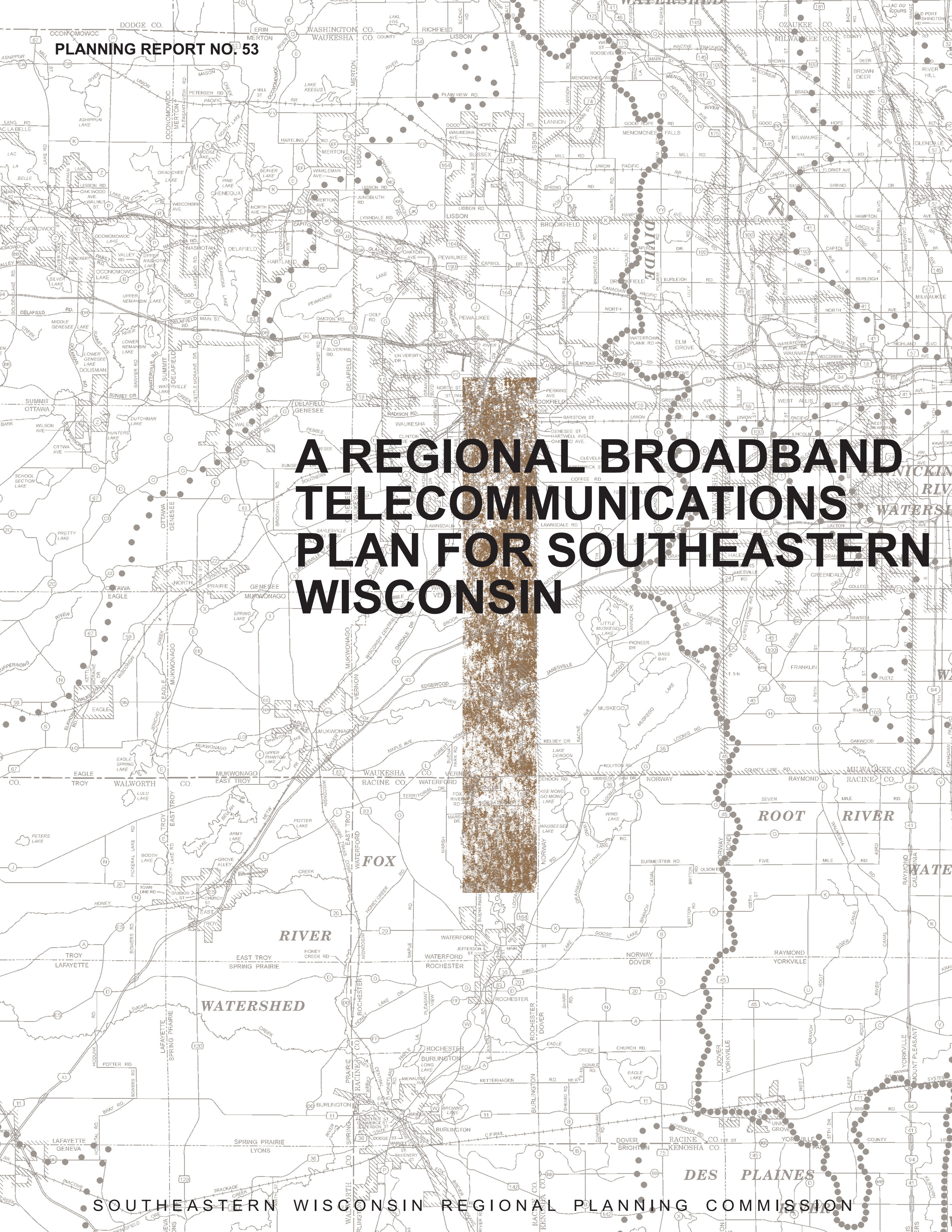
PLANNING REPORT NO. 53

A REGIONAL BROADBAND TELECOMMUNICATIONS PLAN FOR SOUTHEASTERN WISCONSIN



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Special acknowledgement is due the following former member of the Committee: Jody McCann, Network Domain Manager, Wisconsin Department of Administration, BadgerNet.

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A REGIONAL BROADBAND TELECOMMUNICATIONS PLAN FOR SOUTHEASTERN WISCONSIN

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Outside Region $20.00

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October 29, 2007

STATEMENT OF THE CHAIRMAN

The Regional Planning Commission in 2004 undertook a program intended to help develop a high level of telecommunications service within the Southeastern Wisconsin Region. The initiation of this program recognized the vital role of telecommunications in maintaining the economic competitiveness of the Region and of providing certain important social services. This report is the third in a series of three reports which present the findings and recommendations of this planning program.

The first report–SEWRPC Memorandum Report No. 164, published in September 2005–described the importance and potential application for high capacity telecommunication services in meeting growing needs in such areas as public safety emergency response, freeway traffic management, home health care, and environmental monitoring. The second report–SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin*, published in September 2006–set forth recommendations concerning the development of high capacity wireless telecommunications services within the Region. It recognized that, like transportation planning, telecommunications planning relates to infrastructure networks. Such planning differs, however, from public infrastructure system planning in two important respects: one, the rapid pace of technological change in telecommunications; and two, the role of private carriers in plan implementation.

This, the third report in the series, integrates the wireless service plan set forth in SEWRPC Planning Report No. 51 with a wireline services plan. The report presents background information about the Regional Planning Commission, the regional planning concept in Southeastern Wisconsin, and about the seven-county planning Region. It sets forth the basic principles and concepts underlying the regional telecommunications planning process; and describes that process, and the technologies involved in both wireless and wireline telecommunications networks. Importantly, this report sets forth a set of eight objectives that should be met by the telecommunications system of the Region together with supporting principles and standards. These objectives relate to system performance, as measured by data transmission rates, availability, quality of voice transmission, error rate and packet loss; universality of service; redundancy; antenna site number optimization; applications to be served; cost minimization; antenna site aesthetics and safety; and potential for coordination with the development and use of public safety telecommunication networks. The report presents information on the geographic coverage areas and telecommunications service offerings of both wireline and wireless service providers within the Region including, importantly, information on AT&T's current deployment of Project Lightspeed, and documents the current performance of the existing wireless and wireline telecommunication networks within the Region. The report describes four alternative primary and two alternative adjunct regional telecommunication system plans. The alternative primary plans include a community-based wireless plan; a regional wireless plan; a fiber-to-the node wireline plan; and a fiber-to-the-premises wireline plan. The two alternative adjunct plans provides for mobile cell phone service in support of the primary plans that emphasize service to fixed users.

The report documents the findings of the evaluation of the alternative plans considered on the basis of the ability of those plans to meet the specified objectives. A recommended plan–the regional wireless plan–is proposed. The evaluation recognizes that the fiber-to-the-node wireline plan has the potential to perform as well as the recommended regional wireless plan except with respect to the objective of universal service. The report sets forth procedures for implementing the recommended plan.

The recommended regional wireless telecommunications plan would provide high speed, broadband telecommunications service to the entire Region in a cost effective manner, thereby promoting the social and economic welfare of the Region. A central feature of the recommended plan is the potential for cooperative effort by the public and private sectors in which the infrastructure costs entailed are shared between the public safety and commercial networks. Implementation of the recommended plan will require county or multi-county action, although partial implementation can be achieved at the community or multi-community level.

Although this report presents all of the information that should be needed for county and municipal governments within the Region to consider plan adoption and implementation, in depth consideration of the findings and recommendations of the regional telecommunications planning process requires review of all three reports in the series.

Very truly yours,

Thomas H. Buestrin
Chairman

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TABLE OF CONTENTS

Page Page

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

Chapter VI

Chapter VII

Chapter I

INTRODUCTION

INTRODUCTION

The Southeastern Wisconsin Regional Planning Commission is charged by law with the function and duty of "making and adopting a master plan for the physical development of the Region." The permissible scope and content of this plan, as outlined in the enabling legislation, extend to all phases of regional development, implicitly emphasizing, however, the preparation of spatial designs for the use of land and for supporting transportation, and other utility facilities, including telecommunications facilities.

The scope and complexity of areawide development problems prohibit the making and adopting of an entire comprehensive development plan at one time. The Commission has, therefore, determined to proceed with the preparation of individual plan elements which together can form the required comprehensive plan. Each element is intended to deal with an identified areawide developmental or environmental problem. The individual elements are coordinated by being related to an areawide land use plan. Thus, the land use plan comprises the most basic regional plan element, an element on which all other elements are based. The regional comprehensive telecommunications plan for Southeastern Wisconsin is also strongly linked to the regional land use and transportation plans based on the relationship between land use patterns, major transportation facilities, and telecommunications traffic generation.

Because regional telecommunications planning comprises an integral part of a broader regional planning program, an understanding of the need for, and objectives of, regional planning and the manner in which these needs are being met in southeastern Wisconsin is necessary for a full understanding of the telecommunications planning process and of its findings and recommendations as presented in this report. To that end, this chapter describes the need for, and status of, the regional planning effort within the Southeastern Wisconsin Region.

NEED FOR REGIONAL PLANNING

Regional planning may be defined as comprehensive planning for a geographic area larger than a county but smaller than a state, united by economic interest, geography, and common areawide developmental and environmental problems. The need for such planning has arisen from certain important social and economic changes which, while national phenomena, have had far-reaching impacts on the problems facing local government. These changes include growth and redistribution of population and attendant urban development; changes in agricultural and industrial productivity, income levels, and leisure time; generation of mass recreational needs and pursuits; intensive use and consumption of natural resources; development of private water supply and sewage disposal systems; development of extensive electric power and communications networks; and development of limited-access highways and mass automotive transportation. Through the effects of these changes, entire regions like Southeastern Wisconsin are being subjected to the widespread diffusion of urban development and are thereby becoming, large, mixed rural and urban socio-economic complexes. This urban diffusion, in turn, creates serious and complex areawide developmental and environmental problems.

The areawide problems which necessitate a regional planning effort in Southeastern Wisconsin all have their source in the changes in population size, composition, and distribution and in the attendant urban diffusion occurring within the Region. These area-wide problems include, among others: drainage and flooding; air and water pollution; increased demand for park and outdoor recreation facilities, sewerage and water supply facilities, and housing; traffic congestion; a growing demand for high speed, broadband telecommunications; and, underlying all of the foregoing problems, rapidly changing land use development. These problems are all truly regional in scope, transcending both the geographic boundaries and the fiscal capabilities of the local municipal units of government comprising the Region, and can be properly addressed only within the context of a continuing, cooperative, areawide, comprehensive regional planning effort.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission was created in August 1960, pursuant to the provisions of Section 66.0303 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in solving areawide problems and in planning for the more orderly and more economic development of Southeastern Wisconsin. The Commission's role is entirely advisory, and participation by local units of government in its work is on a voluntary, cooperative basis. The Commission is composed of 21 citizen members, three from each county in the Region. One Commissioner from each county is appointed to the Commission by the county board, one by the Governor from a list certified to him by the county board, and one by the Governor on his own motion.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in the enabling legislation. The Commission is authorized to employ a staff and to appoint advisory committees to assist it in the execution of its responsibilities. Basic funding to support Commission operations is provided by the member counties, with the budget apportioned among the seven counties on the basis of relative equalized property valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government to accomplish its objectives, and is authorized to deal directly with the state and federal governments for this purpose. The organizational structure of the Commission and its relationship to the constituent units and agencies of government comprising or operating within the Region is shown in Figure 1.

THE REGIONAL PLANNING CONCEPT IN SOUTHEASTERN WISCONSIN

Regional planning, as conceived by the Commission, is not substitute for, but a supplement to, local, state, and federal planning. Its objective is to assist the various levels and units of government in finding cooperative solutions to areawide developmental and environmental problems which cannot be properly resolved within the framework of a single municipality or county. As such, regional planning has three principal functions:

1. Inventory: the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis so that, in light of such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community development.

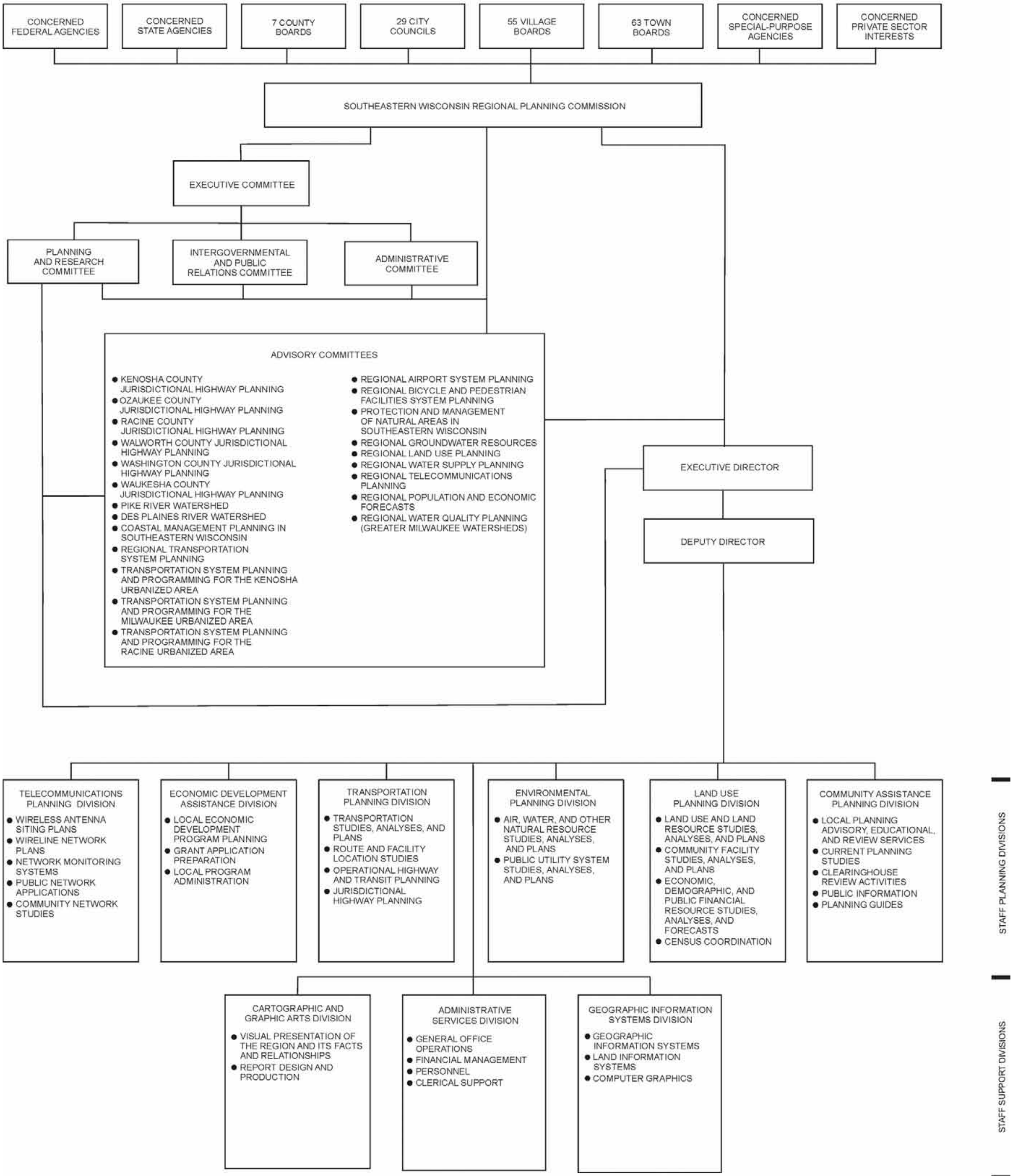
2. Plan Design: the preparation of a framework of long-range plans for the physical development of the Region, these plans being limited to functional elements having areawide significance.

3. Plan Implementation: promotion of plan implementation by providing a center to coordinate the planning and plan implementation activities of the various levels and agencies of government in the Region and by providing the introduction of information on areawide problems, recommended solutions to these problems, and alter-natives thereto, as part of the existing decision-making process.

