for Southern California by the U.S. Forest Service. These data are essential to the environmental assessment process, serving a wide variety of needs including fire hazard, mudflow, habitat, visual quality, noise and recreation.

The vegetation pattern was photo-interpreted using the process described for landforms. In the highly urbanized areas, vegetation classes which represent the vegetation found on vacant properties were used and assigned to the entire urban sector. Overlay of the land use information from the land use file can be used to identify the actual land cover in the built up part of these urban areas. This technique eliminated the necessity of drafting numerous "urban"polygons and helped to lower the cost of automation without sacrificing detail.

Soils

Soil series were mapped by name. This allowed assignment of any of the soil interpretations or characteristics normally used by the Soil Conservation Service through the use of an interpretive matrix.

Soils were mapped from the SCS soil survey at a scale of 1:24,000 by a process photo-reduction followed by visual comparison to the recent air photos to resolve conflicts with other data plains and to account to recent geomorphic events such as changes in river channels.

<u>Percent Slope</u>

The average percent slope was mapped to provide an input to development capability and suitability ratings. The classes chosen represent those normally used by planners and architects to establish different types and densities of land use patterns.

The slope classes were interpreted by inspection of the contour line densities on the U.S.G.S. Topographic Base Maps. These classes, therefore, reflect overall slope rather than site specific conditions.

<u>Surface Configuration</u>

Surface configuration was included to provide an overall assessment of micro-relief. It is useful for a variety of aesthetic interpretations and helps to assess land use suitability.

These data were interpreted by comparison of air photo stereo views with the crenelation of contour lines on the U.S.G.S. Topographic Sheet Base Maps.

<u>Depth to Groundwater</u>

The average depth to groundwater was mapped to allow identification of potential liquefaction or structural problems associated with high water tables. This data is highly generalized and subject to wide seasonal variations. It should be noted that another source of groundwater information is found on the soil survey matrix of interpretations.

Groundwater information was taken from a generalized map of groundwater in 1960 which was at a scale of 1:48,000. These data were photographically reduced to 1:62,500 and integrated with the other data plains.

Manuscript #2 - Surface Hyrdrology and Faults

Manuscript #2 is the surface hydrology and faults manuscript, which includes two types of data: 1)stream course lines and 2) geologic fault lines.

Surface hydrology locates and classifies major streams and most of the minor streams in the study area. This data can be used to locate water courses, identify possible pollution problems, critical habitats, and locate construction constraint areas, for example, those areas that may require bridges or stream culverts. Faults locates and classifies known and suspected earthquake faults. This data can be used to screen areas for geologic hazards associated with ground motion and ground rupture and can be used in conjunction with the Alquist-Priolo Special Study Zones mapped on Manuscript #1.

Surface Hydrology

Stream course lines were the first feature to be mapped for the manuscript. This was done by registering a sheet of mylar to each base map. These were then registered to their corresponding photo images. The stream courses were then mapped from the base map. Each stream was not traced exactly as it appeared on the imagery or the base map; short, straight line segments were used instead. This process allows the stream lines to be digitized and displayed for a much lower cost than if the streams were digitized directly as they appear (continuously curving lines). These short line segments at no time misrepresent a stream more than 150 feet from its actual location.

Each stream course map was then rechecked against the imagery. If there were discrepancies between the base map data and imagery, the streams were adjusted to the imagery.

Stream values were given in the form of stream order and flow (perenniality) . Stream order is described by the first code number in a numeric code value assigned to each stream segment.
Flow characteristic was determined by either use of the legend of the base map and/or interpretation from imagery.

Photo-interpretation was used to establish where stream segments are channelized.

Faults

Fault lines, known or suspected were mapped by registering photo-reduced collateral maps to the U.S.G.S. base maps and simply, manually transferring the lines. Dotted or dashed lines on the data source maps were represented as solid lines on the manuscript.

No photo-interpretation was done for faults.

Manuscript #3 Land Use

Manuscript #3 is a polygon map which copies the land use map from the San Bernardino County Consolidated General Plan. It is included for the purpose of comparing, through an automated overlay process, the land use plan elements with the existing land use (described in the Land Use Updating Report Appendix A) and with the output of the capability/suitability mapping to be performed for this project.

This map was prepared by overlaying the U.S.G.S. topographic base map with attached mylar drafting film atop the county's land use map and manually transferring the lines. Adjustments were made only to insure registration of the maps. The alpha/numeric legend shown on the county's map were converted to purely numeric codes for ease of computer processing (see code listing).

Manuscript #4 - Transportation

This manuscript consists of lines. Variables included in this manuscript are data for roads classified by responsible agency, intensity of use, surface quality and whether scenic or not. Railroads and airports are shown on the land use update maps.

Road data were collected from the topographic base maps, Automobile Association of America Maps and imagery at a scale of 1:62,500. The data were first mapped directly from the base maps onto a mylar overlay. The Automobile Association maps were then used to supplement that data. All additional information was optically/manually reduced and transcribed to the 1:62,500 working scale. Each road was then image verified and coded.

Railroad collateral was found on the topographic maps. The same procedures used for mapping roads were used here.

CIRSS SAN BERNARDINO VERTICAL INTEGRATION

MANUSCRIPT CODES

Manuscript #1 - Integrated Terrain Unit Map

Land Cover
Geologic Type
Percent Slope
Landform
Soils
Surface Configuration
Geologic Hazards
  Alquist-Priolo Act Fault Designation Zones
  Landslide Suseptibility
Depth to Ground Water
Flood-Prone Areas

Manuscript #2 - Surface Hydrology and Fault Map

Stream Order
Flow Characteristics
Channelization
Faults

Manuscript #3 - General Plan Land Use Map

Land Use

Manuscript #4 - Transportation

Responsible Agency
Roads Classified by Intensity of Use Grouping
Roads by General Surface Qualities
Scenic Road
Railroads

Manuscript #1 - Integrated Terrain Unit Map

Land Cover, Column 1 and 2

Codes	Variables
01	Douglas Fir and Big Cone Douglas Fir
02	Ponderosa and Jeffrey Pine
04	White Fir
07	Sugar Pine
08	Lodgepole Pine
09	Incense-Cedar
11	Coulter Pine
12	Pinyon Pine
15	Limber Pine
16	Deciduous Woodland
17	Live Oak Woodland
18	Joshua Tree Woodland
19	Ceanothus Chaparral (Shrub Oak Inc.)
20	Chamise Chaparral
21	Manzanita Chaparral
22	Red Shank Chaparral
23	Juniper-Scrub Oak - Pinyon Woodland
24	Coastal Sage
25	Great Basin Sage
26	Riparian, Live Oak
27	Riparian, Alder-Willow-Aspen
28	Riparian, Sycamore-Cottonwood
29	Desert Scrub Veg. (Creosote)
30	Grassland
31	Barren, Urban or Agriculture

32	Wilderness Area
33	Water Body

Geologic Type, Column 3 and 4

00	Water Body
01	Quaternary alluvium-sands, gravels and clays in active stream or lake beds or on active fans
02	Quaternary landslide deposits-debris deposited by landslide movement
03	Quaternary talus rubble-talus cones or aprons deposited on steep slopes by mass wasting
04	Quaternary older alluvium-partially consolidated sand and gravel deposits currently above base level
05	Quaternary glacial till-unsorted angular fragments carried downslope and deposited by Pleistocene glaciers
06	Pliocene sedimentary deposits-sandstone, conglomerates, minor mudstones, and rare associated volcanic rocks
07	Pre-Pliocene Tertiary sedimentary deposits-sandstones, conglomerates, minor mudstones and rare associated volcanic rock
08	Tertiary volcanic rocks-basalt flows and dikes
09	Mesozoic plutonic rocks-granodiorite, diorite, gabbro, quartz diorite, quartz monzonite, quartz latite porphyry, and granite
10	Pre-Tertiary gneiss or schist-gneiss or schistose metamorphic rocks and old (pre-Mesozoic) metamorphosed plutonic rocks
11	Pre-Tertiary quartzite-quartzite and meta-sandstones
12	Pre-Tertiary marble-marble and meta-limestone
13	Artificial fill-solid waste disposal sites and earth filled dams

14	Wilderness-all areas within a wilderness area
15	Quaternary active river channel alluvium-unconsolidated alluvium of major stream channels subject to, or recently subject to, stream flood
16	Quaternary Santa Ana River channel alluvium-unconsolidated sandy alluvium of the Santa Ana River channel
17	Quaternary alluvial fan deposits-unconsolidated deposits of young coarse alluvium, radiating from mountain fronts
18	Quaternary younger alluvium undifferentiated-unconsolidated alluvium of valley areas and along some major drainage courses
19	Quaternary colluvium and talus-major occurrences of unconsolidated coarse rocky colluvium and talus
20	Quaternary eolian sand areas-major areas subject to active blowing sand which may include some small sand dunes and other thin concentrations of wind blow sand
21	Quaternary dune sand-major deposits of unconsolidated dune sand
22	Undifferentiated mixture of Quaternary younger alluvium undifferentiated and Quaternary older alluvium undifferentiated (Quaternary alluvium undifferentiated dominant)
23	Undifferentiated mixture of Quaternary older alluvium undifferentiated and Quaternary younger alluvium undifferentiated (Quaternary older alluvium undifferentiated dominant)
24	Undifferentiated mixture of Quaternary older alluvium undifferentiated and Quaternary alluvial fan deposits (quaternary older alluvium undifferentiated dominant)
25	Undifferentiated mixture of Quaternary older alluvium undif-

ferentiated and Pliocene sedimentary deposits (Quaternary older alluvium undifferentiated dominant)

26	Undifferentiated mixture of Quaternary alluvial fan deposits and Quaternary older alluvium undifferentiated (Quaternary alluvial fan deposits dominant)
27	Undifferented mixture of Pliocene sedimentary deposits and Quaternary older alluvium undifferentiated (Pliocene sedimentary deposits dominant)

Percent Slope, Column 5

1	0 - 8% slope
2	8 -15% slope
3	15-30% slope
4	30-50% slope
5	50% slope and over
6	Water Body
7	Wilderness

Landform, Column 6 and 7

00	Water Body
01	Rock outcrop
02	Mountain ridge top
03	Mountain sideslopes
04	Badlands
05	Bench or terrace
06	Glacial deposits
07	Colluvial land
08	Upland valley bottoms

09	Alluvial fans- Bajada
10	River lands
11	Artificial fill
12	Wilderness
13	Mountain Uplands
14	Landslides
15	Wash
16	Floodplain
17	Sand Dune, Sand Sheet
18	Hills
19	Escarpment
20	Valley floor

Soils, Column 8 and 9

01	Alo clay - AaF
02	Chino silt loam- Cb
03	Chualar clay loam - CkA, CkC, CkD
04	Cieneba sandy loam- CnD
05	Cieneba-Friant sandy loam - Cp
06	Cieneba-Rock outcrop complex - Cr
07	Crafton-Rock outcrop complex, eroded - CsZ
08	Delhi fine sand - Db
09	Fontana clay loam - FoE, FoF
10	Friant-Rock outcrop complex - Fr
11	Garretson very fine sandy loam - GaC
12	Gaviota-Rock outcrop complex - Go
13	Grangeville fine sandy loam - Gr
14	Grangeville fine sandy loam, saline-alkali - Gs
15	Greenfield sandy loam - GtC, GtD
16	Greenfield cobbly sandy loam - GuD
17	Hanford coarse sandy loam - HaC, HaD
18	Hanford sandy loam - HbA
19	Hilmar loamy fine sand- Hr
20	Merrill silt loam - Me
21	Metz coarse sandy loam- MgC
22	Monserate sandy loam - MoC
23	Nacimiento clay loam - NaE, NaF
24	Oak Glen sandy loam - OaC
25	Oak Glen gravelly sandy loam - OgD, OgE
26	Psamments and Fluvents, frequently flooded - Ps
27	Ramona sandy loam - RmC, RmD

28	San Emigdio sandy loam - SaD
29	San Emigdio gravelly sandy loam - SbC
30	San Emigdio fine sandy loam - ScA, ScC
31	San Timoteo loam , eroded - SgFZ
32	Saugus sandy loam - ShF
33	Soboba gravelly loamy sand - SoC
34	Soboba stony loamy sand - SpC
35	Soper gravelly loam - SrE, SrF
36	Sorrento clay loam - StA, StB
37	Tollhouse sandy loam - ToF
38	Tujunga loamy sand - TuB
39	Tujunga gravelly loamy sand - TvC
40	Vista-Rock outcrop complex - Vr
41	Quarry-Gravel pit - G.P.
50	Water

<u>Surface Configuration, Column 10</u>

1	Simple
2	Undulating
3	Complex

<u>Geologic Hazards, Column 11, 12</u>

Alquist-Priolo Act Fault Designation Zones, Column 11

1	Area not within fault zone
2	Area within fault zone

Landslide susceptibility, Column 12

1	Generally devoid of landslides, not a known landslide
2	Generally devoid of landslides, known landslide
3	Low to moderate landslide susceptibility, not a known landslide

4	Low to moderate landslide susceptibility, known landslide
5	Moderate to high landslide susceptibility, not a known landslide
6	Moderate to high landslide susceptibility, known landslide

