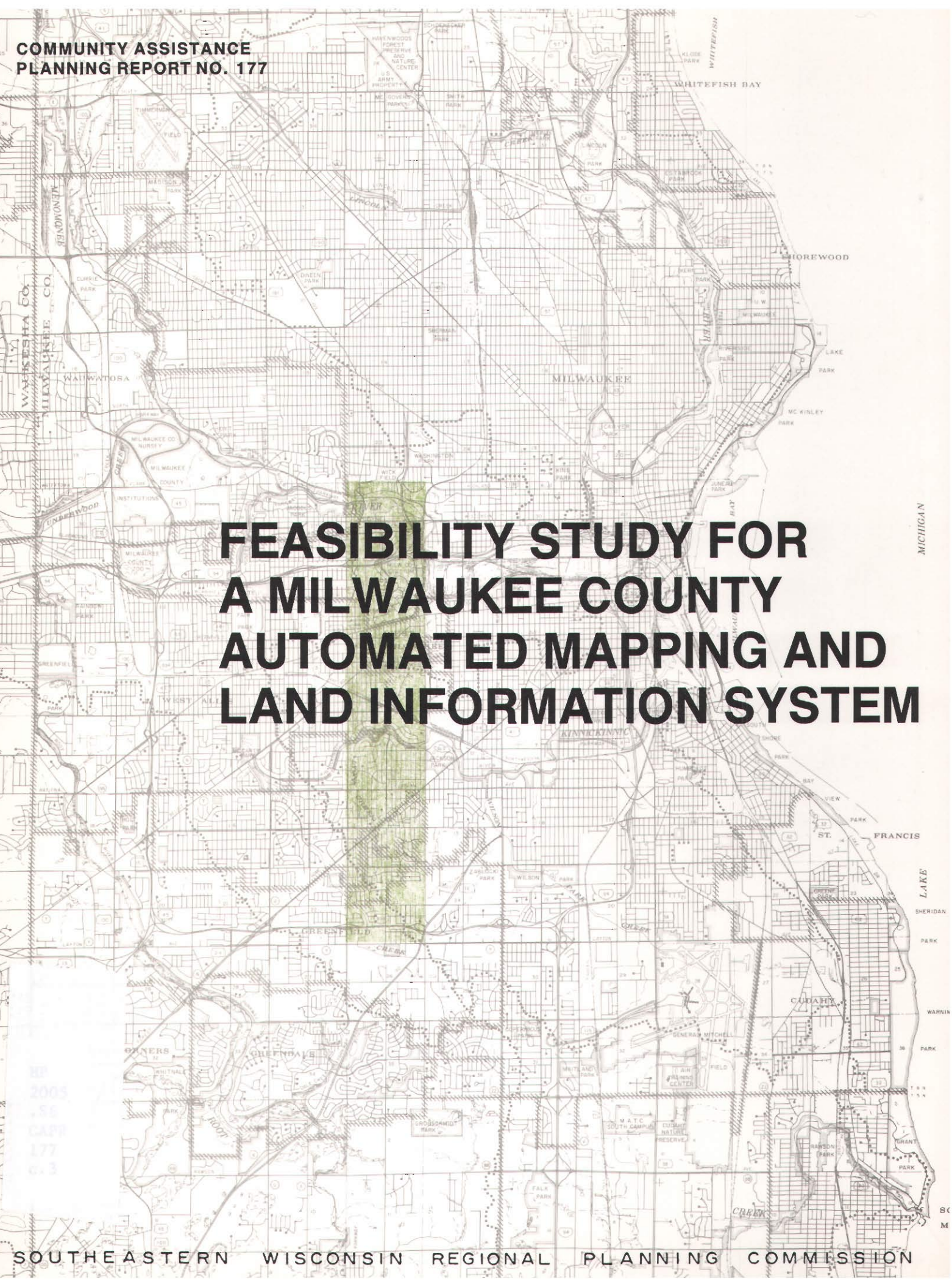
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 177

FEASIBILITY STUDY FOR A MILWAUKEE COUNTY AUTOMATED MAPPING AND LAND INFORMATION SYSTEM



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Special acknowledgement is due Mr. Thomas D. Patterson, SEWRPC Graphic Systems Manager, for his contribution to this report.

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COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 177

FEASIBILITY STUDY FOR A MILWAUKEE COUNTY AUTOMATED MAPPING AND LAND INFORMATION SYSTEM

Prepared by the

Southeastern Wisconsin Regional Planning Commission
P. O. Box 1607
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916 N. East Avenue
Waukesha, Wisconsin 53187-1607

October 1989

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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August 25, 1989

Milwaukee County Board of Supervisors
c/o Mr. Rod Lanser, County Clerk
Milwaukee County Courthouse
901 N. Ninth Street
Milwaukee, Wisconsin 53233

Mr. David F. Schulz
County Executive
Milwaukee County Courthouse
901 N. Ninth Street
Milwaukee, Wisconsin 53233

Ladies and Gentlemen:

On June 16, 1988, the Milwaukee County Board of Supervisors adopted a resolution requesting the Southeastern Wisconsin Regional Planning Commission to convene an advisory committee to analyze the feasibility and cost-effectiveness of modernizing land records within the County by developing an automated mapping and land information system. This resolution was approved by the Milwaukee County Executive on July 18, 1988. Acting in response to this request, the Regional Planning Commission created an advisory committee composed of knowledgeable representatives of the City and County of Milwaukee, the Milwaukee County suburban cities and villages, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell to guide the preparation of this report, which presents the findings and recommendations of the requested study.

The Advisory Committee concluded that the existing situation with respect to automated mapping in Milwaukee County has led to duplication of effort between the various organizations involved, and that this duplication may be expected to increase as additional units of government and public utilities undertake conversion of their analog mapping and records activities to automated environments. The cost of this duplication is ultimately borne by the area residents, who pay for it in the form of tax payments, utility rate payments, and various user fees. Accordingly, better coordination of these efforts with its concomitant reduction in total costs would be in the best interests of the area residents.

The Advisory Committee further concluded that coordination of these efforts could be enhanced by the provision of a single automated mapping base for the entire County. This basic mapping system would provide an automated mapping capability suitable for the development by the individual agencies concerned of a wide variety of applications, such as land ownership and title recordation systems, real property assessment and taxation systems, public and private utility inventory and management systems, environmental inventory and management systems, and zoning and other code monitoring and enforcement systems.

It is the recommendation of the Advisory Committee that Milwaukee County assume the responsibility for providing the basic system of U. S. Public Land Survey corner monumentation, attendant horizontal and vertical control surveys, digital planimetric and topographic maps, digital cadastral map overlays, and parcel identifiers that constitute this basic automated mapping system; and that—once the system is completed—the County assume the responsibility of maintaining the system in a current condition.

The creation of a set of digital planimetric and topographic base maps and digital cadastral map overlays for Milwaukee County is estimated to cost $4.16 million. Because of the benefits a coordinated automated mapping and land information system could be expected to provide to both the government and private utility sectors, it is the Advisory Committee's recommendation that this cost be shared by the County and by the major public and private utilities operating in Milwaukee County. The members of the Advisory Committee, however, could not agree on the extent of the private versus the public funding. Accordingly, the cost allocation table set forth on page 38 of this report must be regarded only as a point of departure in interagency negotiations should the County determine to proceed with the program. The cooperative development of an automated mapping system and the cooperative funding arrangement recommended in this report represent a unique opportunity for cost reductions to the area residents through the cooperation of the public and private sectors.

The Regional Planning Commission is pleased to have been of assistance to the County in this study. The Commission stands ready, upon request, to assist the County, its constituent local units of government, and the public and private utilities within the County in considering the recommendations contained in this report; and, if approved, to assist the County in implementation of those recommendations.

Sincerely,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

BACKGROUND

On June 16, 1988, the Milwaukee County Board of Supervisors adopted a resolution requesting the Southeastern Wisconsin Regional Planning Commission to convene an advisory committee to analyze the feasibility and cost-effectiveness of modernizing land records within the County by developing an automated mapping and land information system. The resolution was approved by the Milwaukee County Executive on July 18, 1988. A copy of the adopted resolution is provided in Appendix A.

The resolution directed the advisory committee to analyze the potential for implementation of a countywide automated mapping and land information system under three different operating scenarios. The first of these scenarios would involve modernization of the county land records by the use of the City of Milwaukee's existing automated mapping system, with the City continuing to maintain ownership and control of the system. The second scenario would involve the establishment of a jointly operated and maintained county-city system. The third scenario would involve the creation of a shared system utilized and partially funded by the units of government concerned; by utilities such as the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell; and possibly by other private businesses which rely on local maps and land records, such as title insurance companies.

PURPOSE OF THE REPORT

The basic purpose of this report is to explore and document the need for, and the feasibility and cost-effectiveness of, the development of an automated mapping and land information system within Milwaukee County. The report is intended to provide sufficient information to permit the Milwaukee County Board of Supervisors, the Milwaukee County Executive, the concerned local units of government, the utilities, and private businesses to consider the benefits and costs of creating such a system, and thereby to determine the desirability of proceeding with its implementation. To this end, the report is intended to accomplish the following purposes:

1. To provide county and local officials, utility and business executives, and concerned citizens with a basic understanding of the components of an automated mapping and land records system and the manner in which these components must be assembled to provide a conceptually and technically sound operational system.

2. To identify and briefly describe existing automated mapping and land information systems whose operation pertains to all or portions of Milwaukee County.

3. To examine the advantages and disadvantages of different organizational arrangements for the development of an automated mapping and land information system for Milwaukee County, including the use of the City of Milwaukee's system by the County, a jointly owned and operated county-city system, and a multi-user, shared system utilized and partially funded by the involved units of government, utilities, and private businesses which rely on local maps and land records.

4. To identify those technical issues which, in the case of a shared, multi-user, automated mapping and land records system, would need to be resolved before the development of a shared system could occur.

5. To estimate the time and resource requirements for implementing an automated mapping and land records system for Milwaukee County under the alternative organizational structures considered.

6. To recommend a course of action.

ADVISORY COMMITTEE STRUCTURE

To provide the forum for the preparation of the report and for seeking agreement on the course of action to be recommended, an advisory committee with representation of the various interests concerned was created. That committee included knowledgeable representatives of the

City and County of Milwaukee, the Milwaukee County suburban cities and villages, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Company, the Wisconsin Gas Company, and Wisconsin Bell. A roster of the advisory committee is reproduced on the inside front cover of this report.

The purpose of the Advisory Committee was to place the knowledge and experience of the committee members at the disposal of the study, and to actively involve the various interests in the study. The committee carefully reviewed and approved the findings and recommendations of this report.

Chapter II

AUTOMATED MAPPING AND LAND INFORMATION SYSTEMS: AN OVERVIEW

INTRODUCTION

For more than a decade now, there has been growing interest in the United States in land information systems. This interest ranges from a relatively narrow concern about the need to modernize land title recordation systems to a relatively broad concern about the need to create entirely new land-related data banks for multipurpose applications. This growing interest has involved many disciplines, ranging from surveyors, abstractors, assessors, and attorneys concerned with the fiscal and legal administration of real property to planners, engineers, public utility managers, public administrators, and elected officials concerned with resource management and community development. Much of the interest initially centered around the use of electronic computers for the storage, manipulation, and retrieval of land-related information and, more recently, for the use of computer-assisted graphics collection and display hardware for the reproduction of the data in mapped as well as tabular form.

As interest in the area of land data systems has grown, the topic has become increasingly prominent as a subject of professional papers, reports, conferences, and the meeting programs of various professional organizations. Accordingly, a body of professional literature on the subject of automated mapping and land information systems has begun to coalesce and accumulate. Over this same time frame, an increasing number of local units of government and private utilities have undertaken the implementation of automated mapping and land information systems—including several systems that currently exist in the Milwaukee metropolitan area. This chapter presents a summary of pertinent literature in the area of automated mapping and land information systems, and identifies and briefly describes currently operating automated mapping and land information systems whose operation pertains to all or portions of Milwaukee County.

NATIONAL RESEARCH COUNCIL STUDIES

In 1979, the National Research Council convened a Panel on a Multipurpose Cadastre to review the status of cadastral activities at the federal, state, and local governmental levels and in the private sector and to review a number of demonstration projects that had been undertaken at various locations. This action was taken by that Council in response to the growing interest in land data systems and to the perceived increasing need for land-related information by all levels of government and by the private sector. In 1980, a report was issued, the principal finding of which was that:

> "There is a critical need for a better land-information system in the United States to improve land-conveyance procedures, furnish a basis for equitable taxation, and provide much needed information for resource management and environmental planning."[1]

The report set forth the concept of the multipurpose cadastre as a basis for a dynamic public process that could effectively collect, maintain, and disseminate land-related information. It identified the land resource-related problems faced by public and private organizations and outlined the basic structure of a multipurpose cadastre that could help to remedy those problems. However, the report did not address how governments, especially local governments, could carry out the recommendations made in the report.

To address the questions left unanswered by its 1980 report, the National Research Council prepared a second report which set forth a set of recommended procedures and standards for

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[1] *National Research Council, Assembly of Mathematical and Physical Sciences, Committee on Geodesy, Panel on a Multipurpose Cadastre, Need for a Multipurpose Cadastre, National Academy Press, Washington, D. C., 1980.*

the design and implementation of a multipurpose cadastre.[2] It was the intent of this report to assist the local units of governments wishing to pursue the development of cadastral records systems for their own jurisdictions and also the many other regional, state, and federal agencies, as well as private businesses, whose participation will be needed for the development over time of true multipurpose land information systems.

The procedural model put forth by the Panel identified the basic components of a modern land information system as: 1) a spatial reference framework consisting of monumented geometric control points; 2) a series of accurate, large-scale topographic base maps; 3) a cadastral overlay to the base maps that delineates all cadastral—that is, real property ownership—parcels; 4) a cadastral parcel numbering scheme that provides for unique identification of each cadastral parcel; and 5) a series of compatible registers of interests in, and data about, the land parcels keyed to the parcel identifier. It is important to note, in this regard, that the creation of such land information systems requires as a foundation a means of spatial reference for the data. An adequate geometric framework for such spatial reference must, if it is to serve even the narrowest purposes of a land information system, permit identification of land areas by coordinates down to the individual ownership parcel level. A geometric framework of adequate accuracy and precision to permit system operation at the highly disaggregated parcel level is the most demanding specification possible, but, once achieved, permits ready aggregation of information from the more intensive and detailed level to the more extensive and general level as may be necessary.

The local mapping and survey control network recommended by the Southeastern Wisconsin Regional Planning Commission since 1964—which is described in detail in Chapter III of this report—provides two of the five basic components of a modern land information system as set forth by the Panel, namely: 1) the required spatial reference framework, and 2) the required accurate large-scale topographic base maps; and facilitates the creation of the third component, a cadastral map overlay. The spatial reference framework is provided by the relocation, monumentation, and placement on the State Plane Coordinate System of the U. S. Public Land Survey corners. The Commission-recommended topographic maps provide the base maps specified by the Panel. In addition, by placing the U. S. Public Land Survey corners on the State Plane Coordinate System, the Commission-recommended system provides the basis for the ready and economical preparation of accurate cadastral—that is, real property boundary line—overlays to the topographic base maps, since all real property boundary descriptions in Wisconsin are, by law, tied to these corners. Less obvious, but of equal importance, the Commission-recommended survey control network ties these real property boundary descriptions to the State Plane Coordinate System and, in turn, to latitude and longitude, thereby facilitating the precise correlation of real property boundary lines and earth science data—a necessary condition to the creation of a modern, automated land information system.

It is important to note in this regard that the Commission-recommended local mapping and survey control network program was one of a select few local land information system modernization efforts described by the Panel in its reports and, therefore, put forth as a system for emulation across the nation.

It is also important to note—particularly within the context of the development of this report—that both National Research Council reports determined that for much of the United States, the county presented the most logical locus for the development of multipurpose land information systems.

WISCONSIN LAND RECORDS COMMITTEE

Within Wisconsin there has also been growing interest in land information systems and land records modernization. In 1985, then Governor Anthony Earl appointed the Wisconsin Land Records Committee, a group representing state, regional, and local governmental interests, private utilities, and other private businesses that utilize local maps and land records. Over a

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[2]*National Research Council, Assembly of Mathematical and Physical Sciences, Committee on Geodesy, Panel on a Multipurpose Cadastre, Procedures and Standards for a Multipurpose Cadastre, National Academy Press, Washington, D. C., 1983.*

period of two years, this group issued 13 reports on various aspects of automated mapping and land records modernization, and a final report[3] that summarized the more important findings of the Committee's deliberations.

Like the National Research Council Panel, the Wisconsin Land Records Committee determined a need for continued efforts directed at land records modernization, and recognized the contribution that could be made by computer technology in certain aspects of this modernization process. The Committee determined that the costs to develop modernized land records systems would not be trivial, but that these costs would be reasonable, nonetheless, in view of the sums already being expended for current outdated and inefficient land information management practices. The Committee recognized, correctly, that the ultimate costs of land records modernization would be borne by citizens in the form of tax bills and utility bills and, accordingly, recommended that various levels of government, private utilities, and other private businesses involved in the use of land information make every effort to jointly develop and use automated systems to minimize their total societal costs.

The Committee recognized that its recommendation for the development of shared approaches to land information systems modernization would create new organizational and institutional strains that would be as demanding in their solutions as the technical issues involved in the creation of new, automated land information systems. The Committee accordingly recommended that the educational and coordinative aspects of land records modernization receive as much attention as the technical issues.

The deliberations of the Committee and its published reports reaffirmed the validity of the procedural model advanced by the National Research Council Panel for the development of modern, automated land information systems and, as did the National Research Council reports, highlighted the Commission-recommended local mapping and survey control network program as a basis for the development of modern, automated land information systems.

Also, like the National Research Council Panel, the Wisconsin Land Records Committee recognized that there is a central role to be played by counties in the land records modernization process. Although the Committee chose not to precisely define that role, preferring instead to have individual counties make that determination, at the minimum, a coordinative role was seen as necessary in view of the records maintenance functions given to the counties by the state constitution and state statutes.

ALTERNATIVE TYPES OF OPERATIONAL COMPUTER SYSTEMS AVAILABLE FOR THE DEVELOPMENT OF AN AUTOMATED MAPPING AND LAND INFORMATION SYSTEM

The professional literature currently categorizes operational automated mapping and land information systems into three general types: strictly automated mapping or computer-assisted drafting (CAD) systems; automated mapping-facilities management (AM-FM) systems; and geographic information systems (GIS). The distinction between these types of systems is somewhat artificial and stems from marketplace segmentation strategies adopted by vendors of computer hardware and software. Nevertheless, as long as it is recognized that operational systems comprise a continuum and that many systems will resist being neatly categorized as one or another of the three general types of systems, the tripartite division is a useful one for discussion purposes.

The computer hardware components comprising these three types of systems usually provide no basis for categorization, and the different systems are virtually identical in a physical sense. Computer software available for operating the different system types generally provides a basis for distinguishing between CAD systems on the one hand and the AM-FM and GIS systems on the other; but, the differences between the software utilized to operate AM-FM systems and GIS systems is often less clear. Indeed, a number of proprietary software products currently purport to support either type of operation equally well.

[3] *Wisconsin Land Records Committee, Final Report of the Wisconsin Land Records Committee, Modernizing Wisconsin's Land Records, University of Wisconsin-Madison, Center for Land Information Studies, Madison, Wisconsin, 1987.*

Functionally, the CAD systems are perhaps the easiest of the three to categorize since they tend to be almost exclusively automated mapping systems with little or no capability for the management of associated land records. Both AM-FM and GIS systems possess automated mapping and records management capabilities, although the distinction between the two as often as not is a function of the type of associated land information managed by the system rather than of any pronounced functional difference between system components. Typically, systems categorized as AM-FM systems are found where the predominant function is to manage information associated with networks: for example, water distribution systems, sanitary sewerage systems, telephone systems, and electric power and natural gas distribution systems. GIS systems are usually systems that manage information associated with areas: real property parcels, administrative districts, land use polygons, and soil mapping units. While these distinctions between predominant functions of AM-FM and GIS systems are helpful in a taxonomic sense, in practice these distinctions are often more apparent than real as virtually all currently available AM-FM software systems—while they may, in fact, be designed for optimal operation in network data analysis environments—are capable of analyzing polygon data. Likewise, virtually all currently popular GIS software is capable of performing network data analysis functions.

CURRENTLY OPERATING AUTOMATED MAPPING AND LAND RECORDS SYSTEMS PERTAINING TO ALL OR PARTS OF MILWAUKEE COUNTY

It was noted earlier in this chapter that there are several automated mapping and land information systems already in existence whose areas of operation cover all or portions of Milwaukee County. Since one of the primary purposes of this report is to determine the feasibility of some type of shared or joint operation of a countywide automated mapping and land information system, these existing systems are identified and their operations briefly described below.

The different map coordinate systems utilized by the different automated mapping operations in the Milwaukee area represent an issue of central importance in any discussion of potential cooperative mapping efforts or even, for that matter, any discussion of the transfer of existing digital map information between the existing automated mapping sites. Therefore, the map coordinate system or systems utilized and the horizontal map datum upon which the coordinate system is based are identified for each operation.

The universe of all map coordinate systems is rather large, although currently, only two such systems are in regular use in the Milwaukee area: the State Plane Coordinate System and the Universal Transverse Mercator (UTM) coordinate system. Both of these systems are based upon the North American Datum of 1927 (NAD27) which is, in turn, derived from the Clarke 1866 mapping spheroid. Since both the State Plane Coordinate System and the UTM coordinate system are based upon NAD27, it is possible, albeit computationally tedious, to translate with mathematical precision from one of these coordinate systems to the other. It is, in an analogous fashion, further possible to move with mathematical precision between either of these two systems and any other map coordinate system derived from NAD27, although again, the procedure is tedious.

Recently, the National Geodetic Survey of the National Oceanic and Atmospheric Administration, U. S. Department of Commerce—the federal government agency responsible for the maintenance of the nation's geodetic control system—has begun to move all federal mapping activity from the Clarke 1866 mapping spheroid onto the Global Reference System of 1980 (GRS80), a newly defined mapping spheroid. As part of this transfer, an entirely new horizontal datum, NAD83, has been developed for use with GRS80. Any precise conversion between NAD27 and NAD83 requires recomputation utilizing the original control survey field measurements. The implications for the conversion from NAD27 to NAD83 of the type of control network and related large-scale planimetric mapping typically prepared by local units of government and utilities are therefore both technically severe and operationally very costly. A similar situation exists for large-scale topographic mapping with the proposed replacement of the National Geodetic Vertical Datum of 1929 (NGVD29) by NGVD87 which has been developed for use with GRS80 and NAD83. Importantly, the replacement of NAD27 and NGVD29 with NAD83 and NGVD87 will be costly while offering no

improvement in map accuracy or precision for locally oriented large-scale mapping operations.

City of Milwaukee

The City of Milwaukee installed INTERGRAPH computer hardware and software in 1976 to begin its automated mapping activities. Between 1978 and 1982, the City converted a series of 444 one-quarter section real estate maps from analog to digital form. This series constitutes the primary digital mapping base for a variety of applications that have been developed since that time. The City represents about 40 percent of Milwaukee County's total area of about 242 square miles. The map digitizing was originally accomplished using a local map coordinate system, but in 1984 the City staff undertook a conversion to the State Plane Coordinate System, NAD27, utilizing control survey data acquired by the Regional Planning Commission. To carry out this transformation between the two coordinate systems, the city staff developed computer software utilizing affine transformation algorithms to perform the translations between the two coordinate systems in a manner analogous to the procedures used to ratio and rectify aerial photography. The 444 one-quarter section real estate maps have therefore been reprojected onto the State Plane Coordinate System and "fitted" to that system by this process.

Since the original installation, the INTERGRAPH system has been expanded and upgraded on several occasions. Beginning in 1988, the City expects to expand its digital mapping capability through the addition to the existing digital map base of utility facility networks such as sewerage, water distribution, and street lighting. As part of this expansion, the City is currently investigating the feasibility of producing a new citywide digital map base using direct digitization from stereoscopic models. This aerial photographic compilation base would provide a mechanism for the precise delineation of such physical features as, among others, the edges of the traveled way, sidewalks, utility poles, manhole covers, and storm sewer catchment basins. A pilot project encompassing about one square mile of area is planned for late 1988 or early 1989. Rather than acquiring new photography, however, current plans for the pilot project call for the utilization of aerial photography prepared to Commission-recommended specifications and obtained in 1986 by the Milwaukee Metropolitan Sewerage District for the preparation of analog format, 1:1,200 scale, two-feet contour interval, topographic mapping.