The work of the Commission, therefore, is seen as a continuing planning process providing outputs of value to the making of development decisions by public and private agencies and to the preparation of plans and plan implementation programs at the local, state, and federal levels. It emphasizes close

Figure 1

SEWRPC ORGANIZATIONAL STRUCTURE: 2005



cooperation between the governmental agencies and private enterprises responsible for the development and maintenance of land uses in the Region and for the design, construction, operation, and maintenance of the supporting public and private facilities. All Commission work programs are intended to be carried out within the context of a continuing overall planning program which provides for periodic re-evaluation of the plans produced and for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, these seven counties have a total of 2,689 square miles, or about 5 percent of the total land and inland water area of Wisconsin, and a total resident population of about 1.97 million people. About 36 percent of the population of the State lives in these seven counties, which contain three of the fifteen metropolitan statistical areas which are wholly or partially located in Wisconsin. The seven counties provide about 1.19 million jobs, or about 36 percent of the total employment of the State. The Region contains real property valued at about $145.4 billion as measured in equalized valuation, or about 37 percent of all of the tangible wealth of the State, as measured by such valuation. The Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 major watersheds.

Geographically the Region is located in a relatively good position with regard to continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use, and is an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within 250 miles of the Region, and over 27.3 million people reside within this radius.

COMMISSION WORK PROGRAMS TO DATE

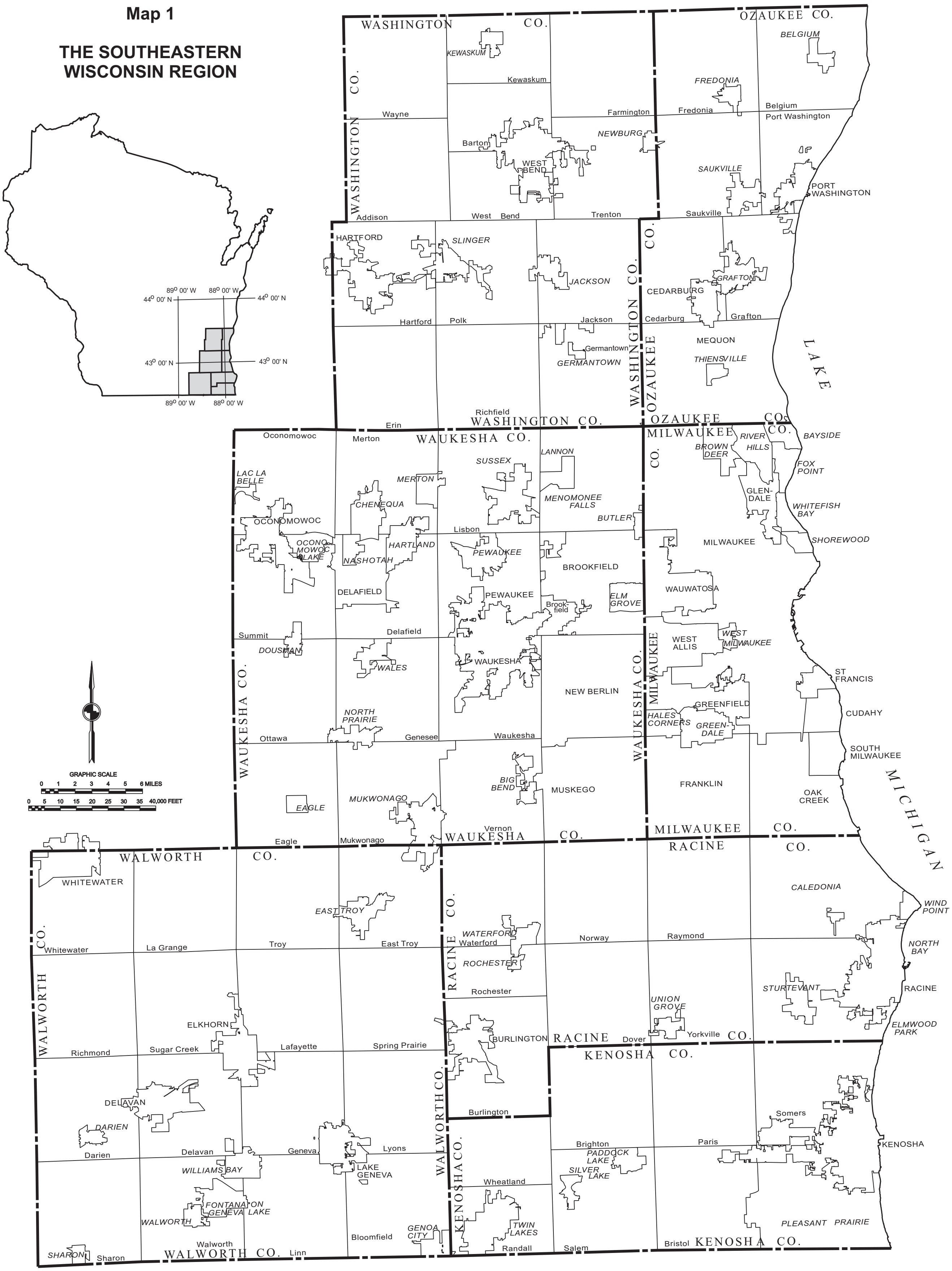
Since its creation in 1960, the Regional Planning Commission has diligently pursued its three basic functions of areawide inventory, plan design, and promotion of plan implementation through intergovernmental cooperation and coordination, although the relative emphasis placed upon these functions has changed somewhat over time. Initially, major emphasis in the Commission's work program was on the inventory function, with increasing attention being placed over the years on the plan design and on the intergovernmental coordination functions.

With respect to the inventory function, the Commission's planning program, as conducted since 1961, has resulted in the creation of a data bank containing in a readily usable form the basic planning and engineering information required for sound, areawide planning. The data assembled in the regional data bank include, among others, definitive data on streamflows; floodlands; surface and groundwater quality; woodlands, wetlands, and wildlife habitat; sites having scenic, scientific, cultural, and recreational value; soils; existing and proposed land uses; travel habits and patterns; transportation system capacity and utilization; existing and proposed utility service areas; and the demographic and economic base and structure of the Region. The data base also includes an extensive topographic and cadastral base mapping and horizontal and vertical survey control file. In wireless networks, the inventories include a comprehensive layout of antenna sites in the Region along with the areal coverage of these sites for the various wireless frequency bands and radio technologies.

Some of the data in the regional planning data bank have been assembled through the collation of data collected by other agencies. Data so assembled include data on highway and transit facility capacity, use, and service levels; transportation terminal facility capacity; automobile and truck availability; and population and economic activity levels. Much of the data in the regional data bank, however, have been assembled through original inventory efforts conducted by the Commission itself. Such inventory efforts have ranged from aerial photography, large-scale topographic and cadastral base mapping, and control survey programs; through extensive land use, woodland, wetland, wildlife habitat, potential park site, and public utility system inventories; to massive

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

travel inventory, detailed operational soil survey, and streamflow gaging and water quality monitoring efforts. Wireless inventory data sources used by the Commission include federal databases such as the Federal Communications Commission and Federal Aviation Administration; permit records of local units of government; and data from wireless service providers.

The regional planning data bank is supported by an extensive data conversion, filing, and retrieval capability which permits the basic data to be readily manipulated and tabulated by various geographic areas, ranging in size from the Region as a whole down through natural watersheds, counties, and minor civil divisions to planning analysis areas, census enumeration districts and tracts, traffic analysis zones, U.S. Public Land Survey sections and quarter-sections, and, for certain data, urban blocks and block faces. Of increasing importance in the regional planning data bank is the Commission's automated geographic information systems capability. A key regional map file consists of land use data which have been digitized, allowing for automated map reproduction and related data analysis functions. The Commission's planning data bank provides valuable points of departure for all Commission work efforts and is, moreover, available for use by the constituent agencies and units of government and the private sector.

With respect to the plan design function, the Commission has placed great emphasis upon the development of a comprehensive plan for the physical development of the Region in the belief that such a plan is essential if land use development is to be properly coordinated with development of supporting transportation, telecommunications, utility, and community facility systems; if the development of each of these individual functional systems is to be coordinated with the development of each of the others; and if serious and costly developmental and environmental problems are to be avoided and a safer, more healthful and attractive, as well as more efficient regional settlement pattern is to be achieved. Under the Commission's approach, the preparation, adoption, and use of the comprehensive plan are considered to be the primary objective of the planning process; and all planning and plan implementation efforts are related to the comprehensive plan.

Telecommunication networks have become a vital resource in the physical development of metropolitan regions. Business firms, local units of government, educational facilities, and individual households all depend on communications in the conduct of their daily lives and high speed—broadband—communications for data and video as well as voice communications is becoming an integral part of a modern society.

The comprehensive plan not only provides an official framework for coordinating and guiding growth and development within a multi-jurisdictional urbanizing region, but also provides a good conceptual basis for the application of systems engineering skills to the growing problems of such a region. The comprehensive regional plan also provides the essential framework for more detailed physical development planning at the county, community, and neighborhood levels.

As previously noted, because the scope and complexity of areawide development problems prohibit the preparation of an entire comprehensive plan at one time, the Commission has determined to proceed with the preparation of individual plan elements which together comprise the required comprehensive plan. By the end of 2003, the adopted regional plan consisted of 29 individual plan elements. Four of these elements are land use related: the regional land use plan, the regional housing plan, the regional library facilities and services plan, and the regional park and open space plan. Twelve of the plan elements relate to transportation. These consist of the regional transportation plan including highway and transit elements, the regional airport system plan, the transportation systems management plan, the elderly and handicapped transportation plan, the regional bicycle and pedestrian facilities plan, and detailed transit development plans for the Kenosha, Racine Waukesha, and West Bend urbanized areas and for Ozaukee, Washington, and Waukesha Counties. Eleven of the adopted plan elements fall within the broad functional area of environmental planning. These consist of the regional water quality management plan, the regional wastewater sludge management plan, the regional air quality attainment and maintenance plan, and comprehensive watershed development plans for the Des Plaines, Fox, Milwaukee, Menomonee, Kinnickinnic, Pike River, Root River, and Oak Creek watersheds. The final two plan elements consist of comprehensive community development plans for the Kenosha and Racine urbanized areas.

The telecommunications planning program is new to the Commission with the initial planning studies beginning in 2004. The program initiation was in recognition of the vital role of telecommunications in the regional economy. In form, it most closely resembles transportation planning, with both relating to infrastructure networks. It differs, however, in the rapid pace of technological change and the role of private carriers in plan implementation.

The Commission also carries on an active community assistance planning program, in which functional guidance and advice on planning problems are provided to local units of government and regional planning studies are interpreted locally so that the findings and recommendations of these studies may be incorporated into local development plans and plan implementation programs. Six local planning guides have been prepared under this program to provide information helpful in the preparation of local plans and plan implementation ordinances. The subjects of these guides are land subdivision control, official mapping, zoning, organization of local planning agencies, floodland and shoreland development, and the use of soils data in development planning and control. Telecommunications planning services will also be extended to local units of government as part of the Commission's community assistance program. Beyond the questions related to antenna siting, some communities may require assistance in assessing telecommunications service levels and needs. Other communities have expressed interest in the Commission providing comprehensive telecommunications plans for expanding broadband telecommunication services in their areas.

TELECOMMUNICATIONS—DEFINITION AND IMPORTANCE

Telecommunication networks provide the infrastructure for information interchange in all advanced societies. Such networks are vital for the efficient production and distribution of goods and services in a modern economy. Telecommunication exchanges also serve to help weave the social and political fabric of modern day life. Recent and continuing advances in communications technology have allowed for information transfer at rates considered infeasible even a decade ago. Although originally developed for voice communication only, telecommunication networks now transmit data, video, and multimedia forms of information.

Varying rates of deployment of new communications technologies in different areas of the United States and in the rest of the world have produced one aspect of the so-called "digital divide,"[1] placing areas with outmoded telecommunication technologies at a competitive disadvantage in national and global commerce. Such disadvantaged areas are also prevented from introducing communications-based advances in fields such as telemedicine, public safety, education, environmental monitoring, and transportation that have major impacts on the quality of life. For all of the above reasons, telecommunications planning should be an important concern of elected and appointed public officials in a metropolitan region such as Southeastern Wisconsin.

One mode of telecommunications, terrestrial wireless communications, is advancing more rapidly than other modes such as traditional wireline and satellite wireless communications. Although the first commercial cellular wireless network did not become operable until 1983, wireless telephony is rapidly becoming the predominant form of local and long distance voice communication in the United States and elsewhere. Some countries in Europe and Asia, have higher rates of wireless telephone usage than does the United States. With the advent of the third generation (3G) of wireless communication technology, wireless is expected to become important in data and video as well as voice transmission. Beyond 3G networks, emphasis in this regional telecommunications plan is on fourth generation networks (4G) that will allow Southeastern Wisconsin to compete in a global economy. These 4G networks support data rates exceeding 20 megabits and are characterized as "big broadband" as compared to the "little broadband" of current telephone and hybrid

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[1] *The term "digital divide" is commonly used to refer to the differences between households, businesses and other organizations that, for whatever reasons, have access to personal computers and the Internet and those that do not. It can also be used to distinguish between areas that are underserved in that the areas do not have high speed data service available. Such underserved—or disadvantaged—areas may exist in urban, as well as rural areas.*

cable networks which generally have throughput under six megabits per second. The comprehensive telecommunications plan alternatives will feature varying proportions of wireless and fiber wireline networks in access and backhaul networks depending on population density and other socio-economic variables.

ADVISORY COMMITTEE

The long-established practice of the Commission has been to conduct major regional planning programs with the assistance of appropriately structured advisory committees. The membership of such committees was to be drawn, as appropriate, to include knowledgeable and concerned representatives of the constituent counties and municipalities; of concerned State and Federal agencies; of the academic community; and of concerned private businesses and industries. Accordingly, an Advisory Committee on Regional Telecommunications Planning was created by the Commission to guide the preparation of the recommended plans. The Committee consists of the following members:

Kurt W. Bauer, Chairman	Executive Director Emeritus, SEWRPC
William R. Drew, Vice-Chairman	SEWRPC Commissioner; and Executive Director, Milwaukee County Research Park
Roger Caron	President, Racine Area Manufacturers and Commerce
Bob Chernow	Chairman, Regional Telecommunications Commission
David L. DeAngelis	Village Manager, Village of Elm Grove
Michael Falaschi	President, Wisconsin Internet
Barry Gatz	Network Supervisor, CenturyTel
Michael E. Klasen	Director of Regulatory Affairs, SBC
J. Michael Long	Attorney at Law, Murn and Martin, SC
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Jody McCann	Network Domain Manager, Wisconsin Department of Administration, BadgerNet
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Dale R. Shaver	Director, Waukesha County Department of Parks and Land Use
Michael Ulicki	Vice President and Chief Technology Officer, Norlight Telecommunications
Darryl Winston	Director of Data Services, City of Milwaukee Police Department
Gustav W. Wirth, Jr.	SEWRPC Commissioner

Special acknowledgement is due the following former members of the Committee: Kenneth Brown, RF Engineer, Nextel Communications, Inc.; Brahim Gaddour, Director of Network Operations, Time Warner Telecom of Wisconsin; and Paul R. Schumacher, former Program Manager, TriCounty Business Partnerships.

PROSPECTUS

On December 4, 2002 the Commission authorized the preparation of a Prospectus for a Regional Telecommunications Planning Program. During the following year the Commission staff, under the guidance of a predecessor Advisory Committee, prepared a prospectus for a regional telecommunications planning program. This prospectus described in some detail the need for, and the major work elements of such a planning program. In December 2003, the Commission approved the initiation of a Regional telecommunications planning program based on this prospectus. The prospectus envisions the regional telecommunication plan to be comprised of two elements: a wireless antenna siting and related infrastructure plan; and an overall telecommunications network plan. In addition, the preparation of a technical report presenting the findings of an inventory of the existing regional telecommunications system and system performance; and a memorandum report on public enterprise networks were envisioned.