<u>Depth to Ground Water, Column 13</u>

1	0 - 50'
2	50-100'
3	100' and greater

<u>Flood Prone Areas, Column 14</u>

1	Not flood prone
2	Flood prone

<u>Manuscript #2 - Surface Hydrology and Fault Map</u>

Stream Order, Column 1

1	First Order
2	Second Order
3	Third Order
4	Fourth Order
5	Fifth Order
6	Sixth Order

Flow Characteristics, Column 2

1	Intermittent Flow
2	Perennial Flow

Channelization, Column 3

1	Not channelized
2	Channelized

Faults, Column 4

1	Accurately located fault
2	Well located fault

3	Concealed fault
4	Fault inferred from seismic activity

Manuscript #3 - General Plan Land Use Map

Land Use, Columns 1, 2, 3 and 4

Residential

1001	1 dwelling unit maximum per acre
1002	2 dwelling unit maximum per acre
1003	3 dwelling unit maximum per acre
1004	4 dwelling unit maximum per acre
1005	5 dwelling unit maximum per acre
1006	6 dwelling unit maximum per acre
1007	7 dwelling unit maximum per acre
1008	8 dwelling unit maximum per acre
1009	9 dwelling unit maximum per acre
1010	10 dwelling unit maximum per acre
1011	11 dwelling unit maximum per acre
1012	12 dwelling unit maximum per acre
1013	13 dwelling unit maximum per acre
1014	14 dwelling unit maximum per acre
1015	15 dwelling unit maximum per acre
1016	16 dwelling unit maximum per acre
1017	17 dwelling unit maximum per acre
1018	18 dwelling unit maximum per acre
1019	19 dwelling unit maximum per acre
1020	20 dwelling unit maximum per acre
1021	30 dwelling unit maximum per acre

1022	36 dwelling unit maximum per acre
1023	43 dwelling unit maximum per acre
1024	45 dwelling unit maximum per acre
1025	90 dwelling unit maximum per acre

Rural Living

1101	1 acre minimum parcel size allowed
1102	2.5 acre minimum parcel size allowed
1103	5 acre minimum parcel size allowed
1104	10 acre minimum parcel size allowed
1105	20 acre minimum parcel size allowed

Non-Residential

1200	Commercial
1300	Industrial
1600	Public
2100	Agriculture
2300	Rural Conservation

<u>Manuscript #4 - Transportation Map</u>

<u>Roads, Column 1, 2 3 and 4</u>

Responsible Agency, Column 1

1	U.S. Highways
2	State Roads
3	County Roads

Roads Classified by Intensity of Use Grouping, Column 2

1	Arterial
2	Collector
3	Local

Roads by General Surface Qualities, Column 3

1	Paved
2	Not Paved

Scenic Roads, Column 4

1	Scenic
2	Not Scenic

Railroads, Column 5

1	Major railroad

MANUSCRIPT #1 - INTEGRATED TERRAIN UNIT MAP

LAND COVER CODE DESCRIPTIONS:

01. Douglas-Fir and Big Cone Douglas-Fir:

Douglas-Fir: Pseudotsuga menziesii is the dominant overstory species. Representatives of this series may occur as extensive "pure" stands. The most extensive stands of Douglas-fir are in western Oregon and Washington, though the species grows throughout the western states ranging from British Columbia south to Mexico.

Big Cone Douglas-Fir: Overstory species is Pseudotsuga macrocarpa with canyon live oak and occasionally black oak. Dense stands are found in canyons or on north-facing slopes. Mature stands have a sparse herbaceous layer. Younger stands may have a chaparral shrub understory. The total range of big cone Douglas-fir is within southern California.

02. Ponderosa and Jeffrey Pine:

Jeffrey pine: Pinus jeffreyi is dominant overstory species. It generally occurs on the drier or higher elevation sites.

Ponderosa pine: Pinus ponderosa occupies the more mesic midelevation habitats where the ranges of the two species coincide.

Ponderosa pine is present in dominant stands in mountains throughout the western states. Jeffrey pine ranges from southern Oregon to the mountains of Baja California.

04. White Fur:

Abies concolor is the dominant overstory species and may occur in nearly pure stands. The understory vegetation is sparse with a moderate accumulation of litter, including needles and fallen branches. White fir is widely distributed in the western states from Oregon to

New Mexico.

07. Sugar Pine:

Pinus lambertiana is the dominant overstory species with moderate to heavy accumulations of litter. Sugar pine occurs throughout the California mountains, north into Oregon and south into the Sierra San Pedro Martir of Baja California.

08. Lodgepole Pine:

Pinus contorta is the dominant overstory species in sparse stands within xeric high elevation habitats or in dense stands surrounding meadows. Understory also varies according to habitat. Lodgepole pine range from Alaska to Baja California. It grows in a wider range of elevations, sea level to 12,000 feet, than any other pine. In southern California, this series is a dominant one above 8,000 feet.

09. Incense-Cedar:

Calocedrus decurrens is the dominant overstory species with heavy accumulations of litter. Incense-cedar often occurs with sugar pine, white fur, and Jeffrey pine. Incense-cedar occurs throughout the California Mountains, north into Oregon and south into the Sierra San Pedro Martir of Baja California.

11. Coulter Pine:

Pinus coulteri is the dominant overstory species with chaparral shrubs or interior live oaks in the understory. This series interfaces with the chaparral formation. Coulter pine ranges from Contra Costa County south to Baja California.

12. Pinyon Pine:

Pinus monophylla are dominant overstory species with shrubs in the understory. In southern California, pinyon pine occurs in deserts, mountains from Inyo County west to Santa Barbara County and south to San Diego County.

15. Limber Pine:

    Pinus flexilis is the dominant overstory species, a subalpine tree growing in sparse stands with a sparse understory. Above 11,000 feet elevation, limber pine tends to form krummholtz stands, the prostrate forms appearing more like shrubs than ancient trees. Southern California stands are scattered on the highest peaks of the Inyo, Panamint, San Gabriel, San Bernardino and San Jacinto Mountain ranges.

16. Deciduous Woodland:

    Black oak, Quercus kelloggii, is the dominant overstory species. It is a deciduous tree which produces a well-developed litter layer. Understory includes shrubs, grasses and perennial forbs. Black oak will sometimes survive fire and resprout from crown. If crown are fire-killed, it resprouts from the base. Black oak occurs from Oregon south to the Laguna Mountains in San Diego County.

17. Live Oak Woodland:

    Quercus wislizenii is the dominant overstory species with chaparral shrubs in the understory. This series occupies xeric habitats between chapparral and forest formations, but follows intermittent streams into chaparral. The species is very sensitive to fire. The larger trees are usually located in areas that have not burned in 50 to 100 years. More often this live oak is present in dense shrublike thickets with multiple stems, the result of resprouting from the base following fire. Interior live oak is generally a California species ranging from Siskiyou County south to Baja California.

18. Joshua Tree Woodland:

The dominant overstory species is _Yucca_ _brevifolia_. Understory shrubs include desert and chaparral species. The herbaceous understory varies from moderately dense in mountain foothills to virtually absent on the Mojave Desert. The Joshua tree occurs in foothill and desert highlands surrounding the Mojave Desert, from San Bernardino County north to Inyo County, into Nevada and northern Arizona.

19. _Ceanothus_ Chapparral:

Ceanothus species are the dominant overstory vegetation. This series can produce open stands when mature since _Ceanothus_ shrubs are rather short lived. Fifty year old stands may have herbaceous vegetation interspersed with shrubs. _Ceanothus_ is one of the chaparral shrubs with the ability to fix nitrogen in soils. _Ceanothus_ spp. occur from southwestern Oregon to Baja California.

20. Chamise Chapparral:

Adenostoma _fasciculatum_ is the dominant overstory shrub. The mature vegetation is dense and excludes any herbaceous understory. This series occupies the hottest and driest of chaparral sites. Chamise covers more land in California than any other single series. It exists from the north Coast Ranges south to Baja California.

21. Manzanita Chapparral:

Arctostaphylos species are the dominant overstory. Mature stands are very dense and impenetrable. The form varies from low mats to small trees. This series comprises higher elevation chaparral and is sometimes referred to as "cold chaparral". Manzanita occurs from southern Oregon to Baja California and east through Central Arizona.

22. Red Shank Chaparral:

Adenostoma sparsifolium is the dominant overstory shrub. Individual shrubs have open crowns and therefore a herbaceous understory may be present, even in mature stands. Red Shank exists for San Luis Obispo County south along the coast to Los Angeles County, then shifts its distribution inland to the Peninsular Mountain ranges, following them south into Baja California.

23. Juniper - Scrub Oak - Pinyon Woodland:

Juniper: California juniper, Juniperus californica is an overstory vegetation species with desert and chaparral shrubs in the understory. California juniper is an arborescent shrub which occurs from Rehama County south to San Diego County.

Scrub Oak: Quercus dumosa and Quercus turbinella are overstory vegetation species with no understory in mature stands. Many other shrub species may be associated with the scrub oak series. Quercus dumosa ranges from Baja California throughout the State. Quercus turbinella ranges from transmontane California east to Texas.

Pinyon Woodland: Pinus monophylla is an overstory species with shrubs in the understory. In southern California pinyon occurs in desert mountains from Inyo County west to Santa Barbara County and south to San Diego County.

24. Coastal Sage:

Artemisia californica is the dominant shrub overstory with a grass/forb understory. This series is present on low-elevation coastal foothills and interior valleys from Baja California north to San Francisco Bay including the Channel Islands.

25. Great Basin Sage:

Artemisia tridentata is the dominant shrub. It is an evergreen shrub and may be associated with perennial grasses. Great basin sage is found from the mountains of southern California north to Oregon and throughout the Great Basin. The series occurs at 7,000 feet elevation interspersed with series of the closed forest or woodland formations, as well as in the Mojave Desert.

26. Riparian Live Oak:

Canyon live oak, Quercus chrysolepis, is an overstory species often occurring in riparian habitats. Interior live oak, Quercus wislizenii may also be found in riparian habitats. Canyon live oak is usually fire-killed, resprouting from the base rather than the crown. This species occurs from southwestern Oregon to Baja California east to central Arizona. Interior live oak is also very sensitive to fire. The larger trees are usually located in areas that have not burned in 50 to 100 years. More often this live oak is present in dense shrublike thickets with multiple stems, the result of resprouting from the base following fire. This species ranges from Siskiyou County south to Baja California

27. Riparian, Alder-Willow-Aspen:

Alder: Alnus rhombifolia (white alder) is the dominant overstory species in this series, which occurs in riparian habitats with flowing water. Understory shrubs, such as Ribes and Salix species with abundant herbaceous vegetation, make this a multistories, diverse habitat. White alder is found throughout California north in British Columbia and east to Idaho.

Willow: Salix lasiolepis (arroyo willow), Salix gooddingii (black willow) and other Salix spp. are dominant overstory species. They may be trees or scrublike and always indicate riparian habitats. The understory is herbaceous. Since willows are deciduous, dense stands have deep litter layers. In southern California, the series may occur wherever surface water or subsurface seeps are present.

Aspen: Populus tremuloides is the dominant overstory species. The series occurs around moist moutain meadows and riparian habitats. In southern California aspen populations occur in the White Mountains and San Bernardino Mountains.

28. Riparian, Sycamore-Cottonwood:

Sycamore: The dominant overstory species is Platanus racemosa. Sycamores follow perennial and intermittent streams with a soft chaparral shrub and herbaceous understory. California sycamore range from Baja California north to Shasta County.

Cottonwood: Dominant overstory species are Populus fremontii or Populus trichocarpa. Both are riparian species and are deciduous. Fremont cottonwood, populus fremontii, follows streams and dry washes at low elevations. Black cottonwood, Populus trichocarpa, occurs at higher elevation in southern California. Both species of cottonwood are present throughout California.

29. Desert Scrub Veg. (Creosote):

Larrea tridentata, an evergreen shrub, is the dominant overstory. Understory plants vary, but burrobush, Ambrosia dumosa, is most often codominant in California. Creosote is found throughout both deserts, ranging south from Inyo County into Mexico and east into Texas.

30. Grassland:

Most grasslands encountered within the San Bernardino Valley and Mountain areas are introduced species growing on disturbed areas. Brome grass, Bromus species, wild oats, Avena burbata or Avena fatua, and wild rye, Elymus species, along with other grasses grow within the study area.

31. Barren, Urban, Agriculture:

Barren, Urban, Agriculture includes areas where no natural vegetation exists. This may be the result of natural causes, such as landslides or barren stream channels or the result of human activities such as agriculture or urbanization.

32. Wilderness Area:

Wilderness areas are regions officially designated by Congress as protected areas in which access is limited and development is prohibited.

33. Water Body:

Water body includes all naturally occurring and man made bodies of water.

INTEGRATED TERRAIN UNIT MAPS (ITUM)

GEOLOGY DESCRIPTION

The following is a geologic glossary containing a table of Geologic time and descriptions of various rock types.

RELATIVE GEOLOGIC TIME

ERA		PERIOD		EPOCH	ATOMIC TIME
Cenozoic	Late	Quaternary	Late	Holocene	11,000
			Early	Pleistocene	500,000 2 million
	Early	Tertiary		Pliocene	12 million
				Miocene	26 million
				Oligocene	38 million
				Eocene	54 million
				Paleocene	65 million
Mesozoic		Cretaceous		Late Early	136 million
		Jurassic		Late Middle Early	193 million
		Triassic		Late Middle Early	225 million
Paleozoic		Permian		Late Early	280 million
		Carboniferous	Pennsylvanian	Late Middle Early	
			Mississippian	Late Early	345 million
		Devonian		Late Middle Early	395 million
		Silurian		Late Middle Early	435 million
		Ordovician		Late Middle Early	500 million
		Cambrian		Late Middle Early	570 million
Pre-Cambrian					3,600+ million

Modified after Putnam (1971).

Figure A2-6

ROCK TYPES

No Additional rock type

Gravel - unconsolidated sedimentary material of igneous, sedimentary, or metamorphic origin whose grain size is between 2 and 64mm in diameter.

Sand - unconsolidated sedimentary material of igneous, sedimentary or metamorphic origin whose grain size is between .06 and 2 mm in diameter.

Mud, Clay or Organic Material - unconsolidated sedimentary material of igneous, sedimentary, metamorphic, or organic origin whose grain size is between .0005 and .004 mm in diameter.