Southeastern Wisconsin
Regional Planning Commission

The Southeastern Wisconsin Regional Planning Commission installed CALMA hardware and software in 1976 to begin conversion to digital format of its land use and natural resource inventory data. Since that date, the Commission has converted its analog land use inventories for 1963, 1970, and 1975 for its 2,689-square-mile planning area, has completed digital land use inventory updates for 1980 and 1985 for the entire planning area, and has digitized operational soil surveys for about 2,111 square miles, or about 78 percent, of its planning area. Milwaukee County lies completely within the Commission's planning area. The primary system products are land use maps, interpretive soil maps, and summary areal extent statistics prepared in support of long-range planning activities, and "camera ready" artwork prepared for the printing of thematic maps appearing in published reports. The Commission utilizes the State Plane Coordinate System, NAD27, for its digital mapping activities.

In 1984 and 1985, the Commission, in cooperation with Kenosha County and the State of Wisconsin, undertook a demonstration project in the Town of Randall and the Village of Twin Lakes in Kenosha County to determine the feasibility of building a multipurpose, automated, land information system utilizing then-current computer hardware and software technology. The demonstration project covered an area of about 24 square miles containing urban, suburban, and rural land use development patterns and resulted in the preparation of digital map overlays of real property boundary lines, right-of-way easement lines, hydrography, structure outlines, existing land use, soil mapping units, zoning districts, floodplain limits, and shoreland boundary areas.[4]

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[4]*SEWRPC Technical Report No. 30, The Development of an Automated Mapping and Land Information System: A Demonstration Project for the Town of Randall, Kenosha County, Waukesha, Wisconsin, 1985.*

Kenosha County had already began a program in 1980 to implement the Commission-recommended local mapping and survey control system throughout the County. The large-scale topographic base maps previously produced for the project area under this program—which will be completed in 1988—provided the source for the digitization of most of the planimetric map features captured—surface water and stream channels; the traveled way, or pavement edges, of public streets and highways; and structure outlines. The positions of these features had been determined by photogrammetric methods during the original preparation of the topographic maps, and therefore appeared on the finished maps. These maps also provided a precise base for the subsequent delineation of floodplain limits and shoreland boundary districts prior to their digitization. Recorded subdivision plats, certified survey maps, abbreviated legal descriptions, recorded easement descriptions, plats of right-of-way locations, and surveyors' field notes were used to locate real property boundary lines and real property boundary line-related information, such as easement and right-of-way lines, on maps prior to digitization. The real property boundary lines were constructed on the maps in the same way a land surveyor would construct those lines in the field. This was made possible by the framework of control provided by the known locations of the U. S. Public Land Survey corners on the State Plane Coordinate System and the attendant known grid lengths and grid bearings of all quarter-section lines.

Following the demonstration project, Kenosha County contracted with the Commission for the preparation of equivalent digital map files in adjoining portions of the County. Currently, this automated mapping conversion effort, including the research and delineation of real property boundary lines on correct map bases, has been undertaken for an area of about 80 square miles, including the original 24-square-mile demonstration area. Accordingly, about 29 percent of the area of the County already has, or is in the process of acquiring, a basic automated mapping and land information system capability. These 80 square miles contain approximately 13,700 real property ownership parcels, or about 24 percent of all such parcels in the County.

The experience gained in more than a decade of automated land use and natural resource mapping and in the Kenosha County projects provided a valuable base upon which to evaluate the available hardware and software products when, in 1986, the Commission reached a decision to acquire new computer hardware and software for its automated mapping operation. In 1987, a completely new automated mapping system was installed comprised of DELTAMAP software running on Hewlett-Packard and Calcomp hardware. The enhanced operational capability provided by this new system allowed the Commission staff to begin taking steps in 1988 to convert its large-scale and intermediate-scale base mapping operations from analog to digital format.

State of Wisconsin

Two agencies of state government currently possess and use automated mapping systems: the Department of Transportation and the Department of Natural Resources.

The Department of Transportation installed INTERGRAPH hardware and software in 1982. This system is used primarily for maintaining and updating the Department's official State Highway Map and the Department's statewide series of county highway maps. Some of the map data for these two programs were created by optical scanning of color separation plates that had been used for color map printing. The system is also used for project mapping in support of highway construction and improvement projects. The map data for this activity are usually acquired through direct digitization from stereoscopic models. All of the Department of Transportation's digital mapping currently utilizes the State Plane Coordinate System, NAD27, although the Department is in the process of evaluating whether or not to shift its mapping datum to NAD83.

The Department of Natural Resources began building a digital map data collection system in 1980. This system has been, in effect, custom built by Department staff who have configured purchased hardware components and written their own computer software. The system is used primarily in support of separate small area projects, but was used to create, and currently maintains, a statewide inventory of wetlands. The Department of Natural Resources has not chosen a standard coordinate system for its digital mapping, and, although it utilizes the UTM coordinate system, NAD27, for many projects, it also utilizes the State Plane Coordinate System, NAD27, for a portion of its projects

and local coordinate systems on occasion. The Department possesses computer software translation capability between UTM and State Plane coordinates. The Department of Natural Resources, like the Department of Transportation, is in the process of evaluating whether or not to shift its mapping datum to NAD83, although it is not as far along in its evaluation as is the Department of Transportation.

Recently, both the Department of Transportation and the Department of Natural Resources started using the proprietary software ARC/INFO to develop network and polygon map data analysis capability, while continuing to maintain their automated mapping functions on the originally acquired systems. The Department of Transportation has acquired the software and is running it on Digital Equipment Corporation (DEC) hardware which it recently installed for that purpose. The Department of Natural Resources is running the software in a "time share" mode on the University of Wisconsin's DEC system, and has recently utilized this system to develop a statewide analysis—including a state map prepared by computer-assisted methods—of groundwater contamination susceptibility.

Wisconsin Energy Corporation

Wisconsin Electric Power Company (WEPCo) and Wisconsin Natural Gas (WNG), both subsidiaries of Wisconsin Energy Corporation, have been jointly developing a digital map base upon which to place their respective electric and gas service networks. This effort was initiated in 1979 with the installation of INTERGRAPH hardware and software at WEPCo. Milwaukee County lies completely within the service territory of WEPCo, while approximately the southern one-third of Milwaukee County lies within the service territory of WNG. The companies completed the development of digital map coverage for the southern one-third of the County prior to 1985, and completed the remaining coverage during 1988, utilizing in part the City of Milwaukee's digital mapping which WEPCo acquired from the City.

Throughout much of the Southeastern Wisconsin Region, WEPCo and WNG utilized data from large-scale topographic mapping and control survey projects prepared to Commission-recommended specifications to establish their spatial reference framework. These data were acquired in State Plane Coordinate System, NAD27, format and converted by WEPCo and WNG to the UTM coordinate system, NAD27, which the two companies continue to utilize for their digital mapping activity.

Wisconsin Energy Corporation has recently begun to transfer a portion of its automated mapping capability to IBM hardware and software in order to utilize the digital maps created on the INTERGRAPH system for the mapping of nongraphic attribute data stored on the Corporation's corporate data base which is maintained on IBM equipment.

Wisconsin Gas Company

Wisconsin Gas Company installed IBM hardware and software in 1984 to begin its automated mapping activities. It is currently acquiring its digital mapping base through a combination of board digitizing and direct digitizing from stereoscopic models, but no digital conversion has been undertaken inside Milwaukee County at the present time. The Company expects to begin converting its facility network information late in 1988. Approximately the northern two-thirds of Milwaukee County lies within Wisconsin Gas Company's service territory. Wisconsin Gas is utilizing the State Plane Coordinate System, NAD27, having obtained the spatial reference framework for its automated mapping in Ozaukee, Washington, and Waukesha Counties with the assistance of the Commission. At the Company's request, the Commission arranged for the relocation, monumentation, and placement on the State Plane Coordinate System of certain carefully selected additional U. S. Public Land Survey corners in Ozaukee and Washington Counties to provide the necessary ground control for the large-scale aerial photography obtained by the Company for the direct digitization from stereoscopic models of its automated mapping base in these areas.

In the Brookfield area in Waukesha County, the Company is board-digitizing its automated mapping base from large-scale topographic maps prepared in 1986 to Commission-prepared specifications under Waukesha County's large-scale topographic mapping and survey control program. In recent years, the Company has been one of the advocates of cooperative digital mapping efforts, and in 1987 approached both Waukesha County and the Commission, as the County's agent for mapping, concerning the preparation of topographic mapping in digital rather than analog format in the Menomonee

Falls area. Much of this area had been mapped in the 1960's, and a revision to this mapping—including the preparation of new mapping in some small previously unmapped pockets—using standard photogrammetric procedures was scheduled for 1987 and 1988. The Company agreed to pay the incremental cost between the preparation of entirely new mapping in digital format and the preparation of mostly revised and some new mapping in analog format as originally planned. Accordingly, the specifications for the project were modified by the Commission to provide for the delivery of the mapping in digital format, and digital map files began to be delivered in this format in the summer of 1988, with copies being provided to the Company for its use. Subsequently, Waukesha County decided to have all new mapping completed under the countywide large-scale topographic mapping and control survey program delivered in digital format beginning with the 1988 project areas.

Wisconsin Bell

In about 1982, Wisconsin Bell acquired digital map files through a commercial vendor for approximately 75 percent of Milwaukee County, but did not acquire any computer hardware or software to manipulate the digital data at that time. After a hiatus attributable in part to the issues surrounding the federal court-ordered corporate reorganization of American Telephone and Telegraph and its subsidiaries, Wisconsin Bell is again evaluating hardware and software products for the initiation of its own corporate automated mapping and facilities management system, and a decision may be made before the end of 1988. Wisconsin Bell anticipates using the UTM coordinate system, NAD27, for its digital mapping inasmuch as this system is already being utilized for its present analog mapping operations.

PREVIOUS EFFORTS AT JOINT DEVELOPMENT OF AUTOMATED MAPPING SYSTEMS IN MILWAUKEE COUNTY AND SOUTHEASTERN WISCONSIN

The feasibility of joint development of automated mapping resources is not a new issue in the Milwaukee metropolitan area, and the preparation of this report does not represent the first attempt to determine the interest of area units of governments and utilities in pursuing joint development and use of digital mapping capability. On several occasions during the 1970's, there were informal discussions concerning the feasibility and desirability of cooperative development of automated mapping capability, but no agreements toward that end were forthcoming. Most recently, in 1985 and 1986, this discussion was again taken up on an ad hoc basis among project manager and system manager level staff of Milwaukee County, the City of Milwaukee, the Milwaukee Metropolitan Sewerage District, the Southeastern Wisconsin Regional Planning Commission, the Wisconsin Electric Power Company, the Wisconsin Gas Company, and Wisconsin Bell, among others. Approximately 15 meetings were held by this ad hoc group over a period of about nine months in an attempt to find sufficient common ground for the mounting of a coordinated effort to jointly produce and maintain those items of map information that were common to all or most of the then-existing or contemplated automated mapping systems. Several meetings were also held that involved management level staff of the involved groups before it was determined that a consensus for undertaking a joint effort did not exist.

Items that could not be mutually agreed upon as part of these discussions included the following:

1. The nature, density of spacing, and precision of the underlying survey control network.
2. The map projection system upon which any jointly developed digital map system would be placed and maintained.
3. The inclusion of hypsometric features in any jointly developed digital map base.
4. The precision to which planimetric map features would be located.
5. The types of planimetric features that would be mapped and the map symbology that would be utilized in any jointly developed digital map base.
6. The precision to which cadastral information would be mapped.
7. The type of joint organizational structure to be developed.

8. The issue of legal liability for incorrect map information in a cooperative or joint organizational structure.

9. The manner in which the costs of creating and maintaining the system would be allocated among the participants.

10. The manner in which digital map data would be shared among the potential users of a shared system given the various proprietary hardware and software systems already in existence.

11. The issue of whether or not a "shared" digital map base might inadvertently provide an unauthorized pathway into sensitive corporate or governmental digital data files.

Any new attempt to determine the feasibility of developing a shared automated mapping and land information system in Milwaukee County will need to address these issues. Continued failure to establish a consensus on these issues will result in citizens continuing to pay through their tax bills and utility bills for those duplicative portions of the multiple systems that are being developed. In addition, the opportunity to achieve true efficiencies and economies of operation through the use of such devices as a common reference framework, a standard set of map features and map symbology, and a standard set of map data exchange procedures will be lost—probably forever—to the individual systems in the Milwaukee area if this consensus is not forthcoming.

SUMMARY

For more than a decade, there has been growing interest in the United States in land information systems. This interest ranges from a relatively narrow concern about the need to modernize land title recordation systems to a relatively broad concern about the need to create entirely new land-related data banks for multipurpose applications. This growing interest has involved many disciplines, ranging from surveyors, abstractors, assessors, and attorneys concerned with the fiscal and legal administration of real property to planners, engineers, public utility managers, public administrators, and elected officials concerned with resource management and community development. Much of the interest initially centered around the use of electronic computers for the storage, manipulation, and retrieval of land-related information and, more recently, for the use of computer-assisted graphics collection and display hardware for the reproduction of the data in mapped as well as tabular form.

In 1979, the National Research Council convened a Panel on a Multipurpose Cadastre to review the status of cadastral activities at the federal, state, and local governmental levels and in the private sector. This action was taken by that Council in response to the growing interest in land data systems and to the perceived ever-increasing need for land-related information by all levels of government and by the private sector. In 1980, the Panel issued a report, the principal finding of which was that there is a critical need to modernize the land information systems of the United States and to improve land conveyance procedures, to furnish a basis for equitable taxation, and to provide much-needed information for resource management and environmental planning.

The report set forth the concept of the multipurpose cadastre as a basis for a dynamic public process that could effectively collect, maintain, and disseminate land-related information; however, the report did not address how governments, especially local governments, could carry out the recommendations made in the report. To address the questions left unanswered by its 1980 report, the National Research Council prepared a second report, issued in 1983, which set forth a set of recommended procedures and standards for the design and implementation of a multipurpose cadastre. It was the intent of this report to assist local units of governments in the development of cadastral records systems for their own jurisdictions, and also, the many other regional, state, and federal agencies, as well as private businesses, whose participation will be needed for the development over time of true multipurpose land information systems.

These two reports provide a conceptually sound model for the development of automated mapping and land information systems, and have come to be regarded in some circles as de facto standards for land records modernization. The procedural model put forth by the Panel identified the basic components of a modern land information system as: 1) a spatial reference framework consisting of monumented geometric

control points; 2) a series of accurate, large-scale topographic base maps; 3) a cadastral overlay to the base maps that delineates all cadastral—that is, real property ownership—parcels; 4) a cadastral parcel numbering scheme that provides for unique identification of each cadastral parcel; and 5) a series of compatible registers of interests in, and data about, the land parcels keyed to the parcel identifier. The local mapping and survey control network recommended by the Southeastern Wisconsin Regional Planning Commission since 1964 provides two of the five basic components of a modern land information system as set forth by the Panel, namely: 1) the required spatial reference framework, and 2) the required accurate large-scale topographic base maps; and facilitates the creation of the third component, a cadastral map overlay. Less obvious, but of equal importance, the Commission-recommended survey control network provides a mechanism for relating real property boundary descriptions to the State Plane Coordinate System and, in turn, to latitude and longitude, thereby facilitating the precise correlation of real property boundary lines and earth science data—a condition necessary for the creation of a modern, automated land information system.

The Commission-recommended local mapping and survey control network program was one of a select few local land information system modernization efforts described by the Panel in its reports, and therefore put forth as a system for emulation across the nation. It is also important to note—particularly within the context of the development of this report—that both National Research Council reports determined that for much of the United States, the county presented the most logical locus for the development of multipurpose land information systems.

In 1985, then Governor Anthony Earl appointed the Wisconsin Land Records Committee, a group representing state, regional, and local governmental interests, private utilities, and other private businesses, to examine land records modernization issues in Wisconsin. This group issued 13 reports on various aspects of automated mapping and land records modernization and a final report that summarized the more important findings of the Committee's deliberations. Like the National Research Council Panel, the Wisconsin Land Records Committee determined a need for continued efforts directed at land records modernization.

The Committee determined that the costs to develop modernized land records systems would not be trivial, but that the costs would be reasonable in view of the sums already being expended for current outdated and inefficient land information management practices, and further suggested that various levels of government, private utilities, and other private businesses involved in the use of land information make every effort to jointly develop and use automated systems in order to minimize their total societal costs, recognizing, as they did, that the ultimate costs of land records modernization would be borne by the State's citizens in the form of tax bills and utility bills.

The Committee recognized that its recommendation for the development of shared approaches to land information systems modernization would create new organizational and institutional strains that would be fully as demanding in their solution as the technical issues involved in the creation of new, automated land information systems. Accordingly, the Committee recommended that the educational and coordinative aspects of land records modernization receive as much attention as the technical issues.

The deliberations of the Committee and its published reports reaffirmed the validity of the procedural model advanced by the National Research Council Panel for the development of modern, automated land information systems and, as did the National Research Council reports, called attention to the Commission-recommended local mapping and survey control network program as a basis for the development of modern, automated land information systems. Finally, as did the National Research Council Panel, the Wisconsin Land Records Committee recognized that there is a central role to be played by counties in the land records modernization process.

Three general types of automated mapping and land information systems operational structures are currently recognized: strictly automated mapping or computer-assisted drafting (CAD) systems; automated mapping/facilities management (AM-FM) systems; and geographic information systems (GIS). Although the distinctions between the types are not always clear, the CAD systems are perhaps the easiest of the three to

categorize since they tend to be almost exclusively automated mapping systems with little or no capability for the management of associated land records.

Both AM-FM and GIS systems possess automated mapping and records management capabilities, although the distinction between the two systems is quite often a function of the type of associated land information managed by the system rather than of any pronounced functional difference between the two system types. Typically, systems categorized as AM-FM systems are found in situations where the predominant function is to manage information associated with networks: for example, water distribution systems, sanitary sewerage systems, telephone systems, and electric power and natural gas distribution systems. GIS systems are usually systems that manage information associated with areas: real property parcels, administrative districts, land use polygons, and soil mapping units.

There are a number of automated mapping and land information systems already in existence whose areas of operation include all or portions of Milwaukee County. Several of these systems—those of the City of Milwaukee, the Southeastern Wisconsin Regional Planning Commission, and the Wisconsin Energy Corporation—have been functional for a decade or more and have developed extensive digital map holdings. These systems currently utilize a variety of proprietary computer hardware and software products in their operation, and are using two different, although mathematically relatable, map coordinate systems.

There has been prior interest expressed in developing a cooperative approach to automated mapping in the Milwaukee area, with the most recent discussions taking place in the latter part of 1985 and early 1986, and including the staff of, among others, Milwaukee County, the City of Milwaukee, the Milwaukee Metropolitan Sewerage District, the Southeastern Wisconsin Regional Planning Commission, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell. This exercise, in common with previous discussions going back to at least the middle 1970's, did not elicit a consensus on a number of issues that provide a necessary basis for moving forward with a joint automated mapping and land information system development effort. These issues include, but are not necessarily limited to, a common spatial reference framework, precision and accuracy standards, the categories of information to be mapped in a cooperative arrangement, organizational structure and control of the cooperative effort, and the allocation of costs among the participants.

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Chapter III

COMPONENTS OF AN AUTOMATED MAPPING AND LAND INFORMATION SYSTEM

INTRODUCTION

This chapter provides a description of the major elements of a multi-purpose cadastre, and discusses such a cadastre within the more general context of land information systems. Since the development of a multipurpose cadastre generally assumes that the relevant land-related information will be transformed into a computer-readable format, this chapter also provides a description of the process whereby land-related information stored in the form of maps and aerial photographs is converted into a form whereby it can be manipulated by computer. This process is commonly referred to as "digitization." Finally, the chapter describes remonumenting and base mapping efforts previously carried out in the Region and in Milwaukee County, which provide the essential base for the establishment of an automated mapping and land information system.

THE CADASTRE AS PART OF A LARGER SYSTEM OF LAND INFORMATION

A cadastre may be defined as a record of interests in land, encompassing both the nature and extent of these interests. Historically, cadastres have been created and maintained for the purpose of taxing these interests, and evidence of the existence of cadastres goes back through hundreds of years of human civilization. It is possible to develop an automated version of a cadastre defined in this more narrow, historical sense; and, in fact, the development of such single-purpose cadastres has been advanced on the premise that the development of more complex multipurpose cadastres and land information systems ought to begin with the development of single-purpose cadastres relating only to the value of real property as a basis for taxation, and perhaps the registration of land ownership, being extended later in an evolutionary manner to other applications.

Thus, the development of a more narrowly defined cadastre can be considered a preliminary step in the development of a broader land-related information system. Additional information subsequently incorporated into such a system may include data on land use; certain natural characteristics of the land such as soil and geologic conditions; natural hazards such as flooding and shoreline erosion; environmentally sensitive areas such as woodlands and wetlands; permits; public and private infrastructure systems; and aggregate social and economic data, to name just a few. These broader land information systems are considered to contain, in addition to the information considered to be part of a single-purpose cadastre, all types of land-related information both cultural and natural.

ELEMENTS OF A MULTIPURPOSE CADASTRE

A multipurpose cadastre can be conceptualized as a public, operationally and administratively integrated, land-related information system which provides continuous, readily available, and comprehensive information at the ownership parcel level. The Panel on a Multipurpose Cadastre of the National Research Council has proposed the procedural model shown in Figure 1 for the development of multipurpose cadastres. This model consists of the following five basic elements: 1) a geographic reference frame consisting of a geodetic survey network; 2) a series of current, accurate, large-scale base maps properly related to the geographic reference frame; 3) a cadastral map overlay delineating all cadastral parcels which is also properly related to the geographic reference frame; 4) a unique identifying number assigned to each parcel; and 5) a series of registers, or land data files, each including a parcel index for purposes of information retrieval and cross referencing with information in other land data files. Additional elements in the form of maps and records of land-related information can be readily added to the base over time.

Geodetic Reference Framework

A reference frame—or survey control network—consisting of a system of survey monuments having geodetically based coordinates, is necessary for defining the relative spatial location of

all land-related data, and as such comprises the first component for a multipurpose cadastre. Unfortunately, in the United States, two different, and heretofore largely uncoordinated, systems of survey control have evolved. One of these two systems, the State Plane Coordinate System, is founded in the science of measurement and is intended to be utilized as a basis for the collection of earth science data and the preparation of earth science maps, such as topographic, geologic, soils, and hydrographic maps. The other of these two systems—the U. S. Public Land Survey System—is founded in the principles of property law, as well as in the science of measurement, and is utilized for the collection of cadastral data and the preparation of cadastral maps, such as real property boundary line maps.

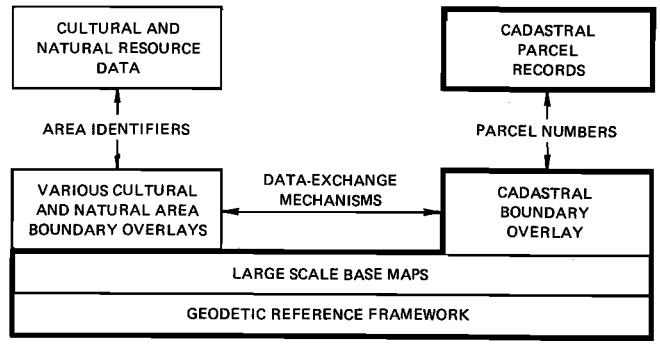
U. S. Public Land Survey System: For most of the United States, the federal government has provided the basic survey control system for cadastral mapping in the form of the U. S. Public Land Survey System. Under regulations imposed by the Congress, the U. S. Public Land Survey System has been extended into 30 of the 50 states, including Wisconsin.

This system is founded in the best features of the English common law of boundaries, superimposing on that body of law systematic land survey procedures under which the original public domain is surveyed, monumented, and platted before patents are issued; legal descriptions are by reference to a plat; lines actually run and marked on the ground control boundaries; adjoiners are respected; and the body of law in effect at the time of the issuing of the deed is controlling, and forever a part of, the deed. Unlike scientific surveys, which are made for the collection of information and can be amended to meet improved standards or changing conditions, the original government land survey in an area cannot be legally ignored, repudiated, altered, or corrected as long as it controls rights vested in lands affected.

The U. S. Public Land Survey System is one of the finest systems ever devised for describing and marking land. It provides a basis for a clear, unambiguous title to land, together with the physical means by which that title can be related to the land it describes. The system is ingenious, being simple and easy to comprehend and administer; and without it, the nation would unquestionably have been poorer. The "rectangular" land survey system, however, has one serious flaw. Its use requires the perpetuation of monuments set by the original government surveyors, the positions of which are not precisely related to the surface of the earth through a scientifically established map projection.