NEED FOR REGIONAL TELECOMMUNICATIONS PLANNING

Based upon a careful examination of the historical background and of the current state of telecommunications facilities and services within the Region, the Advisory Committee that guided the preparation of the afore-referenced Prospectus concluded that seven factors contribute to the need for the conduct of a regional telecommunications planning program and the preparation of a regional telecommunications plan for Southeastern Wisconsin. These factors are:

1. The lack of comprehensive information on the state of telecommunications facilities and services within the Region readily available to county and municipal officials, businessmen and industrialists, and concerned citizens.

   In past years, comprehensive information on the Regional telecommunications infrastructure was available from the Public Service Commission of Wisconsin (PSC). The PSC no longer has any jurisdiction over the growth areas of the telecom infrastructure, i.e. the packet-switched wireline network and all wireless networks. Without such information, public planning of any kind is not possible.

   Quality of service information on telecommunication services within the Region is also lacking. Many users of data services are often unaware of the degraded nature of transmission rates provided in some parts of the Region. Remedies for the correction of service deficiencies often take extended time periods with increasing subscriber frustration. At the same time, information on levels of service is rarely publicized. A regional network monitoring system could assist significantly in identifying network deficiencies as well as publicizing service quality levels throughout the Region.

2. The increasing need for advanced telecommunication facilities and services to support the economic development of the Region.

   Currently, primary economic competitors of the Region include countries of East Asia—South Korea, Japan and increasingly China. Manufacturing jobs especially are moving from Southeastern Wisconsin to East Asia. East Asia is reported to be ahead of the United States and the Region in broadband telecommunications services—both in terms of transmission speeds and in lower costs of these services. A regional telecommunications plan would assist Southeastern Wisconsin in recovering and maintaining its competitive position in the global economy by identifying the telecommunications infrastructure required to prosper in the current economic environment.

3. The need to address the universal provision of adequate broadband telecommunication services within the Region.

   A long term public approach to planning for the universal provision of broadband services within the Region is needed. Such an approach requires the evaluation of alternative network configurations and technologies to ascertain what is in the best socioeconomic interests of the people of Southeastern Wisconsin.

4. The need to address differences in the provision of adequate telecommunication services in rural and other underserved areas of the Region.

   The governor in 2003 called for the provision of universal broadband communication services to all areas of Wisconsin as part of a needed economic development program. Creative network design innovations are required to make such universal coverage cost-effective in rural and disadvantaged areas in a more effective manner. Such innovations can be evaluated as part of a regional telecommunications planning process.

5. The need to develop special purpose public telecommunication networks within the Region for applications such as telemedicine, public safety, transportation, environmental monitoring, and education.

   Some of the greatest benefits of advanced telecommunications technology can result from the development of special public networks in areas such as emergency telemedicine, home health care telemedicine, air and water pollution monitoring, transportation system management, and education.

Many of these public network applications are regional in scope and planning for such would be enhanced by a regional telecommunication planning program.

6. The need to assist local units of government in telecommunication network development.

   Wisconsin municipalities have authority to provide telecommunications services, and court decisions have upheld this authority. Over 25 municipalities have been certified by the Wisconsin Public Service Commission to provide competitive telecommunications services. The Village of Jackson, within the Southeastern Wisconsin Region, is creating a broadband telecommunication utility to provide telecommunication facilities and services within the Village. Municipalities choosing this route could significantly benefit from planning assistance at the regional level. All municipalities within the Region will, however, require planning assistance with respect to telecommunication issues, particularly as related to future wireless and broadband communications services. In this respect, it should be noted that Section 66.0295(2)(d) of the Wisconsin Statutes requires that local comprehensive plans specifically address telecommunications facilities as an integral part of the utilities and community facilities element of such plans.

7. The need to develop a well-conceived comprehensive broadband telecommunications systems plan for the Region.

   Technical advances in telecommunications particularly in low cost wireless broadband networks have emphasized the need for a comprehensive telecommunications system plan for the Region. Based on detailed investigations of alternative wireless and fiber based wireline technologies, the plan will recommend broadband communication alternatives for all parts of the Region from low density rural areas to urbanized villages and cities.

PLAN DESIGN YEAR

The wireless antenna siting and related infrastructure plan for the Southeastern Wisconsin Region, as set forth in SEWRPC Planning Report No. 51, has a plan design year 2015. This design year was selected to correspond with the year 2015 stage of a set of new land use and transportation system plans being prepared for the Region. These plans are to have a design year 2035 with appropriate ten year stages. The plan design year of 2015 was also selected to provide a long-range, as opposed to a short-range, basis for the planning effort. Because of the rapidly changing economic, technological, regulatory, and market conditions concerned, private sector telecommunications planning efforts tend to be relatively short range, a five year time horizon often being used. A longer time horizon—10 years—was selected for the antenna siting and related infrastructure planning effort in order to permit the planning to reflect probable new technologies, including fourth generation (4G) wireless technology, and new versions of the Internet. A plan design year of 2015 was selected for the regional telecommunications plan presented in this report in order to be consistent with the plan design year selected for the wireless antenna siting and related infrastructure plan set forth in SEWRPC Planning Report No. 51. The designation of a design year is not intended to preclude the earlier introduction of 4G technology, but only to specify the latest date by which such technology should be in use within the Region.

SCHEME OF PRESENTATION

The findings and recommendations of the regional comprehensive broadband telecommunications system planning program are documented in this report. Following the Introduction, Chapter II sets forth the principles and concepts underlying the comprehensive broadband telecommunications planning program and outlines the major steps in the planning process. Chapter III presents the objectives of the comprehensive planning program and the standards by which alternative plans will be judged. Chapter IV documents the demographic, economic land use and transportation system inventory findings—the background conditions for the comprehensive telecommunications plan. Chapter V documents the findings of the broadband telecommunications infrastructure inventory required for the planning effort. Chapter VI describes a wide range of performance inventory findings for both wireline and wireless broadband networks. Throughput performance in both the download and upload directions is tabulated and illustrated at the national, state and local levels. Chapter VII presents applicable technologies and alternative system plans for broadband service. The alternative regional broadband telecommunications system plans considered are described and costed in preparation for comparative plan evaluation and recommended plan selection in the chapter that follows. Chapter VIII provides the findings of the comparative evaluation of the alternative plans and based upon that evaluation, sets forth a recommended plan. Chapter IX deals with plan implementation. Chapter X provides a summary of the findings and recommendations of the regional comprehensive broadband telecommunication planning effort.

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Chapter II

BASIC PRINCIPLES AND CONCEPTS

INTRODUCTION

In the preparation of a the comprehensive telecommunications system plan, the Regional Planning Commission followed a systematic planning approach that combined traditional regional planning procedures with well established telecommunications system engineering procedures. This chapter describes the approach followed by the Commission in preparing the comprehensive telecommunications system plan. More specifically, this chapter details the major elements of the planning process and how the telecommunications system engineering was integrated into the regional planning process. Definitions are provided for the various technologies concerned, both wireless and wireline, together with the descriptive parameters that characterize the applications of these technologies.

BASIC PRINCIPLES UNDERLYING THE REGIONAL PLANNING PROCESS

The planning process applied in the regional telecommunications planning effort is based on four basic principles. These are:

1. Telecommunications planning must be regional in scope. The need for and demand in telecommunication services develops over the entire urban region without regard to corporate limit lines. Thus, telecommunications planning cannot be accomplished successfully within the confines of a single municipality or a single county if that municipality or county is a part of a larger urban complex. The regional telecommunications system, which is comprised of wireless and wireline facilities and attendant services, must form an interoperable system over the entire region, a system which can adequately serve the developing telecommunication needs of the developing region.

2. Telecommunications planning must be conducted concurrently with and cannot be separated from land use planning. The land use pattern determines the amount and spatial distribution of the need and demand for telecommunication services; and for wireless communications, local use development has a major impact on radio propagation patterns.

3. Telecommunications planning must be comprehensive, considering in an integrated manner access, distribution and core networks using various wireless and wireline technologies for multiple service applications and media.

4. Private sector companies are significant providers of telecommunications services within the Region. These private sector companies independently prepare plans for the development of their networks; independently develop their own levels of service; and independently provide competitive services. Meaningful public tele-

communication planning effort must recognize the existence of these private sector planning efforts; and pursue the public planning effort in close cooperation with the private providers, actively involving these providers in the public planning process.

PLANNING PROCESS

The planning process used consisted of the following sequential work elements:

1. Formulation of Objectives and Standards
   A set of telecommunications facility and service objectives and standards were formulated. These objectives and standards emphasize the provision of areawide, low-cost, fixed, nomadic (laptop computer) and mobile broadband telecommunications facilities and services. The objectives are supported by a set of standards that provide quantifiable measures of availability, response time, throughput, and accuracy, the parameters that define the performance of a communications system that will meet the agreed upon objectives.

2. Conduct of Facilities and Services Inventory
   A sound planning process must be based upon factual data about the existing state of the system being planned. Such data are provided by an inventory function that for the communications infrastructure planning process includes the collation and collection of definitive information on the location of existing telecommunications infrastructure and on the technical specifications of the facilities. The inventory data are then used as inputs to the telecommunications network infrastructure planning process providing information on both communication needs and the ability of existing networks to service these needs. A second dimension to the inventory relates to network performance.

   A network monitoring system has been established at the Commission offices that provides a means for measuring the quality of the existing network services. A central server computer located at the Commission offices scans remote site transceivers located at various changing locations throughout the Region. The data collected from these scans is used to compile data on the quality of service within the Region.

   Additional performance data for both wireline and wireless network were collected through specialty websites that routinely record broadband communications throughput performance (DSL, cable and wireless) at the national, state and regional levels. These data allowed for comparisons with the SEWRPC monitoring system and for continuing updates on regional broadband performance.

   In order to be comprehensive, the inventory, in addition to infrastructure providing commercial service, also includes facilities that provide public support services.

3. Analyses and Forecasts
   In the classic approach to systems planning, forecasts are made of those factors that affect the structure of the system plan concerned, but which lie outside of the scope of the system being planned. Thus, public infrastructure systems planning typically involves the preparation of forecasts of probable future system demand—expressed in terms of such parameters as person trips, per capita sewage contribution, or per capita water demand—derived from population, household, employment, and land use forecasts for the plan design year. The forecast period is determined by the physical and economic life of the facilities concerned—for most types of public works facilities this period approximates 20 years. Procedures for developing such forecasts are well established and widely used for transportation, sanitary sewerage, storm water drainage and flood control, and water supply system planning. In transportation system planning, for example, population, household, employment, and land use forecasts are used to estimate future travel demand by mode. This demand is then used in the simulation of the performance of the arterial street and highway and transit systems through mathematical modeling. This permits quantitative analyses of the performance of alternative system plans considered, and facilitates the selection and more detailed design of a recommended system plan.

This classic approach to systems planning was originally intended to be applied in the regional telecommunications planning effort. The formulation and calibration of the necessary mathematical simulation models, however, required detailed information about the configuration, capacity and utilization of the existing telecommunications facilities within the Region that would permit the correlation of such utilization with socioeconomic and land use data for use in forecasting probable future demand. The necessary information was available only from the existing service providers, which refused to provide the information to the Commission. Therefore, the classic approach to systems planning could not be applied in the regional telecommunications process.

Consequently, a different approach to the plan design process was taken. Telecommunication supply and demand are known to be greatly influenced by the rate of new technology adoption and user acceptance. User acceptance is typically measured by a "take rate" which may vary widely, perhaps from 2 to 50 percent, or by a ratio of 25 to 1. This uncertainty of demand for a new broadband telecommunication service creates a need for system designs that may be expected to be profitable at the lowest expected take rate, but which have the capacity to accommodate much higher take rates at the desired levels of service. Thus, in the absence of being able to base alternative plan designs on long term forecasts and performance simulation, alternative plans were designed so that "break even" operation would be possible at low take rates, but which possessed capacities able to serve much higher take rates at the desired level of service.

In the planning process, the ability to achieve break even operation at low take rates was assessed on the basis of analyses of the capital costs involved. The adequacies of the system capacity were assessed on the basis of analyses of the level at which subscriber arrival rates and message sizes would become unacceptable with respect to the level of throughput desired. The alternative plans were, moreover, designed to permit the ready expansion of the initially available capacity through simple changes in the software and hardware concerned, without changes in the basic structure of the system plan. Analyses of the network capacities were based on modified versions of traffic engineering formulas originated by the Danish mathematician, A. K. Erlang, and used for many years by the Bell System in determining the capacity of circuit-switched telephone systems. The probability distributions involved—Poisson and Erlang—and their supporting algorithms were converted from circuit-switched to packet-switched network form for application to the network system plans developed under the regional telecommunications plan program.

4. Plan Design
   Plan designs are primarily generated based on two communications technologies: broadband wireless and broadband fiber wireline. These technologies compete in both access and core networks. The challenge of broadband communications system design is to select and deploy the most cost effective technology in urban, suburban and rural areas. Low density rural areas will generally favor wireless access networks with their low infrastructure cost and geographic coverage. High density urban areas, depending on their socio-economic characteristics, may support fiber-to-the premises networks. Business organizations with their high volume data requirements are also strong candidates for ultra-high speed fiber communications. In plan design, studies of various land use categories will be made to establish the basis for selected wireless and wireline networks throughout the Region.

5. Plan Test and Evaluation
   A number of means exist for plan test and evaluation. The most commonly used is system simulation in which a dynamic model of the network is used to simulate the performance of the existing system—or of alternative planned systems—on a computer. Such simulation can take place at varying levels of detail from high level evaluations of system capacity based on statistical estimates of subscriber usage, to detailed investigations of network packet transmissions. Interest at the regional system planning level emphasizes models that view a

network as a service provider. The objective of a modeling effort is to determine the system coverage and capacity and the level of service possible at various traffic loadings.

6. Plan Selection And Implementation
   Following public informational meetings and hearings on alternative wireless network plans, one of the alternative plans, or some composite version of these plans, will be adopted to help guide the short and long-range development of the regional telecommunications infrastructure within Southeastern Wisconsin. In presenting the alternative plans for public informational meetings and hearings, strong emphasis will be placed on the performance standards characterizing each alternative plan and how these standards relate to the capital investment and operating costs implicit in implementing each plan. Since one of the alternative plans will always represent a no-plan projection of current trends, these performance standards data will play a critical role in plan selection and adoption.

INVOLVED TECHNOLOGIES

Although the above description of the planning process delineates the basic work elements of regional telecommunications planning, it does not define the various technologies and provider networks that will establish the scope of the planning program. This section describes these technologies and networks as well as the frequency bands involved in wireless network planning in Southeastern Wisconsin.

Mobile Wireless Networks
The major antenna site users—owners or renters—in Southeastern Wisconsin are the mobile cellular/ Personal Communication System (PCS) service providers such as Cingular, Sprint/Nextel and Verizon. Based on the Commission inventory data there were, in 2005, 1,010 antenna sites within the Region. These sites are a resource not only for their present applications in second generation (2G, 2.5G) networks, but also as a resource for co-location of 3G and 4G networks.

The emphasis for wireless 2G, 2.5G and 3G infrastructure planning will be on a regional set of antenna sites that will provide adequate coverage, capacity, and quality of service for the Region as such coverage, capacity and quality of service are defined by objectives and standards set forth in this report. Second generation networks are already in place. Planning issues will relate mostly to coverage and quality of service. Third generation networks are just coming on the scene in Southeastern Wisconsin. Primary planning decisions here relate to planned coverage of the various service providers and their selection of antenna sites.