Talus - Produced mainly by rockfall with individual blocks falling, shattering, rolling, bouncing. Talus is composed of a high percentage of coarse blocks, with fine sizes in the minority.

Till - Composed of unsorted rock fragments of various sizes; huge boulders are mixed with all sizes of fragments down to silt and finer grained material.

Alluvial Fan Deposits - Accumulations of boulder, gravel, and sand deposited by dry climate streams. Particle size generally decrease from the apex to the toes of the fan.

Conglomerate or Breccia - both are sedimentary material of igneous, sedimentary or metamorphic origin. Conglomerate is unconsolidated to consolidated mixture of rock types of varying grain sizes. Breccia differs only in that the larger rock fragments are angular.

Sandstone - consolidated sedimentary rock composed predominantly of sand.

Siltstone - consolidated sedimentary rock composed predominantly of silt whose grain size ranges between .004 and .06.

Shale, Mudstone, or Claystone - consolidated sedimentary rock composed predominantly of mud and clay.

Limestone or Dolomite - sedimentary rock of organic origin. Limestone is made up chiefly of calcium carbonate ($CaCO_3$), dolomite is made up of magnesium carbonate ($CaMg(CO_3)_2$).

Slate - a metamorphic rock whose grain size is less than 1 mm. The rock has a well developed fissility.

Schist - a metamorphic rock whose grain size ranges between 1 and 5 mm. The rock has dominant micaceous minerals is a sub-parallel orientation.

Gneiss - a metamorphic rock whose grain size is greater than 5 mm. The rock show bands of granular minerals alternating with schistose minerals.

Quartzite - a metamorphic rock consisting essentially of quartz.

Serpentine - an ultrabasic metamorphic rock essentially composed of the mineral serpentine. The serpentine mineral is derived from alteration of olivine and pyroxene.

Granite, Monzonite, Granodiorite, Tonalite, Diorite, Gabbro -

Granite - a coarse grained (> 5 mm) plutonic rock composed of alkalic feldspar (orthoclase) and quartz. Other minerals include small amounts of sodic plagioclase, biotite, muscovite and hornblende.

Monzonite - a coarse-grained (> 5 mm) plutonic rock containing equal amounts of orthoclase and plagioclase. Other minerals present in smaller amounts include quartz (< 2%), hornblende, and biotite.

Granodiorite - a coarse grained (> 5 mm) plutonic rock composed of quartz, calcic oligoclase (plagioclase), orthoclase, with biotite, hornblende, or pyroxene. Contains twice as much plagioclase as orthoclase.

Tonalite-Quartz Diorite - a coarse grained (> 5 mm) plutonic rock composed of plagioclase, quartz, hornblende and biotite.

Diorite - a coarse grained (> 5 mm) plutonic rock composed of sodic plagioclase and hornblende, biotite or pyroxene. Small amounts of quartz and orthoclase may be present.

Gabbro - a coarse-grained (> 5 mm) plutonic rock composed of calcic plagioclase and clinopyroxene, with or without orthopyroxene and olivine. Dark in color.

Basalt, Andesite or Diabase

Basalt - a fine grained (< 1 mm) extrusive rock composed of calcic plagioclase and pyroxene, with or without olivine.

Andesite - a fine grained (< 1 mm) extrusive rock composed of andesine plagioclase pyroxene hornblende, or biotite may be present in varying amounts.

Diabase - an intrusive rock consisting of labradorite plagioclase and pyroxene characterized by an ophitic texture. Olivine may be present.

Rhyolite - a very fine grained (< 1 mm) extrusive rock of same composition as granite.

Landslide Deposits - Deposits of any origin which have slipped downslope from a formally stable position.

Tuff or Tuffaceous Sediments - a medium to fine grained (< 5 mm) rock composed of compacted volcanic pyroclastic fragments.

Urban, Water or Artificial Fill

Urban - man altered areas

Water - natural lakes, reservoirs, coastal lagoons

Artificial Fill - areas of man deposited sediments.

SLOPE CODE DESCRIPTIONS

Percent slope is the number of units of vertical rise per 100 units of horizontal distance.

	Angle of Inclination	Slope Ratio	Gradient (Feet Per Mile)
1 = 0 - 8%	4° 35'	12,5:1	422
2 = 8 -15%	8° 36'	6,66:1	792
3 = 15-30%	17° 11'	3,33:1	1584
4 = 30-50%	28° 39'	2:1	2640
5 = 50% greater	greater than 28° 39'	greater than 2:1	greater than 2640

6 = Water Body - Lakes, reservoirs, rivers (0% slope)

7 = Wilderness - Wilderness areas are regions officially designated by Congress as protected areas, in which access is limited and development is prohibited.

LANDFORM CODE DESCRIPTIONS

00. Water Body - Water body includes all naturally occurring and man made bodies of water.

01. Rock Outcrop - Rock outcrops are areas in which the crystalline or well consolidated sedimentary bedrock is not covered by soil or debris. Foothill and mountain areas have numerous small rock outcrops which were not mapped because they fell below the minimum mapping resolution.

02. Mountain Ridge Top - Mountain ridge tops are nearly level to gently sloping (10-15% slope) areas on the tops of mountains or ridges. Only the larger ridge tops of at least 5 acres were mapped.

03. Mountain Sideslope - Mountain sideslopes are areas with slope greater than 30% and local relief greater than 500 ft. These areas are underlain by crystalline or well consolidated sedimentary rock covered by thin soils and rock debris.

04. Badlands - Badlands are extremely dissected regions characterized by very fine drainage networks and short steep slopes with narrow interfluves. These areas are underlain by poorly consolidated sedimentary rocks which undergo rapid erosion.

05. Bench or Terrace - Benches and terraces are areas with slopes less than 30%, above the current erosional base and below higher steeper lands. Terraces are topographic platforms in river valleys that usually represent former levels of the valley floor. Benches are platforms whose position is controlled by the geologic structure and have no implications of former valley floor levels.

06. Glacial Deposits - Glacial deposits include moraine deposits and areas underlain by glacial till. Moraines are composed of glacial sediments of varying particle size which are transported and deposited

08. Upland Valley Bottoms - Upland valley bottoms are areas underlain by crystalline or well consolidated sedimentary rocks with slopes less than 30%. This type of valley bottom is found in the mountainous areas.

09. Alluvial Fans - Bajada - An alluvial fan is a body of stream deposits whose surface approximates a segment of a cone that radiates downslope from the point where the stream leaves a mountainous area. Bajadas are broad slopes of alluvial outwash, which are often in the form of multiple coalescing alluvial fans.

10. River Lands (Canyon Bottoms) - River lands are areas underlain by poorly to moderately consolidated sedimentary rocks at the bottom of canyons includes meadows. River lands are located within the mountain foothill areas.

11. Artificial Fill - Artificial fill includes the following man-made areas: solid waste disposal sites, earth filled dams and road fills.

12. Wilderness Areas - Wilderness areas are regions officially designated by Congress as protected areas in which access is limited and development is prohibited.

13. Mountain Uplands - Mountain uplands are strongly sloping to steep areas, slopes less than 30%, found within mountainous areas. Not included in this class are valley bottoms, mountain sideslopes, mountain ridgetops, or benches. These areas are underlain by crystalline or well consolidated sedimentary rocks with a venier of soil or rock debris.

14. Landslides - Landslides are perceptible downslope movements of rock, soil, or artificial fill. The motion may be either that of a slide, a flow or fall acting singly or together. Landslides generally

indicate areas which are geologically unstable and unsuitable for urban development.

15. Wash - Washes are ephemeral river channels found in arrid and semi-arrid environments. They flow only in direct response to precipitation.
16. Floodplain: Floodplains are flat areas adjacent to stream, composed of unconsolidated sediments, which is subject to periodic flooding.
17. Sand Dune, Sand Sheet - Sand dunes and sand sheets are topographic features of eolian origin composed of sand grains deposited downwind from a natural source of sand.
18. Hills - Hills are isolated, moderately sloping to steep areas with less than 500 ft. local relief. They are underlain by crystalline or well consolidated sedimentary rock with a venier of soil or rock debris.
19. Escarpment - The only escarpments, long cliffs, mapped in this study were terrace sideslopes which are steep areas found along the edges of terraces.
20. Valley Floor - Valley floors are broad, nearly level to gently sloping areas underlain by poorly to moderately consolidated sedimentary rocks.

SOIL CODE DESCRIPTIONS

01. Alo Clay - Alo Clay consists of well-drained steep soils, 30 to 50% slope, that formed on foothills in material weathered from shale and fine grained sandstone. Runoff is rapid after soil is wet and the hazard of erosion is moderate. Vegetation is annual grasses and forbs.

02. Chino Silt Loam - Chino silt loam consists of somewhat poorly drained, nearly level soils. This soil formed on broad smooth valley bottoms and in basins in moderately fine textured alluvium. Runoff is slow and the hazard of erosion is slight. Vegetation is annual grasses and forbs.

03. Chualar Clay Loam - Chualar clay loam consists of well-drained nearly level to strongly sloping soils, 0 to 15% slope. This soil formed on alluvial fans and terraces in mixed, moderately fine textured alluvium. Runoff is slow to medium. The hazard of erosion is slight. Vegetation is annual grasses and forbs.

04. Cieneba Sandy Loam - Cieneba sandy loam consists of somewhat excessively drained strong sloping soils, 9 to 15% slope. This soil formed on foothills throughout the uplands in material weathered from granitic rock. Runoff is medium and the hazard of erosion is moderate if the soil is protected or not overgrazed. If this soil is left bare or burned over, the hazard of erosion can be high. Vegetation is chaparral. chamise, and annual grasses and forbs.

05. Cieneba-Friant Sandy Loam - Cieneba-Friant sandy loam consists of somewhat excessively drained soils on steep slopes, 30 to 50% slope. The Cieneba soil formed on slightly concave sideslopes and rounded ridgetops in material weathered from granitic rocks. The Friant soil formed on ridgetops and on the upper part of north-facing slopes

in material weathered from mica schist. Runoff is rapid and the hazard of erosion is moderate if soils are burned over or overgrazed. Vegetation is chaparral, chamise, big sagebrush, and annuals, forbs and grasses.

06. Cieneba - Rock Outcrop Complex - Cienaba-Rock outcrop complex consists of excessively drained soils on steep upland slopes, 30 to 50% slope. It is composed of about 60% Cieneba sand loam, which form on uplands in material weathered from granitic rock and 30% granitic rock outcrops. Runoff is rapid and the hazard of erosion is moderate if vegetation is burned off or overgrazed. Vegetation is chaparral, chamise, and annual grasses and forbs.

07. Crafton-Rock Outcrop Complex, Eroded - Crafton-Rock outcrop complex, eroded consist of well-drained steep soils, 30 to 50% slope. It is composed of about 60% Crafton sandy loam which form on foothills in material weathered from micaceous, schist and 30% micaceous schist rock outcrops. Runoff is rapid and the hazard of erosion is moderate to high where soil is left bare because of fire or overgrazing. Vegetation is chamise, chaparral, live oak, and annual grasses and forbs.

08. Delhi Fine Sand - Delhi fine sand consists of somewhat excessively drained nearly level to strongly sloping soils, 0 to 9% slope that formed on alluvial fans in course-textured, wind reworked granitic material. Runoff is very slow, and the hazard of soil blowing is generally moderate. Vegetation is annual grasses and forbs.

09. Fontana Clay Loam - Fontana clay loam consists of well-drained moderately steep to steep soils, 15 to 50% slope. This soil formed on rounded foothills in material derived from calcareous weathered

shale and fine-grained sandstone. Runoff is medium to rapid and hazard of erosion is slight to medium. Vegetation is annual grasses and forbs, and some scrub oak along drainageways.

10. Friant-Rock Outcrop Complex - Friant-Rock outcrop complex consist of somewhat excessively drained, steep soils, 30 to 50% slope. These soils formed in uplands in material weathered from mica schist. It is about 55 percent Friant fine sandy loam and 30 percent mica schist outcrop. Runoff is rapid, and hazard of erosion is moderate. If soils are left bare, because of fire or overgrazing, the hazard of erosion is high. Vegetation is big sagebrush, chamise and annual forbs and grasses.

11. Garretson, Very Fine Sandy Loam - Garretson very fine sandy loam consists of well-drained gently sloping to moderately sloping soil, 2 to 9% slope. This soil formed on alluvial fans in alluvium derived from mixed but largely sandstone sources. Runoff is medium, and the hazard of erosion is slight to moderate where this soil is left bare. Vegetation is annual grasses and forbs.

12. Gaviota-Rock Outcrop Complex - Gaviota-Rock outcrop complex consists of somewhat excessively drained, steep soil, 30 to 50% slope, formed on uplands in material weathered from sandsone. It is about 60% Gaviota fine sandy loam and 35% sandstone outcrop. Runoff is rapid, and the hazard of erosion is moderate to high if soils are left bare as a result of fire or overgrazing. Vegetation is chamise, annual grasses and forbs and a few live oaks.

13. Grangeville Fine Sandy Loam - Grangeville fine sandy loam consists of somewhat poorly drained nearly level soils. This soil formed on the slopes of alluvial fans in moderately course textured granitic alluvium. Runoff is slow and the hazard of erosion is slight. Vegetation is annual grasses and forbs and scattered cottonwood trees.

14. Grangeville Fine Sandy Loam, Saline-Alkali - Grangeville fine sandy loam, saline-alkali consists of somewhat poorly drained, nearly level, moderately saline and strongly alkali soils. This soil formed on the slopes of alluvial fans in moderately course textured granitic alluvium. Runoff is slow, and the hazard of erosion is slight. Vegetation is annual grasses and forbs and scattered cottonwood trees.

15. Greenfield Sandy Loam - Greenfield sandy loam consists of well-drained, gently sloping to strongly sloping soils, 2 to 15% slope. This soil formed on alluvial fans in moderately course textured granitic alluvium. Runoff is moderate to rapid and hazard of erosion is moderate. Vegetation is chamise annual grasses and forms.