Figure 1

COMPONENTS OF A MULTIPURPOSE CADASTRE



The basic elements of a multipurpose cadastre (in heavy outline) provide a ready framework for the incorporation of additional land related information in the form of maps and records.

Source: National Research Council and SEWRPC.

State Plane Coordinate System: A strictly scientific survey control system designed to provide the basic control for all federal—and most private—topographic and other earth science mapping operations exists separately from the U. S. Public Land Survey System in the triangulation and traverse stations established by the National Geodetic Survey (formerly U. S. Coast and Geodetic Survey). The triangulation and traverse stations established by this agency comprise a nationwide network connecting thousands of monumented points whose geodetic positions, expressed in terms of latitude and longitude, are known. In order to make the National Geodetic Survey control network more readily available for local use, the U. S. Coast and Geodetic Survey devised the State Plane Coordinate System in 1933. This system transforms the spherical coordinates—latitudes and longitudes—of the stations established in the national geodetic survey into rectangular coordinates—eastings and northings—on a plane surface. This plane surface is mathematically related to the spheroid on which the spherical coordinates of latitude and longitude have been determined. The mutual relationship, which makes it practicable to pass with mathematical precision from a spherical to a plane coordinate

system, makes it also practicable to utilize the precise scientific data of the National Geodetic Survey control network for the reference and control of local surveying and mapping operations. A limitation on such uses, however, is imposed by the relatively widespread location of the basic triangulation and traverse stations and the difficulties often encountered in the recovery and use of these stations.

Large-Scale Base Maps

To satisfy the growing need for an integrated, land-related information base, a system capable of handling a variety of information ranging from such earth science-related data as flood hazard boundary line locations, to such cadastral-related data as real property boundary line locations, is required. It is also mandatory that field work, data resolution, and information presentation be consistent with the most detailed level of land-related decision-making, that of the individual proprietary parcel. These requirements call for base maps at scales significantly larger than those generally available in the United States as the second component of a multipurpose cadastre.

Cadastral Overlay

The third component of a multipurpose cadastre is the cadastral overlay. Preparation of the cadastral overlay requires identifying and delineating the most fundamental unit of land—a cadastral parcel. This unit of land becomes the basic building block for maintaining real property boundary line-related information, including information on rights and interests. A cadastral parcel is, therefore, an unambiguously and uniquely defined unit of land within which rights and interests are legally recognized and for which there is a unique and complete group of rights. The primary type of interest, for this definition, is land ownership associated with that set of rights and interests that may be acquired and transferred.

Parcel Number

The fourth component of a multipurpose cadastre is the parcel identifier, defined as a code for recognizing, selecting, identifying, and arranging information to facilitate storage and retrieval of parcel records. It may also be used for spatial referencing of information and as a means for referring to a particular parcel in lieu of a full legal description. There is general agreement that the identifier system used should provide for the assignment of a unique code to each parcel, should be easily understandable and usable to the general public—or at least to that segment of the public that may have cause to use the system, should be capable of serving a variety of different uses, and should be reasonably permanent.

Land Information Files

The fifth and last component of a multipurpose cadastre consists of the land information files, or land data files, which contain facts about the land parcel in question and are related to the cadastral map through the parcel identifier. The various types of information that may be compiled about the land are potentially voluminous, and may include information about both natural and cultural—that is, man-made—features of the parcel. Perhaps the most familiar land information files are those of local land-title records systems and tax assessment and collection records systems.

CONVERSION OF GRAPHIC DATA INTO A COMPUTER COMPATIBLE FORMAT

Much of the current interest in the modernization of land data systems has centered in the use of electronic computers for the storage, manipulation, and retrieval of the data and, more recently, the use of computer-assisted graphic collection and display hardware for the reproduction of the data in mapped as well as tabular form. Nongraphic land information—parcel identification numbers, legal descriptions, and assessment information, for example—can be entered into a computer through standard "key punch" data entry procedures. Land information that has traditionally been maintained in the form of maps—such as real property boundary lines—however, must be converted into a numeric, or digital, format before it can be entered into a computer. This is most often accomplished by a device, sometimes itself computer controlled, called a "digitizer," and the process by which the conversion is completed is often identified as "board digitizing."

A digitizer, therefore, is a machine system which transforms mapped information into a computer-readable form to facilitate information manipulation and display. A digitizer is usually comprised of the following hardware components:

1. A controller, which is often a small to medium size computer.

2. An on-line data storage device.

3. An operator work station, which consists of a keyboard for entering commands and nongraphic data into the system and a graphic display screen or screens for viewing collected information.

4. A digitizing board or tablet which allows for determining the accurate relative location of a point identified on the surface of the board using a device—a cursor—which is able to move freely over the surface of the board.

Additional equipment may include a printer, a computer tape unit, and graphic production devices called "plotters." Each component can vary greatly in size and capability depending on requirements of the particular system.

The transformation of mapped information into computer-readable information requires maps which are related to some system of geometric control and which have at least two or three points for which an x-y coordinate pair can be determined. The coordinate system utilized can vary from an arbitrary scale unique to the base map to some more universal system such as the State Plane Coordinate System. Once the base map has been placed on the digitizer board, the known coordinates of the map are entered into the digitizer and located on the base map with the cursor. When this operation is complete the map is said to be "scaled," and positions of other points on the map can be established based upon their relative positions to the known points.

Each line on the map is defined as a series of connected points. The cursor is used to identify each point, which is then assigned an x-y coordinate pair based on the position of the point relative to the known base points used to scale the maps. Each map line is then stored in the system as a series of x-y coordinates. Each line or segment can be stored separately or combined with other segments to form closed polygons with defined attributes and measurable areas.

Base map accuracy is an important consideration when digitizing. A digitizing system does not improve the accuracy of a base map but only replicates the map features, including errors and discrepancies. While the board digitizing procedure just described is the most common technique for conversion of map data into digital form, several other techniques have been developed which work well in certain specialized situations or with certain specific types of map information. These are optical scanning, direct digitizing from stereoscopic models, and coordinate geometry entry.

An optical scanning system is a machine system that is much like a board digitizing system in its physical arrangement. It merely substitutes an optical scanning device for the digitizing board or tablet. In operation, the document to be converted to digital form is mounted on a large drum that rotates at high speed under an optical device that scans the drum and "reads" the document. While these devices are capable of converting documents to digital form more rapidly than can board digitizing, they have typically required quite complex software to perform editing and categorizing of the converted data. For anything other than very simple maps, these devices have yet to supplant board digitizing.

Direct digitizing from stereoscopic models is relatively more recent in origin than either board digitizing or optical scanning, but is, however, based upon long-established photogrammetric engineering procedures. In a direct, stereoscopic digitizing system, the digitizing board or tablet that would be present in a board digitizing system is replaced by a stereoscopic map compilation machine. Stereoscopic aerial photography acquired for map compilation purposes can be used to establish a stereoscopic model in the traditional manner, but rather than utilizing the model to prepare an analog map manuscript for subsequent board digitization, the operator optically "digitizes" map features directly from the model, thereby producing the digital map files directly.

An additional means of converting map information into maps is coordinate geometry entry, sometimes referred to as "precision digitizing." In coordinate geometry entry, there is no analog device present in the machine system for the conversion of map documents to digital maps. All of the information needed to construct a map is key entered and the map is constructed utilizing plane geometry relationships and formulae contained in highly specialized computer software. Conversion of map data by

coordinate geometry is exceedingly tedious and is generally used only for relatively small project areas, or for areas where the quality and precision of the data available warrant the additional effort of this procedure. Of all the currently available methods of data entry, however, coordinate geometry procedures are the only procedures that do not result in a loss of precision and are the only conversion procedures that produce digital map data that are truly scale independent.

Once the initial map data are transformed into digital form with the digitizer, a variety of manipulations become possible. Data mapped at one scale can be reproduced at different scales, provided that the accuracy limitations of the original maps are recognized in any enlargement, as opposed to reduction, in scale. Graphic base files collected from different sources can be merged and reproduced at a uniform scale. Data for special study areas can be identified, reproduced, and measured; and information on the base maps can be identified in such a manner that only selected portions of that information are reproduced at a time.

EXISTING FRAMEWORK FOR THE DEVELOPMENT OF MULTIPURPOSE CADASTRES WITHIN SOUTHEASTERN WISCONSIN

It should be noted that the first three elements of the procedural model for the creation of a multipurpose cadastre as proposed by the National Research Council have long been embodied in the Regional Planning Commission's recommended large-scale base mapping program. Recognizing the importance of good large-scale maps and attendant survey control to sound community development and redevelopment, the Commission has, for over two decades, encouraged the preparation of large-scale topographic and cadastral maps within its 2,689-square-mile Planning Region. These maps are based on a unique system of survey control that combines the best features of the U. S. Public Land Survey System and State Plane Coordinate System. The large-scale maps and attendant survey control system, where they already exist, provide, in a highly cost-effective manner, the technical foundation for the creation of multipurpose cadastres within the Region. Because of their critical and central importance to the implementation of a multipurpose cadastre, these three elements—the geodetic reference frame, large-scale base maps, and the cadastral overlays—are discussed in greater detail in the following sections.

A Composite System for the Geodetic Reference Framework

From the preceding brief discussion of the U. S. Public Land Survey and State Plane Coordinate Systems, it is apparent that two essentially unrelated survey control systems have been established in the United States by the federal government. One of these—the U. S. Public Land Survey System—is founded in the legal principles of real property description and location and was designed primarily to provide a basis for the accurate location and conveyance of ownership rights in land. The other—the State Plane Coordinate System—is founded in the science of geodesy and was designed primarily to provide a basis for earth science mapping operations and for the conduct of high-precision scientific and engineering surveys over large areas of the earth's surface. Both systems have severe inherent limitations for use as a geographic framework for a local land data system. By combining these two separate survey systems into one integrated system, however, an ideal system for the geometric control required for land data systems is created.[1] This ideal system includes the relocation and monumentation of all U. S. Public Land Survey section and quarter-section corners, including the centers of sections, within the geographic area for which the land data system is to be created, and the utilization of these corners as stations in second order traverse and level nets, both nets being tied to the National Geodetic Datum. The traverse net establishes the precise geographic positions of the U. S. Public Land Survey corners in the form of state plane coordinates, while the level net establishes the precise elevation above mean sea level of the monuments marking the corners.

Such a system of survey control has at least the following three advantages as a geographic framework for a multipurpose cadastre:

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[1] *See K. W. Bauer, "Geometric Framework for Land Data Systems," Journal of the Surveying and Mapping Division, Proceedings of the American Society of Civil Engineers, Volume 107, Number SU1, November 1981.*

1. It provides an accurate system of control for the collection and coordination of cadastral data, since the boundaries of the original government land subdivision form the basis for all subsequent property divisions and boundaries. As all subsequent legal descriptions and plats must be tied to the U. S. Public Land Survey System, accurate reestablishment and monumentation of the quarter-section lines and corners permits the ready compilation of accurate property boundary line data and the ready maintenance of these data in current form over time. These data can be readily and accurately updated and extended since, in Wisconsin, all new land subdivisions must by law be tied to corners established in the U. S. Public Land Survey, and since the accuracy of the surveys for these subdivisions can be readily controlled by state and local land subdivision regulations. The recommended survey control system thus fully meets the needs of a narrowly defined cadastre for the fiscal and legal administration of real property, yet this cadastre can be developed readily and soundly into a multipurpose land data system.

2. It provides a common system of control for the collection and mapping of both cadastral and earth science data. By relocating the U. S. Public Land Survey corners and accurately placing them on the State Plane Coordinate System, it becomes possible to accurately correlate real property boundary line information with earth science data. This placement of property boundary and earth science data on a common datum is absolutely essential to the sound development of any multipurpose land data system. Yet such a common control datum is rarely used. The establishment of state plane coordinates for the U. S. Public Land Survey corners permits the correlation with mathematical precision of data supplied by aerial and other forms of earth science mapping with property boundary line data compiled through the usual land surveying methods. Only through such a common geometric control system can all of the information required for a multipurpose land data system be accurately collected for, and correlated in, the system.

3. It permits lines and areas entered into the data base—whether these lines represent the limits of land to be reserved for future public uses, the limits of land to be taken for immediate public use, the limits of districts to which public regulations are to be applied, or the location and alignment of proposed new property boundary lines or of proposed constructed works—to be accurately and precisely reproduced upon the ground.

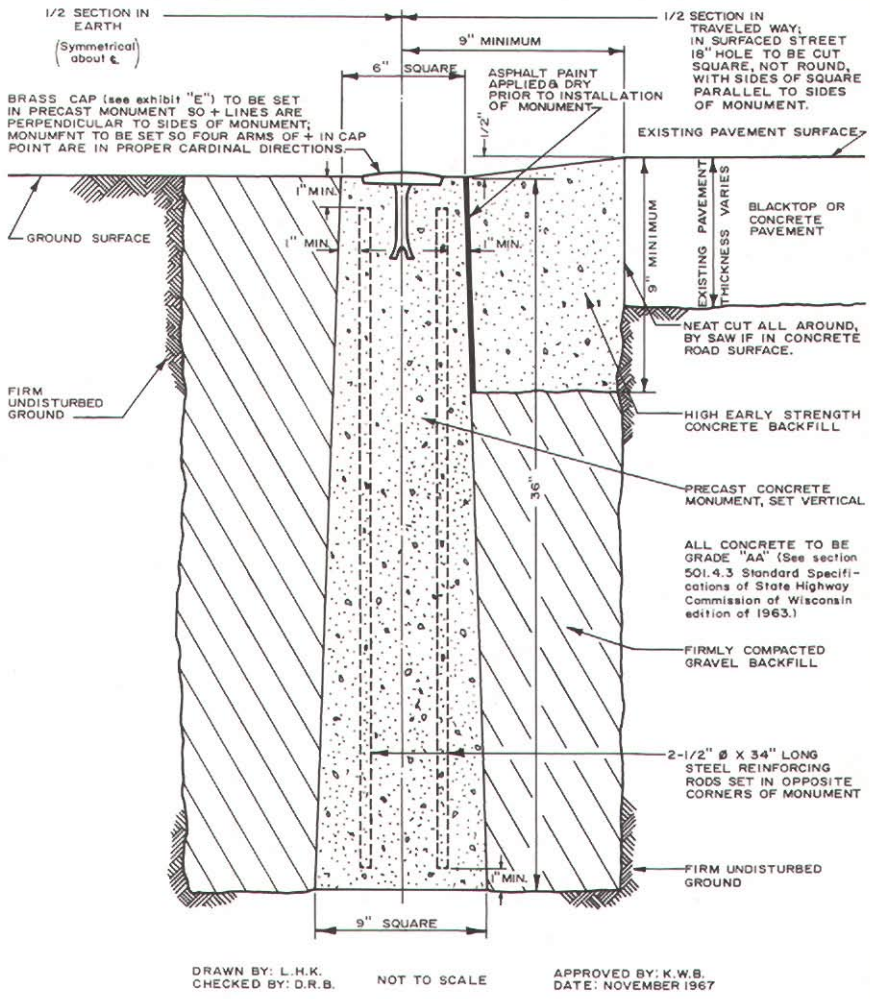
Commission Specifications for Geometric Framework and Base Maps

As already noted, the Regional Planning Commission has, since 1961, promoted the preparation of large-scale topographic and cadastral base maps based upon a survey control system which combines the U. S. Public Land Survey and State Plane Coordinate Systems. The maps and attendant control survey system, in addition to providing essential municipal planning and engineering tools, were intended to provide the foundation for the eventual development of automated, multipurpose cadastres within the Planning Region. Since the Commission-specified base maps and survey control system are already in place in a significant portion of Milwaukee County, a description of those specifications herein is warranted.

Specifications for Relocation, Monumentation, and Coordination of U. S. Public Land Survey Corners: The Commission specifications governing the creation of the necessary survey control network requires the relocation of all U. S. Public Land Survey corners in the areas to be mapped, and the marking of the relocated corners by reinforced concrete monuments, having engraved bronze caps imbedded in the tops (see Figures 2 and 3). The bronze caps are stamped with the corner notation—quarter-section, town, and range. The monuments placed are referenced by ties to at least four witness marks. The specifications require that the survey engineer provide a dossier on each control station established in order to permit its ready recovery and use. The dossier sheets provide for each station a sketch showing the monument erected in relation to the salient features of the immediate vicinity, all witness monuments together with ties, the state plane coordinates of the corner, its U. S. Public Land Survey descrip-

Figure 2

DETAIL OF MONUMENT INSTALLATION FOR SURVEY CONTROL STATIONS



Source: SEWRPC.

tion, the elevation of the monument, and the location of appurtenant reference benchmarks referred to National Geodetic Vertical Datum of 1929 (see Figure 4). These dossier sheets are recorded with the County Surveyor as well as with the Commission, and are thereby readily available to all land surveyors and engineers operating in the area mapped.

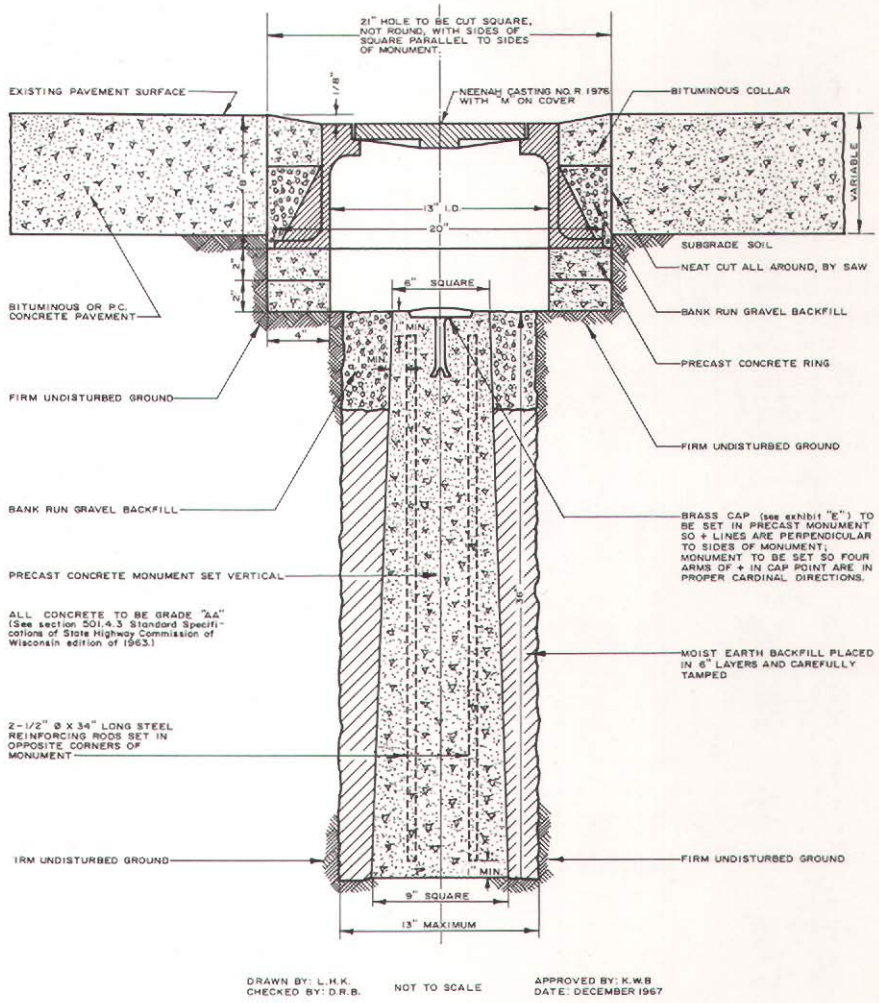
The specifications require the control survey data to be summarized by means of a control survey summary diagram showing the exact grid and ground lengths and grid bearings of the exterior boundaries of each U. S. Public Land Survey quarter section; the area of each quarter section; all monuments erected; the number of degrees, minutes, and seconds in the interior angles of each quarter section; the state plane coordinates of all quarter-section corners together with their Public Land Survey System identification; the benchmark elevations of all monuments set; and the basic National Geodetic Survey control stations utilized to tie the Public Land Survey corners to the horizontal geodetic control datum, together with the coordinates of these stations. The angle between geodetic and grid bearing is noted, as is the combination sea-level and scale-reduction factor (see Figure 5).

All the work necessary to execute the control surveys and provide the finished topographic maps described below has been done in southeastern Wisconsin on a negotiated contract basis with an experienced photogrammetric and control survey engineer. In this regard, it was considered essential to retain a photogrammetric and control survey engineer familiar with higher order field methods and procedures and with the attendant geodetic survey computations and adjustments, and whose crews were properly equipped with state-of-the-art survey instruments. Electronic distance-measuring equipment was employed in the work, as well as optically reading theodolites and appurtenant traverse equipment, automatic levels, and precision level rods. Indeed, the control survey system used is made economically feasible only through the application of these relatively recently developed instruments, particularly the electronic distance-measuring devices. It should be further noted that emerging technologies and techniques—such as the use of satellites in earth orbits to establish ground survey station locations—offer the prospect of continued reductions in the cost of establishing suitable geodetic reference frameworks for multipurpose cadastres.

Although the specifications governing the work make the photogrammetric engineer responsible for overall supervision and control of the mapping work, as well as for the quality of the finished maps, they require that the actual relocation of the Public Land Survey corners be done by a local land surveyor employed as a subcontractor by the photogrammetric engineer or as a contractor by the Commission directly. The specifications thereby recognize that this portion of the work requires expert knowledge of local survey custom and boundary and title law, as well as the assembly and careful analysis of all authoritative survey information—such as title documents and attendant legal descriptions, land subdivision plats and certified survey maps, survey records, and, of cardinal importance, records on existing land survey monumentation and land occupation—in order to arrive at the best possible determination of the location of the land survey corners. In the areas mapped, the land survey portion of the control survey work requires a very high degree of professional competence, as almost all of the Public Land Survey corners fall under the federal definition of either obliterated or lost corners. The importance of this phase of the work and its impact on real property boundaries throughout the community can hardly be overemphasized.

Figure 3

DETAIL OF ALTERNATIVE CONTROL SURVEY MONUMENT INSTALLATION IN SURFACE TRAVELED WAY OF STREETS AND HIGHWAYS



Source: SEWRPC.

Specifications for Topographic Mapping: The specifications provide for the completion of finished topographic maps that can serve as the base maps for the preparation of a multipurpose cadastre by accurately recording the basic geography of the area mapped. In addition to showing the usual contour information, spot elevations, planimetric and hydrographic detail, and coordinate grid ticks, the maps show, in their correct position and orientation, all U. S. Public Land Survey quarter-section lines and corners established in the control surveys (see Figure 6). The specifications require that the maps be prepared to National Map Accuracy Standards. Thus, all state plane coordinate grid lines and tick marks and all horizontal survey control stations must be plotted to within 1/100 inch of the true position as expressed by the coordinates for the control survey stations, and 90 percent of all well-defined planimetric features must be plotted to within 1/30 inch of their true positions, and no such features may be off by more than 1/20 inch. Ninety percent of the elevations indicated by the solid-line contours

Figure 4

A TYPICAL U. S. PUBLIC LAND SURVEY CONTROL STATION DOSSIER SHEET

RECORD OF U.S. PUBLIC LAND SURVEY CONTROL STATION

U.S. PUBLIC LAND SURVEY CORNER 11|11 / 14|14 T 6 N, R 21 E, MILWAUKEE COUNTY, WIS.

GEODETIC SURVEY BY: J.C. ZIMMERMAN ENGINEERING CORP. YEAR: 1975

STATE PLANE COORDINATES OF: QUARTER SECTION CORNER

NORTH 366,799.79

EAST 2,541,034.12

ELEVATION OF STATION:

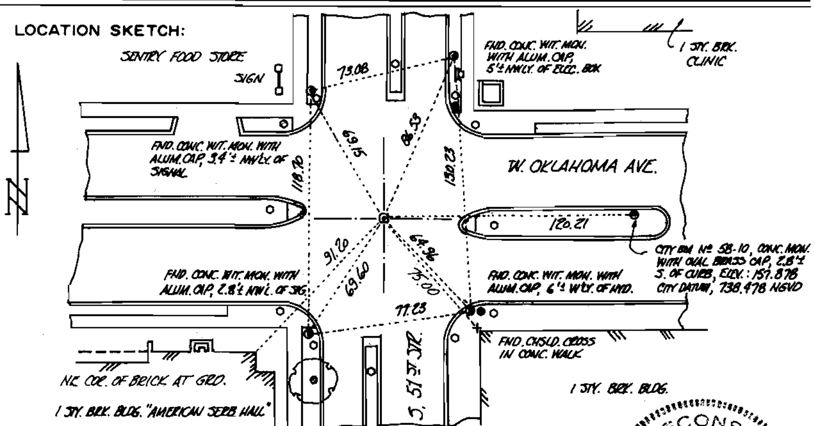
HORIZONTAL DATUM: WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE

VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM OF 1929

CONTROL ACCURACY: THETA ANGLE: + 1-23-22

HORIZONTAL: THIRD ORDER, CLASS I VERTICAL:

LOCATION SKETCH:



SURVEYOR'S AFFIDAVIT:

STATE OF WISCONSIN) SS
WAUKESHA COUNTY)

I HEREBY CERTIFY THAT I found a concrete monument with brass cap in a cast iron hand hole as set to mark this corner in October 1987 by Rodale F. Formella, S-916, following street reconstruction; replacing a brass rod set in the old concrete pavement then marking this corner, said brass rod dating back to March 1963 as indicated by records of the City Engineer; and replacing in turn an old cut limestone monument marking this corner dating back to at least July 1928; and that I referenced the same as shown hereon.