Fourth generation (4G) wireless infrastructure planning will proceed with significantly different objectives and procedures. The primary objective of the 4G plan is to present an imaginative, big broadband (20-100 megabits/second) fixed and mobile wireless plan for the Region that provides universal, region-wide coverage at affordable costs to all citizens of the Region. Current mobile cellular networks operate in the 800-900 MHz frequency bands. PCS networks utilize the 1900 MHz band. Although 3G networks will continue to operate in these same bands, 4G systems will move to higher frequencies such as the 5.2-5.9 GHz range.

Fixed Wireless Networks
Fixed wireless networks in the Region are currently small in size as compared to their mobile cellular/PCS counterparts. They are, however, expected to expand rapidly in the next few years, particularly with the advent of WiMAX technology. Most fixed wireless systems are now managed by Internet Service Providers (ISPs). Because they operate in higher frequency ranges (2.4 GHz or 5.7 GHz), their radius of coverage is limited to about 3 miles from each base station. Since they serve subscribers at fixed locations, there is no need to provide wide coverage, but instead they locate in areas with higher population densities to enhance their revenue potential. Most fixed wireless operators deploy proprietary systems such as the Motorola Canopy System. They tend to serve local areas mostly within a single county. In the future, however, it is expected that larger scale fixed wireless networks will be deployed by larger service providers offering a region-wide broadband service alternative. The advent of WiMAX (IEEE 802.16) technology is expected to lead to a merger of fixed and mobile communications networks all based on Internet operation. Although wireless communications networks, fixed and mobile, are now generally confined to frequencies below 6 GHz, future systems, particularly mesh network systems,

are expected to employ higher frequencies up to and including the 60 GHz band because of the faster transmission rates possible at these frequencies. Although shorter in range coverage and subject to strong atmospheric alternation, these frequency bands will play a role in multi-hop mesh network and other configurations. In some deployments, even free space near infrared optical links can expand performance capabilities.

Wireline Networks

Wireline networks in the form of telephone company DSL services and cable company hybrid fiber coaxial cable services dominate current day broadband telecommunication both in the Region and in the Nation at large. In their current forms, these technologies are reaching the limits of their performance capabilities. Advances for fourth generation broadband performance will require conversions to one of two emerging landline-based broadband telecommunications technologies – fiber-to-the-node (FTTN) and fiber-to-the-premises (FTTP).

In the FTTN approach, optical fiber cables are extended out from a telephone central office to a remote geographic node that will service users in an approximate 3,000 foot radius area using the existing copper wire infrastructure. Such a fiber-connected node using advanced forms of DSL such as VDSL is able to increase throughput performance levels to fourth generation standards exceeding 20 megabits per second. Still more advanced versions of DSL are promising throughputs up to 100 megabits per second. Although FTTN represents a significant advance for telephone service providers, it is architecturally quite similar to the hybrid fiber-coaxial cable structure employed by cable operators where optical fiber is brought to a "headend" which is then converted to an electrical signal for transmission on a copper-based coaxial cable to individual users.

A wireline technology with greater throughput performance potential utilizes an optical fiber connection direct to the end user – FTTP. Since a single optical fiber has throughput potential in the terabits per second range, FTTP in its pure form uses a dedicated individual fiber to connect each user to the central office. Such an arrangement is called an active optical network (AON). The performance of an AON is limited only by the electro-optical equipment employed at the central office and user ends of the dedicated fiber. For practical purposes, the bandwidth is essentially infinite. AON networks, however, are costly both in initial capital equipment and continuing maintenance costs. A simpler, lower-cost, but also lower performing optical architecture employs a passive optical network (PON).

In a PON network, there are no active electronic elements between the central office and the user. Rather a single fiber from the central office is passively split into multiple fibers—usually 32—at a remote location fanning out to serve 32 end users. PON networks are less costly to install and maintain, but they are also less able to utilize the full bandwidth of an optical fiber. Current PON networks are designed for throughputs around 100 megabits per second far below the data rate potential of the fiber medium.

SUMMARY

Regional planning for regional communications infrastructure development combines traditional planning procedures with the methodology of communications systems engineering. A six-step process is followed: beginning with the formulation of objectives and standards, and a determination of the current state of the system in terms of both infrastructure and performance. These two initial steps are followed by the preparation of forecasts of probable future demand for services which establishes the requirements for network coverage and capacity. Alternative plans meeting these requirements are then prepared, tested, and evaluated. The plan test involves computer simulation modeling that permits the evaluation of each alternative plan in terms of ability to meet the objectives and standards. The best plan is then selected for adoption and implementation. Implementation takes place in the form of guidance to private service providers and regulatory agencies concerned; or directly through public sector applications. The regional telecommunications planning process encompasses both wireline and wireless networks that also include fixed and mobile wireless technologies in both their present second (2G) and third (3G) generations, and future fourth generation (4G) technology that merges all of these technologies into one Internet based infrastructure.

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Chapter III

OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

Planning is a rational process for formulating and meeting objectives. Therefore, the formulation of objectives is an essential task which must be undertaken before a comprehensive plan can be prepared and evaluated. Objectives guide the preparation of plans and, when converted to specific measures of plan effectiveness, termed standards, provide the structure for evaluating how well the plan meets planning objectives. Because planning objectives provide this basis for plan preparation and evaluation, the formulation of objectives is a particularly important step in the planning process.

Accordingly, a set of recommended objectives with supporting principles and standards was formulated as a part of the telecommunications infrastructure planning effort. The associated standards perform an important function in plan design since they provide the basis for relating the objectives to alternative plan configurations.

It is important to note that the objectives, principles, and standards presented herein are intended to serve as a basis for determining desired alternative and recommended telecommunications infrastructure. The standards, particularly, must be applied with judgment in the more detailed public and private planning and engineering studies which will be needed during plan implementation. The objectives, principles, and standards formulated herein relate to all portions of the comprehensive regional telecommunications plan to be prepared by the Regional Planning Commission. The comprehensive plan will include both wireless and wireline elements relating to core as well as access networks. The objectives, principles, and standards presented herein will also apply to all segments of the comprehensive plan.

It is also important to note that the objectives, principles, and standards presented herein were formulated within the context of other objectives, principles, and standards previously adopted by the Regional Planning Commission. These other objectives, principles, and standards relate to socio-economic, land use, transportation, and sewerage system development within the Region and to environmental protection and enhancement. As such, the telecommunications system development objectives, principles, and standards are intended to support these other regional development objectives, principles, and standards.

DEFINITIONS

The terms “objective,” “principle,” “standard,” “plan,” “policy,” and “program” are subject to a range of interpretations. To clarify their meanings, the Regional Planning Commission has defined these terms as they are used within the context of this planning process as follows:

1. Objective: A goal or end toward the attainment of which plans and policies are directed.

2. Principle: A fundamental, generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: A criterion used as a basis of comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: A design which seeks to achieve agreed-upon objectives.

5. Policy: A rule or course of action used to ensure plan implementation.

6. Program: A coordinated series of policies and actions to carry out a plan.

Although this chapter deals with only the first four of these terms, an understanding of their inter-relationship and the concepts they represent is essential to the following discussion of objectives, principles, and standards.

To be useful in planning, objectives must be logical and clearly stated. The consideration of objectives for plan design and evaluation is facilitated by complementing each objective with one or more quantifiable standards. These standards are, in turn, directly related to a planning principle which supports the objective. The objectives relate primarily to the provision of wireless broadband telecommunications services within the Region, and to the desired performance of the system, its availability, and the overall quality of service. Each objective, together with its supporting principle and standards, is given in the following section. The following objectives, principles and standard, or standards are intended to be used in the formulation and evaluation of alternate telecommunications infrastructure plans and in the preparation of a recommended plan that will provide 4G wireless telecommunication services within the Region.

In considering the objectives and supporting standards set forth in this Chapter, it should be recognized that those objectives and supporting standards are intended to be applied at the system planning level, and that the effect of individual facilities on each other, or on the system as a whole, requires the application of mathematical models to quantitatively test alternative systems, thereby permitting adjustment of the subsequent configuration of the system concerned to meet the existing and forecast demand. It should also be recognized that an overall analysis of each alternative system plan considered must be made on the basis of cost. Such an analysis may show that the attainment of one or more of the standards is beyond economic practicality, and that the standard or standards concerned cannot be achieved and must be either reduced or eliminated. It should also be recognized that it is unlikely that any one plan proposal will meet all of the standards fully; and the extent to which each standard is met, exceeded, or violated must serve as a measure of the ability of each alternative plan considered to achieve the specific objectives which the given standard or standards compliment. It should be further recognized that certain objectives and standards inherently may be in conflict, requiring resolution through compromise; and that meaningful alternative plan evaluation can only take place through comprehensive assessment of each alternative plan considered against all of the objectives and standards. The selected plan will thus represent a compromise with respect to meeting conflicting objectives supporting standards. Finally, it should be recognized that the standards must be judiciously applied to areas which are already partially or fully served in order to avoid any unreasonable extensive reconstruction programs. Given the important role of the private sector in providing telecommunications facilities and services within the Region, and given the concern of these providers about the continued freedom to operate independently in a competitive market, it is important to note that the following objectives, principles, and standards are not intended to have any regulatory implications, but are intended for use solely in plan preparation and evaluation.

OBJECTIVES, PRINCIPLES, AND STANDARDS

Objective No. 1—Broadband Telecommunications Performance

A level of broadband telecommunications performance that is competitive in a global economy and supports cost effective enhancements of public sector services.

Principle

High quality telecommunication services are vital to the expeditious conduct of national and international business and industrial transactions, and to prompt responses to emergencies. To be competitive in a global economy, the Region requires advanced, low cost broadband telecommunications services, which can be provided by either wireline or wireless telecommunications technology. The services should have a level of availability and continuity which facilitate business and industrial transactions, but which also ensure prompt responses to emergencies.

Standards

- Broadband communications services should provide a transmission rate in the range of 20 to 200 megabits per second.[1]
- Broadband communication networks should be available 99.9 percent of the time.[2]
- Voice service should be provided at a minimum MOS Standard Value of 4.0.[3]

Objective No. 2—Universal Broadband Telecommunications Services
The provision of broadband telecommunication services to all geographic areas of the Region.

Principle
Residents and organizations of the Region, regardless of geographic location, should be offered an equal access to broadband telecommunications services in order to promote the social and economic welfare of the Region.

Standards

- Broadband communications network coverage should be provided in all geographic areas of the Region and should be available to all residences, businesses, industries, and organizations of the Region.

Objective No. 3—Redundancy
The provision of alternative transmission paths through the individual providers of telecommunication networks so as to minimize network congestion, reduce susceptibility to interference, and provide high immunity to catastrophic failure.

Principle
Robust and reliable networks are required in a communications dependent economy and society and in emergency situations.

Standard

- Redundancy is measured based on the average number of alternative transmission paths between users in a network. Desirably, the ratio of the average number of alternative transmission paths to the total number of links in the network should be at least 20 percent.[4]

Objective No. 4—Antenna Site Number Optimization
The number of wireless antenna site locations within the Region should be optimized.

Principle
Optimization of the number of antenna sites within a planning area is consistent with minimization of infrastructure investment costs, with the provision of redundancy in the service of each individual provider, and with promotion of environmental protection and the pursuit of a high aesthetic quality in the land and cityscape.

Standard

- The number of antenna sites should be the smallest number that provide universal coverage and quality of service within the Region.

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[1] *The generally accepted range for both IEEE 802.16a, d and 4G wireless networks is 20 to 100 megabits per second. The high end target value was raised to meet the needs of high definition television on demand.*

[2] *While wireline telephone service has a general availability standard of 99.999 percent (equivalent to a total of 3 minutes down time per year), wireless service availability has not yet reached this level. The standard of 99.9 percent (equivalent to a total of 8.6 hours of down time per year) is believed to represent an achievable goal by the plan target year 2015.*

[3] *Mean Opinion Score, (MOS) was originally defined based upon a subjective evaluation of voice quality by a group of listeners. It is now objectively defined as an ITU-T P.800 specification, and is determined from a standard formula based upon signal to noise ratio (SNR), line delays, and other factors. The value ranges from 1.0 to 5.0, corresponding to lowest and highest levels of voice quality satisfaction.*

[4] *This standard value was based on partial mesh paths in a full mesh topology where the number of links L=N(N-1))/2; and N=number of nodes in network.*

Objective No. 5—Serve Most Demanding Application

Telecommunications systems should be designed to serve the most demanding expected system application, thereby permitting all applications to be accommodated.

Principle

The planned telecommunication system should not preclude needed applications of the system.

Standard

- The planned network bandwidth should be the broadest possible with projected technologies within the planning period; approximately 200 megabits per second.

Objective No. 6—Network Infrastructure Cost Minimization

Achieve the provision of wireless telecommunication networks which are both economical and efficient, meeting all other objectives at the lowest cost possible.

Principle

Minimization of capital and operating costs conserves limited public and private capital resources. Any undue investment in telecommunication facilities and services must occur at the expense of other public and private investment; therefore, total telecommunication costs should be minimized for the desired level of service.

Standards

- The sum total of telecommunication system capital investment and operating costs should be minimized.
- Full use should be made of existing facilities and such facilities should be supplemented only with additional major facilities as necessary to serve the anticipated demand for the desired level of services.

Objective No. 7—Antenna Site Aesthetics and Safety

A high aesthetic quality and safe design in the telecommunication antennae and supporting structures and equipment with proper visual relation to land and cityscape.

Principle

Beauty and safety in the physical environment are conducive to the physical health and well-being of people; and as major features of the land and cityscape, telecommunication facilities have an important impact on the aesthetic quality of the total environment. In order to ensure public safety, careful attention must always be given to structural design principles and practices, including careful conformance to existing regulatory codes.

Standards

- Telecommunication facilities should be located to avoid the destruction of visually pleasing buildings, structures, and natural features, and to avoid interference with visitors to such features.
- Co-location on existing antenna sites is preferred over new antenna support structure deployment.
- Antenna locations on existing buildings, or other existing structures are preferred over new antenna tower construction.
- Antenna structures should be designed, constructed and maintained to insure a safe environment.
- Antenna support structure heights should be minimized consistent, however, with maximizing the potential for antenna co-location, and with providing a potential for height extension and capacity expansion.

Objective No. 8—Preference For Use In Public Safety Emergencies

A broadband telecommunications network that assures capacity for, and provides preference to police, fire, emergency medical, and homeland security agencies for use in times of public emergencies.

Principle

The potential for interagency communication by police, fire, emergency medical, and homeland security agencies in times of public emergencies—such as national disasters including flooding and wind, snow and sleet storms, and freezing rain, and in times of culturally related disasters such as fire, explosions, nuclear electric power generation plant failures, and terrorist attack, must be protected and preserved.

Standard
Public safety related multi-media traffic should be assigned the highest priority based on network port designation and assignment.

UNIVERSAL BROADBAND SERVICE AND AFFORDABILITY

The Commission Advisory Committee recognized the need to define universal broadband telecommunications service in terms of affordability as well as geographic coverage. The Committee could not, however, agree on the percentage of gross monthly household income which should as a maximum be allocated to broadband telecommunication service. The Committee concluded that the issue of affordability needs to be addressed by the Congress and the President at the national level and that adoption of an affordability standard by the Commission should await action at the national level.

APPLICATION—SPECIFIC REQUIREMENTS

The broadband communications performance standard of 20 to 200 megabits per second specified above is ultimately justified based on network applications. The term broadband is often confusing to many as a measure of data transmission rate since it is measured in Hertz (cycles per second). Data transfer rate, however, is measured in bits per second or more typically in megabits (millions of bits) per second. The term broadband derives from the radio frequency spectral bandwidth licensed to a particular service provider or unlicensed to the general public. This bandwidth is measured in Hertz or in the broadband range megahertz (millions of cycles per second) or gigahertz (billions of cycles per second). High data transfer rates require wide or broadband widths. The ratio of data transfer rate to bandwidth expressed in percentage is spectral efficiency. With 100 percent spectral efficiency, 100 megahertz of bandwidth allows for a data transfer rate of 100 megabits per second.