16. Greenfield Cobbly Sandy Loam - Greenfield cobbly sandy loam consists of well-drained moderately sloping to strongly sloping soil, 5 to 15% slope. This soil formed on broad, short, alluvial fans in moderately course textured granitic alluvium with 15% of the surface area occupied by cobblestones. Runoff is medium and the hazard of erosion is slight. Vegetation is chamise, annual grasses and forbs.

17. Hanford Coarse Sandy Loam - Hanford coarse sandy loam consists of well-drained gently sloping to strongly sloping soil, 2 to 15% slope, that formed in recent granitic alluvium on valley floors and alluvial fans. Runoff is slow to medium and the hazard of erosion is slight to high if the soil is left without plant cover. Vegetation is mainly

annual grasses and forbs.

18. Hanford Sandy Loam - Hanford Sandy Loam consists of well-drained nearly level soil that formed in recent granitic alluvium on valley floors. Runoff is slow and the hazard of erosion is slight if the soil is left unprotected. Vegetation is mainly annual grasses and forbs.

19. Hilmar Loamy Fine Sand - Hilmar loamy fine sand consists of somewhat poorly drained, nearly level soil on alluvial valley floors and fan. These soils formed in wind-laid, coarse-textured material underlain by medium textured granitic alluvium. Runoff is slow and the hazard of water erosion is slight. If the soils are left without a protective cover of vegetation, the hazard of soil blowing is high.

20. Merril Silt Loam - Merril silt loam consists of somewhat poorly drained, nearly level soils that formed on alluvial fans in medium-textured granitic alluvium. Runoff is slow and the hazard of erosion is slight. Vegetation is mainly annual grasses and forbs, but perennial grasses grow in some areas.

21. Metz Coarse Sandy Loam - Metz coarse sandy loam consists of somewhat excessively drained, gently sloping to moderately sloping soils, 2 to 9% slope that formed in coarse-textured, mixed recent alluvium on alluvial fans. Runoff is slow and the hazard of water erosion is slight. The hazard of soil blowing is slight to moderate on bare soil. Vegetation is annual grasses and forbs,

22. Monserate Sandy Loam - Monserate sandy loam consists of moderately well-drained, gently sloping to moderately sloping soils, 2 to 9% slope. This soil formed on alluvial fans and terraces in granitic alluvium. Runoff is medium, and the hazard of erosion is slight to moderate if the soil is left without a protective cover of vegetation.

23. Nacimiento Clay Loam - Nacimiento clay loam consists of well-drained, moderately sloping to steep soils, 9 to 50% slope, that formed on uplands in material weathered from soft shale or fine-grained sandstone. Runoff is rapid and the hazard of erosion is moderate to high where soils are left bare. Vegetation is annual grasses and forbs.

24. Oak Glen Sandy Loam - Oak Glen sandy loam consists of well-drained gently sloping to moderately sloping soils, 2 to 9% slope, that formed on alluvial fans in alluvium derived from granite. Runoff is slight to medium and the hazard of erosion is slight. Vegetation is annual grasses and forbs, oak trees and some pine trees.

25. Oak Glen Gravelly Sandy Loam - Oak Glen gravelly sandy loam consists of well-drained, strongly sloping to moderately steep soils, 9 to 30% slope, that formed on alluvial fans in alluvium derived from granite. Runoff is medium to rapid and hazard of erosion is moderate to high if the soil is not protected by a cover of vegetation. Vegetation is annual grasses and forbs, oak trees, and some pine trees.

26. Psamments and Fluvents - Frequently flooded Psamments and fluvents consist of sandy and gravelly material in major intermittent streambeds. Some areas consist of cobbles, stones, and boulders. During each flood, alluvium from stream banks is freshly deposited and partly reworked. Vegetation is limited, consisting mainly of a few scanty growth of annual grasses and forbs and a few willows and cottonwood trees.

27. Ramona Sandy Loam - Ramona sandy loam consists of well-drained, gently sloping to moderately steep soils, 2 to 30% slope that formed on fans and terraces in granitic alluvium. Runoff is medium to rapid, and the hazard of erosion is moderate to high where the soil is not protected

by vegetation. Vegetation is chamise and annual grasses and forbs

28. San Emigdio Sandy Loam - San Emigdio sandy loam consists of well-drained strongly sloping soils 9 to 15% slope. This soil formed on alluvial fans in somewhat mixed alluvium derived mainly from sedimentary materials. Runoff is slow to medium, and the hazard of erosion is moderate in places where the soil does not have a protective cover of vegetation. Vegetation is chamise, annual grasses and forbs.

29. San Emigdio Gravelly Sandy Loan - San Emigdio gravelly sandy loam consists of well-drained gently sloping to moderately sloping soils, 2 to 9% slope. This soil formed on alluvial fans in somewhat mixed alluvium derived mainly from sedimentary materials. Runoff is slow to medium, and the hazard of erosion is slight. Vegetation is chamise, annual grasses and forbs.

30. San Emigdio Fine Sandy Loam - San Emigdio fine sandy loam consists of well-drained nearly level soils, 0 to 2% slope. This soil formed on alluvial fans in somewhat mixed alluvium derived mainly from sedimentary materials. Runoff is slow and the hazard of erosion is slight. Vegetation is chamise, annual grasses and forbs.

31. San Timoteo Loam Eroded - San Timoteo loam eroded consists of well-drained steep soils, 30 to 50% slope. This soil formed on uplands in material derived from soft, weathered sandstone. Runoff is rapid and the hazard of erosion is moderate to high in places where the soil is left bare. Vegetation is chamise, annual grasses and forbs.

32. Saugas Sandy Loam - Saugus sandy loam consists of well-drained steep soils, 30 to 50% slope. This soil formed on uplands in weakly consolidated sediment. Runoff is rapid and the hazard of erosion is

moderate to high in places where the soil is left bare. Vegetation is chamise, annual grasses and forbs.

33. Soboda Gravelly Loamy Sand - Soboda gravelly loamy sand consists of excessively drained, nearly level to moderately sloping soils, 0 to 9% slope. This soil formed on long, broad alluvial fans in granitic alluvium. Runoff is very slow, and the hazard of erosion is slight. Vegetation is chamise, annual grasses and forbs.

34. Soboda Stony Loamy Sand - Soboda stony loamy sand consists of excessively drained gently sloping to moderately sloping soils, 2 to 9% slope. This soil formed on long, broad, smooth alluvial fans in granitic alluvium. Runoff is slow and the hazard of erosion is slight. Vegetation is chamise, annual grasses and forbs.

35. Soper Gravelly Loam - Soper gravelly loam consists of well-drained, moderately steep to steep soils, 15 to 50% slope, that formed on uplands in material weathered from weakly consolidated sandstone or conglomerate. Runoff is rapid and the hazard of erosion is moderate to high in places where the soil is left unprotected by vegetation cover. Vegetation is annual grasses and forbs and scattered live oak trees.

36. Sorrento Clay Loam - Sorrento clay loam consists of well-drained, nearly level to gently sloping soils, 0 to 5% slope. This soil formed on alluvial fans in alluvium derived from mixed granitic and sedimentary sources. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Vegetation is annual grasses and forbs.

37. Tollhouse Sandy Loam - Tollhouse sandy loam consists of excessively drained, steep soils, 30 to 50% slope, that formed on uplands in material weathered from granitic rocks. Runoff is rapid to very

rapid and the hazard of erosion is moderate to high in places where soil is left bare.

38. Tujunga Loamy Sand - Tujunga loamy sand consists of somewhat excessively drained, nearly level to gently sloping soils 0 to 5% slope, that formed on broad long alluvial fans in granitic alluvium. Runoff is slow to very slow. The hazard of water erosion is slight. The hazard of soil blowing is moderate to high on bare soil. Vegetation is thin stands of chamise, some big sagebrush and annual grasses and forbs.

39. Tujunga gravelly loamy sand - Tujunga gravelly loamy sand consists of somewhat excessively drained, nearly level to moderately sloping soil, 0 to 9% slope, that formed on long, broad, smooth alluvial fans in granitic alluvium. Runoff is very slow to slow and the hazard of erosion is slight because of the gravelly surface layer. Vegetation is thin stands of chamise, some big sagebrush, and annual grasses and forbs.

40. Vista-Rock Outcrop - Vista-Rock outcrop complex consists of well-drained, steep soils, 30 to 50% slope, that formed on foothills in the uplands in material weathered from granitic rock. This soil complex is about 50% Vista sandy loam and 30% rock outcrop. Runoff is medium to rapid, and the hazard of erosion is moderate. Vegetation is chamise and annual grasses and forbs.

41. Quarry-Gravel Pit - Quarry and gravel pit are areas where the soil has been removed so that a mineral or sand and gravel can be commercially extracted.

50. Water - Water includes all naturally occurring and man-made waterbodies.

SURFACE CONFIGURATION CODE DESCRIPTION

1 = Simple Surface - a single, continuous plain with only minor variations over the entire surface of the area. This plain may be flat, concave or convex in profile and/or transect.

2 = Undulating Surface - gently fluctuating plains in profile and/or transect; without angularity.

3 = Complex Surface - multiple changes of slope and aspect with angular or mixed breaks in slope.

GEOLOGIC HAZARDS

Alquist Priolo Fault Zones Code Description

Alquist Priolo zones are seismic hazard zones adjacent to potentially active faults. The boundaries for the zones were determined by California Division of Mines and Geology.

1. Area not within fault zone. These areas fall outside official Alquist Priolo Fault hazard zones.
2. Area within fault zone. These areas are within official Alquist Priolo Fault hazard zones.

Landslide Susceptibility Code Descriptions

Landslide susceptibility information came from Major Landslides and Generalized Relative Slope Stability Southwestern San Bernardino County California by D. M. Morton. This map divided the landscape into three landslide susceptibility regions: generally devoid of landslides, low to moderate landslide susceptibility, and moderate to high landslide susceptibility. Also delineated on this map were the location of known landslides.

1. Generally devoid of landslides, not a known landslide. This code indicates that the area is within the generally devoid of landslides region with no landslide present.
2. Generally devoid of landslides, known landslide. This code indicates that the area is a known landslide which is located within a generally devoid of landslides region.
3. Low to moderate landslide susceptibility not a known landslide. This code refers to areas within the low to moderate landslide susceptibility region which are not known landslides.

4. Low to moderate landslide susceptibility, known landslide. This code indicates that the area is a known landslide which is located within a low to moderate landslide susceptibility region.
5. Moderate to high landslide susceptibility, not a known landslide. This code indicates that the area is within the moderate to high landslide susceptibility region with no landslides present.
6. Moderate to high landslide susceptibility, known landslide. This code indicates that the area is a known landslide which is located within a moderate to high landslide susceptibility region.

DEPTH TO GROUND WATER-CODE DESCRIPTION

Depth to ground-water indicates the depth from the surface, measured in feet at which ground-water is encountered. Fluctuations in the ground-water level will occur in response to precipitation, ground-water recharge and ground-water mining.

1. 0-50' - Within this class ground-water is encountered between the surface and 50 feet.
2. 50'-100' - Within this class a ground-water is encountered between 50 to 100 feet.
3. 100' and Greater - Within this class ground-water is encountered at 100' or greater.

FLOOD-PRONE AREAS CODE DESCRIPTION

The approximate boundaries of flood-prone areas are shown on this map. There is, on the average, about 1 chance in 100 that the designated flood-prone areas will be inundated in any year.

1. Not Flood-Prone - These areas fall outside designated flood-prone areas.
2. Flood-Prone - There is 1 chance in 100 that the area will be inundated in any year.

MANUSCRIPT #2 SURFACE HYDROLOGY AND FAULT MAP

STREAM ORDER CODE DESCRIPTION

The order of a stream is a representation of its place in a hierarchy of streams feeding into it. This is a functional relationship of course line segments as described below.

1 = First Order - A first order stream is one with no tributary streams. All of its flow is derived as runoff from a single basin.

2 = Second Order - A second order stream drains two or more primary drainage basins containing first order streams. A second source of water comes from runoff along the course line itself.

3 = Third Order - A third order stream drains at least two second order streams as well as an unlimited number of first order streams and interbasin runoff.

4 = Fourth Order - A fourth order stream drains at least two third order streams, as well as an unlimited number of first and second order streams, and interbasin runoff.

5 = Fifth Order - A fifth order stream drains at least two fourth order streams as well an unlimited number of first, second and third order streams, and interbasin runoff.

FLOW CHARACTERISTICS CODE DESCRIPTION

The flow regime indicates whether the stream flows the year around or not.

1 = Perennial Flow - The stream continues to flow throughout the year.

2 = Intermittent Flow - The stream does not flow continuously throughout the year. Flow may occur only after storms, during the rainy season or from snow melt. During the rest of the year the streambed is dry. This must not be confused with ephemeral streams which flow and dry up daily.

CHANNELIZATION CODE DESCRIPTION

Channelization indicates whether a stream's course has been altered by man. Within most of the study area, streams running through populated valley areas are channelized to minimize the flood hazard.

1. Not Channelized - This indicates that the stream follows a natural course.
2. Channelized - This indicates that the stream flows within a man-made channel.

FAULT CODE DESCRIPTION

1. Accurately located fault
2. Well located fault
3. Concealed Fault
4. Fault inferred from seismic activity

Accurately Located Fault - An accurately located fault is one for which there is not only good evidence for the existence of the fault, but the exact location of the fault is known.

Well Located Fault - A well located fault is one for which there is good evidence for the existence of the fault, but the exact location of the fault trace is not certain.

Concealed Fault - A concealed fault is one for which the trace of the fault is covered by a younger rock unit not affected by the fault; thus, the exact location of the fault is unknown.