WISCONSIN K. W. BAUER MILWAUKEE, WIS. LAND SURVEYOR

DATE OF SURVEY: 5 November 1987 [signature] S - 157
REGISTERED LAND SURVEYOR

FORM PREPARED BY SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Source: SEWRPC.

must be within one-half contour interval of the true elevation, and no such elevation may be off by more than one contour interval. A combination sea level and scale-reduction factor, and the angle between geodetic and grid bearing, are noted on each map sheet, as is the equation between any local datum and mean sea level.

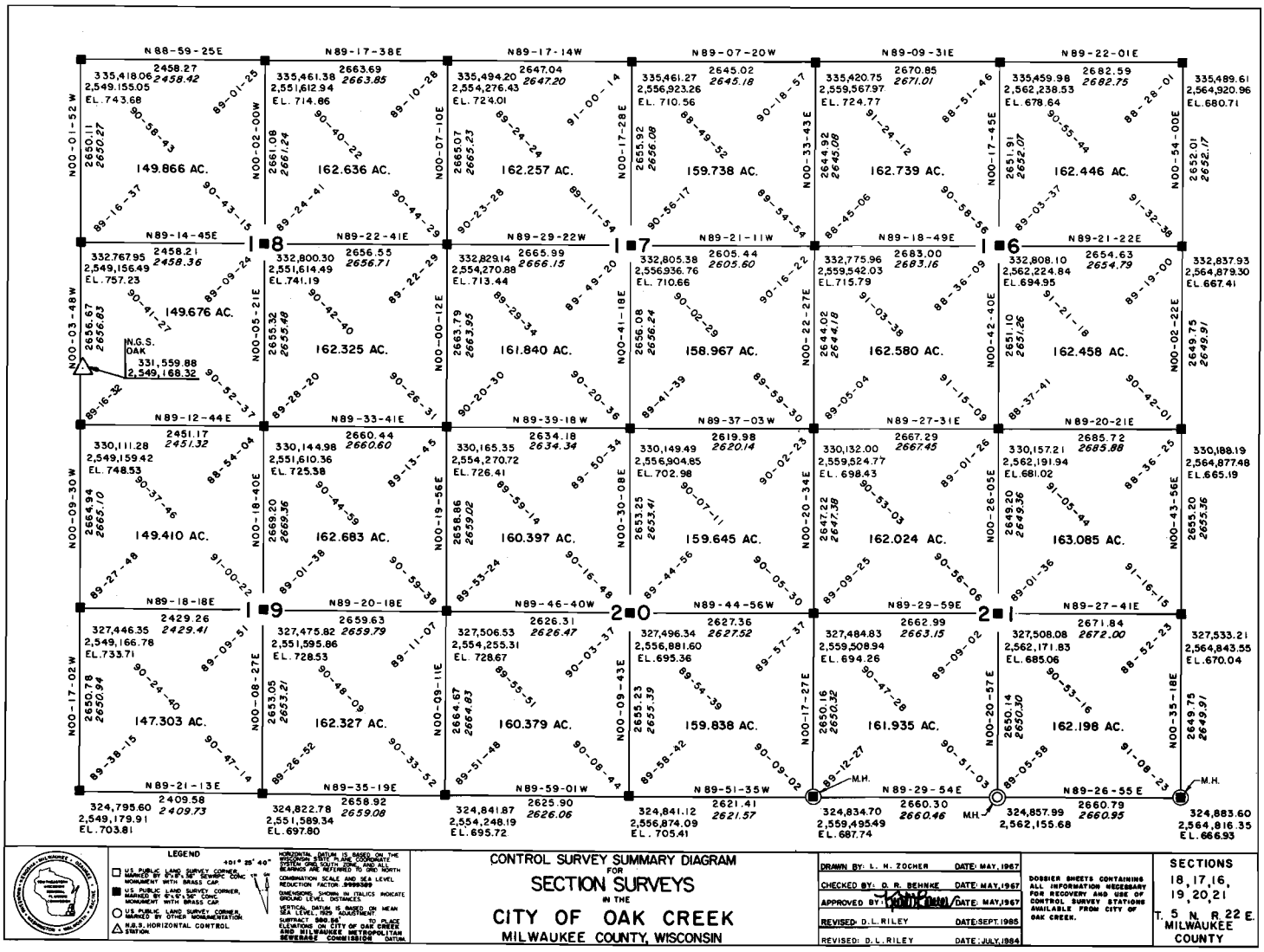
Specifications for Cadastral Mapping: The Commission's specifications visualize the preparation of real property boundary line maps, complementing the topographic maps, by the units of government concerned utilizing resident engineering and planning staffs or consultants. The property boundary line maps are compiled at a scale matching that of the topographic maps, each map sheet covering, like the topographic maps, a U. S. Public Land Survey section or quarter section.

As the topographic maps are being compiled, the Commission specifications require that the photogrammetric engineer provide cadastral base sheets. These sheets consist of reproducible duplicates of the partially completed topographic maps showing, in addition to the state plane coordinate grid, the U. S. Public Land Survey section and quarter-section lines and corners in their correct position and orientation, together with the attendant ground lengths and grid bearings, and such salient planimetric detail and hydrographic features as may be helpful in the subsequent plotting of real property boundary lines, including railway tracks, electric power transmission lines, principal structures, wetlands, and such hydrographic features as streams and lakes.

Utilizing recorded subdivision plats, certified survey maps, and legal descriptions, all real property boundary lines, including street right-of-way lines and major utility easement lines, are then constructed on the base sheets working within the framework of control provided by the ground lengths and grid bearings of the U. S. Public Land Survey quarter-section lines. The property boundary lines are constructed in a manner that parallels the location of these lines on the surface of the earth following land surveying practice in the State of Wisconsin. The specifications require that all real property boundary lines be plotted within 1/30 inch of their true position based on analysis of all authoritative information available. Dimensions are shown

Figure 5

A TYPICAL CONTROL SURVEY SUMMARY DIAGRAM



Source: SEWRPC.

for all platted areas as shown on the recorded subdivision plats. Wisconsin Statutes have long required that such plats be prepared to an accuracy of 1 part in 3,000, as compared to the accuracy of 1 part in 10,000 required by the specifications for the basic survey control network. Any overlaps or gaps between adjoining property boundary lines, as indicated by the constructions and plotting of those lines, are noted on the cadastral maps. Finally, a cadastral parcel identification number is added.

The property boundary line maps thus show the ground length and grid bearing of all quarter-section lines; the state plane coordinates of all quarter-section corners; the monuments marking these corners; the recorded dimensions of all street lines, alley lines, and boundaries of public property; recorded street widths; platted lot dimensions; and a parcel identification number. In unplatted areas, real property boundaries are shown by scale alone. Railway tracks, electric power transmission lines, principal structures, fences, wetlands, lakes, streams, and drainage ditches are also shown (see Figure 7). As previously noted, these boundary line maps can be readily and accurately updated and extended as new land subdivision plats and certified map surveys, utilizing the survey control, are made and recorded.

Status of Survey Control and Large-Scale Base Mapping in Milwaukee County

As previously noted, the Commission has long recognized the importance of good large-scale maps to the proper administration of local government functions, and has encouraged counties, cities, and villages within the Region to prepare such maps. Map 1 shows those areas in Milwaukee County for which large-scale topographic maps have been or are being prepared to Commission-recommended standards, including the relocation, monumentation, and placement on the State Plane Coordinate System of the U. S. Public Land Survey corners. This area totals 146.5 square miles, or about 60 percent of the total area of the County. A total of 961 U. S. Public Land Survey corners in the County have been or are being relocated, monumented, and coordinated, representing about 90 percent of all such corners in the County. Therefore, a significant portion of the initial effort necessary to begin the development of a countywide automated mapping and land information system has already been accomplished.

SUMMARY

A multipurpose cadastre can be conceptualized as a public, operationally and administratively integrated, land information system which provides for continuous, readily available, and comprehensive land-related information at the parcel level. The National Research Council has proposed that multipurpose cadastres consist of the following five elements: 1) a geographic reference frame consisting of a geodetic network; 2) a series of current, accurate, large-scale topographic base maps properly related to the geographic reference frame; 3) a cadastral map overlay delineating all cadastral parcels, which is also properly related to the geographic reference frame; 4) a unique identifying number assigned to each parcel; and 5) a series of registers, or land data files, each including a parcel index for purposes of information retrieval and cross-referencing with information in other land data files.

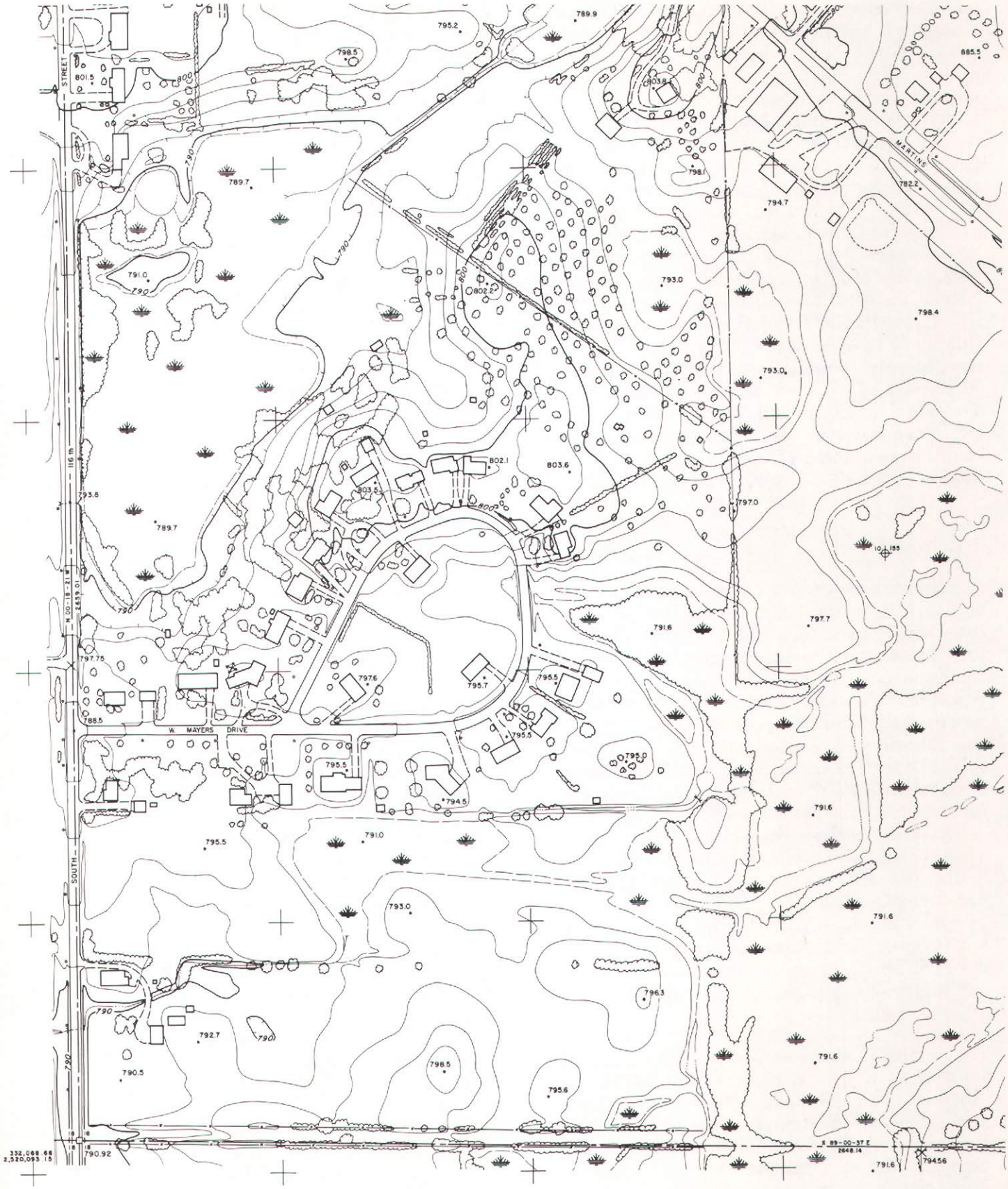
The first three elements of the procedural model for the creation of a multipurpose cadastre as proposed by the National Research Council have long been embodied in the Regional Planning Commission's recommended large-scale base mapping and attendant survey control program. Recognizing the importance of good large-scale maps and attendant survey control to sound community development and redevelopment, the Commission has for over two decades encouraged the preparation of large-scale topographic and cadastral maps within its 2,689-square-mile Planning Region. These maps are based on a unique system of survey control that combines the best features of the U. S. Public Land Survey System and State Plane Coordinate System. The large-scale maps and attendant survey control system, where they already exist within the Region, provide in a highly cost-effective manner the technical foundation for the creation of multipurpose cadastres within the Region, providing the first two of the five elements of such a cadastre, and a part of the third element.

Within Milwaukee County, large-scale topographic maps have been or are being prepared to Commission-recommended standards for an area of about 146.5 square miles, or about 60 percent of the total area of the County. A total of 961 U. S. Public Land Survey corners in the County have been or are being relocated, monumented, and coordinated, representing about 90 percent of all such corners in the County. Therefore, a significant portion of the initial effort necessary to begin the development of a countywide automated mapping and land information system has already been accomplished.

Much of the information that would be incorporated within a multipurpose cadastre or an automated mapping and land information system has traditionally been stored in the form of maps. Conversion of map information into a digital format where it can be manipulated and operated upon by a computer requires the use of a device called a digitizer. Alternatively, certain forms of specialized data conversion procedures such as optical scanning, direct digitizing from stereoscopic models, or coordinate geometry entry can be utilized. Once the initial map data are transformed into numeric form, a variety of manipulations become possible. Data mapped at one scale can be reproduced at different scales, provided that the accuracy limitations of the original maps are recognized in any enlargement, as opposed to reduction, in scale. Graphic base files collected from different sources can be merged and reproduced at a uniform scale. Data for special study areas can be identified, reproduced, and measured; and information on base maps can be identified in such a manner that only selected portions of that information are reproduced at a time.

Figure 6

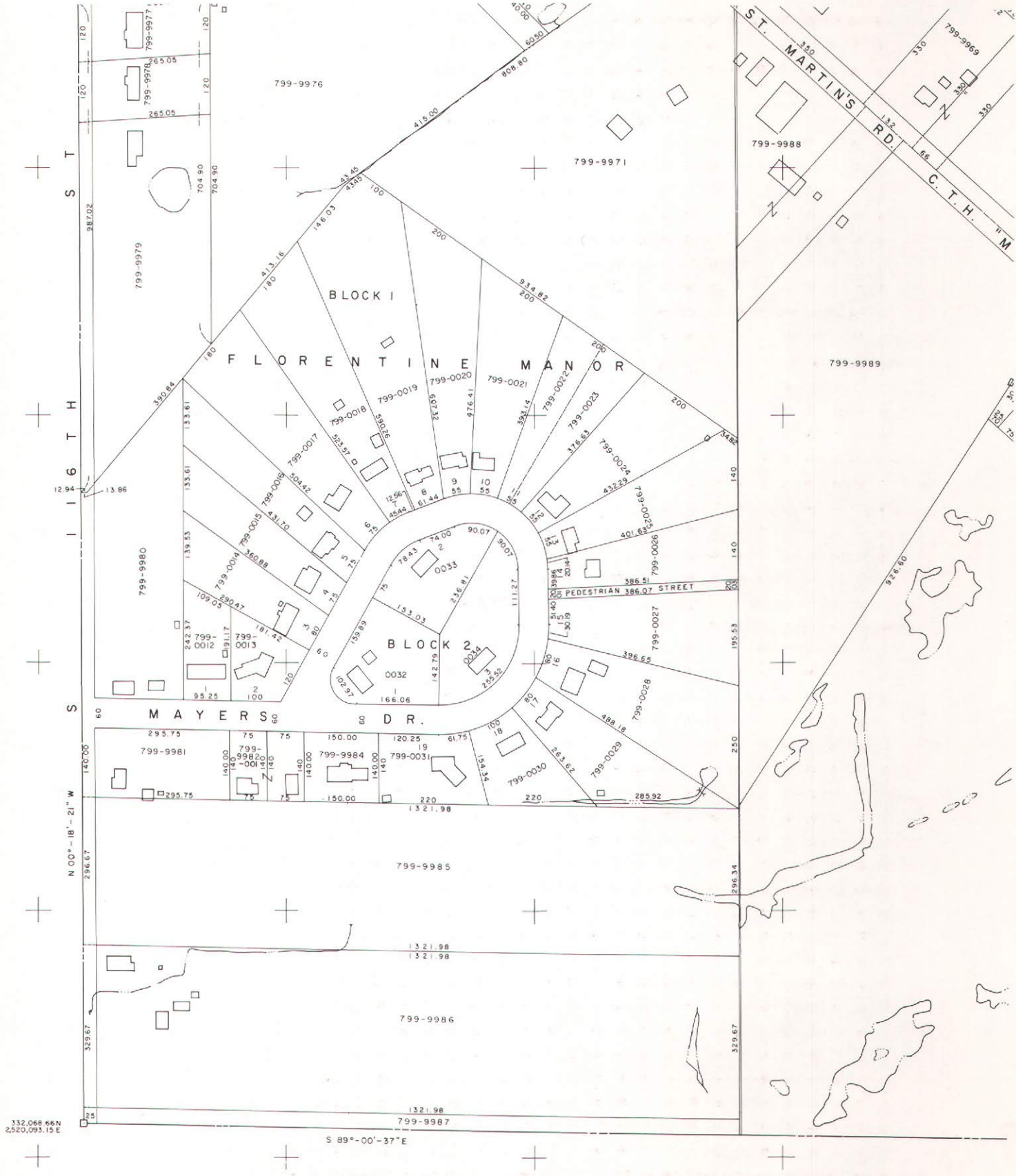
A PORTION OF A TYPICAL LARGE-SCALE TOPOGRAPHIC MAP PREPARED IN ACCORDANCE WITH THE COMMISSION'S RECOMMENDED SPECIFICATIONS



Source: SEWRPC.

Figure 7

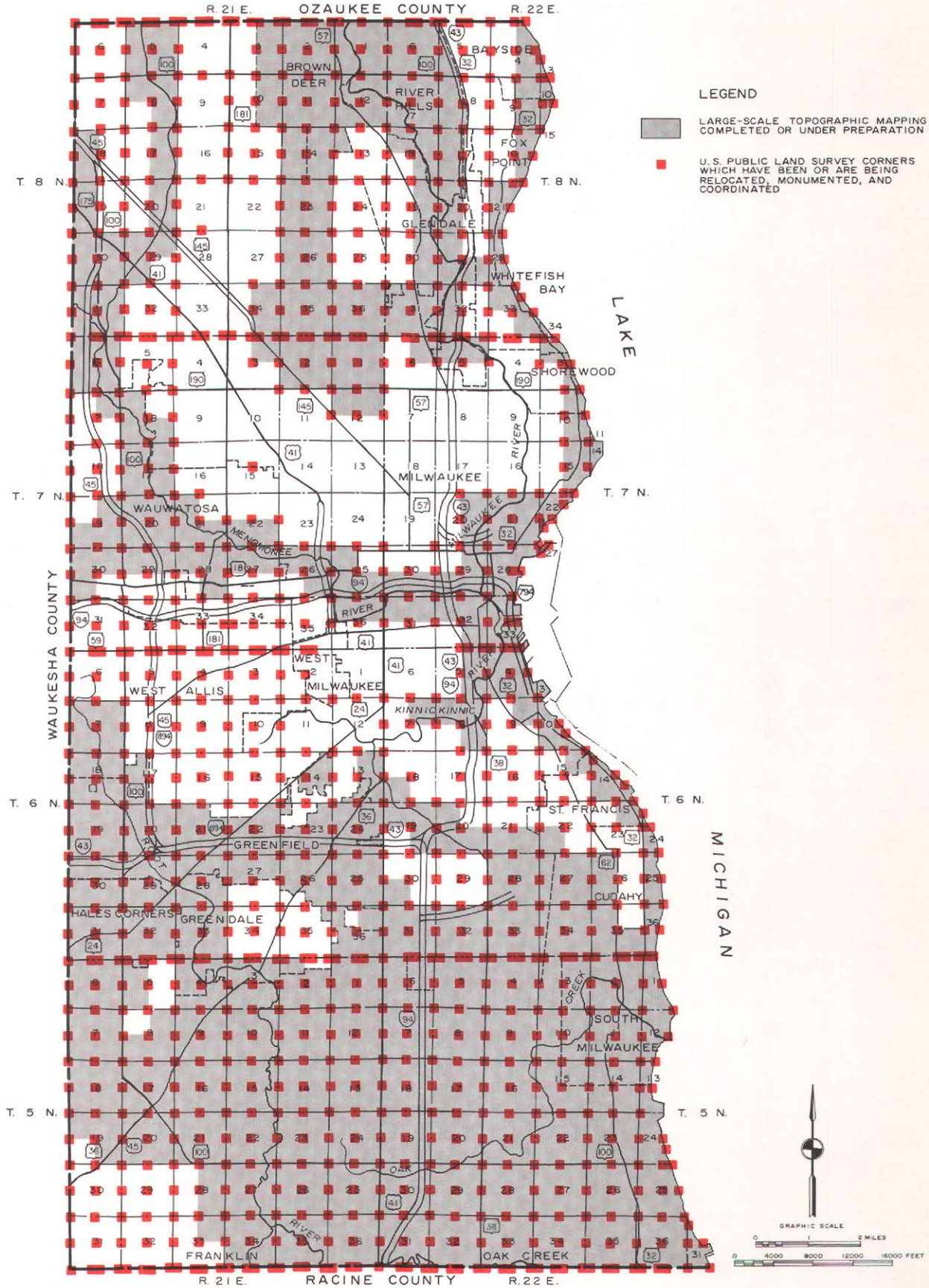
A PORTION OF A TYPICAL CADASTRAL MAP PREPARED IN ACCORDANCE WITH THE COMMISSION'S RECOMMENDED SPECIFICATIONS



Source: SEWRPC.

Map 1

STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE RELOCATION, MONUMENTATION, AND COORDINATION OF U. S. PUBLIC LAND SURVEY CORNERS IN MILWAUKEE COUNTY: JANUARY 1989



Source: SEWRPC.

Chapter IV

IMPLEMENTATION OF AN AUTOMATED MAPPING AND LAND INFORMATION SYSTEM FOR MILWAUKEE COUNTY

INTRODUCTION

Previous chapters of this report have presented an overview of the current status of automated mapping and land information system capability within the Milwaukee area—including previous investigations concerning shared development of this capability—and have identified the National Research Council model for the creation of automated cadastres as the recommended model for the development of a multipurpose, multiuser, automated mapping and land information system in the Milwaukee area. The components of a multipurpose automated mapping and land information system have been identified, and the status of implementation of the first two of those elements—the establishment of a geometric framework in the form of a monumented survey control network and the preparation of a series of large-scale, topographic base maps—within Milwaukee County has been reported. This chapter sets forth a recommendation for the completion of the survey control network and large-scale topographic and cadastral mapping as the initial step in the development of a countywide automated mapping and land information system; sets forth recommended standards for use in the implementation of a countywide automated mapping and land information system; provides cost estimates for the completion of the survey control network and the preparation of the necessary large-scale topographic base maps and cadastral map overlays in those areas of Milwaukee County not already covered by these elements; and evaluates three alternative operational arrangements, including preliminary cost estimates, for a countywide automated mapping and land information system.