Wide bandwidths and fast data transfer rates are important only as they relate to applications. DSL and cable broadband are often sold to consumers based on faster downloads of Web pages many of which contain images and video. The objectives and standards for this communications infrastructure plan must also consider other potential public sector and private sector applications that create the need for broadband telecommunication networks.

The dominant underlying media in all advanced broadband applications is video. A brief summary of the bandwidth requirements of the three predominant media reveals the sharp differences in media bandwidth requirements:

1. Voice—64 kilobits per second
2. Data—1 megabit per second
3. Video—5 to 200 megabits per second

Even though many applications require a mix of media to be effective, video bandwidth needs are so much larger that they predominate in multimedia bandwidth specifications. Video bandwidth requirements are a function of: format resolution, frame rate, modulation methods, and compression technology.

For one form of video communications, video conferencing, a range of bandwidth requirements based on international standard H.323 are:

1. VCR Quality Resolution: 352 x 288 pixels—3.8 megabits per second
2. TV Quality Resolution: 740 x 480 pixels—13.4 megabits per second

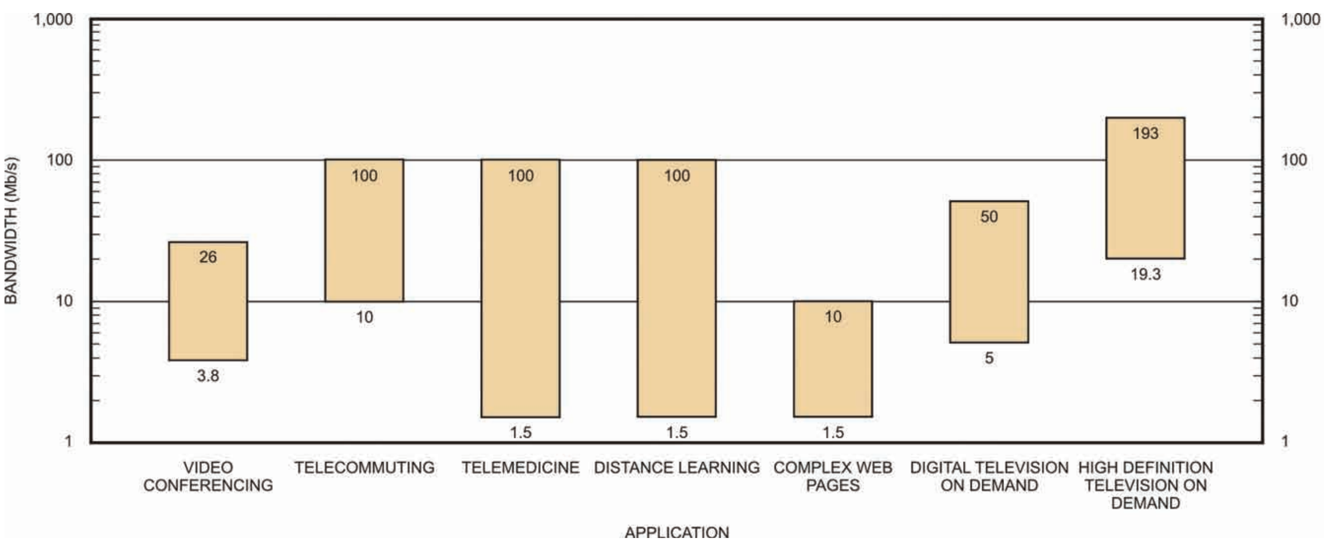
Video teleconferencing plays a key role in many public and private applications of broadband including areas such as telecommuting, home healthcare, and distance learning. It, therefore, represents a key capability in terms of broadband performance. It may, in fact, be the primary application for public sector, business and professional uses of the system.

In the consumer domain, television in both its standard and high definition formats is the equivalent driving force for major broadband capabilities. To accommodate 10 channels of high definition digital television on demand, a network with a bandwidth of about 193 megabits per second will be required. Such an Internet based capacity would allow potential users to purchase televised entertainment services from any content provider serving the Internet.

These two primary examples are given to illustrate the need for a "big broadband" communications capability. It is not possible, or appropriate, to review all potential broadband applications. To indicate the future scope of broadband communications, however, a display of a number of applications and the attendant bandwidth needs are shown in Figure 2.

Figure 2

APPLICATIONS SPEED MATRIX



Source: SEWRPC.

Chapter IV

INVENTORY FINDINGS–BACKGROUND CONDITIONS

INTRODUCTION

Reliable planning data are essential for the formulation of workable development plans. Consequently, an inventory of existing conditions is the first step in the planning process. The crucial nature of factual information in the planning process should be evident, since no reliable forecasts can be made or alternative courses of action evaluated without knowledge of the current state of the system being planned. The necessary inventory not only provides data describing the existing conditions, but also provide a basis for identifying existing and potential problems in the planning area and opportunities for development. The inventory data are also crucial to the forecasting of future facility and service needs, formulating alternative plans, and evaluating such plans.

Information regarding existing conditions and historic trends with respect to the demographic and economic base, to certain elements of the natural environment, and to certain elements of the man-made environment of the planning area provides a sound foundation for undertaking the telecommunications planning process. The Regional Planning Commission has developed an extensive database pertaining to these and other aspects of the Southeastern Wisconsin Region, updating that database periodically. A major inventory update effort was carried out by the Regional Planning Commission in the early 2000s in support of the preparation of new land use and transportation system plans and other elements of the comprehensive plan for the Region. This section presents a summary of the results of that inventory update pertaining to the population, economy, land use pattern, natural and agricultural resource base, and the transportation system within the Region.

DEMOGRAPHIC AND ECONOMIC BASE

Population[1]

Historic Trends and Distribution Among Counties

The total resident population of the Region stood at 1,931,200 in 2000, compared to 1,810,400 in 1990. The increase of 120,800 persons, or 7 percent, in the regional population during the 1990's is substantially greater than the increase experienced during the 1970s (8,700 persons) and 1980s (45,600 persons)—but less than the increases of 333,000 persons and 182,500 persons experienced during the 1950s and 1960s, respectively (see Table 1).

In relative terms, the Region's population grew at a somewhat slower rate than the population of the State and of the United States during the 1990's. As a result, the regional share of the State population,

[1]*The Regional Planning Commission conducted a detailed inventory and analysis of the regional population in 2004 following the release of the 2000 Federal census. The findings are presented in detail in SEWRPC Technical Report No. 11 (4th Edition),* The Population of Southeastern Wisconsin, *dated July 2004.*

Table 1

POPULATION TRENDS IN THE REGION, WISCONSIN, AND THE UNITED STATES: 1950-2000

Year	Region			Wisconsin			United States			Regional Population as a Percent of:	
	Population	Change from Preceding Year		Population	Change from Preceding Year		Population	Change from Preceding Year			
		Number	Percent		Number	Percent		Number	Percent	Wisconsin	United States
1950	1,240,618	- -	- -	3,434,575	- -	- -	151,325,798	- -	- -	36.1	0.82
1960	1,573,614	332,996	26.8	3,951,777	517,202	15.1	179,323,175	27,997,377	18.5	39.8	0.88
1970	1,756,083	182,469	11.6	4,417,821	466,044	11.8	203,302,031	23,978,856	13.4	39.7	0.86
1980	1,764,796	8,713	0.5	4,705,642	287,821	6.5	226,504,825	23,202,794	11.4	37.5	0.78
1990	1,810,364	45,568	2.6	4,891,769	186,127	4.0	249,632,692	23,127,867	10.2	37.0	0.73
2000	1,931,165	120,801	6.7	5,363,675	471,906	9.6	281,421,906	31,789,214	12.7	36.0	0.69

Source: U.S. Bureau of the Census and SEWRPC.

decreased slightly, from 37 percent to 36 percent while the regional share of the national population also declined. As indicated in Table 1, the regional share of the State and national populations has been gradually decreasing since 1960.

During the 1990s, six of the constituent counties of the Region experienced significant population growth, while Milwaukee County lost population. Waukesha County experienced the greatest gain in population during the 1990s, increasing by 56,100 persons. Kenosha, Ozaukee, Racine, Walworth, and Washington Counties gained between 9,400 and 22,200 persons each. Milwaukee County lost 19,100 persons.

The past decade saw further change in the relative distribution of the population among the counties of the Region, continuing long-term trends in this respect (see Table 2 and Figure 3). Milwaukee County’s share of the regional population decreased by about 4 percentage points during the 1990s, while the share of each of the other six counties increased. Over the past fifty years, the most notable change in the distribution has been the increase in Waukesha County’s share, from 7 percent to 19 percent of the regional population, and the decrease in Milwaukee County’s share, from 70 percent to 49 percent.

Components of Population Change

Population change can be attributed to natural increase and net migration. Natural increase is the balance between births and deaths in an area over a given period of time; it can be measured directly from historical records on the number of births and deaths for an area. Net migration is the balance between migration to and from an area over a given period of time; as a practical matter, net migration is often determined as a derived number, obtained by subtracting natural increase from total population change for the time period concerned.

Of the total population increase of 120,800 persons in the Region between 1990 and 2000, 116,900 can be attributed to natural increase; the balance to modest net in-migration—about 3,900 persons. The level of natural increase in the Region has been relatively stable since the 1970s, averaging about 119,000 persons per decade (see Table 3 and Figure 4). This is significantly lower than the levels experienced during the 1950s and 1960s—which include much of the post-World War II baby-boom era—when natural increase in the Region reached very high levels of 224,500 and 202,400 persons, respectively.

As noted above, the Region experienced a modest net in-migration during the 1990s—the first decade since the 1950s that the Region as a whole experienced positive net migration. The net in-migration of 3,900 persons for the Region during the 1990s followed three decades of net out-migration—out-migrations of 81,800 persons during the 1980s, 104,400 persons during the 1970s, and 19,900 persons during the 1960s.

An important aspect of net migration is the in-migration of persons to the Region from abroad. There was a significant movement of foreign-born persons into the Region during the 1990s. About 45,400 foreign-born persons in the Region in 2000 were reported by the U.S. Census Bureau to have entered the country between 1990 and 2000; this is significantly greater than the figures ranging from 12,300 to 18,300 reported in the 1970, 1980, and 1990 censuses. The increase in the foreign born

Table 2

POPULATION IN THE REGION BY COUNTY: 1950-2000

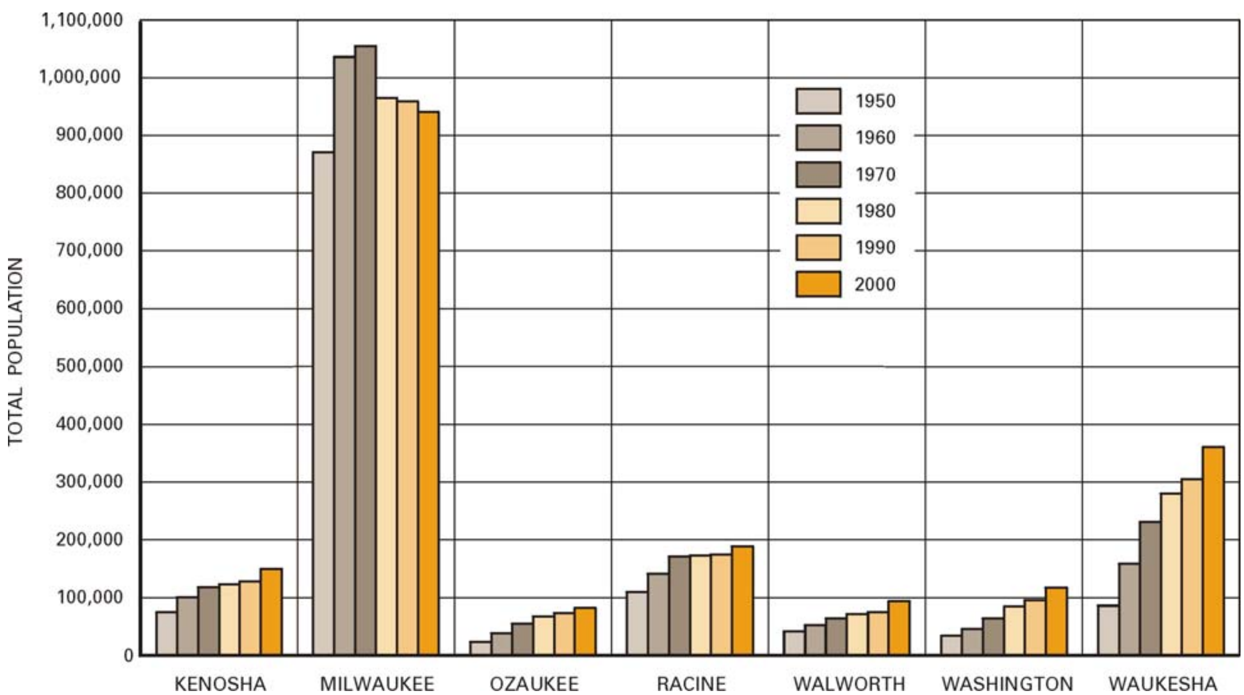
County	1950 Number	1950 Percent of Total	1960 Number	1960 Percent of Total	1970 Number	1970 Percent of Total	1980 Number	1980 Percent of Total	1990 Number	1990 Percent of Total	2000 Number	2000 Percent of Total
	Total Population											
Kenosha	75,238	6.1	100,615	6.4	117,917	6.7	123,137	7.0	128,181	7.1	149,577	7.7
Milwaukee	871,047	70.2	1,036,041	65.8	1,054,249	60.1	964,988	54.7	959,275	53.0	940,164	48.7
Ozaukee	23,361	1.9	38,441	2.5	54,461	3.1	66,981	3.8	72,831	4.0	82,317	4.3
Racine	109,585	8.8	141,781	9.0	170,838	9.7	173,132	9.8	175,034	9.7	188,831	9.8
Walworth	41,584	3.4	52,368	3.3	63,444	3.6	71,507	4.0	75,000	4.1	92,013	4.7
Washington	33,902	2.7	46,119	2.9	63,839	3.6	84,848	4.8	95,328	5.3	117,496	6.1
Waukesha	85,901	6.9	158,249	10.1	231,335	13.2	280,203	15.9	304,715	16.8	360,767	18.7
Region	1,240,618	100.0	1,573,614	100.0	1,756,083	100.0	1,764,796	100.0	1,810,364	100.0	1,931,165	100.0

County	1950-1960 Number	1950-1960 Percent	1960-1970 Number	1960-1970 Percent	1970-1980 Number	1970-1980 Percent	1980-1990 Number	1980-1990 Percent	1990-2000 Number	1990-2000 Percent
	Population Change									
Kenosha	25,377	33.7	17,302	17.2	5,220	4.4	5,044	4.1	21,396	16.7
Milwaukee	164,994	18.9	18,208	1.8	-89,261	-8.5	-5,713	-0.6	-19,111	-2.0
Ozaukee	15,080	64.6	16,020	41.7	12,520	23.0	5,850	8.7	9,486	13.0
Racine	32,196	29.4	29,057	20.5	2,294	1.3	1,902	1.1	13,797	7.9
Walworth	10,784	25.9	11,076	21.2	8,063	12.7	3,493	4.9	17,013	22.7
Washington	12,217	36.0	17,720	38.4	21,009	32.9	10,480	12.4	22,168	23.3
Waukesha	72,348	84.2	73,086	46.2	48,868	21.1	24,512	8.7	56,052	18.4
Region	332,996	26.8	182,469	11.6	8,713	0.5	45,568	2.6	120,801	6.7

Source: U.S. Bureau of the Census and SEWRPC.

Figure 3

POPULATION IN THE REGION BY COUNTY: 1950-2000



Source: U.S. Bureau of the Census and SEWRPC.