Fault Inferred From Seismic Activity - A fault inferred from seismic activity is one which has little or no surface evidence, but whose existence is suspected because of seismic activity in the area of the inferred fault.

MANUSCRIPT #3 GENERAL PLAN LAND USE

GENERAL PLAN LAND USE CODE DESCRIPTION

This land use map was obtained from the San Bernardino County General Plan. The map shows permitted land uses projected for the next 5 to 20 years. It represents partial land use policy for unincorporated areas only. For city areas this map is only diagramatic. For policy guidance within city areas the user should refer to the appropriate city general plan. The code structure is self-explanitory, therefore, no code description are given.

MANUSCRIPT #4 TRANSPORTATION AND INFRASTRUCTURE MAP

ROADS

Responsible Agency Code Description

The following agencies constructed and are responsible for maintaining the roads.

1. State road
2. County road
3. National Forest Service road
4. U.S. Highways

Road Classified by Intensity of Use Grouping Code Description

This item classifies road according to traffic intensities.

1. Arterial - Freeways were the arterial highway mapped for this study.
2. Collector - Collectors included all major highways. The San Bernardino County General Plan Circulation Map was used to identify collector road.
3. Local - No local roads within the valley area were mapped.

Roads by General Surface Qualities Code Description

This item classifies roads according to surface quality.

1. Paved - A paved road is one which has improved road beds and all weather surface.
2. Non-Paved - No non-paved roads within the valley area were mapped.

Scenic Roads Code Description

Scenic roads are State Highways officially designated as scenic.

1. Not Scenic - This indicates that a road is not a scenic road.
2. Scenic- This indicates that a road is a State Scenic Highway.

RAILROADS

RAILROAD CODE DESCRIPTION

Only major railroad lines were mapped for this study.

1. Major Railroad - This indicates that the specified line segment is a major railroad.

ANNOTATED BIBLIOGRAPHY

The following is an annotated bibliography containing description of each collateral item used for this study.

DESCRIPTION: The following L:24,000 U.S.G.S. topographic sheets were photographically reduced and composited together to produce the San Bernardino and Redlands 1:62,500 topographic base maps.

San Bernardino 1:62,500	Date	Redlands	Date
Fontana 1:24,000	1967	Harrison Mtn. 1:24,000	1967
Devore 1:24,000	1966	Keller Peak 1:24,000	1967
San Bernardino North 1:24,000	1967	Redlands 1:24,000	1967
San Bernardino South 1:24,000	1967	Yucaipa 1:24,000	1967

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ITEM NAME: Topographic Base Maps

SOURCE: Environmental Science Research Institute (ESRI)
Note:ESRI reformatted 1:24,000 U.S.G.S. topographic maps to produce the 1:62,500 base maps used for this study

AGE:
Date of Preparation 1/1981
Date of Publication
Date of Revision

CURACY:
[X] Suitable for site specific evaluation
[ ] Suitable for identification of local area conditions/features
[ ] Suitable for identification of regional conditions/features
[ ] Non-Geographic
Other

REVISION SCHEDULE:
Frequency of scheduled revisions
Published revisions available [ ] Yes [XX] No

SCALE: 1:62,500

COST:

DATA CLASSES/LEGEND CATEGORIES:
Standard U.S.G.S. mapping symbols
Topographic contours
(Urban tint deleted)

ERAGE:
[X] Complete for study area
[ ] Partial for study area
[ ] Individual sites only
Other # of maps = 8

ACQUISITION NOTES: ESRI
380 New York St.
Redlands, CA 92373
Note: USGS mylar topographic sheets can be ordered from:
U.S.G.S.
Branch of Distribution
Denver Federal Center
Denver, Colorado 80225

AT:
[ ] Published Map/Report
[ ] Unpublished Map/Report
[ ] Records/Files
[ ] Other

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Geographic Coordinates (latitude, longitude)Universal Transverse Mercator, Congressional Survey (Township,Range)State Plane Coordinates
Stable Base [X] Yes [ ] No
Individual Map Size 14 1/2" x 17 1/2"

CONTACT PERSON:
Russ Michal
ES..
380 New York St Redlands CA 92373 (714)793-2853

NICAL ASSISTANCE:
A -ilabl om s [XX]

SCRIPTION:

Fault zone was acquired from State of California special studies maps which identified both faults and seismic hazard zones. The fault and seismic hazard information were printed on 1:24,000 U.S.G.S. Topograph sheets. The following maps were used :

Name	Published	Name	Published
Devore	1974	Harrison Mtn.	1974
San Bernardino North	1974	Keller Peak	1974
San Bernardino South	1977	Redlands	1977
Yucaipa	1979		

B-70

ITEM NAME;

State of California Special Studies Zones

SOURCE: California Division of Mines and Geology

AGE:
Date of Preparation ____
Date of Publication 1974-1979
Date of Revision ____

URACY:
[ ] Suitable for site specific evaluation
[X] Suitable for identification of local area conditions/features
[ ] Suitable for identification of regional conditions/features
[ ] Non-Geographic
Other ____

REVISION SCHEDULE:
Frequency of scheduled revisions ____
Published revisions available [ ] Yes [ ] No

SCALE: 1:24,000

COST: No Cost

DATA CLASSES/LEGEND CATEGORIES:

Potentially Active Faults
Aerial Photo Lineaments
Special Study Zone Boundaries

RAGE:
[X] Complete for study area
[ ] Partial for study area
[ ] Individual sites only
[ ] Other # of Maps = 8

T:
[ ] Published Map/Report
[ ] Unpublished Map/Report
[ ] Records/Files
[ ] Other ____

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Geographic coordinates (latitude and longitute) Universal Transverse Mercator Congressional Survey (township,range) State Plane Coordinates
Stable Base [ ] Yes [X] No
Individual Map Size 19"x22 1/2"

ACQUISITION NOTES:

Maps acquired over the counter from the San Bernardino County Planning Department

ICAL ASSISTANCE:
Available from source [X] Yes [ ] No

CONTACT PERSON: Ron Matyas
San Bernardino County Planning Department
San Bernardino, CA

ESCRIPTION:

The soil survey maps soils to the series and phase level. The accompaning text describes each soil series in detail

B-71

ITEM NAME:

Soil Survey of San Bernardino County Southwestern Part, California

SOURCE: United States Department of Agriculture, Soil Conservation Service in Cooperation with University of California Agricultural Experiment Station

AGE:
Date of Preparation 1977
Date of Publication Jan.1980
Date of Revision

CURACY:
- [ ] Suitable for site specific evaluation
- [X] Suitable for identification of local area conditions/features
- [ ] Suitable for identification of regional conditions/features
- [ ] Non-Geographic

Other

REVISION SCHEDULE:
Frequency of scheduled revisions
Published revisions available [ ] Yes [X] No

SCALE: 1:24,000

COST: No Cost

DATA CLASSES/LEGEND CATEGORIES:

Soil series and phases

ERAGE:
- [X] Complete for study area
- [ ] Partial for study area
- [ ] Individual sites only
- [ ] Other # of maps = 8

ACQUISITION NOTES: U.S. Department of Agriculture
Soil Conservation Service
Redlands Field Office
Redlands, California

AT:
- [ ] Published Map/Report
- [ ] Unpublished Map/Report
- [ ] Records/Files
- [ ] Other

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Congressional Township and Range and Latitude, Longitude Cartesian Coordinate
Stable Base [ ] Yes [X] No
Individual Map Size 19" x 22 1/2"

CONTACT PERSON:

NICAL ASSISTANCE:
labl ...m so... [X] ...es [ ] no

SCRIPTION:

The Thomas Bros. Street Atlas was used to identify State scenic highways

B-72

ITEM NAME:

San Bernardino County Popular Street Atlas

SOURCE:

Thomas Bros. Maps

AGE:
Date of Preparation N/A
Date of Publication 1980
Date of Revision N/A

RACY:
[X] Suitable for site specific evaluation
[ ] Suitable for identification of local area conditions/features
[ ] Suitable for identification of regional conditions/features
[ ] Non-Geographic
Other

RAGE:
[X] Complete for study area
[ ] Partial for study area
[ ] Individual sites only
[X] Other # of Maps = 19

REVISION SCHEDULE:
Frequency of scheduled revisions
Published revisions available [ ] Yes [ ] No

SCALE: 1:62,500

COST: $15.00

DATA CLASSES/LEGEND CATEGORIES:

Scenic State Roads
Topographic Information

ACQUISITION NOTES: Available at many bookstores

T:
[X] Published Map/Report
[ ] Unpublished Map/Report
[ ] Records/Files
[ ] Other

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Congressional Survey T and R and Thomas Bros. Alpha/numeric Coordinate System
Stable Base [ ] Yes [X] No
Individual Map Size 7" x 8"

CONTACT PERSON:

NICAL ASSISTANCE:
Available from source [X] Yes [ ] No

ESCRIPTION:

This map identifies permitted land use groupings. It depicts generalized land use patterns printed on 1:62,500 U.S.G.S. topographic sheets

ITEM NAME:

San Bernardino County General Plan Land Use.
East Valley
San Bernardino County Consolidated General Plan
and Implementation System

SOURCE: San Bernardino County Planning Department

AGE:
Date of Preparation ____
Date of Publication 1979
Date of Revision ____

B-73

CURACY:
- [ ] Suitable for site specific evaluation
- [ ] Suitable for identification of local area conditions/features
- [x] Suitable for identification of regional conditions/features
- [ ] Non-Geographic
- Other ____

REVISION SCHEDULE:

Frequency of scheduled revisions ____

Published revisions available [ ] Yes [ ] No

SCALE: 1:62,500

COST: No Cost

DATA CLASSES/LEGEND CATEGORIES: Seven permitted land use groupings

1. Residential
2. Agricultural
3. Public
4. Rural living
5. Rural conservation
6. Commercial
7. Industrial

ERAGE:
- [x] Complete for study area
- [ ] Partial for study area
- [ ] Individual sites only
- [ ] Other ____

'AT:
- [x] Published Map/Report
- [ ] Unpublished Map/Report
- [ ] Records/Files
- [ ] Other ____

FOR MAPPED INFORMATION ONLY:

Type of Coordinate System Township and Range

Stable Base [ ] Yes [x] No

Individual Map Size 19" x 29"

ACQUISITION NOTES: San Bernardino County Planning Department
1111 E. Mill St.
San Bernardino, Calif.

CONTACT PERSON: Ron Matyas
San Bernardino County Planning De
4) 3 J72

NICAL ASSISTANCE:

abl m sc [x] .. [ ]

SCRIPTION:

The circulation map shows Freeways, major highways, divided major highways and secondary highways. No local roads or trails are mapped

ITEM NAME; San Bernardino County General Plan Circulation
San Bernardino County Consolidated General Plan and Implementation System

SOURCE: San Bernardino County Planning Department

AGE:
Date of Preparation ______
Date of Publication 1979
Date of Revision ______

B-74

RACY:

] Suitable for site specific evaluation
] Suitable for identification of local area conditions/features
x] Suitable for identification of regional conditions/features
] Non-Geographic
Other ______

REVISION SCHEDULE:

Frequency of scheduled revisions ______
Published revisions available [ ] Yes [ ] No

SCALE: 1:62,500

COST: No cost

DATA CLASSES/LEGEND CATEGORIES:

Freeway, divided major, major and secondary highways.

AGE:

] Complete for study area
] Partial for study area
] Individual sites only
] Other # of Maps = 1

T:

] Published Map/Report
] Unpublished Map/Report
Records/Files
Other ______

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Congressional Survey Township and range
Stable Base [ ] Yes [XX] No
Individual Map Size 19" x 29"

ACQUISITION NOTES: San Bernardino County Planning Department
1111 E. Mill St.
San Bernardino, CA

CONTACT PERSON: Ron Matyas
San Bernardino County Planning Dept.

ICAL ASSISTANCE:

Available from source [x] Yes [ ] No

ESCRIPTION:

This map shows general depth to groundwater in 25' increments, delineated on U.S.G.S. topographic sheets. It was obtained from the following report: Geologic Hazards in Southwestern San Bernardino County, California, Special Report 113, Plate 4B, California Division of Mines and Geology

B-75

CURACY:

- [ ] Suitable for site specific evaluation
- [ ] Suitable for identification of local area conditions/features
- [XX] Suitable for identification of regional conditions/features
- [ ] Non-Geographic
- Other

ERAGE:

- [X] Complete for study area
- [ ] Partial for study area
- [ ] Individual sites only
- [ ] Other # of Maps = 1

AT:

- [X] Published Map/Report
- [ ] Unpublished Map/Report
- [ ] Records/Files
- [ ] Other

FOR MAPPED INFORMATION ONLY:

Type of Coordinate System Geographic Coordinates (latitude, longitude)

Stable Base [ ] Yes [X] No

Individual Map Size 22 1/2" x 37"

NICAL ASSISTANCE:

Available from source [XX] Yes [ ] No

ITEM NAME:

Map showing surface waters and marshes in the late 1800's and generalized depth to groundwater (1960), Upper Santa Ana Valley, Southwestern San Bernardino County, California
Compiled by Donald L. Fife

SOURCE: California Division of Mines and Geology

AGE:
Date of Preparation
Date of Publication 1974
Date of Revision

REVISION SCHEDULE:

Frequency of scheduled revisions N.A.