THE NEED FOR AN AUTOMATED MAPPING AND LAND INFORMATION SYSTEM FOR MILWAUKEE COUNTY

Based upon statistics generated by the Wisconsin Land Records Committee in its study of Wisconsin's land information modernization needs, Milwaukee County residents pay about $27,000,000 annually to support present land information operations in both the public and private sectors.[1] This Committee also estimated that about one half of all expenditures for land information operations in Wisconsin are made by local units of government—that is, counties, cities, villages, and towns. Most studies of land information operations have concluded that there is redundancy in the various land information systems currently maintained by various governmental and private agencies and organizations. Indeed, much of the current interest in the establishment of multipurpose, multiuser, automated mapping and land information systems is based upon acceptance of the premise by the users and operators of existing land information mechanisms that the same land information is needed regularly by many different agencies and organizations for many different purposes. Based upon review of previous studies of land information use, the Wisconsin Land Records Committee reported that as much as 80 percent of all local government transactions, revenues, expenditures, and other day-to-day management functions involve the use of, or rely upon, land information in some fashion.

The development and common use of a parcel-based multipurpose cadastre would be a major step toward the elimination over time of redundancy in currently established operations, and would forestall the continued development of new, partially redundant operations. As reported in preceding sections of this report, past discussions among current operators have failed to

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[1] *The Wisconsin Land Records Committee estimated an annual per capita cost of $29 to maintain Wisconsin's present land information base. Components of this $29 amount include costs such as portions of local, state, and federal taxes and of utility rate payments required to support land information record keeping; deed and record filing fees; land surveying fees; and real estate title insurance. With a 1988 estimated resident population of 931,000 persons, there is a yearly cost to Milwaukee County residents of about $27,000,000 to support current land information operations.*

result in a consensus on the establishment of a common digital map base despite the continued interest of the participants in so doing. The most divisive issue in these discussions has been the manner in which the cost of developing a common digital map base would be apportioned among the users. However, the ultimate payers of these costs are the area residents. Therefore, the continued inability of the area digital mapping community to successfully resolve this issue represents a continuing disservice to the citizens of the area.

RECOMMENDED STANDARDS FOR AN AUTOMATED MAPPING AND LAND INFORMATION SYSTEM IN MILWAUKEE COUNTY

When discussing the design of an automated mapping and land information system, it has usually been assumed that the "system" is the computer hardware and software and that the "system" is physically centralized—that is, a single hardware configuration upon which reside all of the digital maps and associated land information of all system users. Users of this type of system operate in terminal fashion from the central computer. For many years this type of operation was dictated at least in part by the available computer technology. Recent advances in computer hardware and software technology—particularly as they pertain to decreasing unit costs for computational and mass data storage capability, to networking between the hardware of different vendors, and to the translation of digital map data between different proprietary software products—now permit a different type of "system" to be specified—that is, one in which the system users share digital maps and an agreed-upon set of map-related information, but maintain their own separate—or distributed—computing capability.

If the centralized system concept is discarded, then a number of issues that have in the past been impediments to the development of a shared automated mapping and land information system in the Milwaukee metropolitan area are no longer pertinent. These are the organizational structure and the cost allocation among participants of a centralized operation, and the maintenance of data security on "proprietary" files in a centralized operating environment.

More importantly, perhaps, the ability to replace the centralized operating concept with a distributed operating concept permits discussion to be focussed on the true system components of an automated mapping and land information system. In a distributed operating environment, the "system" is not hardware and software, but an agreed-upon set of procedures and specifications for the production and maintenance of a basic set of digital maps and map-related information, and an agreed-upon set of procedures and specifications for the interchange of these data between system users. It must be stressed that no amount of state-of-the-art computer technology can compensate for the absence of a robust set of specifications and standards for those elements that will be used in common.

The following recommended standards for an automated mapping and land information system for Milwaukee County assume that initially only a selected set of elements—namely, a survey control network, large-scale topographic base maps, and a cadastral map overlay—would be developed for joint use. Discussions held over the past several years among local operators of automated mapping systems indicate that these elements in the aggregate represent a set of map feature information common to most of the users. The provision of a common set of map information in this manner would provide a base sufficient to support a wide variety of uses, including local government and utility preliminary site engineering, outside plant and utility network mapping, the design and construction of public and private works, planning and zoning administration, vehicle routing, and emergency services provision, among others. It is assumed that these more specialized applications would be developed by the users either singly or in small groups as may be appropriate or necessary, rather than being jointly developed.

System Accuracy

The issue of map accuracy in a multiuser environment has been the subject of intense debate among the local mapping organizations, particularly as this issue might affect the allocation of the costs of shared development among the various participants in a multiuser system. In spite of past discussion, however, the ramifications of this issue are still not fully understood or appreciated by all participants in the dialogue. Debate, unfortunately, has focused

on the relative cost of various levels of accuracy and how those costs might be allocated rather than on the true issue, which is the level of accuracy required to support a true multipurpose, multiuser system of digital map resources. If the agreed-upon system is incapable of supporting the needs of the most demanding of the users, the development of multiple systems is inevitable and the creation of a multipurpose, multiuser system cannot, by definition, occur.

In this regard, the recommended standards for a joint automated mapping and land information system as set forth herein are based upon the Commission-recommended standards for the development of survey control networks and local large-scale mapping programs. These Commission programs already represent formally adopted or de facto standards for much of southeastern Wisconsin, including portions of Milwaukee County. In addition, these programs have been subjected to critical review by knowledgeable professionals who have judged them to be both conceptually and procedurally sound.

The large-scale mapping and survey control programs have been in use for more than 25 years in manual mapping environments, and within the most recent decade have been successfully transported to digital mapping environments. They therefore represent successfully "field tested" standards and specifications. The maps and attendant survey control have been demonstrated to support a wide variety of operations to necessary levels of accuracy in both the public and private sectors, and are therefore ideally suited to a multipurpose, multiuser environment.

Map Projection System

It is recommended that the State Plane Coordinate System, NAD27, be used as the map projection system for a countywide automated mapping and land information system. This system is already the system of choice of much of the local mapping community, and a great deal of effort and expense has been expended in its establishment and maintenance. Those organizations in the local area that have chosen to use the UTM system have, in fact, converted much of their existing basic map information to the UTM system from the State Plane Coordinate System. Accordingly, the methodology for the conversion process between the two map projection systems already exists for these organizations and they can continue to "load data" in this manner if they so choose.

The map projection grid should be constructed inside computer memory through key entry procedures. This requirement, if combined with the key entry of all survey control network data, will produce a map projection that is essentially independent of map scale. Constructed in this manner, the map projection will be able to accept and accurately reference not only digitized data from mapped sources at any scale, but also numeric data derived from direct field measurements. This capability is as important as it is subtle, given the increasing availability and affordability of field devices such as "total stations."

Survey Control Network and Large-Scale Topographic Base Mapping

It has been previously noted in this report that the Commission-recommended survey control network and large-scale topographic base maps already exist in a majority of Milwaukee County, and that where this system exists, it is being utilized by units of government and certain utilities in their automated mapping. Through this use, the survey control network and associated topographic base mapping are, in effect, a de facto standard that has already been accepted by the existing automated mapping community in Milwaukee County. Accordingly, the completion of this program in the remainder of Milwaukee County should be pursued, and it should be considered the standard for common use.

Control Surveys: The horizontal control survey work to be undertaken in Milwaukee County should include the recovery or relocation and monumentation of the approximately 104 U. S. Public Land Survey corners not previously recovered or relocated and monumented, including section and one-quarter section corners, centers of sections, and correction corners. Having recovered or relocated and monumented all remaining corners, control survey traverses should be run which utilize and incorporate all of the monumented corners as stations to determine the coordinates of the corners and the lengths and bearings of all quarter-section lines. All coordinates should be based upon the Wisconsin Coordinate System, South Zone, and sufficient survey connections should be made to basic National Geodetic Survey (NGS) control stations of the NGS control net to permit the proper checks and adjustments to be made in

both the traverse lengths and bearings and in the coordinate values of the monumented U. S. Public Land Survey corners. The accuracy of the horizontal control surveys should conform to the specifications for NGS third-order, class I accuracy for traverse.

The vertical control survey work should be based upon National Geodetic Vertical Datum, 1929 Adjustment, as established by the NGS. Closed level circuits should be run as necessary to establish permanent bench marks in the areas remaining to be mapped. All level circuits should be of NGS second-order, class II accuracy and accurately adjusted for closure by NGS methods. Elevations should be determined for the monuments marking the section and quarter-section corners throughout the areas remaining to be mapped, and these monuments should serve as permanent bench marks, each monument being supplemented by at least one reference bench mark.

Large-Scale Topographic Maps: For those areas of Milwaukee County where large-scale topographic base maps have yet to be prepared, these maps should be acquired as digital map files. These digital map files should be prepared to National Map Accuracy Standards at a scale of 1:1,200 (one inch equals 100 feet). Use of these standards will ensure that all map projection grid lines, horizontal control stations, section corners, and quarter-section corners will be plotted on finished maps to within 1/100 of an inch of their true position at the stated scale of 1:1,200. Ninety percent of all well-defined planimetric features will be plotted to within 1/30 of an inch of their true coordinate position. Ninety percent of the elevations determined from the solid-line contours of the map will have an accuracy with respect to true elevation of one-half the contour interval.

The digital map files should contain the following map information:

1. Hypsography by contour lines having a vertical interval of two feet.

2. All planimetric detail such as pavements, curbs, walks, trails, railways, power lines, telephone lines, buildings, fences, wooded areas, dams, piers, dock walls, culverts and culvert head walls, bridges and bridge wing walls, retaining walls, airport runways and taxiways, and other identifiable features on the aerial photography from which the maps are compiled.

3. All hydrographic features such as marshes, lakes, streams, watercourses, and drainage ditches.

4. All section and quarter-section lines and U. S. Public Land Survey corners in their correct position and orientation, together with their exact grid lengths and bearings.

5. Such lettering as may be secured from available maps of the area or as may be furnished by the participating organizations relative to the names of salient geographic features. The names of all state and county trunk highways, public streets, and major streams and lakes should be shown on the maps.

Estimated Cost to Complete Milwaukee County: The cost to complete the survey control network and large-scale topographic mapping for the remaining areas of Milwaukee County has five components: 1) the land surveying costs associated with relocating and monumenting the remaining U. S. Public Land Survey corners; 2) the control surveying costs associated with establishing the State Plane coordinates of the relocated and monumented corners; 3) the control surveying costs associated with establishing the vertical elevation above the datum of the relocated and monumented corners; 4) the photogrammetric engineering costs associated with preparing the large-scale topographic maps in digital format for those portions of Milwaukee County not previously mapped; and 5) the costs of board digitizing selected map features from the large-scale topographic maps previously completed in analog format.

As of December 1988, there were an estimated 104 U. S. Public Land Survey corners remaining to be recovered or relocated and monumented in Milwaukee County. Based upon an estimated average cost of $500 per corner, a total expenditure of about $52,000 would be needed to complete this task. These same 104 corners would need to have their State Plane coordinates computed. Based upon an estimated average cost of $650 per corner, a total expenditure of about $68,000 would be needed to complete this task.

As of December 1988, there were an estimated 240 corners remaining in Milwaukee County for

which vertical elevations need to be determined. Based upon an estimated average cost of $350 per corner, a total expenditure of about $84,000 would be needed to complete this task.

In order to complete the large-scale topographic mapping in Milwaukee County, it would be necessary to acquire mapping for an additional 96 square miles of the County. This mapping should be acquired in digital rather than the traditional analog format. The cost of acquiring this mapping in digital format would be approximately $10,000 per square mile, or a total amount of $960,000 to complete the mapping of the County.

For the approximately 146 square miles of Milwaukee County that have had large-scale topographic mapping prepared in analog format, selected map features should be board digitized to provide the availability throughout the County of a minimum set of base map information in digital format, and to provide a suitable digital map base for the preparation of digital cadastral map overlays. The estimated cost of board digitization of planimetric map features such as land water contact lines, buildings, pavement edges, railways, and major structures such as dams, piers, bridges, retaining walls, and airport runways and taxiways—including the lettering of all salient geographic features such as state and county trunk highways, public streets, and major streams and lakes—is $4,500 per square mile, or a total amount of about $657,000 to carry out this task.

Board digitization of contour lines and spot elevations for the approximately 146 square miles of Milwaukee County that have been mapped in analog format could be carried out at an estimated cost of $3,600 per square mile, or a total amount of $526,000 to carry out this task.

Based upon the foregoing unit costs, a total expenditure of about $2,347,000 would be required to complete the survey control network and large-scale topographic base mapping for those portions of Milwaukee County not yet covered by these elements, and to provide a consistent set of digital planimetric and topographic map feature information throughout the County. It should be noted that, for budgeting purposes, the cost of completing these elements could be spread over a period of several years rather than being committed over a shorter time frame such as one or two years.

Cadastral Mapping Specifications

Much of what is identified as cadastral mapping in the Milwaukee area cannot be mathematically related to the surface of the earth, and therefore does not meet the definition of a map. These "cadastral maps" are more properly identified as cadastral diagrams and are manifestly unsuited to be digitized as the cadastral layer of an automated mapping and land information system where one of the stated intents is the ability to accurately correlate real property boundary line information with earth science information such as floodplain boundaries. To meet the rigorous requirements of a modern land information system, it is usually necessary that real property boundary line maps be recompiled on the map projection system established for the land information system utilizing a permanently monumented survey control network as the mechanism for this recompilation.

Unfortunately, within Milwaukee County a large proportion of the real property parcels have already been digitized from cadastral diagrams rather than from correctly compiled cadastral maps. Approximately 155,000 real property parcels in the City of Milwaukee—representing about 60 percent of the approximately 260,000 real property parcels in the County—were originally digitized from uncontrolled source material. As noted earlier in this report, however, the staff of the City has in recent years attempted to fit their uncontrolled cadastral source documents to the survey control network that has been established for large-scale topographic mapping in portions of the City. While this procedure is less rigorous than recompiling the real property boundary line maps within the framework provided by the survey control network, a limited evaluation of the results of this procedure has indicated that the resulting maps should prove satisfactory as long as it is recognized that use of this material in a more rigorous setting might make recompilation of portions of the City necessary at some future time.

For the remainder of the County, it is recommended that digitization of real property boundary lines be accomplished only from correctly compiled cadastral maps. These maps should cover one U. S. Public Land Survey one-quarter section at a scale of 1:1,200. The maps should utilize the Wisconsin State Plane Coordinate System as the map projection and should show all section and quarter-section lines and corners

together with their grid and ground level lengths and grid bearings, all in their correct position and orientation. The State Plane Coordinate grid should be plotted to within 1/100 of an inch of its true position and each U. S. Public Land Survey section and quarter-section corner should likewise be plotted to within 1/100 of an inch of its true position as expressed by the State Plane coordinate values for the corner. Ninety percent of all well-defined planimetric features plotted on the maps as an aid in the delineation of real property boundaries, such as the threads of major streams and watercourses, fence lines, pavements, and principal buildings, should be plotted to within 1/30 of an inch of their true positions.

Determination of the location of real property boundary lines should be based upon the examination and interpretation of all recorded subdivision plats and certified survey maps within the area to be mapped; legal descriptions, and where available, plats of all public utility easements in the area to be mapped; copies of legal descriptions and, where available, plats of all street right-of-way openings, reservations, or dedications in the area to be mapped; and legal descriptions contained in the most recently recorded deed transaction in the records of the county Register of Deeds for all real property boundaries in the area to be mapped not included within recorded subdivision plats or certified survey maps.

Based upon review and interpretation of these materials, the cadastral maps should show, all in their correct position and orientation, all real property boundary lines, all street right-of-way lines, and all major cross-country public and utility easement lines. These lines should be graphically constructed in a manner which parallels the location of the lines on the surface of the earth following land surveying practice in the State of Wisconsin.

It is recognized that the recorded dimensions and orientation of real property boundaries plotted in this manner may not always agree with the horizontal survey control data also shown on the maps, since most property descriptions were written using field survey data obtained prior to the relocation of section and quarter-section corners and completion of the horizontal control network tied to the Wisconsin State Plane Coordinate System. Further, the required survey accuracy for property boundary descriptions for land subdivisions as defined in Chapter 236 of the Wisconsin Statutes and generally adhered to in other property boundary surveys is 1 part in 3,000, as compared with the second order accuracy of 1 part in 10,000 for the horizontal control surveys. As a result, overlapping or separated property boundary descriptions may be expected to exist. The property boundary line maps should record all dimensions as contained in the official records of the county Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlap or gap should be shown as a mapped line. Overlaps or gaps of less than 2.5 feet will be evident only from an examination of the recorded property line dimensions.

For areas covered by recorded subdivision plats and certified survey maps, the following map annotation should be provided:

1. Subdivision name or certified survey map number.
2. Block and lot numbers.
3. Street names.
4. Street, alley, and other public way right-of-way widths to the highest degree of accuracy permitted by the data source.
5. Recorded lot dimensions to the highest degree of accuracy permitted by the data source.
6. Easement right-of-way widths to the highest degree of accuracy permitted by the data source together with the purpose of the easement.
7. Milwaukee County parcel identification numbers.

For all properties other than those contained in a recorded subdivision plat or certified survey map, the following map annotation should be provided:

1. Street names.
2. Street, alley, and other public way right-of-way widths to the highest degree of accuracy permitted by the data source.

3. Recorded property dimensions to the highest degree of accuracy permitted by the data source.

4. Easement right-of-way widths to the highest degree of accuracy permitted by the data source together with the purpose of the easement.

5. Milwaukee County parcel identification numbers.

Estimated Cost to Complete Milwaukee County: Commission staff experience in compiling cadastral maps in the manner outlined above would indicate that these maps can be prepared in graphic form suitable for digitizing at a cost of $5.00 to $10 per real property parcel. Assuming an average per-parcel cost of $7.25, the compilation of suitable source maps for the approximately 105,000 real property parcels in Milwaukee County that have not been digitized would cost about $763,000. Board digitizing of real property parcels from this type of source material—including the digitizing of parcel dimensions, parcel identification numbers, and related parcel map text—could be accomplished for about $10 per real property parcel, or about $1.05 million to digitize the approximately 105,000 real property parcels in Milwaukee County not previously digitized.

Based upon the foregoing unit costs, a total expenditure of about $1,813,000 would be required to complete the digital real property parcel mapping for Milwaukee County. This cost, like the cost associated with completing the survey control network and large-scale topographic mapping, could be spread over several years.

Under the Wisconsin public open records law, no costs should be associated with the use of any existing control survey data, topographic maps, or cadastral maps in either digital or analog form in support of completing a digital map base for Milwaukee County. Accordingly, the existing digital real property boundary maps prepared by the City of Milwaukee and the survey control network data and analog topographic maps prepared by the metropolitan sewerage district and by various cities and villages in Milwaukee County would be available for incorporation into the automated mapping system at no additional cost.

A yearly maintenance cost would be associated with keeping the digital real property maps current as new land parcels are identified through the filing of land subdivision plats and certified survey maps, and as new or revised physical descriptions of existing real property parcels are received through the filing of plats of survey. This cost is estimated to average $10 per real property parcel. On the basis of a review of the record of document filing since 1980, it is estimated that 700 new real estate property parcels are created yearly in Milwaukee County through the filing of land subdivision plats and certified survey maps. About 2,300 real estate parcels annually receive new or revised descriptions through the filing of plats of survey. Accordingly, an amount of about $30,000 would be necessary on a yearly basis to maintain the digital real property parcel maps in a current state.

In moving into an automated mapping and land information environment, it is important to remember that the use of computers to manage records requires an "identifier" for each record that can be used for on-line search and retrieval operations. As a practical matter this means that the current practices involved in the receipt for recording of documents relating to real property may need to be modified in order to achieve desired efficiencies in maintaining the digital real property boundary line maps in a current state. In particular, the revision of current State Statutes to require the presence of a parcel identification number on all real property conveyance documents prior to their recording would be desirable.[2]

In the event it should prove necessary or desirable at some future date to recompile the approximately 155,000 real property parcels contained in the City on suitable map bases for digitization, this cost would approximate an additional $1.13 million, with an additional $1.55 million

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[2] *1989 Assembly Bill 188, which would require the presence of a real estate parcel identification number on all real property conveyance documents prior to their recording, was introduced into the 1989-1990 session of the Wisconsin Legislature in the spring of 1989. At the time that this report was being printed, this bill was still under consideration.*

needed to re-digitize these parcels. It is not currently anticipated that this will prove necessary, however, and these costs are not included in the total project cost estimates set forth in a following section of this chapter.

Digital Graphic Data Exchange

In order to exchange digital map data between two or more physically separated automated mapping and land information systems, one of two conditions must exist. Either the systems must have compatible data structures for the storage of digital map data or an interchange mechanism between the two systems must be provided. It has been noted in this report that the existing automated mapping and land information systems in the Milwaukee area are of several different proprietary types; therefore, before digital map data can be shared, agreement must be reached between the various organizations concerning the manner in which digital map data may be exchanged. Intergraph automated mapping software is currently the single most prevalent type of automated mapping software used in the Milwaukee area, and the majority of the non-Intergraph systems have acquired the necessary computer software to translate from Intergraph data structures to their own proprietary software systems. Accordingly, the most expedient manner in which to establish digital map data exchange would involve the use of Intergraph data exchange mechanisms.

It is recommended, therefore, that Intergraph Standard Interchange Format (ISIF) be utilized as the standard digital map data exchange mechanism for the Milwaukee area automated mapping community. It must be stressed that this recommendation is not equivalent to recommending the purchase of Intergraph automated mapping systems, nor should it be interpreted to preclude the direct transfer of Intergraph files between two Intergraph sites running compatible versions of the Intergraph software when such a direct transfer could be accomplished more efficiently than through the use of ISIF.

This recommendation should be regarded as initial rather than final. While it appears to be the logical recommendation given the present circumstances, it should be subject to periodic review as technology evolves and circumstances change. In this regard, it must be noted that the use of ISIF as the recommended standard for digital map data exchange may pose some unique problems for present or future sites using IBM mainframe computers to operate their automated mapping systems. IBM mainframe systems utilize digital map data storage models that differ from the models used by most other vendors, and translation between IBM models and non-IBM models is not a trivial programming task. This issue has not been addressed in the commercial market to the extent that digital graphic data exchange between other systems has been. The efficient and effective exchange of digital map data between IBM and non-IBM sites, therefore, may well require the use of an alternative graphic data exchange mechanism such as the Initial Graphic Exchange Standard (IGES) or some other mechanism that is more "generic" than ISIF.

Finally, it should be noted that this recommendation is intended to apply to map feature elements, or "geometry," rather than to data that may relate to map features. The National Research Council model, proposed in preceding chapters of this report as the model to guide the implementation of the recommended automated mapping system for Milwaukee County, utilizes the parcel identifier as a "key" to link location, or geometry, of features on maps to nongeometric information about the feature. The transfer of files of nongeometric, or attribute, data can be accomplished using existing procedures for the transfer of character data between different computer systems.

COMPLETION OF AN AUTOMATED MAPPING BASE FOR MILWAUKEE COUNTY

The total project cost for completing the necessary survey control network in Milwaukee County and for providing a digital planimetric, topographic, and cadastral mapping base for the County, as set forth in the preceding sections of this chapter, and as summarized in Table 1, is estimated at $4.16 million. This cost is exclusive of any hardware or software needed to manipulate digital map data, but represents, nonetheless, an important component in providing a modernized, automated land information system for Milwaukee County.

The provision of a single integrated system of survey control and digital planimetric, topographic, and cadastral map elements would be extremely useful in many aspects of property tax assessment and property tax collection, county

Table 1

ESTIMATED COSTS FOR THE CREATION OF AN AUTOMATED MAPPING BASE FOR MILWAUKEE COUNTY

Work Component	Cost
Completion of the Survey Control Network	
Relocate and Monument Remaining 104 U. S. Public Land Survey Corners	$ 52,000
Establish State Plane Coordinates for Remaining 104 U. S. Public Land Survey Corners	68,000
Establish Vertical Elevations for Remaining 240 U. S. Public Land Survey Corners	84,000
Subtotal	$ 204,000
Creation of Planimetric and Topographic Base Map Files	
Acquire Photogrammetrically Compiled Digital Planimetric and Topographic Maps for Approximately 96 Previously Unmapped Square Miles	$ 960,000
Board Digitize Selected Planimetric Map Features for Approximately 146 Previously Mapped Square Miles	657,000
Board Digitize Contour Lines and Spot Elevations for Approximately 146 Previously Mapped Square Miles	526,000
Subtotal	$2,143,000
Creation of Cadastral Map Overlay Files	
Compilation of Real Property Boundary Line Maps for Approximately 105,000 Real Property Parcels	$ 763,000
Board Digitize Real Property Boundary Line and Ancillary Information for Approximately 105,000 Real Property Parcels	1,050,000
Subtotal	$1,813,000
Total of All Components	$4,160,000

Source: SEWRPC.

and municipal planning and zoning, and public works engineering, as well as in private development and redevelopment. The resulting maps and survey control are useful to attorneys; appraisers and assessors; land surveyors; civil engineers in private practice; utility corporations; and particularly governmental agencies, such as city and village planning and engineering departments, county and state highway departments, and county and municipal park departments. The topographic maps, for example, permit drainage areas to be precisely defined and measured, and alternative route locations for various types of public works facilities to be defined and evaluated.