Table 3

LEVELS OF POPULATION CHANGE, NATURAL INCREASE, AND NET MIGRATION FOR THE REGION BY COUNTY: 1950-2000

County	1950-1960			1960-1970			1970-1980		
	Population Change	Natural Increase	Net Migration	Population Change	Natural Increase	Net Migration	Population Change	Natural Increase	Net Migration
Kenosha	25,377	13,931	11,446	17,302	15,125	2,177	5,220	7,746	-2,526
Milwaukee	164,994	150,141	14,853	18,208	122,192	-103,984	-89,261	60,105	-149,366
Ozaukee	15,080	5,926	9,154	16,020	6,090	9,930	12,520	4,798	7,722
Racine	32,196	21,473	10,723	29,057	20,441	8,616	2,294	12,842	-10,548
Walworth	10,784	5,733	5,051	11,076	4,685	6,391	8,063	2,451	5,612
Washington	12,217	7,501	4,716	17,720	8,122	9,598	21,009	7,163	13,846
Waukesha	72,348	19,746	52,602	73,086	25,699	47,387	48,868	18,011	30,857
Region	332,996	224,451	108,545	182,469	202,354	-19,885	8,713	113,116	-104,403

County	1980-1990			1990-2000		
	Population Change	Natural Increase	Net Migration	Population Change	Natural Increase	Net Migration
Kenosha	5,044	8,177	-3,133	21,396	9,365	12,031
Milwaukee	-5,713	69,529	-75,242	-19,111	64,145	-83,256
Ozaukee	5,850	5,141	709	9,486	3,916	5,570
Racine	1,902	13,720	-11,818	13,797	11,127	2,670
Walworth	3,493	2,939	554	17,013	2,592	14,421
Washington	10,480	7,756	2,724	22,168	7,159	15,009
Waukesha	24,512	20,068	4,444	56,052	18,582	37,470
Region	45,568	127,330	-81,762	120,801	116,886	3,915

Source: U.S. Bureau of the Census, Wisconsin Department of Health and Family Services, and SEWRPC.

population, including a significant Hispanic component, is an important aspect of the population migration pattern for the Region during the 1990s.

Households

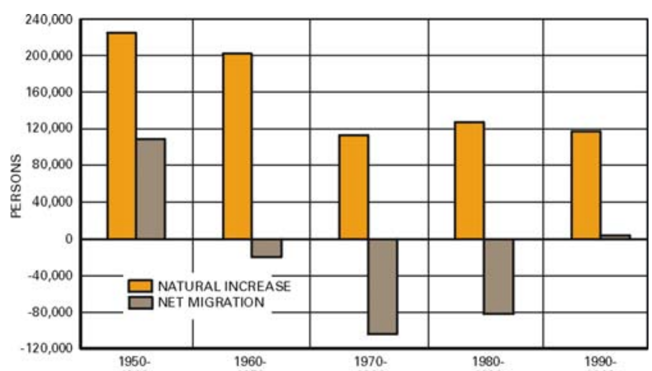
Historic Trends and Distribution Among Counties

In addition to resident population, the number of households, or occupied housing units, is of importance in telecommunications planning. Households directly influence the demand for urban land as well as the demand for transportation and other public facilities and services such as telecommunications facilities and services. By definition, a household includes all persons who occupy a housing unit—defined by the Census Bureau as a house, an apartment, a mobile home, a group of rooms, or a single-room that is occupied, or intended for occupancy, as a separate living quarter.

The number of households in the Region increased by 72,900 households, or 11 percent, from 676,100 households in 1990, to 749,000 households in 2000.

Figure 4

COMPONENTS OF POPULATION CHANGE IN THE REGION: 1950-2000



Source; U.S. Bureau of the Census, Wisconsin Department of Health and Family Services, and SEWRPC.

This follows increases of 48,200 households during the 1980s; 91,500 households during the 1970s; 70,600 households during the 1960s; and 111,400 households during the 1950s.

During the 1990s, all counties in the Region experienced increases in the number of households, led by Waukesha County, which gained 29,200 households, an increase of 28 percent. Milwaukee County gained 4,700 households—a 1 percent increase—during the 1990s, despite experiencing a decrease in total population. Changes in the distribution of households in the Region going back 50 years are indicated in Table 4 and Figure 5. These changes are similar to the distributional changes in the total population.

Household Size

In relative terms, the rate of growth in households in the Region during the 1990s, 10.8 percent, exceeded the rate of growth in the total population, 6.7 percent, as well as the rate of growth in the household population, 6.6 percent. Similar patterns were observed over each of the four previous decades. For the past 50 years overall, the number of households in the Region increased by 111 percent, while the total population increased by 56 percent and the household population increased by 58 percent. These differential growth rates between households and population are reflected in a declining average household size in the Region.

For the Region as a whole, the average household size—calculated as the household population divided by the number of households—was 2.52 persons in 2000 (see Table 5). During the 1990s, the average household size in the Region decreased by about 0.10 person per household, or about 4 percent, from the 1990 figure of 2.62 persons. The decrease in household size during the 1990s represents a continuation of a long-term trend in declining average household size for the Region over the past 50 years. A particularly large decrease in the average household size for the Region occurred between 1970 and 1980. Each of the seven counties in the Region has experienced a similar long-term trend of declining household size, traceable back to the 1970 or prior censuses. The decline in household size is related in part to changing household types in the Region. Single-person households and other non-family households have increased at a much faster rate than family households in the Region over the past three decades.

Employment[2]

Historic Trends and Distribution Among Counties

Information regarding the number and type of employment opportunities, or jobs, in an area is an important measure of the size and structure of the area's economy. Employment data presented in this section pertain to both wage and salary employment and the self-employed, and include both full-time and part-time jobs.

Total employment in the Region stood at 1,222,800 jobs in 2000, compared to 1,062,600 jobs in 1990. The increase of 160,200 jobs during the 1990s compares to 114,400 during the 1980s; 163,300 during the 1970s; 111,900 during the 1960s; and 99,500 during the 1950s (see Table 6).

In relative terms, employment in the Region grew at a somewhat slower rate than both the State and the Nation during the 1990s. As a result, the Region's share of total State employment decreased from about 38 percent to about 36 percent, with the regional share of national employment also showing a slight decrease.

Historically, employment levels, both nationally and within the Region, tend to fluctuate in the short-term, rising and falling in accordance with business cycles. The long period of nearly uninterrupted job growth between 1983 and 2000 is unusual in this respect. Nationally and within the Region, total employment increased each year during that time, with the exception of a slight decrease in 1991. The extended period of employment growth in the Region ended after 2000, with total employment in the Region decreasing each year between 2000 and 2003. Estimated total employment in the Region stood at 1,179,000 jobs in 2003, about 4 percent below the 2000 level.

[2] *The Regional Planning Commission conducted a detailed inventory and analysis of the regional economy in 2004. The findings are presented in detail in SEWRPC Technical Report No. 10 (4th Edition),* The Economy of Southeastern Wisconsin, *dated July 2004.*

Table 4

HOUSEHOLDS IN THE REGION BY COUNTY: 1950-2000

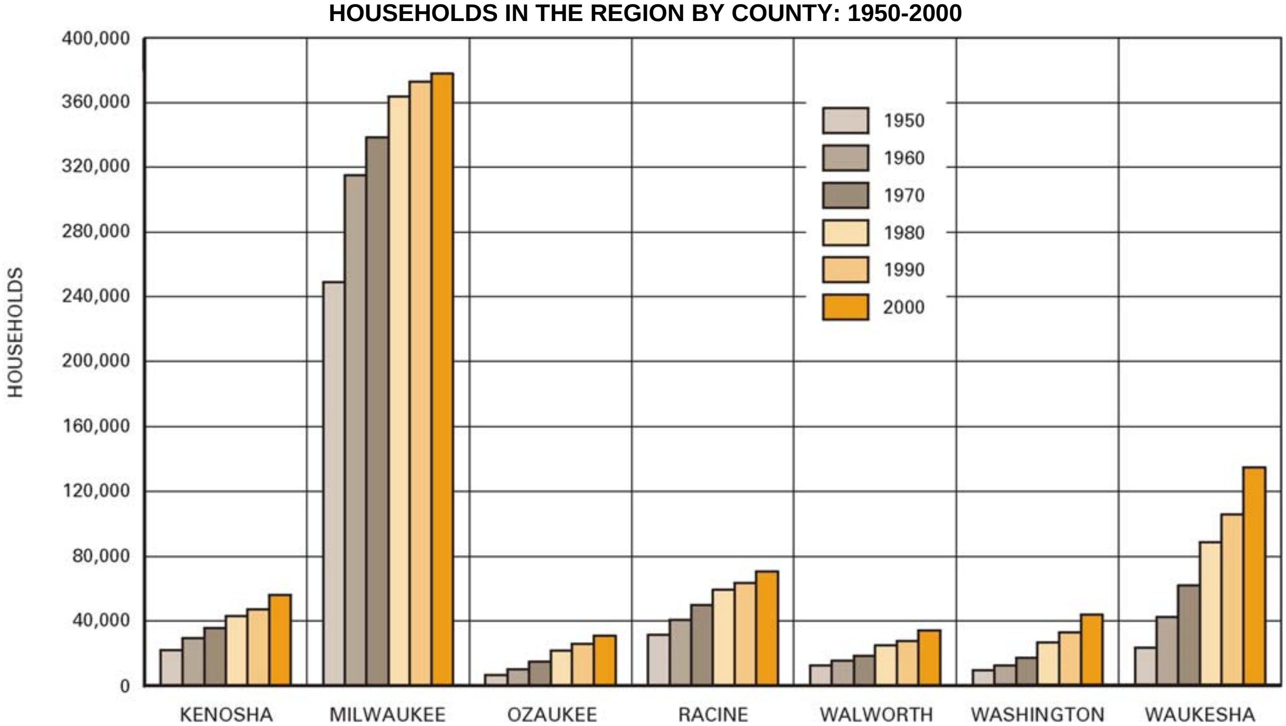
County	Total Households											
	1950		1960		1970		1980		1990		2000	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Kenosha	21,958	6.2	29,545	6.4	35,468	6.6	43,064	6.9	47,029	6.9	56,057	7.5
Milwaukee	249,232	70.3	314,875	67.6	338,605	63.1	363,653	57.9	373,048	55.2	377,729	50.4
Ozaukee	6,591	1.9	10,417	2.2	14,753	2.8	21,763	3.5	25,707	3.8	30,857	4.1
Racine	31,399	8.8	40,736	8.7	49,796	9.3	59,418	9.5	63,736	9.4	70,819	9.5
Walworth	12,369	3.5	15,414	3.3	18,544	3.5	24,789	3.9	27,620	4.1	34,505	4.6
Washington	9,396	2.7	12,532	2.7	17,385	3.2	26,716	4.2	32,977	4.9	43,843	5.8
Waukesha	23,599	6.6	42,394	9.1	61,935	11.5	88,552	14.1	105,990	15.7	135,229	18.1
Region	354,544	100.0	465,913	100.0	536,486	100.0	627,955	100.0	676,107	100.0	749,039	100.0

County	Household Change									
	1950-1960		1960-1970		1970-1980		1980-1990		1990-2000	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	7,587	34.6	5,923	20.0	7,596	21.4	3,965	9.2	9,028	19.2
Milwaukee	65,643	26.3	23,730	7.5	25,048	7.4	9,395	2.6	4,681	1.3
Ozaukee	3,826	58.0	4,336	41.6	7,010	47.5	3,944	18.1	5,150	20.0
Racine	9,337	29.7	9,060	22.2	9,622	19.3	4,318	7.3	7,083	11.1
Walworth	3,045	24.6	3,130	20.3	6,245	33.7	2,831	11.4	6,885	24.9
Washington	3,136	33.4	4,853	38.7	9,331	53.7	6,261	23.4	10,866	32.9
Waukesha	18,795	79.6	19,541	46.1	26,617	43.0	17,438	19.7	29,239	27.6
Region	111,369	31.4	70,573	15.1	91,469	17.0	48,152	7.7	72,932	10.8

Source: U.S. Bureau of the Census and SEWRPC.

Figure 5

HOUSEHOLDS IN THE REGION BY COUNTY: 1950-2000



Source: U.S. Bureau of the Census and SEWRPC.

Table 5

AVERAGE HOUSEHOLD SIZE IN THE REGION BY COUNTY: 1950-2000

County	Average Persons per Household					
	1950	1960	1970	1980	1990	2000
Kenosha	3.36	3.36	3.26	2.80	2.67	2.60
Milwaukee...........	3.34	3.21	3.04	2.59	2.50	2.43
Ozaukee	3.51	3.65	3.66	3.04	2.79	2.61
Racine	3.37	3.39	3.35	2.86	2.70	2.59
Walworth.............	3.25	3.28	3.16	2.74	2.60	2.57
Washington..........	3.55	3.64	3.63	3.14	2.86	2.65
Waukesha...........	3.51	3.66	3.66	3.11	2.83	2.63
Region	3.36	3.30	3.20	2.75	2.62	2.52

Source: U.S. Bureau of the Census and SEWRPC.

Table 6

EMPLOYMENT IN THE REGION, WISCONSIN, AND THE UNITED STATES: 1950-2000

Year	Region			Wisconsin			United States			Regional Employment as a percent of:	
	Jobs	Change from Preceding Year		Jobs	Change from Preceding Year		Jobs	Change from Preceding Year			
		Number	Percent		Number	Percent		Number	Percent	Wisconsin	United States
1950	573,500	- -	- -	1,413,400	- -	- -	61,701,200	- -	- -	40.6	0.93
1960	673,000	99,500	17.3	1,659,400	246,000	17.4	72,057,000	10,355,800	16.8	40.6	0.93
1970	784,900	111,900	16.6	1,929,100	269,700	16.3	88,049,600	15,992,600	22.2	40.7	0.89
1980	948,200	163,300	20.8	2,429,800	500,700	26.0	111,730,200	23,680,600	26.9	39.0	0.85
1990	1,062,600	114,400	12.1	2,810,400	380,600	15.7	136,708,900	24,978,700	22.4	37.8	0.78
2000	1,222,800	160,200	15.1	3,421,800	611,400	21.8	165,209,800	28,500,900	20.8	35.7	0.74

NOTE: Excludes military employment.

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Information on current and historic employment levels is presented by county in (Table 7 and Figure 6). Each county in the Region experienced an increase in employment between 1990 and 2000. With an increase of 81,100 jobs, Waukesha County accounted for just over half of the total increase in the regional employment during the 1990s. Among the other six counties, the growth in employment during the 1990s ranged from 4,800 jobs in Racine County to 16,500 jobs in Kenosha County.

Between 1990 and 2000, Milwaukee and Racine Counties decreased in their share of total regional employment while the share of each of the other five counties increased. Over the past five decades, Milwaukee County has experienced a substantial decrease in its share of regional employment; Waukesha County has experienced a substantial increase; and Ozaukee, Walworth, and Washington Counties have experienced gradual increases. In Kenosha and Racine Counties, the share of total regional employment in 2000 was about the same as in 1950, with some fluctuations occurring over the intervening decades.

Substantial job growth has also occurred in the counties located immediately south of the Region. Employment in Lake and McHenry Counties (Illinois), combined increased by about 146,800 jobs during the 1990s. By 2000 total employment in Lake and McHenry Counties combined stood at 505,200 jobs. A significant number of Kenosha and Walworth County residents find employment in Northeastern Illinois.