Published revisions available [ ] Yes [XX] No

SCALE: 1:48,000

COST:

DATA CLASSES/LEGEND CATEGORIES:

Artesian Areas (1963) (1904)
Streams surveyed 1880's, 1890's
Bog and Swamps (1888)
Depth to groundwater
Faults and groundwater barriers

ACQUISITION NOTES:

California Division of Mines and Geology
Los Angeles District Office
Room 1065
Los Angeles, California 90012

CONTACT PERSON:

SCRIPTION:

The flood prone area maps have flood hazard zones delineated on 1:24,000 U.S.G.S. topographic sheets. The following flood prone maps were used:

	Published	Revised
Fontana	1976	----
Devore	1976	1977
San Bernardino North	1973	----
San Bernardino South	1973	----
Harrison Mtn.	1969	1975
Keller Peak	1973	----
Redlands	1969	1975
Yucaipa	1969	1975

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RACY:

] Suitable for site specific evaluation

] Suitable for identification of local area conditions/features

] Suitable for identification of regional conditions/features

] Non-Geographic

Other

AGE:

] Complete for study area

] Partial for study area

] Individual sites only

] Other # of Maps = 8

T:

Published Map/Report

Unpublished Map/Report

Records/Files

Other

FOR MAPPED INFORMATION ONLY:

Type of Coordinate System Geographic coordinate (latitude, longitude) Universal Transverse Mercator, Congression Survey (township and Range) State Plane Coordinates

Stable Base ☐ Yes ☒ No

Individual Map Size 19" x 22 1/2"

ICAL ASSISTANCE:

Available from source ☒ Yes ☐ No

ITEM NAME:

Map of Flood Prone Areas

SOURCE: U.S. Department of Interior
Geologic Survey
Water Resources Division

AGE:

Date of Preparation

Date of Publication 1973-1977

Date of Revision

REVISION SCHEDULE:

Frequency of scheduled revisions Approximately 10 years

Published revisions available ☒ Yes ☐ No

SCALE: 1:24,000

COST: No cost

DATA CLASSES/LEGEND CATEGORIES:

ACQUISITION NOTES: United States Department of the Interior
Geologic Survey
California District Office
Water Resources Division
855 Oak Grove Avenue
Menlo Park, California 94025

CONTACT PERSON: Nancy Ordazzo

SCRIPTION:

Eight color infrared transparencies were used to map the study area. The imagery was excellent in quality and free of cloud cover. Black and white transparencies were made from these images at a scale of 1:62,500

B-77

URACY:

- [X] Suitable for site specific evaluation
- [ ] Suitable for identification of local area conditions/features
- [ ] Suitable for identification of regional conditions/features
- [ ] Non-Geographic

Other

ERAGE:

- [X] Complete for study area
- [ ] Partial for study area
- [ ] Individual sites only
- [ ] Other # of maps used = 8 photo grames

MAT:

- [ ] Published Map/Report
- [ ] Unpublished Map/Report
- [ ] Records/Files
- [ ] Other Photographs

FOR MAPPED INFORMATION ONLY:

Type of Coordinate System N/A

These are uncontrolled photos

Stable Base [ ] Yes [ ] No

Individual Map Size 9" x 9"

NICAL ASSISTANCE:

lab . om s . . . [X] . . . . .

ITEM NAME:

Imagery:
Color infrared transparencies

SOURCE: Eros Data Center
U.S. Geologic Survey

AGE:
Date of Preparation N/A
Date of Publication 1980
Date of Revision N/A

REVISION SCHEDULE:

Frequency of scheduled revisions

Published revisions available [ ] Yes [X] No

SCALE:

1:120,000 approx.

COST:

$15.00 each

DATA CLASSES/LEGEND CATEGORIES:

ACQUISITION NOTES:

Eros Data Center
U.S. Geologic Survey
Sioux Falls, S.D. 57198

CONTACT PERSON:

DESCRIPTION:

This map shows general depth to groundwater in 50 increments. It was used to map the Yucaipa area which was not covered by the other more detailed sub-surface hydrology source. Maps showing surface water and marshes in the late 1800's and generalized depth to groundwater (1960) Upper Santa Ana Valley, Southwestern San Bernardino County, California.

B-78

ITEM NAME: Geohydrologic Map of Southern California

by W. R. Moyle, Jr.

SOURCE: Department of the Interior
United States Geological Survey

AGE:
Date of Preparation 1974
Date of Publication
Date of Revision

CURACY:
- [ ] Suitable for site specific evaluation
- [ ] Suitable for identification of local area conditions/features
- [XX] Suitable for identification of regional conditions/features
- [ ] Non-Geographic
- Other

REVISION SCHEDULE:
Frequency of scheduled revisions
Published revisions available [ ] Yes [ ] No

SCALE: 1:1,500,000

COST:

DATA CLASSES/LEGEND CATEGORIES:

ERAGE:
- [XX] Complete for study area
- [ ] Partial for study area
- [ ] Individual sites only
- [ ] Other

ACQUISITION NOTES: Department of the Interior
U.S. Geological Survey
Menlo Park, California

MAT:
- [XX] Published Map/Report
- [ ] Unpublished Map/Report
- [ ] Records/Files
- [ ] Other

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Geographic Coordinate System (latitude, longitude)
Stable Base [ ] Yes [ ] No
Individual Map Size 41" x 51"

CONTACT PERSON:

NICAL ASSISTANCE:
Available from source [X] Yes [ ] No

B-79

:SCRIPTION:

This detailed geologic map printed on U.S.G.S. topographic sheets shows formation rock type and geologic age. It was obtained from the following report: Geologic Hazards in Southwestern San Bernardino County, California, Special Report 113, Plate 113, California Division of Mines and Geology

ITEM NAME;

Generalized Geologic Map of Southwestern San Bernardino County California, Compiled by D.M. Morton

SOURCE: California Division of Mines and Geology

AGE:
Date of Preparation ____
Date of Publication 1974
Date of Revision ____

:URACY:

- [ ] Suitable for site specific evaluation
- [x] Suitable for identification of local area conditions/features
- [ ] Suitable for identification of regional conditions/features
- [ ] Non-Geographic

Other ____

REVISION SCHEDULE:

Frequency of scheduled revisions ____

Published revisions available [ ] Yes [ ] No

SCALE: 1:48,000

COST: ____

DATA CLASSES/LEGEND CATEGORIES:

Formation, Rock type, and Geologic age

ERAGE:

- [x] Complete for study area
- [ ] Partial for study area
- [ ] Individual sites only
- [ ] Other # of Maps = 8

ACQUISITION NOTES: California Division of Mines and Geology
Los Angeles District Office
Room 1065
Los Angeles, CA 90012

'AT:

- [x] Published Map/Report
- [ ] Unpublished Map/Report
- [ ] Records/Files
- [ ] Other ____

FOR MAPPED INFORMATION ONLY:

Type of Coordinate System Geographic Coordinates (latitude, longitude)

Stable Base [ ] Yes [x] No

Individual Map Size 22 1/2" x 37"

CONTACT PERSON:

NICAL ASSISTANCE:

Available from sq ... [x]

ESCRIPTION:

This map shows general slope, landslide susceptibility and known landslides delineated, printed on U.S.G.S. topographic sheets. It was obtained from the following report: Geologic Hazards in Southwestern San Bernardino County, Calif., Special Report 113, Plate 3B, California Division of Mines and Geology

B-80

ITEM NAME: Major Landslides and Generalized Relative Slope Stability Map. Southwestern San Bernardino County, California, Compiled by D. M. Morton

SOURCE: California Division of Mines and Geology

AGE:
Date of Preparation ______
Date of Publication 1974
Date of Revision ______

CURACY:
[ ] Suitable for site specific evaluation
[X] Suitable for identification of local area conditions/features
[ ] Suitable for identification of regional conditions/features
[ ] Non-Geographic
Other ______

REVISION SCHEDULE:
Frequency of scheduled revisions ______
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SCALE: 1:48,000

COST:

DATA CLASSES/LEGEND CATEGORIES:

Generalized Slope
Generalized Landslide Susceptibility
Known Landslides

ERAGE:
[X] Complete for study area
[ ] Partial for study area
[ ] Individual sites only
[ ] Other # of Maps - 1

AT:
[X] Published Map/Report
[ ] Unpublished Map/Report
[ ] Records/Files
[ ] Other ______

FOR MAPPED INFORMATION ONLY:
Type of Coordinate System Geographic Coordinates Latitude and longitude
Stable Base [ ] Yes [X] No
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ACQUISITION NOTES: California Division of Mines and Geology
Los Angeles District Office
Room 1065
Los Angeles, California 90012

CONTACT PERSON:

NICAL ASSISTANCE:
Available from source [X] Yes [ ] No

SAN BERNARDINO NATIONAL FOREST VEGETATION CODES

01 = Douglas Fir & Big Cone Douglas Fir
02 = Ponderosa & Jeffrey Pine
04 = White Fir
07 = Sugar Pine
08 = Lodgepole Pine
09 = Incense Cedar
11 = Coulter Pine
12 = Pinon Pine
14 = Juniper
15 = Limber Pine
16 = Deciduous Woodland
17 = Live Oak Woodland
18 = Joshua Tree Woodland
19 = Ceanothus Chapparal (Scrub Oak Inc.)
20 = Chamise Chapparal
21 = Manzanita Chapparal
22 = Red Shank Chapparal
23 = Juniper - Scrub Oak - Pinon Woodland
24 = Coastal Sage
25 = Great Basin Sage
26 = Riparian, Live Oak
27 = Riparian, Alder-Willow-Aspen
28 = Riparian, Sycamore-Cottonwood
29 = Desert Scrub Veg. (Cresote)
30 = Grassland
31 = Barren, Urban, or Agriculture
32 = Wilderness
33 = Water Body
34 = Interior Live Oak Woodland (Emergent)

APPENDIX C

Vertical Integration Data Base
Soil Interpretive Ratings
(San Bernardino Valley Only)

SOIL INTERPRETIVE RATINGS

CIRSS

SAN BERNARDINO VERTICAL INTEGRATION STUDY

for

NASA and ESRI

PREPARED BY:

Aerial Information Systems, Inc.
23537 Crest Forest Drive
P. O. Box 790
Crestline, California 92325

Soils, Column 8 and 9	SOIL PROPERTIES: Depth to Bedrock	Permeability	Shrink-swell	Surface Texture	Available W H C	Drainage	SOIL INTERPRETATIONS: Dwelling w/o Base	Septic Tank	Shallow Excavations	Sanitary Landfills	Cover Materials	Hydrologic Soil	Source of Sand	Source of Gravel	Source of Roadfill	AG CAPABILITY: Irrig vs Dry	Minimum	Maximum	Predominant
01 Alo clay	3	1	3	21	25	3	6	6	6	6	6	7	5	5	4	2	611	611	611
02 Chino silt loam	>5	3	1	14	28	5	3	6	1	1	3	2	5	5	4	1	100	100	100
03 Chualar clay loam	>5	3	2	17	27	3	3	6	3	2	3	2	5	5	4	2	311	100	211
04 Cieneba sandy loam	1 5	6	1	9	22	2	6	6	6	6	6	2	5	5	4	2	411	411	411
05 Cieneba-Friant sandy loam	1 5	6	1	9	14	2	6	6	6	6	6	5	5	5	4	2	711	711	711
06 Cieneba-Rock outcrop complex	1	6	1	9	22	2	6	6	6	6	6	2	5	5	4	2	711	711	711
07 Crafton-Rock outcrop complex, eroded	3	5	1	9	12	3	6	6	6	6	6	4	5	5	4	2	711	711	711
08 Delhi fine sand	>5	6	1	3	07	2	1	1	6	6	6	2	1	5	1	1	314	314	314
09 Fontana clay loam	3	3	2	17	30	3	6	6	6	6	6	4	5	5	4	2	611	411	611
10 Friant-Rock outcrop complex	1 5	5	1	11	14	2	6	6	6	6	6	7	5	5	4	2	711	711	711
11 Garretson very fine sandy loam	>5	5	1	12	23	3	3	3	1	1	1	2	5	5	3	1	211	211	211
12 Gaviota-Rock outcrop complex	1.5	5	1	11	17	2	6	6	6	6	6	7	5	5	4	2	711	711	711
13 Grangeville fine sandy loam	>5	5	1	11	20	5	6	1	1	6	1	3	4	4	3	1	100	100	100
14 Grangeville fine sandy loam, saline-alkali	>5	5	1	11	20	5	6	1	1	6	1	3	4	4	3	1	336	336	336
15 Greenfield sandy loam	>5	5	1	9	16	3	2	1	2	6	1	2	4	4	1	1	311	211	211
16 Greenfield cobbly sandy loam	>5	5	1	9	12	3	3	3	3	6	3	2	4	4	1	1	437	437	437
17 Hanford coarse sandy loam	>5	5	1	10	19	3	2	2	2	6	2	2	4	4	1	1	311	211	211
18 Hanford sandy loam	>5	5	1	9	19	3	1	1	1	6	1	2	4	4	1	1	100	100	100
19 Hilmar loamy fine sand	>5	6	1	7	08	5	2	6	6	6	3	6	5	5	1	1	214	214	214
20 Merrill silt loam	3.5	4	1	14	24	5	3	6	6	1	3	4	5	5	3	1	338	338	338
21 Metz coarse sandy loam	>5	5	1	10	09	2	1	1	6	6	6	1	4	4	1	1	334	334	334
22 Monserate sandy loam	3	5	1	9	15	4	3	6	6	1	3	4	5	5	4	1	318	318	318
23 Nacimiento clay loam	3	3	2	17	28	3	6	6	6	6	6	4	5	5	4	2	611	411	611
24 Oak Glen sandy loam	>5	5	1	9	12	3	1	1	3	6	1	2	4	4	1	1	211	211	211
25 Oak Glen gravelly sandy loam	>5	5	1	10	10	3	5	5	5	6	4	2	4	4	2	1	411	311	311
26 Psamments and Fluvents, frequently flooded	9	9	9	99	99	99	9	9	9	9	9	9	9	9	9	2	821	821	821
27 Ramona sandy loam	>5	5	1	9	12	3	4	6	4	4	5	2	5	5	3	1	411	211	211
28 San Emigdio sandy loam	>5	5	1	9	20	3	3	3	3	6	2	2	4	4	1	1	311	311	311
29 San Emigdio gravelly sandy loam	>5	5	1	10	12	3	1	1	1	6	2	2	4	4	1	1	211	211	211
30 San Emigdio fine sandy loam	>5	5	1	11	20	3	1	1	1	6	2	2	4	4	1	1	211	100	211
31 San Timoteo loam	2 5	4	1	13	25	3	6	6	6	6	6	4	5	5	4	2	611	611	611
32 Saugus sandy loam	4	5	1	9	12	3	6	6	6	6	6	2	5	5	4	2	711	711	711
33 Soboba gravelly loamy sand	>5	6	1	6	06	1	1	1	6	6	6	1	1	1	1	2	631	631	631
34 Soboba stony loamy sand	>5	6	1	6	02	1	1	1	6	6	6	1	5	5	4	2	631	631	631
35 Soper gravelly loam	3	7	1	13	23	3	6	6	6	6	6	2	5	5	4	2	711	611	711
36 Sorrento clay loam	>5	3	2	17	27	3	3	6	3	1	3	2	5	5	4	1	211	100	100
37 Tollhouse sandy loam	1.5	5	1	9	13	1	6	6	6	6	6	7	5	5	4	2	711	711	711
38 Tujunga loamy sand	>5	6	1	5	05	2	1	1	6	6	6	1	4	4	1	1	314	314	314
39 Tujunga gravelly loamy sand	>5	6	1	6	04	2	1	1	6	6	6	1	3	3	1	1	434	434	434
40 Vista-Rock outcrop complex	3 3	5	1	10	12	3	6	6	6	6	6	4	5	5	4	2	711	711	711
41 Quarry-Gravel pit	9	9	9	99	99	99	9	9	9	9	9	9	9	9	9	2	999	999	999
50 Water	9	9	9	99	99	99	9	9	9	9	9	9	9	9	9	2	999	999	999