In addition, these maps permit the distances between existing cultural and topographic features and between such features and existing and proposed property boundary lines and proposed public and private works construction to be accurately scaled, profiles drawn, and grade lines established and computed. Importantly, the attendant control survey network permits lines drawn on the maps to be accurately reproduced in the field when planned land use development and supporting public works projects reach the construction stage, or when public land use controls, such as zoning and official mapping, require precise enforcement. The survey control network also permits the maps to be readily and economically updated, since by law all public works-related surveys should be, and all land surveys must be, tied to the U. S. Public Land Survey System. The control survey network facilitates the conduct of land and engineering surveys whether made for public or private purposes. Most importantly, the maps provide in a convenient, coordinated form the basic information needed to define environ-

Table 2

RECOMMENDED ALLOCATION OF ESTIMATED YEARLY AND FIVE-YEAR TOTAL COSTS FOR THE CREATION OF AN AUTOMATED MAPPING BASE FOR MILWAUKEE COUNTY

Funding Source	Yearly Costs					Total Five-Year Costs
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	
Creation of Automated Mapping Base						
Milwaukee County	$416,000	$416,000	$416,000	$416,000	$416,000	$2,080,000
Milwaukee Metropolitan Sewerage District	104,000	104,000	104,000	104,000	104,000	520,000
Wisconsin Bell	104,000	104,000	104,000	104,000	104,000	520,000
Wisconsin Energy Corporation	104,000	104,000	104,000	104,000	104,000	520,000
Wisconsin Gas Company	104,000	104,000	104,000	104,000	104,000	520,000
Total	$832,000	$832,000	$832,000	$832,000	$832,000	$4,160,000
Maintenance of Cadastral Overlay						
Milwaukee County	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 150,000

Source: SEWRPC.

mental and developmental problems, and to investigate alternative solutions to such problems without further costly field surveys.

The maps and survey control networks are extremely useful, if not absolutely essential, to sound public works system and facility planning, design, and construction layout, and in the preparation of "as built" records. The maps and control network facilitate the planning, design, and construction of streets and highways, sanitary sewers, water supply facilities, stormwater management and flood control facilities, and stream and lakeshore erosion control facilities. The maps are also useful in commercial and industrial building and site development; in land subdivision design and development; and in the day-to-day administration of zoning, land subdivision, and certified survey plat review activities. The maps are absolutely essential to the accurate delineation of flood hazard and shoreland zoning boundaries.

The control survey network also facilitates the development of good land title and survey records in that it permits the ready, yet accurate, reference of land boundaries to both the U. S. Public Land Survey System and the State Plane Coordinate System, thereby relating all land ownership descriptions to known points of beginning and to a common bearing base. Importantly, the maps and survey control network provide a technically sound and rigorous foundation for the evolution of increasingly more powerful automated land records functions and activities.

Because of the benefits such an integrated system could be expected to provide to both the governmental and private utility sectors, it is recommended that one-half of the approximately $4.16 million cost of completing a digital mapping base for Milwaukee County be provided by Milwaukee County on its own behalf as well as on behalf of its constituent cities and villages, with the other one-half being provided jointly by the major public and private utilities operating in Milwaukee County—that is, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell. These costs could be spread over a five-year period so that the cost to the County would approximate $416,000 yearly. The cost to each of the four individual utilities would approximate $104,000 per year. The yearly and total costs over the recommended five-year implementation period for each of the five recommended funding organizations are set forth in Table 2.

The Commission could provide technical assistance to Milwaukee County in undertaking such a program by providing, at no cost, the necessary contract documents and specifications, as well as the necessary field inspection of the

completed control survey monumentation, and the quality control of the topographic mapping and the attendant land and control survey work. Compilation of real property boundary maps and board digitization of these maps and selected map features from previously completed analog topographic maps could be undertaken by county staff, by Commission staff, or by City of Milwaukee staff under contract to the County, or could be contracted to private companies specializing in such work.

ALTERNATIVE ORGANIZATIONAL ARRANGEMENTS

The resolution adopted by the Milwaukee County Board of Supervisors requesting the preparation of this report called for evaluating the potential for implementation of a countywide automated mapping and land information system under three different operating scenarios. The first of these scenarios would involve expansion of the existing City of Milwaukee automated mapping system to cover the remainder of the County, with the City continuing to maintain ownership and control of the system. The second scenario would involve the establishment of a jointly operated and maintained county-city system. The third scenario would involve the cooperative creation of a shared system utilized by the units of government concerned and utilities such as the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell, and possibly by other private businesses which rely on local maps and land records, such as title insurance companies.

This section of the report describes, in overview, how each of these alternatives might be implemented; provides initial cost estimates for the physical system components—that is, hardware and software; and identifies some of the advantages and disadvantages of each alternative. It must be stressed that the cost information provided is intended to establish order of magnitude costs only, and necessarily at this stage of the investigation must rely upon the use of industry standard or industry average cost information. The development of costs suitable for budgeting actual equipment purchases would require more detailed study beyond the scope of this analysis. Likewise, no estimates are made of staffing costs since these would require, at least in part, the development of an anticipated work program.

Use of the City of Milwaukee System by Milwaukee County

Under this alternative, the County would contract with the City of Milwaukee to provide an expanded system. The City would own and manage all hardware involved, would provide all staff management, systems analysis, and programming support, would provide additional staff sufficient to accommodate the expanded operation, and would deal directly with all end users on the County's behalf. To implement this operating arrangement, the County and City would need to arrive at an agreement concerning the conditions under which service would be provided and the fees that the City would charge the County for providing this service.

Under this type of operating arrangement, the City could be expected to incur "one-time" hardware, software, and staff training costs of about $300,000 for a system expansion providing four additional operating positions and additional on-line disk storage capacity. Depending upon the type of service provision agreement negotiated between the County and the City, the County might be expected to incur all of these one-time costs, or the City might prefer to incur these costs and charge them to the County through the medium of user fees.

This operating alternative would offer several advantages to the County. It is a relatively low-cost alternative to implement since it does not involve the purchase of a central processing unit or software licenses. Also, since computer operating system support would be provided by the city staff, this alternative would allow county staff to concentrate their efforts on "using" the system rather than on "maintaining" the system; although as a practical matter, it should be noted that the applicable costs of system maintenance could be expected to be passed on to the County through the user fees.

Disadvantages that the County might expect under this alternative include lack of management control in that decisions concerning the future directions of the development of the physical hardware and software system will most likely be made without the direct participation of county representatives. Further, the implementation of this alternative would commit the County to the use of a particular proprietary hardware and software system without an evaluation as to whether or not that system represents a suitable choice for the County's intended uses.

Creation of a Joint County-City System

Under this alternative, the County and the City would function as partners on equal terms in the operation of a single physical system. A major assumption in this alternative is that the City could be persuaded to relinquish its present independent operating status and that agreement could be reached between the County and the City upon some type of joint management structure. It may also be necessary to arrive at some mutually satisfactory procedure either for the transfer to the County of a portion of the City's existing investment in hardware and software in return for some agreed-upon considerations or for the joint purchase of an entirely new hardware and software system.

A system of sufficient computing power and size and with sufficient operating positions to support the combined operations of the County and City may be expected to cost from $750,000 to $1,500,000 if purchased new in its entirety. If a decision were to be reached to jointly use the present city system as an operating platform, expansion of the existing hardware system would most likely be necessary, at a minimum cost of $300,000. The magnitude of the County's capital costs under this type of an organizational arrangement is difficult to estimate within the context of this report, since these costs might well involve the acquisition by the County of a portion of the ownership of the City's current system, but they could be expected to approximate $500,000.

The use of a joint operating model would provide some advantages to the County over the previously described operation wherein the County would contract with the City to provide an expanded system. As a full partner on equal standing with the City, the County would have greater participation in decisions concerning overall system management, development, and expansion. System overhead and system development could also be shared under this joint operation alternative.

Disadvantages that the County might expect under this operational structure, particularly in comparison to the previously described contract operation, include higher one-time equipment acquisition costs and, possibly, yearly operating costs. Also, unless a decision were reached to acquire a completely new system, the County would again have no choice over the proprietary system used.

Creation of a Shared, Government-Utility-Private, Multiuser System

Under this alternative, the County would join with the City of Milwaukee and other interested cities and villages within the County, special-purpose units of government such as the Milwaukee Metropolitan Sewerage District, the private utility companies, and possibly other public and private organizations in a cooperative program to develop and maintain an agreed-upon set of basic map information. As previously reported in this report, this type of organizational arrangement has been discussed in the Milwaukee metropolitan area on more than one occasion over the past decade. A major assumption necessary for the implementation of this type of organizational arrangement would be, therefore, that the major participants could successfully reach consensus on the issues that have in the past proved to be impediments to the joint development of automated mapping capability.

Because of fundamental changes that have occurred over the past several years in computer-assisted mapping technology, it is now doubtful that a system organized around a multiuser model would ever be physically centralized. Accordingly, those historically divisive issues that pertained to management structure and an allocation of costs among participants for a centralized operating system are no longer germane. A more expected operating arrangement under this type of organizational structure would involve independent central processing units either communicating over networks or transporting data between systems using a medium such as magnetic tape. In this type of organizational structure, the "system" would be provided by an agreed-upon set of digital mapping standards and specifications and the common use of a single set of digital maps.

Under this type of operating arrangement, one-time costs to the County for hardware, software, and staff training could be expected to range from $500,000 to $1,000,000 assuming that all participants in this type of multiuser system would possess their own hardware and software systems. Costs on the higher end of this range would be required for the purchase of a more traditional, minicomputer-based system. Costs on the lower end of this range could be expected for the acquisition of a networked, engineering workstation-based system. Given the rapid

improvement in recent years of engineering workstation-based systems, the acquisition of this less expensive type of system would appear to be a reasonable choice for the County.

This type of operating arrangement would provide the greatest degree of operational independence to the County, albeit at a potentially higher cost than the other alternatives. It would also provide the County with the opportunity to evaluate a wider variety of hardware and software systems, since this choice would no longer be constrained by the need to maintain hardware and software compatibility with the City.

Implementation of the Recommended Government-Utility-Private, Multiuser System in the Private Sector

During its review of the draft of this report, several Advisory Committee members expressed concern over the recommended funding arrangement in that it would appear to penalize the founding organizations as the system user base expanded. Since the recommendations call for the proposed system to be developed in the public domain, upon completion of the system the provisions of the Wisconsin open public records law might permit additional users to acquire access to the system without paying a "fair share" of the system creation costs. This concern was expressed by representatives of the units of government involved, as well as by private utility representatives. One possible redress of this situation discussed by the Committee would be to seek changes in the present open public records law to exempt certain types of information from its provisions. The possible success of such an action, however, would be uncertain, but would in any case add substantially to the time required to implement needed action.

As an alternative to seeking changes in the provisions of the Wisconsin open public records law, some interest was expressed on the part of some members of the Advisory Committee in the possible implementation of the recommended system as a private corporation, possibly organized as a not-for-profit corporation similar to the organizational structure used by the Milwaukee area Digger's Hotline. While such an organizational structure is appealing from the standpoint of providing what is perceived as a more equitable sharing of costs in that it can provide for recovery of a portion of the initial investment of the founding participants, it could also ultimately result in duplicative costs being passed on to the area residents, thus subverting one of the intended benefits of approaching the development of a countywide automated mapping and land information system in a coordinated, cooperative manner.

Accordingly, while the use of a private organizational structure may provide some budgetary advantages to individual organizations, it may provide no advantage to the area residents who, in the final analysis, will pay the system implementation costs.

COMPARISON OF ALTERNATIVE ORGANIZATIONAL ARRANGEMENTS

The one-time costs to the County for hardware and software acquisition and staff training to implement an automated mapping and land information modernization effort could be expected to range from $300,000 to $500,000 under the three alternatives set forth herein. Yearly operating expenses for such items as hardware and software maintenance and support and consumable supplies can be expected to approximate 15 percent of the one-time costs. Yearly staffing costs for even a small operating system could be expected to approximate $100,000, although it is assumed that staff costs will not represent costs for "new" staff positions, but will instead represent existing staff reassigned to new tasks.

Completion of the survey control network and digital map files is, however, of far greater importance to the creation of a countywide automated mapping and land information system than are any decisions concerning computer hardware and software acquisition or operating arrangements. These elements are the essential foundation for the "system," and until they are complete throughout the County, progress in improving efficiency and effectiveness in current land information operations will remain elusive.

From a technological perspective, any of the three organizational structures presented would provide a suitable operating platform for the implementation of a countywide automated mapping and land information system; however, the alternatives calling for contracting with the City to provide countywide capabilities or for a joint county-city system pose institutional problems that may prove difficult to resolve, particularly with respect to achieving a perceived

equitable distribution of costs between the County and the City. Equally important, perhaps, these alternatives—by concentrating on the respective roles of the County and the City—may tend to obscure the roles of other governmental units and the private utilities in achieving a coordinated approach to the issue of land records system modernization in the Milwaukee area.

Accordingly, the best alternative would be for Milwaukee County to acquire its own automated mapping hardware and software. Implementation of a cooperative automated mapping system in Milwaukee County should consist of the cooperative development and use of a set of digital planimetric, topographic, and cadastral map files and a set of specifications and conventions for the exchange of digital map information. In this manner, existing operating systems can concentrate on their individual applications, and new operating systems will be spared the expense of having to create an automated mapping base wholly or partially duplicative of existing systems. Future costs of developing redundant capability will be avoided, and the need for assessing these costs against area residents through taxes, user fees, and utility rate payments should be significantly reduced. This approach would be consistent with national studies of land information modernization issues which have concluded that counties are the most logical agencies to assume lead roles in this area because of the responsibilities assigned to them by State Constitutions and State Statutes for the keeping of basic records and information about land.

While it might be tempting for the County to reach decisions about its appropriate role in the modernization of land information mechanisms strictly on the basis of their impacts on the County's budget, and perhaps by extension on property tax rate impacts, it is important to remember that the area residents will in the final analysis pay either through taxes, user fees, or utility bills for many of the mapping and land information functions described in this report. Accordingly, the interests of county residents would be better served by careful determination of the most effective way in which to provide legally required mapping and land information activities, as well as those mapping and land information activities deemed to be of general value.

SUMMARY

Milwaukee County residents pay about $27,000,000 annually to support land information operations in both the public and private sectors, with about one half of these expenditures for land information operations being incurred by local units of government. Most studies of land information operations have concluded that there is redundancy in the various land information systems currently maintained by various governmental and private agencies and organizations.

The development and common use of a parcel-based automated system would be a major step toward the elimination over time of redundancy in currently established operations, and would forestall the continued development of new, partially redundant operations. Despite the interest manifested in the establishment of a common digital map base in the Milwaukee area over the past decade, there has been no progress in this regard. The most divisive issue in previous discussions has been the manner in which the cost of developing a common digital map base would be apportioned among the users. However, it should be clear that the ultimate payers of these costs are the area residents. Therefore, the continued inability of the Milwaukee area digital mapping community to successfully resolve this issue represents a disservice to the area's citizens.

Past discussions concerning shared system development tended to focus on the need to use a single, centralized computer system. Recent advances in computer hardware and software technology—particularly as they pertain to decreasing unit costs for computational and mass data storage capability, to networking between the hardware of different vendors, and to the translation of digital map data between different proprietary software products—now permit a different type of "system" to be specified—that is, one in which the system users share digital maps and an agreed-upon set of map-related information, but maintain their own separate—or distributed—computing capability. The ability to replace the centralized operating concept with a distributed operating concept permits discussion to be focused on the true system components of an automated mapping and land information system. In a distributed operating environment, the "system" is not hardware and software, but an agreed-upon set of procedures and specifications for the produc-

tion and maintenance of a basic set of digital maps and map-related information and an agreed-upon set of procedures and specifications for the interchange of this data between system users. It must be stressed that no amount of state-of-the-art computer technology can compensate for the absence of a robust set of specifications and standards for those elements that will be used in common.

The standards recommended herein for an automated mapping and land information system for Milwaukee County assume that initially only a selected set of elements—namely, a survey control network, large-scale planimetric and topographic base maps, and a cadastral map overlay—would be developed for joint use. These elements, if properly designed, should, in the aggregate, provide a set of map feature information meeting the needs of all users. The issue of the required accuracy for the preparation of these common map elements in a multiuser environment has been the subject of intense debate among the local mapping organizations. Debate, unfortunately, has focused on the relative cost of various levels of accuracy and how those costs might be allocated rather than on the true issue, which is the level of accuracy required to support a true multipurpose, multiuser system of digital map resources. If the agreed-upon system is incapable of supporting the needs of the most demanding of the users, the development of multiple systems is inevitable and the creation of a multipurpose, multiuser system cannot, by definition, occur.

The development of a single digital mapping base prepared to a sufficiently precise set of specifications is of central importance to the coordination of future digital mapping efforts in Milwaukee County. Unless prudent action is taken in the initial implementation effort, the future ability of participants to exchange digital map data without extensive and expensive "refitting" will be jeopardized, and a portion of the advantages inherent in moving to a digital mapping environment will be lost. Indeed, it is the anticipated ability to be able to transfer digital map data, such as utility system data, between installations that is perceived as one of the major benefits of a shared, digital mapping system.

The Commission-recommended survey control network and large-scale topographic base maps already exist in a majority of Milwaukee County, and where this system exists, it is being utilized by units of government and utilities in their automated mapping. Through this use, the survey control network and associated topographic base mapping are, in effect, a de facto standard that has already been accepted by the existing automated mapping community in Milwaukee County. Accordingly, the completion of this program in the remainder of Milwaukee County should be pursued, and it should be considered the standard for common use.

Completion of the survey control network and topographic base mapping in Milwaukee County would include the recovery or relocation and monumentation of the approximately 104 U. S. Public Land Survey corners not previously recovered or relocated and monumented. Following this monumentation, horizontal control survey traverses would be run which would utilize and incorporate all of the monumented corners as stations to determine the coordinates of the corners and the lengths and bearings of all quarter-section lines. All coordinates would be based upon the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. The accuracy of the horizontal control surveys would conform to the specifications for National Geodetic Survey (NGS) third-order, class I accuracy for traverse.

The vertical control survey work for the approximately 240 section corners remaining in the County would be based upon National Geodetic Vertical Datum, 1929 Adjustment. Closed level circuits would be run as necessary to establish permanent bench marks in the areas remaining to be mapped. All level circuits would be of NGS second-order, class II accuracy. For those areas of the County where large-scale, planimetric and topographic base maps have yet to be prepared, these maps would be acquired as digital map files. These digital map files would be prepared to National Map Accuracy Standards at a scale of 1:1,200 (one inch equals 100 feet). Use of these map standards will ensure that all map projection grid lines, horizontal control stations, section corners, and quarter-section corners will be plotted on finished maps to within 1/100 of an inch of their true position at the stated scale of 1:1,200. Ninety percent of all well-defined planimetric features will be plotted to within 1/30 of an inch of their true coordinate position.

Much of what is identified as cadastral mapping in the Milwaukee area cannot be accurately

related to earth science data, and therefore does not meet the definition of a map. These "cadastral maps" are more properly identified as cadastral diagrams and are manifestly unsuited to be digitized as the cadastral layer of an automated mapping and land information system where one of the stated intents is the ability to accurately correlate real property boundary line information with earth science information such as floodplain boundaries. To meet the rigorous requirements of a modern land information system, it is usually necessary that real property boundary line maps be recompiled on the map projection system established for the land information system utilizing a permanently monumented survey control network as the mechanism for this recompilation.

Within Milwaukee County, a large proportion of the real property parcels have already been digitized from cadastral diagrams rather than from correctly compiled cadastral maps. Approximately 155,000 real property parcels in the City of Milwaukee—representing about 60 percent of the approximately 260,000 real property parcels in the County—were originally digitized from uncontrolled source material. In recent years these uncontrolled cadastral source documents have been fit to the survey control network that has been established for large-scale topographic mapping in portions of the City. While this procedure is less rigorous than recompiling the real property boundary line maps within the framework provided by the high-order survey control network, a limited evaluation of the results of this procedure has indicated that the resulting maps should prove satisfactory as long as it is recognized that use of this material in a more rigorous setting might make recompilation of portions of the City necessary at some future time.

For the remainder of the County, it is recommended that digitization of real property boundary lines be accomplished only from correctly compiled cadastral maps. These maps should cover one U. S. Public Land Survey one-quarter section at a scale of 1:1,200. The maps should utilize the Wisconsin State Plane Coordinate System as the map projection and should show all section and quarter-section lines and corners together with their grid and ground level lengths and grid bearings, all in their correct position and orientation. Determination of the location of real property boundary lines should be based upon the examination and interpretation of all recorded subdivision plats and certified survey maps within the area to be mapped; legal descriptions, and where available, plats of all public utility easements in the area to be mapped; copies of legal descriptions and, where available, plats of all street right-of-way openings, reservations, or dedications in the area to be mapped; and legal descriptions contained in the most recently recorded deed transaction in the records of the county Register of Deeds for all real property boundaries in the area to be mapped not included within recorded subdivision plats or certified survey maps.

The creation of a set of digital topographic base maps and cadastral map overlays for the County is estimated to cost $4.16 million. About $204,000, or about 5 percent, of the total amount would be needed to complete the U. S. Public Land Survey corner monumentation and the attendant high-order horizontal and vertical control surveys in the County. About $960,000, or about 23 percent, of the total amount would be needed to acquire large-scale topographic mapping in digital format for the remaining unmapped 96 square miles of the County. About $1.183 million, or about 28 percent, of the total amount would be needed to prepare digital topographic map files for the previously mapped 146 square miles of the County. About $763,000, or about 18 percent, of the total amount would be needed to complete cadastral map overlays and parcel identifiers for the approximately 105,000 real property parcels in the County outside the City of Milwaukee. Finally, about $1.05 million, or about 25 percent, of the total amount would be needed to prepare digital files of cadastral map overlays for the approximately 105,000 real property parcels in Milwaukee County outside the City of Milwaukee. Digital map files of real property boundary lines have already been created for the City of Milwaukee and would be available for incorporation into the countywide automated mapping system at no additional cost under the provisions of the Wisconsin open public records law.

The estimated system implementation cost of $4.16 million does not include any hardware or software costs for the individual installations that would use the common set of digital maps. The funding of individual operating hardware and software systems and the expenses of their

operation would be the responsibility of each individual participant.

It is recommended that Milwaukee County undertake the responsibility of maintaining the digital real property boundary line information in the shared system. Based upon the record of document filing since 1980, this cost is estimated at $30,000 annually. It should be pointed out, however, that the County already carries out this function in an analog mapping environment and that this cost is, therefore, not a "new" cost.

Because of the benefits such an integrated system could be expected to provide to both the governmental and private utility sectors, it is recommended that one-half of the approximately $4.16 million cost of completing a digital mapping base for the County be provided over a five-year period by Milwaukee County on its own behalf, as well as on behalf of its constituent cities and villages, with the other one-half being provided jointly by the major public and private utilities operating in Milwaukee County—that is, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell. If these costs were spread evenly over the recommended five-year implementation period, the cost to the County would approximate $416,000 yearly. The cost to each of the four individual utilities would approximate $104,000 per year.

The resolution adopted by the Milwaukee County Board of Supervisors requesting the preparation of this report called for evaluating the potential for implementation of a county-wide automated mapping and land information system under three different operating scenarios. The first of these scenarios would involve modernization of the county land records through the use of the City of Milwaukee's existing automated mapping system, with the City continuing to maintain ownership and control of the system. The second scenario would involve the establishment of a jointly operated and maintained county-city system. The third scenario would involve the creation of a shared system utilized and partially funded by the units of government concerned; by utilities such as the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell; and possibly by other private businesses which rely on local maps and land records, such as title insurance companies.

The Advisory Committee determined that the best alternative would be for Milwaukee County to acquire its own automated mapping hardware and software. Implementation of a cooperative automated mapping system in Milwaukee County would consist of the cooperative development and use of a set of digital topographic and cadastral map files and a set of specifications and conventions for the exchange of digital map information. In this manner, existing operating systems would concentrate on their individual applications, and new operating systems would be spared the expense of having to create an automated mapping base wholly or partially duplicative of existing systems. Future costs of developing redundant capability would be avoided, and the need for assessing these costs against area residents through taxes, user fees, and utility rate payments would be reduced or eliminated. This recommendation is consistent with national studies of land records modernization issues which have concluded that counties are the best agencies to assume lead roles in this area because of the responsibilities assigned to them by State Constitutions and State Statutes for the keeping of basic records and information about the land.