Table 7

EMPLOYMENT IN THE REGION BY COUNTY: 1950-2000

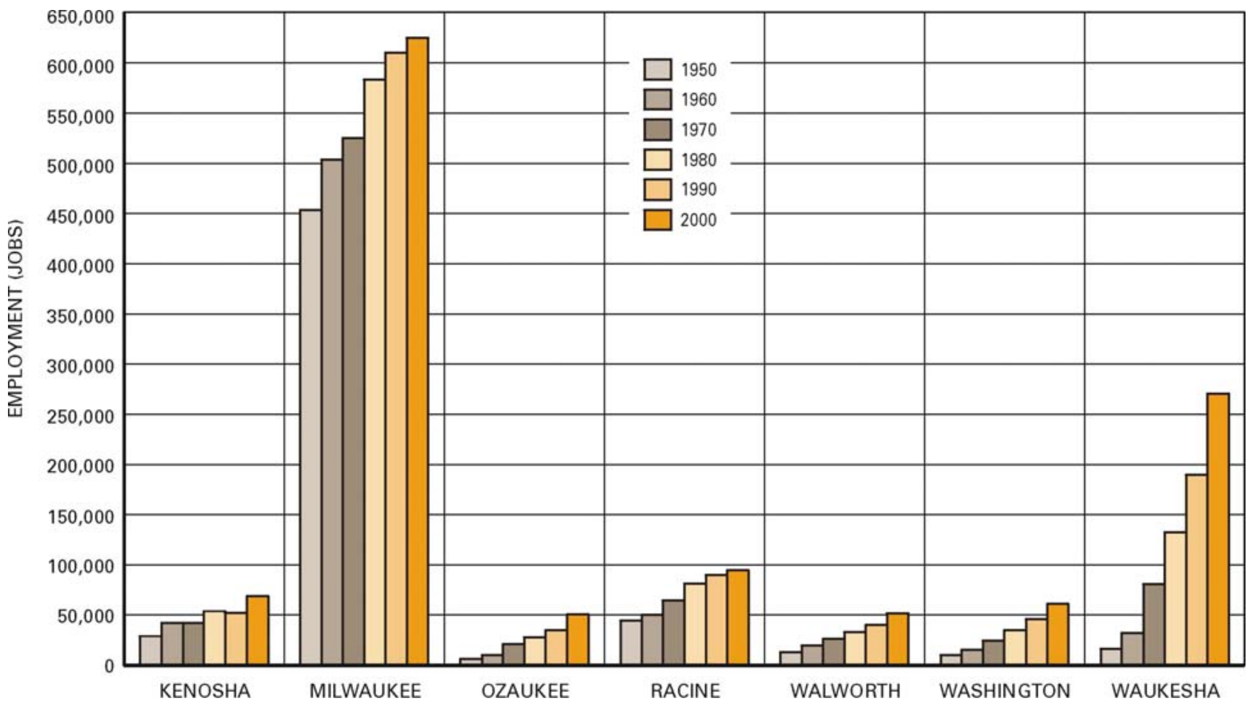
County	Total Employment (Jobs) 1950 Number	1950 Percent of Total	1960 Number	1960 Percent of Total	1970 Number	1970 Percent of Total	1980 Number	1980 Percent of Total	1990 Number	1990 Percent of Total	2000 Number	2000 Percent of Total
Kenosha	29,100	5.1	42,200	6.3	42,100	5.4	54,100	5.7	52,200	4.9	68,700	5.6
Milwaukee	453,500	79.1	503,300	74.8	525,200	66.9	583,200	61.5	609,800	57.4	624,600	51.1
Ozaukee	6,600	1.0	10,200	1.5	21,300	2.7	28,200	3.0	35,300	3.3	50,800	4.2
Racine	44,500	7.8	49,900	7.4	64,600	8.2	81,200	8.6	89,600	8.4	94,400	7.7
Walworth	13,200	2.3	19,600	2.9	26,400	3.4	33,500	3.5	39,900	3.8	51,800	4.2
Washington	10,200	1.8	15,200	2.3	24,300	3.1	35,200	3.7	46,100	4.3	61,700	5.0
Waukesha	16,400	2.9	32,600	4.8	81,000	10.3	132,800	14.0	189,700	17.9	270,800	22.2
Region	573,500	100.0	673,000	100.0	784,900	100.0	948,200	100.0	1,062,600	100.0	1,222,800	100.0

County	Employment Change 1950-1960 Number	1950-1960 Percent	1960-1970 Number	1960-1970 Percent	1970-1980 Number	1970-1980 Percent	1980-1990 Number	1980-1990 Percent	1990-2000 Number	1990-2000 Percent
Kenosha	13,100	45.0	-100	-0.2	12,000	28.5	-1,900	-3.5	16,500	31.6
Milwaukee	49,800	11.0	21,900	4.4	58,000	11.0	26,600	4.6	14,800	2.4
Ozaukee	3,600	54.5	11,100	108.8	6,900	32.4	7,100	25.2	15,500	43.9
Racine	5,400	12.1	14,700	29.5	16,600	25.7	8,400	10.3	4,800	5.4
Walworth	6,400	48.5	6,800	34.7	7,100	26.9	6,400	19.1	11,900	29.8
Washington	5,000	49.0	9,100	59.9	10,900	44.9	10,900	31.0	15,600	33.8
Waukesha	16,200	98.8	48,400	148.5	51,800	64.0	56,900	42.8	81,100	42.8
Region	99,500	17.3	111,900	16.6	163,300	20.8	114,400	12.1	160,200	15.1

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Figure 6

EMPLOYMENT IN THE REGION BY COUNTY: 1950-2000



Source: U.S. Bureau of Economic Analysis and SEWRPC.

Table 8

EMPLOYMENT BY GENERAL INDUSTRY GROUP IN THE REGION: 1970-2000

	Employment								Percent Change in Employment			
	1970		1980		1990		2000					
General Industry Group	Jobs	Percent of Total	Jobs	Percent of Total	Jobs	Percent of Total	Jobs	Percent of Total	1970-1980	1980-1990	1990-2000	1970-2000
Agriculture	12,000	1.5	10,000	1.0	7,200	0.7	6,000	0.5	-16.7	-28.0	-16.7	-50.0
Construction	32,400	4.1	33,900	3.6	45,100	4.2	53,800	4.4	4.6	33.0	19.3	66.0
Manufacturing	254,400	32.4	264,200	27.9	223,500	21.0	224,300	18.3	3.9	-15.4	0.4	-11.8
Transportation, Communication, and Utilities	38,500	4.9	42,200	4.4	46,300	4.4	54,800	4.5	9.6	9.7	18.4	42.3
Wholesale Trade	37,200	4.7	46,200	4.9	55,300	5.2	64,400	5.3	24.2	19.7	16.5	73.1
Retail Trade	133,900	17.1	153,900	16.2	185,400	17.4	193,700	15.8	14.9	20.5	4.5	44.7
Finance, Insurance, and Real Estate	47,600	6.1	75,600	8.0	81,800	7.7	93,700	7.7	58.8	8.2	14.5	96.8
Services	141,800	18.1	216,700	22.8	304,700	28.7	406,000	33.2	52.8	40.6	33.2	186.3
Government and Government Enterprises[a]	84,400	10.8	101,100	10.7	106,200	10.0	114,400	9.3	19.8	5.0	7.7	35.5
Other[b]	2,700	0.3	4,400	0.5	7,100	0.7	11,700	1.0	63.0	61.4	64.8	333.3
Total	784,900	100.0	948,200	100.0	1,062,600	100.0	1,222,800	100.0	20.8	12.1	15.1	55.8

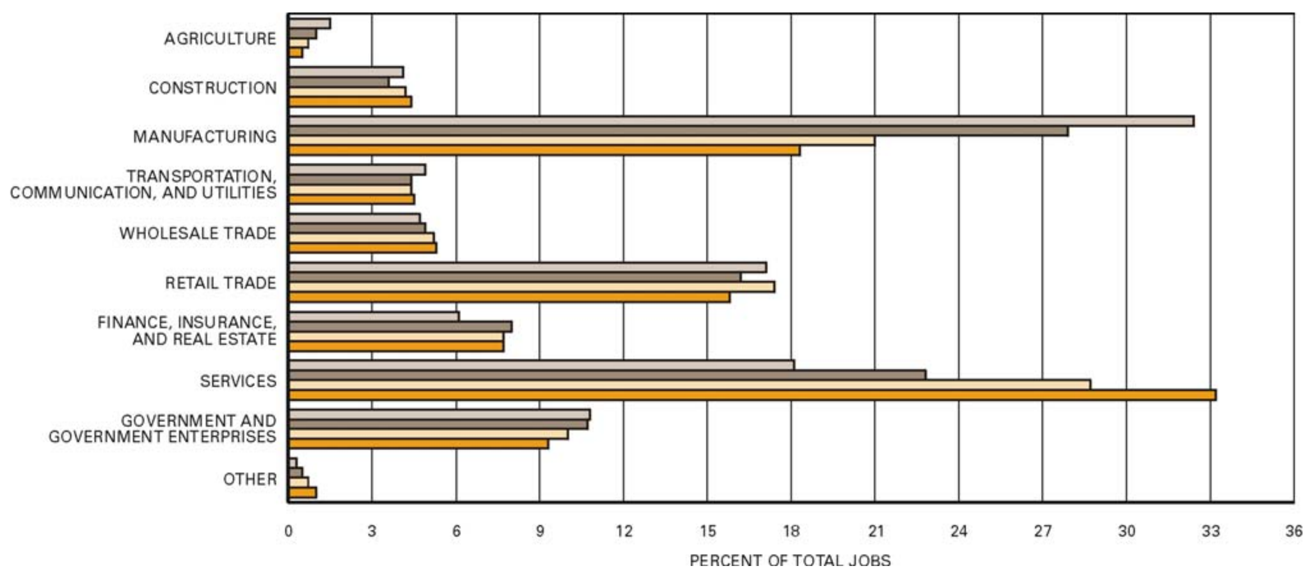
[a] *Includes all nonmilitary government agencies and enterprises.*

[b] *Includes agricultural services, forestry, commercial fishing, mining, and unclassified jobs.*

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Figure 7

PERCENT DISTRIBUTION OF EMPLOYMENT BY GENERAL INDUSTRY GROUP IN THE REGION: 1970, 1980, 1990, AND 2000



Source: U.S. Bureau of Economic Analysis and SEWRPC.

Employment by Industry

Information regarding employment by industry group provides insight into the structure of the regional economy and changes in that structure over time. As indicated in Table 8 and Figure 7, the services sector made up the largest proportion of regional employment in 2000, accounting for 33 percent of total employment. This was followed by manufacturing and retail trade, with 18 percent and 16 percent of total regional employment, respect-tively. Together, these three sectors accounted for roughly two-thirds of regional employment in 2000.

The 1990s saw a continuation of a shift in the regional economy from a manufacturing to a service orientation. Manufacturing employment in the Region was virtually unchanged during the 1990s, following a 15 percent decrease during the 1980s, and a modest 4 percent increase during the 1970s. Conversely, service-related employment increased substantially during each of the past three decades—by 33 percent during the 1990s, 41 percent during the 1980s, and 53 percent during 1970s. Due to these differential growth rates, the proportion of manufacturing jobs relative to total jobs in the Region decreased from 32 percent in 1970 to 18 percent in 2000, while service-related employment increased from 18 percent in 1970 to 33 percent in 2000. In comparison to the manufacturing and services industry groups, other major industry groups—such as wholesale trade, retail trade, government, and finance, insurance and real estate—have been relatively stable in terms of their share of total employment in the Region over the last three decades.

The State of Wisconsin and the United States have experienced a similar shift from manufacturing to service-related employment. However, the trend in manufacturing employment for the State overall has been more robust than for the Region. Manufacturing employment in the State increased by 24 percent between 1970 and 2000; the Region's manufacturing employment decreased by 12 percent during this time. While historically the Region exceeded the State in the proportion of manufacturing jobs relative to total jobs, by 2000 the Region and State had about the same proportion of jobs in manufacturing—just over 18 percent. In comparison, manufacturing jobs comprised about 12 percent of all jobs in the Nation in 2000.

LAND USE

The Commission relies on two types of inventories and analyses in order to monitor urban growth and development in the Region—an urban growth ring analysis and a land use inventory. The urban growth ring analysis delineates the outer limits of concentrations of urban development and depicts the urbanization of the Region over the past 150 years. When related to urban population levels, the urban growth ring analysis provides a good basis for calculating urban population and household densities. By contrast, the Commission land use inventory is a more detailed inventory that places all land and water areas of the Region into one of 66 discrete land use categories, providing a basis for analyzing specific urban and nonurban land uses. Both the urban growth ring analysis and the land use inventory for the Region have been updated to the year 2000 under the continuing regional planning program.

Urban Growth Ring Analysis

The urban growth ring analysis illustrates the historical pattern of urban settlement, growth, and development of the Region since 1850 for selected points in time. Areas identified as urban under this time series analysis include areas of the Region where residential structures or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of residential, commercial, industrial, governmental, institutional, or other urban land uses. In addition, the identified urban areas encompass certain open space lands such as urban parks and small areas being preserved for resource conservation purposes within the urban areas.[3]

As part of the urban growth ring analysis, urban growth for the years prior to 1940 was identified using a variety of sources, including the records of local historical societies; land subdivision plat records; farm plat maps; U.S. Geological Survey topographic maps; and Wisconsin Geological and Natural History Survey records. Urban growth for

[3] *As part of the urban growth ring analysis, urban areas are defined as concentrations of residential, commercial, industrial, governmental, or institutional buildings or structures, along with their associated yards, parking, and service areas, having a combined area of five acres or more. In the case of residential uses, such areas must include at least 10 structures—over a maximum distance of one-half mile—located along a linear feature, such as a roadway or lakeshore, or at least 10 structures located in a relatively compact group within a residential subdivision. Urban land uses which do not meet these criteria because they lack the concentration of buildings or structures—such as cemeteries, airports, public parks, golf courses—are identified as urban where such uses are surrounded on at least three sides by urban land uses that do meet the aforereferenced criteria.*

the years 1940, 1950, 1963, 1970, 1980, 1990, and 2000 was identified using aerial photographs. Because of limitations inherent in the source materials, information presented for the years prior to 1940 represents the extent of urban development at approximately those points in time, whereas the information presented for later years can be considered precisely representative of those respective points in time.

The urban growth ring analysis, updated through 2000, is presented graphically on Map 2. In 1850, the urban portion of the Region was concentrated primarily in the larger urban centers located at Burlington, Kenosha, Milwaukee, Racine, Waukesha, and West Bend, along with many smaller settlements throughout the Region. Over the 100-year period from 1850 to 1950, urban development in the Region occurred in a pattern resembling concentric rings around existing urban centers, resulting in a relatively compact regional settlement pattern. After 1950, there was a significant change in the pattern and rate of urban development in the Region. While substantial amounts of development continued to occur adjacent to established urban centers, considerable development also occurred in isolated enclaves in outlying areas of the Region. Map 2 indicates a continuation of this trend during the 1990s, with significant amounts of development occurring adjacent to existing urban centers, and with considerable development continuing to occur in scattered fashion in outlying areas.

The urban growth ring analysis, in conjunction with the Federal censuses, provides a basis for calculating urban population and household densities in the Region and changes in density over time. Table 9 relates the urban area identified by the urban growth ring analysis with the urban population and households, going back to 1940.[4] In Table 9, the "urban population" is the total population of the Region excluding the rural farm population, as reported by the U.S. Bureau of the Census; similarly, "urban households" as reported in that table consist of all households other than rural farm households.[5]

As indicated in Table 9, the population density of the urban portion of the Region—as identified by the urban growth ring analysis—decreased significantly, from 10,700 persons per square mile in 1940 to about 5,100 persons per square mile in 1970, 3,900 persons per square mile in 1980, and 3,500 persons per square mile in 1990. During the 1990s, the urban population density decreased slightly—to about 3,300 persons per square mile in 2000. The long-term decrease in the urban population density is due in part to a trend toward lower density residential development. The decrease is also attributable, in part, to significant increases in the number of jobs—jobs having increased at a faster rate than population since 1960—and the attendant increase in commercial and industrial development in the Region. Part of the decrease in the urban population density also relates to the fact that the number of persons per household—the household being the basic unit of demand for residential development—has decreased by 25 percent since 1950.

A different density trend for the Region emerges when urban density is calculated based upon households rather than population (see Figure 8). Since 1963, the relative decrease in urban household density has been much lower than the decrease in urban population density. Between 1963 and 2000, the urban household density decreased by 23 percent, compared to a 43 percent decrease in the urban population density.