Soils, Column 8 and 9		K Value	T Value
01	Alo clay	.24	2
02	Chino silt loan	.43	5
03	Chualar clay loam	.28	3
04	Cieneba sandy loam	.24	1
05	Cieneba-Friant sandy loam	.28	
06	Cieneba-Rock outcrop complex	.24	
07	Crafton-Rock outcrop complex (eroded)	.32	
08	Delhi fine sand	.20	5
09	Fontana clay loam	.32	2
10	Friant-Rock outcrop complex	.32	
11	Garretson very fine sandy loam	.20	5
12	Gaviota-Rock outcrop complex	.43	
13	Grangeville fine sandy loam	.37	5
14	Grangeville fine sandy loam, saline-alkali	.37	5
15	Greenfield sandy loam	.29	5
16	Greenfield cobbly sandy loam	.17	5
17	Hanford coarse sandy loam	.32	5
18	Hanford sandy loam	.32	5
19	Hilmar loamy fine sand	.24	5
20	Merrill silt loam	.43	5
21	Metz coarse sandy loam	.28	5
22	Monserate sandy loam	.43	3
23	Nacimiento clay loam	.32	2
24	Oak Glen sandy loam	.24	5
25	Oak Glen gravelly sandy loam	.17	5
26	Psamments and Fluvents, frequently flooded	.15	
27	Ramona sandy loam	.32	5
28	San Emigdio sandy loam	.32	5
29	San Emigdio gravelly sandy loam	.32	5
30	San Emigdio fine sandy loam	.32	5
31	San Timoteo loam	.43	5
32	Saugus sandy loam	.32	3
33	Soboba gravelly loamy sand	.15	5
34	Soboba stony loamy sand	.15	5
35	Soper gravelly loam	.32	3
36	Sorrento clay loam	.32	5
37	Tollhouse sandy loam	.24	1
38	Tujunga loamy sand	.20	5
39	Tujunga gravelly loamy sand	.15	5
40	Vista-Rock outcrop complex	.28	
41	Quarry-Gravel pit	.10	
50	Water	00	0

TABLE OF CONTENTS

SOIL PROPERTIES

The soil properties most commonly described, or used for environmental modeling, are developed here.

Depth to Bedrock

Average depth to bedrock is represented by a single digit code indicating the number of feet to bedrock from the surface horizon of the typical pedon, e.g. 3 = 3 feet depth. The numeral 9 means the depth was not recorded.

Permeability

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in the table do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Values shown are inches per hour:

1 = < .06

2 = .06 to .2

3 = .2 to .6

4 = .6 to 2

5 = 2 to 6

6 = 6 to 20

7 = > 20

9 = Too variable to rate

Shrink-swell Potential

Shrink-swell potential is the relative change in volume of a soil material with changes in moisture content. Extent of shrinking soil and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures.

1 = Low

2 = Moderate

3 = High *

4 = Too variable to rate

* A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Surface Texture

The relative proportions of sand, silt, and clay particles in a mass of soil. Values used are listed in order of increasing proportion of fine particles.

1 = Sand

2 = Coarse sand

3 = Fine sand

4 = Very fine sand

5 = Loamy sand

6 = Gravelly loamy sand

7 = Fine loamy sand

8 = Very fine loamy sand

9 = Sandy loam

10 = Gravelly sandy loam

11 = Fine sandy loam

12 = Very fine sandy loam

13 = Loam

14 = Silt loam

15 = Silt

16 = Sandy clay loam

17 = Clay loam

18 = Silty clay loam

19 = Sandy clay

20 = Silty clay

21 = Clay

99 = Variable

Available Water Holding Capacity

Available water holding capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Value ranges are the vapor pressure deficit at permanent wilting point in inches of mercury:

01 = 0.01 - 0.03

02 = 0.03 - 0.05

03 = 0.04 - 0.06

04 = 0.05 - 0.07

05 = 0.06 - 0.07

06 = 0.06 - 0.08

07 = 0.07 - 0.09

08 = 0.07 - 0.10

09 = 0.08 - 0.09

10 = 0.08 - 0.10

11 = 0.09 - 0.10

12 = 0.10 - 0.12

13 = 0.10 - 0.13

14 = 0.10 - 0.14

15 = 0.10 - 0.15

16 = 0.11 - 0.13

17 = 0.11 - 0.14

18 = 0.11 - 0.15

19 = 0.12 - 0.13

20 = 0.12 - 0.14

21 = 0.13 - 0.15

22 = 0.14 - 0.15

23 = 0.14 - 0.16

24 = 0.14 - 0.17

25 = 0.15 - 0.17

26 = 0.16 - 0.20

27 = 0.17 - 0.18

28 = 0.17 - 0.19

29 = 0.17 - 0.20

30 = 0.18 - 0.20

99 = Too variable to rate

Drainage

Drainage class refers to the condition of frequency and duration of periods of saturation or partial saturation that existed during the development of the soils. This differs from altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Classes used are:

1 = Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

2 = Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

3 = Well-drained soils may exhibit some mottling and are commonly of intermediate texture.

4 = Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the upper and mottling in the lower horizons.

5 = Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

6 = Poorly drained soils are wet for long periods, are light gray and most are mottled from the surface downward.

7 = Very poorly drained soils are wet nearly all the time. They have dark-gray or black surface layer. Deeper parts of the profile are gray or light gray, with or without mottling.

9 = Variable

SOIL INTERPRETATIONS

The soil interpretations are based on the soil properties significant to engineering. Ratings are used to summarize limitations or suitability of the soil.

Soil limitations are indicated by the terms slight, moderate, and severe. Slight means that soil properties are generally favorable for the specified use or that limitations are minor and easily overcome. Moderate means that some soil properties are unfavorable but can be overcome or modified by special planning and design. Severe means that soil properties are unfavorable and so difficult to correct or overcome as to require major soil reclamation, special designs, or intensive maintenance.

Soil suitability is shown by the terms good, fair and poor, which have meanings approximately parallel to the terms slight, moderate, and severe.

Dwellings Without Basements

Dwellings without basements are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Classes used are:

- 1 = Slight
- 2 = Slight to moderate
- 3 = Moderate
- 4 = Slight to severe
- 5 = Moderate to severe
- 6 = Severe
- 9 = Variable

Septic Tank Absorption Field

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 5 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Classes used are:

1 = Slight

2 = Slight to moderate

3 = Moderate

4 = Slight to severe

5 = Moderate to severe

6 = Severe

9 = Variable

Shallow Excavations

Shallow excavations are those that require digging or trenching to a depth of less than 5 feet, as for example, excavation for pipelines, sewerlines, phone and power-transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Classes used are:

1 = Slight

2 = Slight to moderate

3 = Moderate

4 = Slight to severe

5 = Moderate to severe

6 = Severe

9 = Variable

Sanitary Landfills

Sanitary landfills (area-type) dispose of refuse. Refuse is placed on the surface of the soil in successive layers. The cover material generally must be brought in. A final cover of soil material at least 2 feet thick is placed over the fill when it is completed. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficabilty.

The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate.

Classes used are:

1 = Slight

2 = Slight to moderate

3 = Moderate

4 = Slight to severe

5 = Moderate to severe

6 = Severe

9 = Variable

Cover Materials for the Area-Type Landfills

Cover material for the area-type landfills generally must be obtained from a source away from the site. Suitability of a soil for use as cover is based upon properties that reflect workability, ease of digging, moving, and spreading over the refuse daily during both wet and dry periods. Slope, wetness, and thickness of the soil material are considered.

Classes used are:

1 = Good

2 = Good to fair

3 = Fair

4 = Good to poor

5 = Fair to poor

6 = Poor

9 = Variable

Hydrologic Soil Group

Hydrologic soil groups are used in watershed planning to estimate runoff from rainfall. Soil properties are considered that influence the minimum rate of infiltration obtained for a bare soil after prolonged wetting. These properties are depth to a seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The influence of ground cover is treated independently and is not considered in the assignment of hydrologic soil groups.

Soils in group A have the lowest runoff potential and highest infiltration rates, and soils in group D have the highest runoff rates and slowest infiltration rates. Soils in groups B and C are intermediate in these characteristics.

Classes used are:

1 = A

2 = B

3 = B to C

4 = C

5 = B to C

6 = C to D

7 = D

9 = Variable

Suitability as a Source of Sand, Gravel and Roadfill

A soil rated as a good or fair source of sand or gravel generally has a layer of sand or gravel at least 3 feet thick, the top of which is within a depth of 5 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and they do not indicate the quality of the deposit.

The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and they reflect the relative ease of excavating the material at borrow areas.

Suitability as a source of sand, gravel and roadfill are rated as:

1 = Good

2 = Good to fair

3 = Fair

4 = Poor

5 = Unsuited

9 = Variable

AGRICULTURAL CAPABILITY

Agricultural Capability units were identified by a series of numeric codes showing whether the recommended rating is for irrigated or dry farming; minimum value received by a soil series phase, maximum value received by a series phase and the predominant value to be applied to the series based upon percentage composition of the phases representing that series.

Irrigated Versus Dry

A single digit code is used to identify recommended farming practice:

1 = Irrigated

2 = Dry Farming

A three digit code is developed for each value to show the minimum, maximum and predominant Agricultural Capability unit. The first digit represents the agricultural classes.

Capability Classes. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

1 = Class I soils have few limitations that restrict their use.

2 = Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

3 = Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

4 = Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

5 = Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. (None in San Bernardino County, Southwestern Part.)

6 = Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

7 = Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

8 = Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreations, wildlife habitat, water supply, or to esthetic purposes.

9 = Not rated.

Capability Subclasses. Capability subclasses are soil groups within one class, they are designated by the second digit of the capability class code.

The second digit represents the agricultural subclass:

0 = No agricultural subclass designated

1 = A risk of erosion unless close-growing plant cover is maintained

2 = Water in or on the soil interferes with cultivation and/or plant growth

3 = Shallow, droughty or stony

4 = Code not used in this area

9 = Not rated.

Capability Units. The third digit of the capability class code represents the capability unit.

0 = No unit designation

1 = An actual or potential erosion hazard. Soils in capability classes V through VIII are given the unit 1.

2 = A limitation of wetness caused by poor drainage or flooding

3 = A limitation caused by slow or very slow permeability of the subsoil or substratus. (Not used in this soil survey)

4 = A limitation caused by coarse soil texture or excessive gravel

5 = A limitation caused by a fine or very fine textured surface layer. (Not used in this soil survey)

6 = A limitation caused by salt or alkali

7 = A limitation caused by cobbles, stones, or rocks

8 = A limitation caused by nearly impervious bedrock or hardpan within the effective rooting depth

9 = Not rated.