Acquisition by the County of computer hardware and software sufficient for its own use of the digital mapping files is estimated to cost $500,000. Under the recommendations made by the Advisory Committee, the County would need to acquire only sufficient capacity to support its own day-to-day operations. Since the recommendations assume a distributed, rather than a centralized, operating scheme, each unit of government and utility would acquire and maintain its own operating system.

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Chapter V

RECOMMENDED COURSE OF ACTION

INTRODUCTION

This chapter of the report sets forth the recommendations of the Advisory Committee concerning the implementation of an automated mapping and land information system for Milwaukee County. A description of the recommended system is provided, along with a proposed time schedule for the implementation of the system, an estimate of the costs associated with the creation of the system, and a proposed allocation of those costs among the major system users.

THE RECOMMENDED AUTOMATED MAPPING AND LAND INFORMATION SYSTEM

The recommended system would consist of a control survey network of permanently monumented stations throughout Milwaukee County, these stations being the corners of the U. S. Public Land Survey System accurately located on the State Plane Coordinate System. Digital planimetric and topographic base maps and digital, parcel-based cadastral map overlays mathematically related to the survey control network would be integral parts of the recommended system, as would a parcel identification scheme. These components would be developed for common use by all units of government, public and private utilities, and private businesses that use maps and associated land records in their day-to-day activities within the County. This basic system—if implemented—would provide an automated mapping capability suitable for the future development by individual operators of a wide variety of applications such as land ownership and title recordation systems, real property assessment and taxation systems, public and private utility facility inventory and management systems, environmental inventory and management systems, zoning and other code monitoring and enforcement systems, 9-1-1 emergency telephone response systems and emergency vehicle routing systems, and service delivery vehicle routing systems.

The development of a single digital mapping base prepared to a sufficiently precise set of specifications is of central importance to the coordination of future digital mapping efforts in Milwaukee County. Unless prudent action is taken in the initial implementation effort, the future ability of participants to exchange digital map data without extensive and expensive "refitting" will be jeopardized, and a portion of the advantages inherent in moving to a digital mapping environment will be lost.

The specifications for the recommended system, which are set forth in detail in Chapter IV, call for the use of the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927, as the map projection system. The horizontal control survey work necessary to locate the corners of the U. S. Public Land Survey System on the State Plane Coordinate System would conform to the specifications for National Geodetic Survey (NGS) third-order, class I accuracy for traverse. The vertical control survey work necessary to determine the vertical elevations of the corners would conform to the specifications for NGS second-order, class II accuracy and would be accurately adjusted for closure by NGS methods. All elevations would be referred to National Geodetic Vertical Datum of 1929.

The large-scale planimetric and topographic base mapping would be prepared to National Map Accuracy Standards at a scale of 1:1,200 (one inch equals 100 feet). Use of these map standards would ensure that all map projection grid lines, horizontal control stations, section corners, and quarter-section corners would be plotted on finished maps to within 1/100 of an inch of their true position at the stated scale of 1:1,200. Ninety percent of all well-defined planimetric features would be plotted to within 1/30 of an inch of their true coordinate position. Ninety percent of the elevations determined from the solid line contours of the map would have an accuracy with respect to true elevation of one-half the contour interval.

Cadastral map overlays consisting of real property boundary lines would also be prepared at a scale of 1:1,200. These maps would also utilize the Wisconsin State Plane Coordinate System as the map projection, and would show all section and quarter-section lines and corners

together with their grid and ground level lengths and grid bearings, all in their correct position and orientation. Determination of the location of real property boundary lines would be based upon examination and interpretation of all recorded subdivision plats and certified maps; legal descriptions and plats of major public utility easements; legal descriptions and plats of all street right-of-way openings, reservations, and dedications; and legal descriptions contained in the most recently recorded deed transactions in the records of the county Register of Deeds for all property boundaries not included within recorded subdivision plats or certified survey maps. The property boundary line maps would record all dimensions as contained in the official records of the county Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlap or gap would be shown as a mapped line.

These specifications are sufficiently precise to meet the most demanding requirement of a modern land information system—that is, the precise correlation of real property boundary lines with earth science data such as floodplain boundary lines. These specifications will meet the requirements of all organizations currently involved in automated mapping in Milwaukee County, and are sufficiently robust to accommodate changing technology in land survey measurement instrumentation. Most importantly, they are attainable specifications since they are virtually identical to specifications already in use in similar projects elsewhere in southeastern Wisconsin.

Equally important, these specifications directly address and resolve those issues concerned with map projections, system accuracy, and features to be mapped that have proved to be contentious issues in previous discussions of cooperative automated mapping system development in the Milwaukee area. The recommended system, since it is proposed to be implemented in a distributed processing environment—that is, each operating agency will supply its own computer hardware and software rather than jointly developing a centralized hardware and software installation—renders moot those additional previously contentious issues such as the apportionment of cost for the purchase and operation of a centralized system, the maintenance of data security for sensitive files in a centralized operating environment, and the legal liability of the partners in a shared operating environment.

It is the further recommendation of the Advisory Committee that Milwaukee County be responsible for providing the basic system of U. S. Public Land Survey corner monumentation, attendant horizontal and vertical control surveys, digital topographic maps, digital cadastral map overlays, and parcel identifiers; and that—once completed—the County would be responsible for maintaining the system in a current condition. It is the belief of the Advisory Committee that the County represents the most logical locus for this activity.

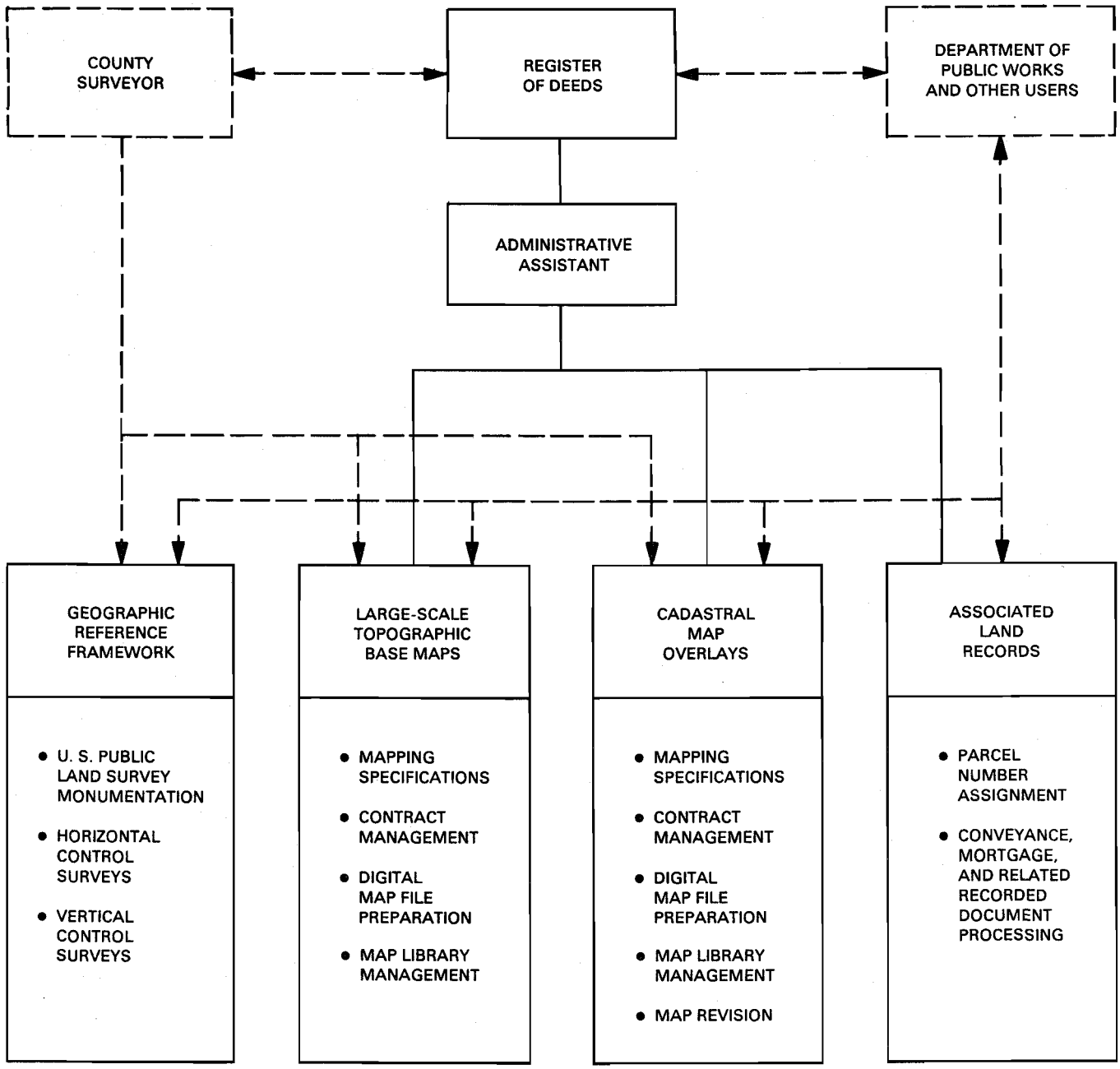
Within the structure of Milwaukee County government, the Register of Deeds office provides one potential location for an automated mapping and land information system. This location is particularly appropriate since this office is the entry point for many of the official records that make up the related land information component of the system. The Department of Public Works represents another potential location for this activity.

A possible organizational structure using the Register of Deeds office as the location of the program is shown in Figure 8. The salient aspects of this structure may be summarized as follows:

1. Register of Deeds
   The Milwaukee County Automated Mapping and Land Information System would be centered in the Register of Deeds office, and the Register of Deeds would function as the executive officer for the system. In this regard, the Register of Deeds would—over the expected five-year time line of the program—prepare a yearly budget for the creation of the system, secure the appropriate funding from the Milwaukee County Board and the public and private utility organizations involved, and administer the funds, once obtained. Further, the Register of Deeds would provide the necessary liaison, reporting to the Milwaukee County Board, the Milwaukee County Executive, the officials of the utilities involved, and the officials of the County's cities and villages concerning the ongoing implementation status of the program.

Figure 8

TENTATIVE ORGANIZATIONAL STRUCTURE FOR A MILWAUKEE COUNTY AUTOMATED MAPPING AND LAND INFORMATION SYSTEM IMPLEMENTATION PROGRAM



Source: SEWRPC.

2. County Surveyor
The County Surveyor would, at the request of the Register of Deeds and utilizing funding made available through the Register of Deeds, carry out the work necessary to extend the existing geographic reference framework into those portions of the County where this framework is incomplete. In this regard, the County Surveyor would prepare the necessary specifications

and contract documents for the conduct of the relocation and monumentation of the U. S. Public Land Survey corners, the horizontal control surveys, and the vertical control surveys. This work would be carried out under contract to the County by engineering firms possessing the specialized equipment and staff expertise to conduct such work. The County Surveyor would be responsible to the Register of Deeds for review of all work completed under these contracts to ensure that the specifications were fully met.

In a similar manner, the County Surveyor would also be responsible for obtaining the digital large-scale topographic base mapping and the digital cadastral map overlays. In this regard, the County Surveyor would prepare the necessary specifications and contract documents for the preparation of the large-scale topographic base mapping and ancillary digital conversion. The County Surveyor would also prepare the necessary specifications and contract documents for the preparation of the cadastral map overlays and ancillary digital conversion. The preparation of topographic base maps requires highly specialized equipment and staff expertise, and should be carried out by a qualified firm specializing in such work. Because of the volume of work that will be involved in the preparation of the cadastral map overlays and in the digital conversion of the cadastral map overlays and previously prepared topographic base maps, it is recommended that this work also be carried out under contract. The County Surveyor would be responsible to the Register of Deeds for review of all work completed under these contracts to ensure that the specifications were fully met.

Since these tasks would be carried out under contracts and since Wisconsin Statutes currently designate the Executive Director of the Regional Planning Commission as the Milwaukee County Surveyor, this work could be carried out without the need for the County to retain any additional staff.

3. Administrative Assistant

   Within the current organizational structure of the Register of Deeds office, groups of related work tasks are carried out by project staff under the direction of an Administrative Assistant, of which there are currently four. The assignment of parcel identification numbers to newly created real property parcels and the processing of real property parcel-related documents and information are already being carried out within the normal day-to-day activities of the office and do not represent new functions that would be added as a result of implementing an automated mapping and land records system. Under the recommended organizational structure, the maintenance and operation of the parcel identification number system would continue to be carried out in present fashion. The parcel numbers, once assigned, provide the needed links between the automated mapping system and the associated files of information about real property parcels. Since this function is already in place, it should not be necessary to retain additional staff to carry out this function.

   One of the existing Administrative Assistants within the Register of Deeds office, perhaps the one that currently directs the parcel numbering operation, would be designated by the Register of Deeds to act as custodian of the digital topographic and cadastral map files as these files are completed and delivered by the contractors. This person would serve as the contact for other users wishing to obtain copies of the digital map files for their own uses.

   Once the maps and digital map files are prepared, occasional maintenance operations such as the addition of newly created real property parcels to the cadastral map overlays will be required. The volume of this work is judged to be such, however, that it could be carried out by existing county staff.

No recommendation is being made with respect to proprietary computer hardware and software for the operation of the system. There are two

important reasons for being nonspecific on this point. First, it is necessary to realize that the hardware and software technology that currently exists in automated mapping is still evolving; therefore, what is currently "state-of-the-art" might well be obsolescent technology within a relatively short time. Second, the various operators of automated mapping systems—while benefiting from the use of a common set of digital maps—potentially have quite different applications that will be developed on these common map bases. Many of the proprietary hardware and software systems available have been developed for specific segments of the existing market and can therefore be expected to possess comparative advantages and disadvantages for individual operators. Accordingly, it is more important in the design of a multiple user system to concentrate on the development of a set of mathematically rigorous and robust specifications for the map elements of the system. Decisions on the purchase of specific types of computer hardware and software are more properly the decision of the individual operators.

While no recommendation is made concerning particular types of computer hardware or automated mapping software, a recommendation is set forth concerning the use of a proprietary data exchange format; namely, Intergraph Standard Interchange Format (ISIF). This is a preliminary recommendation and is based primarily on convenience. The majority of the currently operating automated mapping systems in Milwaukee County either operate Intergraph systems or can utilize ISIF as a mechanism for the exchange of digital map information. In those few situations where ISIF cannot be easily used, the use of an alternative data exchange format such as the Initial Graphic Exchange Standard (IGES) may be necessary. The existence of an agreed-upon interchange mechanism will help to ensure that as additional units of government and private companies establish automated mapping capability, they will be easily able to utilize the common digital map base recommended herein, thereby minimizing their costs.

TIME SCHEDULE

The initial staff recommendation for a time schedule for the creation of the basic automated mapping system described in the preceding chapters of this report envisioned that the implementation effort would be carried out over a period of five years beginning as soon as the necessary funding and management arrangements could be made. Ideally, this would result in the first implementation steps being taken in 1990. During the review of the report by the Advisory Committee, however, several Committee members indicated a desire to accelerate that schedule. It would be possible to accomplish the implementation of the project in less than the five-year time period recommended by the staff; however, because of the sequential nature of the work involved, the project could probably not be accomplished in a time frame any shorter than two years. Even the two-year time schedule is possible only because, as set forth earlier in this report, much of the work necessary to create an automated mapping base in the County has already been accomplished.

While it is technically possible to shorten the time schedule for the proposed project, shortening that time frame would also require that the funding amounts necessary to carry out the proposed project be provided over a shorter time frame. Accordingly, if the necessary funding requirements can be provided, the implementation of the recommended automated mapping and land information system could be accomplished in as little as two years.

ESTIMATED COSTS

The creation of a set of digital topographic base maps and cadastral map overlays for Milwaukee County is estimated to cost $4.16 million, as shown in Table 1 in Chapter IV. About $204,000, or about 5 percent, of the total amount would be needed to complete the U. S. Public Land Survey corner monumentation and the attendant high-order horizontal and vertical control surveys in the County. About $960,000, or about 23 percent, of the total amount would be needed to acquire large-scale topographic mapping in digital format for the 96 square miles of the County not previously mapped. About $1.183 million, or about 28 percent, of the total amount would be needed to prepare digital planimetric and topographic map files for the previously mapped 146 square miles of the County. About $763,000, or about 18 percent, of the total amount would be needed to complete cadastral map overlays and

parcel identifiers for the approximately 105,000 real property parcels in the County outside the City of Milwaukee. This estimated amount assumes that the City of Milwaukee has assigned parcel numbers to the real property parcels in the City in a manner compatible with the identification scheme used in the remainder of the County, and that it would not be necessary to renumber these parcels. Finally, about $1.05 million, or about 25 percent, of the total amount would be needed to prepare digital files of cadastral map overlays for the approximately 105,000 real property parcels in Milwaukee County outside the City of Milwaukee. Digital map files of real property boundary lines have already been created for the City of Milwaukee and would be available for incorporation into the countywide automated mapping system at no additional cost under the provisions of the Wisconsin open public records law.

It is recommended that Milwaukee County undertake the responsibility of maintaining the digital real property boundary line information in the shared system. Based upon the record of document filing since 1980, the cost is estimated at $30,000 annually. It should be pointed out, however, that the County already carries out this function in an analog mapping environment, and that this cost is, therefore, not a "new" cost.

Acquisition by Milwaukee County of computer hardware and software sufficient for its own use of the digital mapping files would cost about $500,000, depending upon the type and capacity of the chosen equipment. It should be noted that under the recommendations made by the Advisory Committee, the County would need to acquire only sufficient capacity to support its own day-to-day operations. Since the recommendations assume a distributed, rather than a centralized, operating scheme, the County would have no need to provide sufficient computational and storage capacity for a centralized hardware system.

Under the distributed operating framework recommended by the Advisory Committee, established operating systems such as the City of Milwaukee, the Wisconsin Energy Corporation, and the Wisconsin Gas Company would continue to operate their existing systems to develop applications specific to their individual needs on the common digital mapping base. As other units of government, public and private utilities, and private companies begin to develop digital mapping capability, they will need to determine whether or not to acquire their own automated mapping software and hardware systems, utilize a service bureau or contractor, or perhaps make arrangements with an existing operator to run their applications on a fee basis. It will be the responsibility of each of these new operators to incur their own capital costs or user fees as the case may be, but with the existence of a common digital map base it will no longer be necessary for each new operator to create its own digital map base, at what has previously been substantial cost. Some examples of system hardware configurations suitable for the implementation of an automated mapping capability in a municipal government environment are set forth in Appendix B.

PROPOSED ALLOCATION OF COSTS

As reported elsewhere in this report, previous attempts to create a cooperative program of digital map creation and maintenance have never successfully resolved the question of cost allocation among the participants. However, as has also been reported, the costs incurred are really borne by the area residents who ultimately bear those costs through tax payments, utility rate payments, and various user fees. Maintenance of the status quo and the duplication of effort involved is therefore a disservice to area residents.

Because of the benefits such an integrated system could be expected to provide to both the governmental and private utility sectors, it is recommended that one-half of the approximately $4.16 million cost of completing a digital mapping base for Milwaukee County be provided over a five-year period by Milwaukee County on its own behalf, as well as on behalf of its constituent cities and villages, with the other one-half being provided jointly by the major public and private utilities operating in Milwaukee County—that is, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell. If these costs were spread evenly over the recommended five-year implementation period, the cost to the County would approximate $416,000 yearly, as shown in Table 2 in Chapter IV. The cost to each of the four individual utilities would approximate $104,000 per year.

POTENTIAL REVENUE SOURCES

With respect to that portion of the implementation costs proposed to be provided by units of government, the most obvious source of revenue is property tax receipts. However, in view of the fact that two of the major proposed uses of an automated system relate to land title recordation and transfer operations and to real property assessment and taxation operations, there is a logical consistency to the use of the real estate transfer tax for some or all of the county cost. Over the period 1983 to 1988, for example, that portion of the total real estate transfer tax retained by the County ranged from a low of about $0.6 million in 1983 to a high of about $1.0 million in 1988. A related source of potential funding exists in the fees collected by the County for recording documents, typically more than half of which are documents such as conveyances and mortgages relating directly to real property. Over the period 1983 to 1988, the fees received by the County from this source ranged from a low of about $0.56 million in 1983 to a high of about $0.80 million in both 1986 and 1987. It would appear that either of these sources could generate sufficient funds over a five-year time horizon to cover the county share of about $0.46 million yearly.

The real estate transfer tax rate—currently $0.30 per $100 of value—is set by State Statute. The fees that are charged for the recording of documents vary depending upon the type of document being submitted for recording and upon the number of pages comprising the document, and are also set by State Statute. For documents pertaining to conveyances and mortgages of real property, these fees are $4.00 for the first page and $2.00 for each additional page. Seeking legislation allowing for increases in one or both of these receipt sources would provide another potential source of revenue for land records modernization efforts. For example, had the legislation currently being recommended by the Wisconsin Land Information Association allowing for an increase of $0.05 per $100 of value—this amount being retained by the County and used for land records modernization purposes—been previously enacted, an amount ranging from a low of about $486,000 in 1983 to a high of about $818,000 in 1988 would have been received by the County from this revenue source over the period 1983 to 1988.[1] Alternatively, if the legislation currently being recommended by the Wisconsin Registers of Deeds Association allowing for an increase of $2.00 in the filing fees for documents pertaining to conveyances and mortgages of real property—this amount being retained by the County and used for land records modernization purposes—had previously been enacted, an amount ranging from a low of $161,600 in 1984 to a high of $230,600 in 1987 would have been received by the County from this revenue source over the period 1983 to 1988.

COORDINATION WITH AUTOMATED MAPPING EFFORTS OUTSIDE MILWAUKEE COUNTY

The issue of coordinating a Milwaukee County automated mapping program with geographic areas external to the County was not explicitly addressed within the context of the preparation of this report; however, this is an area of some concern to the Milwaukee Metropolitan Sewerage District and to the electric, gas, and telephone utilities since their service territories extend beyond the boundaries of the County. It is important to note, therefore, that the underlying specifications set forth in the recommended system for Milwaukee County are fully compatible with—in fact, essentially identical to—the specifications currently in use for both analog and digital mapping in the countywide mapping programs of Kenosha, Racine, and Waukesha Counties. While there are no countywide mapping programs in Ozaukee and Washington Counties, portions of both counties, including all of the immediately adjacent Village of Germantown and a portion of the immediately adjacent City of Mequon, have been mapped to specifications essentially identical to those recommended for the mapping to be prepared in Milwaukee County.

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[1] *1989 Assembly Bill 269, which would implement this funding mechanism for land records modernization efforts, was introduced into the 1989-1990 session of the Wisconsin Legislature in the spring of 1989. A subsequent Assembly Substitute Amendment to this bill deleted the real estate transfer fee as the funding source for land records modernization efforts and substituted a system of user charges to be collected by county offices. The kinds of fees to be established and the amounts to be charged were not set forth in the substitute amendment, but rather would be determined by a statewide board that would be created if and when the bill becomes law. At the time that this report was being printed, this bill was still under consideration.*

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Chapter VI

SUMMARY AND CONCLUSIONS

On June 16, 1988, the Milwaukee County Board of Supervisors adopted a resolution requesting the Southeastern Wisconsin Regional Planning Commission to convene an advisory committee to analyze the feasibility and cost-effectiveness of modernizing land records within the County by developing an automated mapping and land information system. The resolution was approved by the Milwaukee County Executive on July 18, 1988. Acting in response to this request, the Regional Planning Commission created an advisory committee composed of knowledgeable representatives of the City and County of Milwaukee, the Milwaukee County suburban cities and villages, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell to guide the preparation of this report.

The Committee reviewed the pertinent conclusions of recent research efforts in the area of land records modernization, including, most importantly, the reports of the the National Research Council Panel on a Multipurpose Cadastre and the reports of the Wisconsin Land Records Committee. The Committee also reviewed the efforts and accomplishments of those existing automated mapping and land records systems whose operations cover all or portions of Milwaukee County. Finally, the Committee reviewed the results of previous discussions among Milwaukee area units of government and utilities concerning the joint development of automated mapping capability.

The Advisory Committee concluded that the existing situation with respect to automated mapping in Milwaukee County has led to duplication of effort between the various organizations involved and that this duplication may be expected to increase as additional units of government and public and private utilities undertake conversion of their analog mapping and records activities to automated environments. The cost of this duplication is ultimately borne by the area residents, who pay for it in the form of tax payments, utility rate payments, and various user fees. Accordingly, better coordination of these conversion efforts would be in the best interests of the area residents.

The Advisory Committee further concluded that coordination of these efforts could be enhanced by the provision of a single automated mapping base for the entire County. This single mapping base would be prepared to a set of specifications sufficient to meet the most stringent of accuracy and map feature content requirements of all of the users concerned. These specifications are set forth in Chapter IV of this report. The organizations using the automated base would each provide their own operating environment—that is, computer hardware and software. Only the digital maps and parcel identification system would be shared. This basic system would provide an automated mapping capability suitable for the development by individual operators of a wide variety of applications such as land ownership and title recordation systems, real property assessment and taxation systems, public and private utility inventory and management systems, environmental inventory and management systems, zoning and other code monitoring and enforcement systems, 911 emergency telephone response systems and emergency vehicle response systems, and service delivery vehicle routing systems.

It is the recommendation of the Advisory Committee that Milwaukee County undertake the responsibility for providing the basic system of U. S. Public Land Survey corner monumentation, attendant horizontal and vertical control surveys, digital planimetric and topographic maps, digital cadastral map overlays, and parcel identifiers that constitute this basic automated mapping system; and that—once the system is completed—the County undertake the responsibility of maintaining the system in a current condition. It is the belief of the Advisory Committee that the County represents the most logical locus for this activity.

The Milwaukee County Automated Mapping and Land Information System would be centered in the Register of Deeds office, and the Register of Deeds would function as the executive officer of the system. The Register of Deeds would—over the expected five-year period that would be necessary to create the system—prepare a yearly budget for the creation of the system; secure the appropriate funding from the Milwaukee County

Board and the other funding organizations; and administer the funds, once obtained. The County Surveyor would, at the request of the Register of Deeds and utilizing funds made available through the Register of Deeds, carry out the work necessary to extend the existing geographic reference framework into those portions of the County where this framework is incomplete, and would also carry out the work necessary to obtain the digital, large-scale planimetric and topographic base mapping, and the digital cadastral map overlays. Since it is being recommended that these tasks be carried out under contracts and since Wisconsin Statutes currently designate the Executive Director of the Regional Planning Commission as the Milwaukee County Surveyor, this work could be carried out without the need for the County to retain any additional staff.

The assignment of parcel identification numbers to newly created real property parcels, the processing of real property-related documents and information, and the maintenance and revision of the real property boundary lines on the cadastral maps are functions that are already being carried out within the normal day-to-day activities of the Register of Deeds office and do not represent new functions that would be added as a result of the creation of an automated mapping and land information system. Since these functions are already being performed, it should not be necessary for the County to retain additional staff to carry out these functions.

The creation of a set of digital planimetric and topographic base maps and cadastral map overlays for Milwaukee County is estimated to cost $4.16 million. These costs are set forth in detail in Chapter IV of this report. About $204,000, or about 5 percent, of the total amount would be needed to complete the U. S. Public Land Survey corner monumentation and the attendant high-order horizontal and vertical control surveys in the County. About $960,000, or about 23 percent, of the total amount would be needed to acquire large-scale planimetric and topographic mapping in digital format for the 96 square miles of the County not previously mapped. About $1.183 million, or about 28 percent, of the total amount would be needed to prepare digital planimetric and topographic map files for the previously mapped 146 square miles of the County. About $763,000, or about 18 percent, of the total amount would be needed to complete cadastral map overlays and parcel identifiers for the approximately 105,000 real property parcels in the County outside the City of Milwaukee. Finally, about $1.05 million, or about 25 percent, of the total amount would be needed to prepare digital files of cadastral map overlays for the 105,000 real property parcels in Milwaukee County outside the City of Milwaukee. Digital map files of real property boundary lines have already been created for the City of Milwaukee and would be available for incorporation into the countywide automated mapping system at no additional cost under the provisions of the Wisconsin open public records law.

Acquisition by Milwaukee County of computer hardware and software sufficient for its own use of the digital map files would cost about $500,000, depending upon the type and capacity of the chosen equipment. It should be noted that under the recommendations made by the Advisory Committee, the County would need to acquire only sufficient capacity to support its own day-to-day operations. Since the recommendations assume a distributed, rather than a centralized, operating scheme, the County would have no need to provide the additional computational and storage capacity that would otherwise be necessary in a centralized hardware system.

Because of the benefits a coordinated automated mapping and land information system could be expected to provide to both the government and private utility sectors, it is recommended that one-half of the approximately $4.16 million cost of completing a digital mapping base for Milwaukee County be provided over a five-year period by Milwaukee County on its own behalf, as well as on behalf of its constituent cities and villages, with the other one-half being jointly provided by the major public and private utilities operating in Milwaukee County—that is, the Milwaukee Metropolitan Sewerage District, the Wisconsin Energy Corporation, the Wisconsin Gas Company, and Wisconsin Bell. If these costs were spread evenly over the recommended five-year implementation period, the cost to the County would approximate $416,000 yearly. The cost to each of the four individual utilities would approximate $104,000 per year.

During its review of the draft of this report, several Advisory Committee members expressed concern over the recommended funding arrangement in that it would appear to penalize the founding organizations as the system user base

expanded. Since the recommendations call for the proposed system to be developed in the public domain, upon completion of the system the provisions of the Wisconsin open public records law might permit additional users to acquire access to the system without paying a "fair share" of the system creation costs. This concern was expressed by representatives of the units of government involved as well as by the private utility representatives. One possible redress of this concern discussed by the Committee would be to seek changes in the present open public records law to exempt certain types of information—or alternatively, to exempt certain information formats, such as digital records—from its provisions. An alternative may be to regulate access to the system through the interagency contract that would be required to bring the system into being. If the Milwaukee County Board should decide to accept the recommendation of the Advisory Committee and move ahead with the implementation of the recommended system, it is expected that agreements formalizing the recommended funding formula will need to be negotiated between Milwaukee County and the utility organizations involved. As part of the process of reaching agreement at this stage of system implementation, county staff may need to investigate this area more fully, and possibly seek changes in the Wisconsin Statutes as may be determined to be appropriate.

An additional area of concern on the part of several Advisory Committee members—also related to the recommended funding arrangement—had to do with the possibility that the system, once the full implementation costs have been incurred, may generate more "income" than would be required for just its continued maintenance and enhancement. Whether or not such a situation would ever come to pass would in part be a function of the source of the funding chosen for system implementation. As an example, the use of a system of user fees to fund system implementation might eventually generate a surplus of income over expenses. In the event that such a funding source might ultimately be chosen, the organizations sharing in the initial system development costs may well make their formal participation in the project contingent upon an agreement for sharing any future income that the system might generate. Such agreement would obviously require policy decisions on the part of the Milwaukee County Board.

This report contains a recommendation for a five-year implementation program for the creation of the basic countywide automated mapping system. During the review of the report by the Advisory Committee, however, several Committee members indicated a desire to accelerate that schedule. It would be possible to accomplish the implementation of the project in less than the recommended five-year time period; however, the sequential nature of the work involved would make it unlikely that the project could be completed in a time frame any shorter than two years. While it is technically possible to shorten the time schedule for the proposed project, shortening that time frame would also require that the funding amounts necessary to carry out the proposed project be provided over a shorter time frame. Therefore, if the necessary funding requirements can be met, the implementation of the recommended automated mapping and land information system could be accomplished in as little as two years.

In view of the fact that two of the major uses of the proposed automated mapping and land information system relate to land title recordation and transfer operations and to real property assessment and taxation operations, there is a logical consistency to the use of the real estate transfer fee for some or all of the county cost. Over the period 1983 to 1988, for example, that portion of the total real estate transfer tax retained by the County ranged from a low of about $0.6 million in 1983 to a high of about $1.0 million in 1988. A related source of potential funding is the fees collected by the County for recording documents, typically more than half of which are documents such as conveyances and mortgages relating directly to real property. Over the period 1983 to 1988, the fees received by the County from this source ranged from a low of about $0.56 million in 1983 to a high of about $0.80 million in both 1986 and 1987. It would appear that either of these sources could generate sufficient funds over a five-year time horizon to cover the county share of about $0.46 million yearly.

Given the interest in all aspects of land records modernization that currently exists statewide, it is also possible that new funding mechanisms for projects such as the countywide automated mapping and land information system recommended in this report may be forthcoming. 1989 Assembly Bill 269, introduced into the 1989-1990

session of the Wisconsin Legislature during the spring of 1989 while this report was being finalized, proposed among its several provisions an increase of $0.05 per $100 of value in the real estate transfer tax, this amount to be retained by the County in which it is collected and used for land records modernization projects. Had this legislation been in effect over the period 1983 to 1988, an amount ranging from a low of $486,000 in 1983 to a high of $818,000 in 1988 would have been received by Milwaukee County from this revenue source. A subsequent Assembly Substitute Amendment to this bill deleted the real estate transfer tax as the funding source for land records modernization efforts and substituted a system of user charges to be collected by county offices. The kinds of fees to be established and the amounts to be charged were not set forth in the substitute amendment, but rather would be determined by a statewide board that would be created if and when the bill became law. Accordingly, the amount of revenue that might be generated in Milwaukee County by the enactment of this bill cannot be presently determined, but it is clear that the passage of this or similar legislation may well provide a revenue source of some type for land records modernization initiatives such as the one recommended in this report.

As a final note, it is important to point out that the underlying specifications set forth in the recommended system for Milwaukee County are fully compatible with—in fact, essentially identical to—the specifications currently in use for both analog and digital mapping in the countywide mapping programs of Kenosha, Racine, and Waukesha Counties. While there presently are no countywide mapping programs in either Ozaukee or Washington Counties, portions of both counties, including all of the immediately adjacent Village of Germantown and a portion of the immediately adjacent City of Mequon, have been mapped to specifications essentially identical to those recommended for the mapping to be prepared in Milwaukee County. This point is of some importance to the utility companies involved since their service territories extend beyond the boundary of Milwaukee County. This basic compatibility may also be of some importance in issues of intergovernmental cooperation involving adjacent counties.

The Advisory Committee has herein outlined the scope and content of the required implementation effort and has set forth recommended specifications for the technical work involved, along with an organizational structure for the conduct of that work. The Committee recommends that the automated mapping and land information system herein outlined be undertaken at the earliest possible date by the units of government and the public and private utilities concerned, and that the scope, specifications, time sequence, and organizational structure be as recommended in this report.

While there was unanimous support among the Advisory Committee members in the concept of joint development and use of a single automated mapping base, the Advisory Committee was unable to achieve a unanimous position concerning the manner in which the recommended project should be funded. There was clearly a majority position favoring joint public and private funding of the project; however, the Advisory Committee members could not agree on the extent of the private versus the public funding. Accordingly, if the Milwaukee County Board should decide to act favorably upon the recommendations of the Advisory Committee concerning the development of a single automated mapping base for Milwaukee County, including the recommendation for partial funding of the project by Milwaukee County, then the project cost allocation set forth in this report must be regarded only as a point of departure in the interagency negotiations that would be needed to initiate the development of the recommended automated mapping system.

APPENDICES

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Appendix A

MILWAUKEE COUNTY BOARD OF SUPERVISORS RESOLUTION NO. 88-379

File No. 88-379

(Item 5) WHEREAS, during consideration of the 1988 budget, the Committee on Finance reviewed a policy paper prepared by the Department of Administration, which recommended the abolishment of the Property Records Division, County Treasurer's Office; and

WHEREAS, an alternative to this recommendation was proposed wherein three of the seven positions to be abolished would be retained and increased fees for copies of materials and new map drating fees would be imposed in order to place the Division on a sounder financial basis; and

WHEREAS, the Committee on Finance, and subsequently the County Board, approved a 1988 budget action to anticipate the revenue increases due to the increased copy and map drafting fees and funding three positions in the Property Records Division for the full year and budgeting the remaining positions for six months pending a report from County Board staff; and

WHEREAS, County Board staff presented a report to the Committee on Finance, at its June 9, 1988 meeting recommending that the three positions funded for the full year be transferred to the Register of Deeds office and provide a reduced level of service from what is now provided and that the Register of Deeds be requested to evaluate the fees and charges now in place as to their appropriateness and amount; that the Department of Administration-Information Management Services Divsiion be directed to analyze the feasibility and cost effectiveness of computerizing the information now maintained on the "A" cards (auxiliary cards providing a history of ownership of property), by the Property Records Division; that the duty to receive and forward tax bills (assessment notices) be assigned to an employe in the County Clerk's office and that the Southeastern Wisconsin Regional Planning Commission (SEWRPC) be requested to develop a study prospectus to convene a task force to analyze the feasibility and cost effectiveness of Milwuakee County developing an automated mapping and land information system including identifying the cost of and the actions necessary to implement such a system; and

WHEREAS, the Committee on Finance approved the recommendations of County Board staff and, in addition, acted to authorize funding for the balance of 1988 for three positions of Property Records Technician I previously funded for six months in the 1988 adopted budget, with the understanding that the Register of Deeds will evaluate the method in which this Division provides services along with evaluating the appropriateness of the fees charged and the potential for computerizing the "A" cards maintained by the Division and will present a report back to the Committee at its September 1, 1988 meeting with a recommendation relative to the necessary funding for continuation of the positions for the remainder of 1988; now, therefore,

BE IT RESOLVED, that the Property Records Division, consisting of the following six positions, is hereby transferred from the County Treasurer (Org. No. 3090) to the Register of Deeds (Org. No. 3300):

1 Property Records Supervisor
4 Property Records Technician I
1 Drafting Technician III (Property Records)

and

BE IT FURTHER RESOLVED, that the Department of Administration is hereby authorized and directed to transfer the appropriate salaries and wages from accounts within the Treasurer's budget to the Register of Deeds budget; that funding for the balance of 1988 for three positions of Property Records Technician I previously funded for six months in the 1988 adopted budget is also approved, with the understanding that the Register of Deeds will evaluate the method in which this Division provides services and the fees and charges now imposed for this Division's services as to their appropriateness and amount and will also examine other charges that could be imposed; and

BE IT FURTHER RESOLVED, that the Department of Administration-Information Management Services Division is hereby authorized and directed to analyze the feasibility and cost effectiveness of modifying the Register of Deeds computer system or implementing a new system to allow the historical information now maintained on "A" cards (auxiliary cards providing a history of ownership of property) to be maintained by computer, with results of the study to be completed in time for consideration during the 1989 budget process and to be reviewed by the Data Processing Committee before presentation to the Committee on Finance; and

BE IT FURTHER RESOLVED, that the Southeastern Wisconsin Regional Planning Commission (SEWRPC) is hereby requested to develop a study prospectus to convene a Milwaukee County Land Records Task Force to analyse the feasibility and cost effectiveness of Milwaukee County developing an automated mapping and land information system, the study to include identifying the cost of and the actions necessary to implement such a system; the Task Force is to analyze the potential for 1) the County to utilize the City's automated mapping (Intergraph) system, 2) the merging of the County and City's needs into one system, and 3) the potential for creating a system that could also be shared and partially funded by utilities such as the Wisconsin Energy Corporation, the Wisconsin Gas Company, Wisconsin Bell and other private businesses, and that SEWRPC is requested to develop the prospectus as soon as practicable and, if possible, in time for consideration as part of the County's 1989 budget; and

BE IT FURTHER RESOLVED, that the duty to receive and forward tax bills (assessment notices) is hereby assigned to the County Clerk's office; and

BE IT FURTHER RESOLVED, that the County Clerk is hereby authorized and directed to provide, upon adoption a certified copy of this resolution to the Executive Director, SEWRPC, P.O. Box 769, Old Courthouse, 916 N. East Avenue, Waukesha, WI 53187-1607.

OFFICE OF THE COUNTY CLERK

Milwaukee, Wis., July 19, 1988.

I hereby certify that the foregoing is a true and correct copy of a resolution/ordinance adopted by the Board of Supervisors of Milwaukee County, at a Special meeting (continued) of said Board held on the 16th day of June, 1988, signed by the County Board Chairman and County Clerk on the 20th day of June, 1988, and approved by the County Executive on the 18th day of July, 1988.

County Clerk

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Appendix B

A TYPICAL COMPUTER HARDWARE CONFIGURATION FOR THE IMPLEMENTATION OF AN AUTOMATED MAPPING AND LAND INFORMATION SYSTEM IN A MUNICIPAL GOVERNMENT ENVIRONMENT

The Advisory Committee guiding the conduct of the Milwaukee County land records modernization study asked that the Regional Planning Commission staff, for information purposes, configure a typical computer hardware system with which smaller, suburban local units of government could utilize the countywide system of digital maps proposed to be developed. In this respect, it is important to recognize that the needs and capabilities of the local units of government concerned will vary widely. Accordingly, the description set forth herein can serve only as an example. Actual installations can be expected to differ from this example in order to meet the specific requirements and expected uses of individual units of government. Further, it must be recognized that computer equipment and attendant software—and related costs—are constantly changing; therefore, the equipment configuration and costs which are presented must be regarded as planning tools rather than as fixed specifications.

The selection of applications software should precede the selection of computer hardware. Applications software is the software that performs the actual manipulation of the digital map data—that is, the generation of map displays and the analysis of map data. The selection of applications software will require careful consideration on the part of the individual unit of government of the specific types of map displays desired; the types of map data analysis desired; the types of additional mapping and geographic data analysis capability that will be developed, such as utility system mapping; and the specific offices or functions within the governmental unit that will use the mapping system.

The system of digital maps described in this report will also have a bearing on the applications software chosen. The chosen software should be capable of maintaining mathematical precision in computational operations involving numbers containing as many as 10 significant digits in order to preserve the full precision of the survey control system involved. This will normally require the choice of an applications software written in "double precision." Since the recommended system of digital maps is expected to be developed around an Intergraph compatible data structure, the applications software should be able to both receive and transmit digital map data in Intergraph Standard Interchange Format (ISIF).

The selection of a suitable applications software will generally simplify the selection of appropriate computer hardware. Some applications software may be available in what is termed "turn key" fashion. In a turn key system, the applications software is sold in conjunction with the computer hardware appropriate for its use, and the buyer will mainly concern himself with decisions concerning the physical size of the system—the processing capacity of the central processing unit and the amount of on-line data storage—and the number and configuration of the operating positions. In the event a "third party" type of applications software is selected, the buyer will be required to exercise greater judgment in configuring a suitable computer hardware system, but even in this situation the task is simplified by first selecting an appropriate applications software, since many of the applications softwares currently available run on a limited number of brands or models of computer hardware.

In the event that a turn key system is acquired, it will be priced in what is known as "bundled" fashion—that is, a single price for all hardware and software will be quoted. The cost range for such systems is extreme, ranging from less than $20,000 to more than $1 million, although the less expensive systems can be expected to be severely limited in terms of function and capacity. Suitable turn key systems possessing a satisfactory range of capability and capacity and fitting the needs of communities in Milwaukee County may be expected to be priced in the range of $50,000 to $250,000, depending upon the capabilities desired.

In the event that a third party applications software is acquired, it will be necessary to purchase the software separately from the hardware. As with turn key systems, the price range for automated mapping and land information systems software is quite large. Suitable third party automated mapping and land information systems applications software possessing a satisfactory range of capability and capacity and fitting the needs of communities in Milwaukee County may be expected to cost from $10,000 to $40,000. It should be noted that most applications software is leased under a license agreement rather than sold outright, and that the acquisition of leased software will most likely require the payment of an annual license fee above and beyond the payment of the initial license fee.

The examples of equipment configurations that follow are based upon the concept of an equipment module or operating node—that is, a relatively self-contained group of equipment, intended to perform a specified set of functions, that can be added to a network of other modules based upon the need for particular functions or additional capacity. The use of the operating node concept for configuring computer hardware for an automated mapping and land information system has several advantages. It tends to make the design of the physical system more manageable and it provides a procedurally sound basis for the staged acquisition of additional equipment over time in the event that that should prove necessary.

Four basic types of equipment modules are described. The first of these modules is the system controller and would contain a processing unit of some type. The processing unit would operate the system software and function as a controller for a line printer, a graphic output device such as a pen plotter or electrostatic plotter, a tape drive, and on-line storage devices such as magnetic disks. The cost for this equipment module can be expected to range from about $20,000 to $100,000 depending upon the capacity and capability of the chosen components.

In the event that a community has a functioning data processing capability and has selected an applications software that can be operated on its existing computer processing unit, it may be possible to use certain peripheral components of that existing system, such as the line printer, tape drive, or on-line storage devices, to provide a suitable operating platform for an automated mapping and land information system, thereby reducing the cost of this equipment group.

The second type of equipment module is a digitizer operating station which operates in terminal fashion from the processing unit. The primary function of this type of operating station is map digitizing and the editing and updating of digitized maps. The station also possesses the ability to perform map design and data analysis functions. The principal components of such a station are a computer graphic terminal device and a digitizer tablet. The cost of this equipment module can be expected to range from $4,000 to $15,000, again depending upon the capacity and capability of the chosen components.

The third type of equipment module is a graphics terminal device which is used to view digital maps and perform data analysis functions. Such units are primarily used in "look up" situations such as are needed for responding to citizen or staff questions or simple requests for information. This terminal can also be used in conjunction with hardcopy devices such as screen dump printers or small format plotters. The cost of a graphics terminal can be expected to range from $2,000 to $5,000. The addition of a small format hardcopy output device will add from $500 to $5,000 to the cost depending upon the type of device selected.

The fourth type of equipment module is a second processing unit which would only be needed in the event that the configured system required additional capacity to support the desired number of operating positions, or in the event that the configured system was physically separated such that additional processing units are necessary to act as controllers for isolated groups of operating stations. This processing unit may or may not be able to utilize the peripheral equipment—line printer, magnetic storage devices, plotter, and tape drive—of the system control module described previously. In the event this module is needed only as a controller, its cost probably will not exceed $10,000. In the event that it must have its own peripheral devices, or in the event that it must have an

additional operating system software or applications software operating license, its cost could approach that of the system control module.

It must be stressed that the example system described in the following section of this Appendix is intended as a point of departure for the development of specific municipal installations and is intended to identify the key components necessary for a functioning system and to establish costs of a correct order of magnitude for system procurement. The functional uses which each individual community intends to develop with its own system will affect final configuration, size, and cost. In addition, the option exists for two or more communities to share key hardware and software components of a system or to share a complete system. Such an agreement to share in the procurement of an operating system could also be expected to affect final configuration, size, and cost.

A typical configuration for a community having a resident population of 15,000 to 20,000 people might be as follows: one system control module, one digitizer operating station, and two graphics terminals for digital map viewing and map data analysis operations. The applications software chosen for this example is a full function GIS software capable of performing a wide range of network-based and polygon-based applications and capable of operating in a multiple-task, multiple-operator processing environment. In configuring this example system, it has been assumed that the subject community desires, over time, to develop a rather complete set of map overlay information, such as land use, zoning, soil units, and municipal utility systems, and further desires to develop the capability to use this information for real property assessment, planning and zoning administration, the design of public works construction projects, and the maintenance and minor reconstruction of existing municipal infrastructure. It has been further assumed that the example system will need to "communicate" with other similar systems, some of which may be of different vendor types; accordingly, a digital graphic data exchange software package has been included in the system configuration.

The example system has been configured in such a manner that it can be expanded to accommodate additional operator positions or additional hardcopy output devices at some future date if desired. It has also been configured such that additional disk capacity can be provided if the applications developed should make that necessary or desirable at some future date. The components necessary to implement the example system are set forth in the following list. Specific brand name products were used in order to establish reasonable cost estimates for the example system; however, brand names are not specified in the configuration list in order to avoid the appearance of endorsing specific products.

Description	Price
GIS Applications Software License	$ 35,000
Digital Graphic Data Exchange Software License	$ 6,300
System Control Module	
32-bit color engineering workstation with 8 Mbyte RAM, 19-inch 16-color display, operating system software license, keyboard, mouse, and all communications boards and interfaces necessary to function as a system controller	$ 44,800
304 Mbyte fixed disk drive, controller, and cabinet (expandable in steps of 304 Mbyte to 912 Mbyte total)	10,800
1/2" reel to reel, 1600 bpi tape drive and cabinet	16,500

(list continued on following page)

Description	Price
System Control Module (continued)	
136-column, 200 cps, dot matrix impact printer	$ 3,000
High performance 8-pen drafting plotter, A through E size cut sheets or 36-inch roll feed media	9,900
Subtotal	$ 85,000
Digitizer Operating Station	
12-inch 8-color graphics terminal with keyboard and mouse	$ 4,000
High-resolution digitizing tablet (48" x 36" format) with power supply, communications cabling, and power lift base	6,800
Subtotal	$ 10,800
Graphic Terminal Operating Stations (2)	
12-inch 8-color graphics terminal with keyboard and mouse	$ 4,000
Subtotal	$ 8,000
Site Preparation Costs, Incidental Office Furniture, and Miscellaneous Cabling, Connectors, and Communications Wiring	$ 12,500
Total	$157,600