APPENDIX D

Vertical Integration Data Base
Land Use Classification
(SCE, Valley Portion Only)

FIG – 2.1
LAND USE CLASSIFICATIONS

Major Category	Sub-Categories	1979 Codes	1974 San Bernardino	Riverside (Non-urban)
Residential	1. < ½ Acre Residential, RS	RS/110	RS/111	RS/111
	2. > ½ Acre Residential, RS	RSL/111	RS/111	RS/111
	3. Residential, MF	RM/112	RM/112	RM/112
	4. Mobile Homes	RT/113	RT/113	RT/113
	5. Rural Residential (2.5 acres)	RR/114	RR/114	RR/114
Commercial	6. Regional and General Commercial	CRG/121	CR/122, CB/121, CW/126, CH/127	CR/122, CB/121 CW/126, CH/127
	7. Commercial Strip	CS/122	CS/124	CS/124
	8. Neighborhood Center	CC/123	CC/123	CC/123
Industrial/ Extractive	9. Light Industry	IL/131	IL/131	IL/131
	10. Heavy Industry	IH/132	IH/132	IH/132
	11. Extractive	E/133	E/140	E/140
Public/ Institutional	12. Public/Institutional	PI/161	PG/161, PH/162, PX/168	PG/161, PH/162, PX/168
	13. Schools	PS/162	PSE/163, PSJ/164, PSH/165, PSC/166	PSE/163, PSJ/164, PSH/165, PSC/166
Open Space/ Recreation	14. Greenspace - irrigated	GG/171	GG/171, GP/172, GC/173, GX/174	GG/171, GP/172, GC/173, GX/174
	15. Recreation - non-irrigated	GR/172	CE/125	CE/125
Other Committed Uses	16. Transportation/Communication	TC/151	TA/151, TR/152, TF/153	TA/151, TR/152, TF/153
	17. Utilities	TU/152	TE/154, TX/155	TE/154, TX/155
	18. Military	M/153	PM/167	PM/167
	19. Water	W/154	WL/221, WS/222, WX/223	WL/221, WS/222, WX/223
Vacant	20. Vacant with < 24% slope	U1/231	U1/231, U2/232 U3/233, UF/235	U1/231, U2/232 UF/235, IU1/241, IU2/242
	21. Vacant with > 24% slope	U2/232	U4/234, UF/235	U4/233, UF/235, IU4/243
	22. Vacant with improvements	UE/233	GI/175	GI/175

(CONTINUED)

Major Category	Sub-Categories	1979 Codes	1974 San Bernardino	Riverside (Non-Urban)
Agriculture	23. Pasture, Field Crops (Alfalfa, Hay) Irrigated	AG/213	AG/213	AG/213
	24. Row Crops, Grain, Seed, Truck Crops Irrigated	AC/211	AC/211	AC/211
	25. Orchards (Citrus) - Irrigated	AO/212	AO/212	AO/212
	26. Vineyards (Irrigated and non-irrigated)	AV/210	AO/210	AO/212
	27. Dairies and Feed Lots	AD/214	AD/214	AD/214
	28. Poultry Operations	AP/215	AP/215	AP/215
	29. Other Agriculture	AX/216	AX/216	AX/216, AZ/217

Land Use Classification Scheme

1) Urban Categories

(Alpha)	(Numeric)	(Summary Category)	
R	110	1	Residential
RS	111	1	Single Family - detached single family/ duplex dwellings
RM	112	2	Multi-Family - attached single family row housing (condominiums, garden apartments, etc.)
RT	113	2	Mobile Home and Trailer Parks
RR	114	1	Residential (lots 2.5 acres or greater)
C	120	3	Commercial and Services
CB	121	3	Central Business Districts
CR	122	3	Regional Shopping Centers
CC	123	3	Neighborhood Shopping Centers
CS	124	3	Strip or Roadside Commercial Developments
CE	125	4	Drive-In Theatres, Stadiums, Race Tracks, Amusements, Fairgrounds
CW	126	3	Wholesale Services, including trucking companies warehousing, and building materials (i.e., lumber yards, masonry yards, etc.)
CH	127	3	Hotels and motels not otherwise classified above
I	130	5	Industrial
IL	131	5	Light industry, manufacturing and industrial areas, including associated warehouses, storage yards, parking areas, not associated on-site with heavy industry.
IH	132	6	Heavy Industry - Foundaries, scrap yards, primary metals, mechanical processing, chemical processing, etc., and associated facilities.

(Alpha)	(Numeric)	(Summary Category)	
E	140	7	Extractive - Sand and gravel pits, stone quarries, oil and gas wells, etc., associatec storage and tailings areas, and associated facilities.
TCU	150	8	Transportation and Utilities
TA	151	8	Airports (non-military, including runways, park g areas, hangars, and associated facilities.
TR	152	8	Railroads, including yard, terminals, and right: of-way exceeding 210 feet ground distance.
TF	153	8	Freeways, highways, and major arteries whose rights-of-way exceed 210 feet ground distance
TE	154	8	Electric power, including line rights-of-way, stations, and generation facilities, as appropriately provided as collateral data by the Buyer to the Seller.
TX	155	8	Other utilities, gas, water, sewage, and solid waste and sanitary land fill areas and facilities, as appropriately provided as collateral data by the Buyer to the Seller.
P	160	10	Public
PG	161	10	Government institutional facilities, including offices, Fire Stations, Police Stations, etc., as appropriately provided as collateral data from the Buyer to the Seller.
PH	162	10	Health care facilities, as appropriately provided as collateral data from the Buyer to the Seller.
PSE	163	10	Elementary Schools, and associated facilities.
PSJ	164	10	Junior High Schools, and associated facilities.
PSH	165	10	Senior High Schools, and associated facilities.
PSC	166	10	Colleges and Universities, and associated facilities.
PM	167	9	Military establishments, including bases and camps, airports, and supporting facilities.
PX	168	10	Other institutional including religious facilities, cultural and social facilities, etc.

(Alpha)	(Numeric)	(Summary Category)	
G	170	11	<u>Open Space</u>
GG	171	11	Golf Courses
GP	172	11	Parks and recreation areas and associated facilities.
GC	173	11	Cemetaries
GX	174	11	Other open and green space including wildlife preserves and sanctuaries, as provided by the Buyer as collateral data.
GI	175	14	Undeveloped/Improved

2) <u>Non-Urban Categories</u>

A	210	12	<u>Agriculture</u>
AC	211	12	Grain, seed, and truck crops
AO	212	12	Orchards and vineyards
AG	213	12	Pasture and rangeland
AD	214	12	Dairy and livestock feed lots, and associated facilities
AP	215	12	Poultry operations, and associated facilities
AX	216	12	Other agricultural land uses in non-incorporated areas
W	220	13	<u>Water</u>
WL	221	13	Open water, including lakes and reservoirs
WS	222	13	Streams and waterways, including associated floodplains and flood control facilities (the latter shall be appropriately provided as collateral data by the Buyer to the Seller).
WX	223	13	Other
U	230	14	<u>Undeveloped and Forest</u>
U1	231	14	Undeveloped 0-12% slope
U2	232	14	Undeveloped 12-16% slope
U3	233	14	Undeveloped 16-24% slope
U4	234	15	Undeveloped 24%+ slope
UF	235	15	Deciduous and evergreen forest areas, the crown cover of which exceeds 30% ground area.

Appendix II
Land Use Codes and Definitions
for the
San Bernardino/Riverside Update Study

RS/110 Single Family (Density-1 unit/1/2 acre)-These are "typical" urban and suburban residential dwellings with a single home occupying each lot less than 1/2 acre. They become a key component to defining urban because they are served by all utilities, are on paved streets, and are provided with or have access to all urban facilities such as schools, parks, police and fire stations.

RSL/111 Large Lot Residential (Density-1 unit/gross acre to 2.5 acre lots)-These are single homes on lots larger than 1/2 acre, and served by all utilities and are on paved roads. They may be found in totally urban settings and also in rural areas.

RM/112 Multiple Family-The structures in this class house more than one family. They may be duplexes, triplexes, town houses, fourplexes, low-rise or high-rise apartments or attached housing of any type. They are urban in nature and are served with all urban functions.

RT/113 Mobile Home and Trailer Parks-Includes all mobile home parks and subdivisions. This class applies to vacant as well as occupied trailer spaces in mobile home parks. It does not describe isolated mobile homes, which fall within RR/114.

RR/114 Rural Residential-(Density->2.5 acres per unit)-Includes clusters of "urban-like" homes in a rural setting and other isolated residences such as ranches, farmstead and single mobile homes. It also includes areas of suburban horse ranchettes and all of the associated pasture and stable facilities. These sidewalks often lack sidewalks and sewers, and are more or less remote from urban services.

CRG/121 Regional and General Commercial-Includes financial, personal, business, professional services, and also department stores, a full range of smaller shops, restaurants and offices. This class includes the majority of the commercial services and retailing complexes. Includes major hotels and motels, and also shops which perform services such as welding, auto repair, etc.

CS/122 Commercial Strip-This class includes areas offering a wide range of services which are located along major highways and traffic corridors to take advantage of increased customer exposure. These areas tend to have limited parking and contain stores which are very specialized.

CC/123 Neighborhood Shopping Centers-Small commercial centers which provide for daily needs of adjacent neighborhoods, include retail sales such as drugs, groceries, sundries and beverages.

IL/131 Light Industry-This class includes a very wide range of structures and facilities. It includes all manufacturing activities except for major metals and petroleum refining and processing (IH/132). It also includes wholesaling and warehousing, research and development, motion picture industries, wrecking yards and other salvage operations.

IH/132 Heavy Industry-This class includes all foundries, smelters, stamp mills and other heavy metal manufacturing or processing plants. It also includes major oil refineries and associated petrochemical plants.

E/133 Extractive-This class includes all mineral extraction, oil extraction, gas extraction and associated surface and subsurface storage facilities.

PI/161 Public and Institutional Facilities-This class includes all government offices and facilities, health care facilities, special institutional facilities, emergency response facilities, and religious facilities. Among these are civil offices, jails, post offices, courts, libraries, hospitals, clinics, sanitatiums, police and fire stations, churches, temples, etc.

PS/162 Schools-This class includes all public and private schools providing education and training. It includes elementary schools, junior high schools, senior high schools, colleges, universities, adult school and trade schools of many types.

GG/171 Greenspace-Irrigated-This class includes local and regional parks, golf courses and cemetaries, generally dominated by maintained grasses.

GR/172 Recreation-Non-Irrigated-This class includes relatively natural areas which provide recreational facilities, such as boy scout camps, church camps, shooting ranges, race tracks, etc.

TC/151 Transportation/Communication-This class includes airports, railroads, freeways, highways and radio and television facilities.

TU/152 Utilities-This class includes electric transmission corridors and generating plants, solid and liquid waste disposal facilities, and gas and petroleum distribution systems.

M/153 Military-All lands owned, occupied, or controlled by any branch of United States Armed Forces or the California National Guard.

W/154 Water-This class includes lakes, covered or open reservoirs, pumping plants, spreading grounds, flood control channels and water distribution channels.

UI/231 Vacant With Less Than 24% Slope-This class includes lands with no improvements where average slopes exhibit a drop of 0 to 24 feet vertically for every 100 feet of horizontal measurement.

U2/232 Vacant With Greater Than 24% Slopes-This class includes lands with no improvements where average slope exhibits a drop of 24 or more feet vertically for every 100 feet of horizontal measurement.

UE/233 Vacant With Improvements-This class includes areas with evidence of development where some level of grading or construction is taking place.

AG/213 Pasture, Field Crops-Irrigated-This class includes alfalfa, clover or sudan grass, and fenced rangeland with watering facilities.

AC/211 Row and Truck Crops, Grain and Seed-Irrigated-This class includes all lands devoted to the commercial production of vegetables and grain.

AO/212 Orchards-Irrigated-This class includes areas with commercially productive tree or bush crops, such as avocados, nut, citrus and deciduous fruits.

AV/210 Vineyard-This class includes areas with commercially productive vine crops.

AD/214 Dairy and Feed Lots-This class includes dairy yards, milk barns, feed lots and associated facilities.

AP/215 Poultry Operations-This class includes chicken ranches, duck farms, turkey farms and other poultry ranches and associated facilities.

AX/216 Other Agriculture-This class includes commercial agricultural facilities, such as apiaries, worm farms, horse ranches and stables. It also includes greenhouses, nurseries, fallow and non-irrigated farmlands.

APPENDIX E

Small Study Area MVF Descriptions

YUCAIPA AREA MVF

1. Row
2. Column
3. Study Area
4. Valley Terrain Unit Unique Number
5. Valley Map Module Number
6. Valley Terrain Unit Sequence Number
7. Valley Land Cover
8. Valley Geologic Type
9. Valley Slope
10. Valley Landform
11. Valley Soils
12. Valley Surface Configuration, Geologic Hazards
13. Valley Flood Prone Areas
14. Valley Groundwater
15. 1974 Land Use
16. 1979 Land Use
17. General Plan
18. Census Tracts
19. Valley Roads
20. Valley Railroads
21. Valley Streams (3)
22. Valley Fault Lines
23. 1976 CDF Landsat
24. Elevation (DMA)
25. Slope Aspect (from elevation)
26. Slope (from elevation)
27. 1976 Classified Landsat
28. Change Mask (Landsat)
29. 1979 Spectral Classes (Landsat)
30. 1979 Classified Landsat
31. Valley Soil Interpretations (3)
32. Valley Soils K Value

FIRE BUFFER GREENBELT AREA MVF

1. Row
2. Column
3. Study Area
4. Valley Terrain Unit Unique Number
5. SBNF Terrain Unit Unique Number
6. Valley Map Module Number
7. Valley Terrain Unit Sequence Number
8. Valley Land Cover
9. Valley Geologic Type
10. Valley Slope
11. Valley Landform
12. Valley Soils
13. Valley Surface Configuration, Geologic Hazards
14. Valley Flood Prone Areas
15. Valley Groundwater
16. SBNF Map Module Number
17. SBNF Terrain Unit Sequence Number
18. SBNF Land Cover
19. SBNF Geology
20. SBNF Slope
21. SBNF Landform
22. 1974 Land Use
23. 1979 Land Use
24. General Plan
25. Census Tracts
26. Valley Roads
27. Valley Railroads
28. Valley Streams (3)
29. Valley Fault Lines
30. 1976 CDF Landsat
31. Elevation (DMA)
32. Slope Aspect (from elevation)
33. Slope (from elevation)
34. 1976 Classified Landsat
35. Change Mask (Landsat)
36. 1979 Spectral Classes (Landsat)
37. 1979 Classified Landsat
38. Valley Soil Interpretations (3)
39. Valley Soils K Value
40. SBNF Soils
41. SBNF Soils K Value
42. SBNF Soil Interpretations (3)

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16 Abstract

This report describes the creation and use of a vertically integrated data base, including Landsat data, for local planning purposes in a portion of San Bernardino County, California. The project illustrates that a vertically integrated approach can benefit local users, can be used to identify and rectify discrepancies in various data sources, and that the Landsat component can be effectively used to identify change, perform initial capability/suitability modeling, update existing data, and refine existing data in a geographic information system. Local analyses were developed which produced data of value to planners in the San Bernardino County Planning Department and the San Bernardino National Forest staff.

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