Land Use Inventory

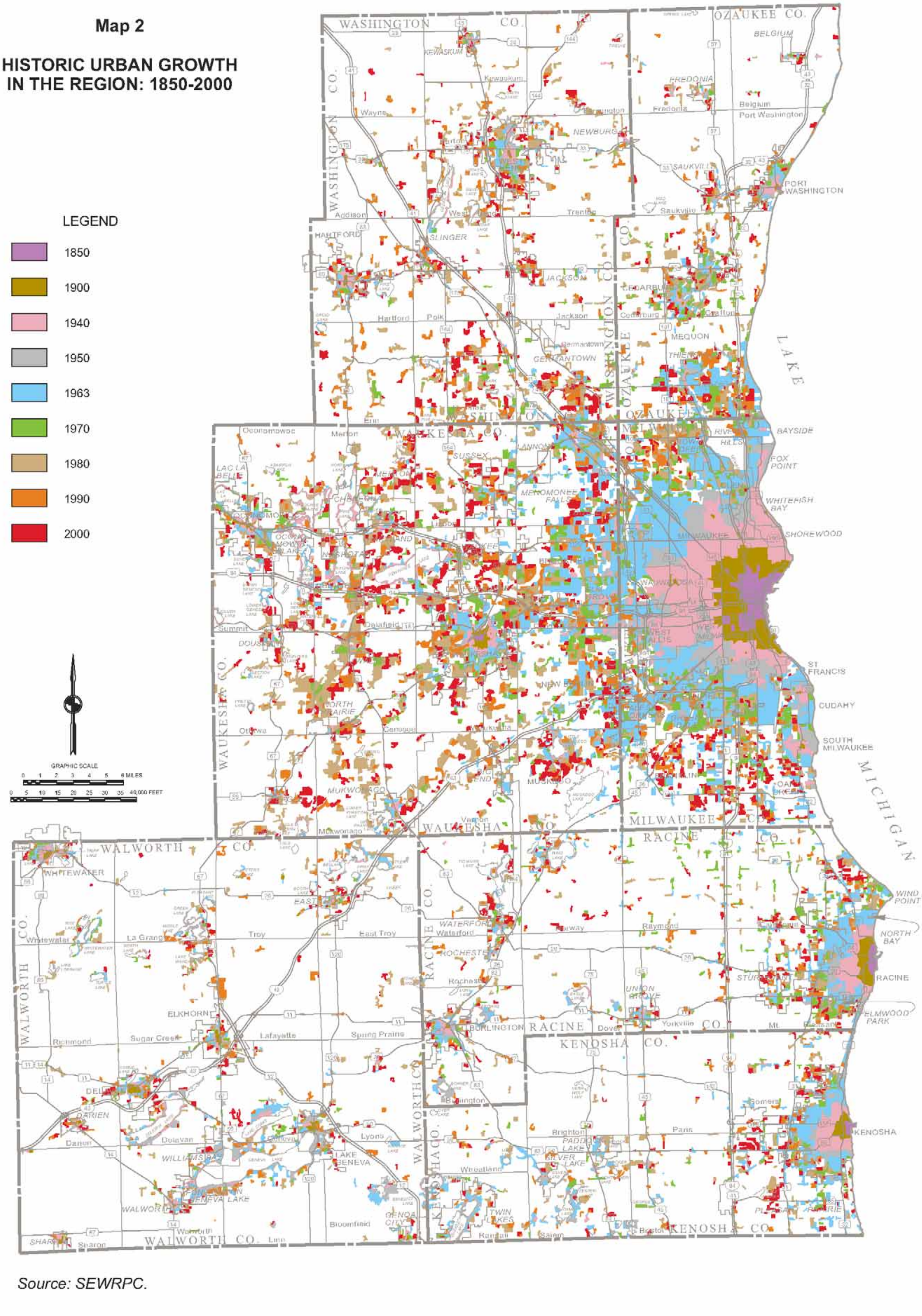
The Commission land use inventory is intended to serve as a relatively precise record of land use for the entire area of the Region at selected points in time. The land use classification system used in the inventory consists of nine major categories which are divisible into 66 sub-categories, making the

[4] *The urban growth ring analysis areas presented in Table 9 were developed using computerized map area measuring software. The area measurements presented in Table 9 differ slightly from the corresponding area measurement reported in the previous regional land use plan report, SEWRPC Planning Report No. 45, those measurements having been based on a combination of manual and computer measurement techniques.*

[5] *The Commission uses this method of approximating the population and households within the urban areas identified in the urban growth ring analysis in the absence of actual population and household counts for these areas. This method may include certain nonfarm residents living outside the identified urban areas in the estimate of the urban population and households for the Region, and, as a result, may overstate somewhat the actual urban population and household densities.*

Map 2

HISTORIC URBAN GROWTH IN THE REGION: 1850-2000



Source: SEWRPC.

Table 9

URBAN POPULATION DENSITY AND URBAN HOUSEHOLD DENSITY IN THE REGION: 1940-2000

		Urban Population		Urban Households	
Year	Urban Area[a] (square miles)	Persons[b]	Density (persons per urban square mile)	Households[c]	Density (households per urban square mile)
1940	93	991,535	10,662	272,077	2,926
1950	146	1,179,084	8,076	338,572	2,319
1963	282	1,634,200	5,795	470,856	1,670
1970	338	1,728,666	5,114	529,404	1,566
1980	444	1,749,238	3,940	623,441	1,404
1990	509	1,800,751	3,538	672,896	1,322
2000	579	1,923,674	3,322	746,500	1,289

[a]*Based upon the Regional Planning Commission urban growth ring analysis.*

[b]*Total population, excluding rural farm population, as reported in the Federal Census; 1963 is Commission estimate.*

[c]*Total households, excluding rural farm households, as reported in the Federal Census; 1963 is Commission estimate.*

Source: U.S. Bureau of the Census and SEWRPC.

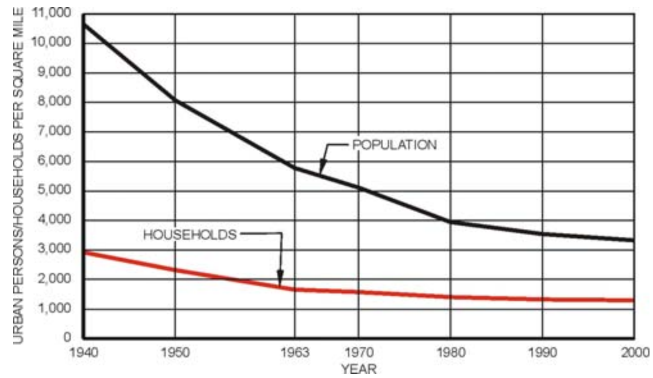
inventory suitable for both land use and transportation planning, adaptable to stormwater drainage, public utility, and community facility planning, and compatible with other land use classification systems. Aerial photographs serve as the primary basis for identifying existing land use, augmented by field surveys as appropriate. The most recent regional land use inventory was carried out based upon aerial photography taken in spring of 2000. The results of that inventory are summarized on Map 3 and Table 10.

Existing Land Use: 2000

Areas considered "urban" under the land use inventory include areas identified as being in residential, commercial, industrial, transportation-communication-utility, governmental-institutional, or intensive recreational uses, along with "unused" urban lands.[6] In 2000, urban land uses as identified in the regional land use inventory encompassed about 761 square miles, or 28 percent of the total area of the Region. Residential land comprised the largest urban land use category, encompassing about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the Region.[7] In combination, commercial and industrial lands encompassed about 63 square miles, or about 8 percent of all urban land and about 2 percent of the Region overall. Land used for governmental and institutional purposes encompassed 34 square miles, or 4 percent of all urban land and 1 percent of the Region overall. Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. Land devoted to transportation, communication and utility uses—including areas used for streets and highways, railways, airports, and utility and communication facilities—totaled 201 square miles, or 26 percent of all urban land and 8 percent of the Region overall. Unused urban lands encompassed 51 square miles, or 7 percent of all urban land and 2 percent of the overall area of the Region (see Table 10).

Figure 8

URBAN POPULATION AND HOUSEHOLD DENSITY IN THE REGION: 1940-2000



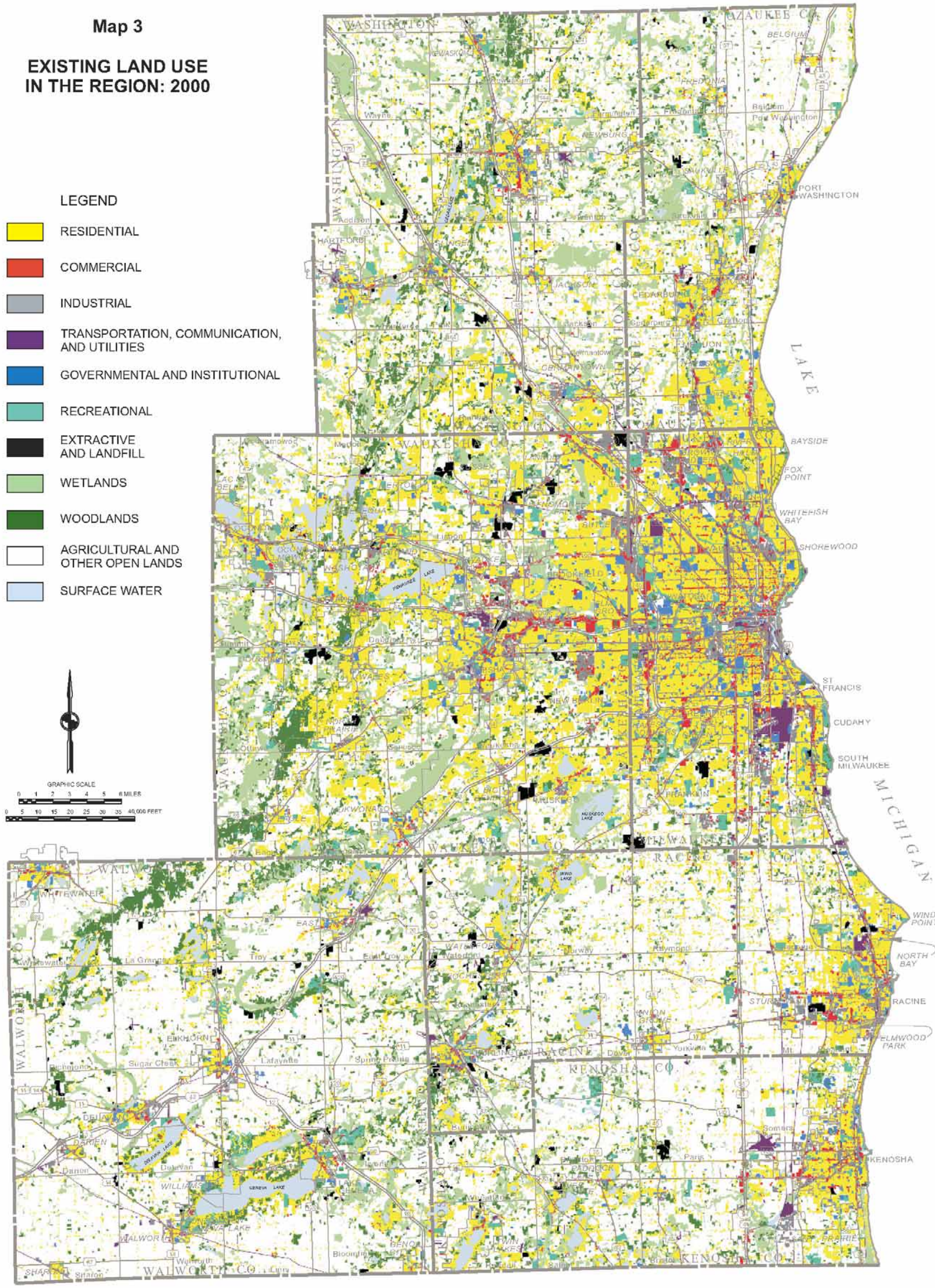
Source: U.S. Bureau of the Census and SEWRPC.

[6] *Unused urban lands consist of open lands, other than wetlands and woodlands, which are located within urban areas but which were not developed for a particular use at the time of the land use inventory. Among the lands included in this category are lands where development was underway but not completed at the time of the inventory, and once-developed lands which have been cleared of development.*

[7] *As identified in the regional land use inventory, the residential land use category encompasses all residential land, including rural residential development, defined as residential development at a density of no more than one dwelling unit per five acres. It is envisioned that, utilizing property boundary information in a digital format, future regional land use inventories will specifically identify the location and extent of rural residential development, enabling the separate reporting of urban and rural residential land.*

Map 3

EXISTING LAND USE IN THE REGION: 2000



Source: SEWRPC.

Table 10

EXISTING LAND USE IN THE SOUTHEASTERN WISCONSIN REGION: 2000

Land Use Category[a]	Square Miles	Percent of Urban/ Nonurban	Percent of Total
Urban			
Residential	362.1	47.6	13.5
Commercial	30.3	4.0	1.1
Industrial	32.9	4.3	1.2
Transportation, Communication, and Utilities	200.9	26.4	7.5
Governmental	33.7	4.4	1.2
Recreational	50.4	6.6	1.9
Unused Urban Land	50.9	6.7	1.9
Subtotal Urban	761.2	100.0	28.3
Nonurban			
Natural Areas			
Surface Water	77.4	4.0	2.9
Wetlands	275.7	14.3	10.2
Woodlands	182.7	9.5	6.8
Subtotal Natural Areas	535.8	27.8	19.9
Agricultural	1,259.4	65.3	46.8
Unused Rural and Other Open Land	133.5	6.9	5.0
Subtotal Nonurban	1,928.7	100.0	71.7
Total	2,689.9	- -	100.0

[a]*Off-street parking is included with the associated land use.*

Source: SEWRPC.

Areas considered “nonurban” under the land use inventory include agricultural lands, wetlands, woodlands, surface water, extractive and landfill sites, and “unused” rural lands.[8] In 2000, nonurban lands as identified in the regional land use inventory encompassed about 1,929 square miles, or 72 percent of the total area of the Region. Agricultural land constituted the largest nonurban land use category, encompassing 1,259 square miles, representing about 65 percent of all nonurban land and about 47 percent of the overall area of the Region. Wetlands, woodlands, and surface water together encompassed 536 square miles, representing about 28 percent of all nonurban land and 20 percent of the Region overall. All other nonurban lands, including extractive, landfill, and unused rural lands, encompassed 134 square miles, representing about 7 percent of all nonurban land and 5 percent of the overall area of the Region.

The results of the year 2000 regional land use inventory are presented along with the results of prior land use inventories for the Region in Table 11. Table 11 indicates a significant increase in urban land uses in the Region between 1990 and 2000. As noted above, the year 2000 land use inventory indicates that urban land uses encompassed about 761 square miles in the Region in 2000. This compares to the figure of 637 square miles indicated by the 1990 land use inventory. It is estimated that about 15 square miles—or 12 percent

[8] *Unused rural lands consist of open lands, other than wetlands and woodlands, which are located within rural areas but which were not in agricultural, pasture, or related use at the time of the land use inventory.*

Table 11

LAND USE IN THE SOUTHEASTERN WISCONSIN REGION AS REPORTED IN THE YEAR 2000 AND PRIOR REGIONAL LAND USE INVENTORIES

Land Use Category[a]	Existing Land Use in Square Miles				
	1963	1970	1980	1990	2000
Urban					
Residential	180.0	210.8	269.1	300.4	362.1
Commercial	11.5	14.8	19.3	24.7	30.3
Industrial	13.5	17.3	22.0	26.1	32.9
Transportation, Communication, and Utilities	134.9	150.0	166.1	171.8	200.9
Governmental	21.8	27.2	30.0	30.8	33.7
Recreational	26.0	33.1	39.3	42.3	50.4
Unused Urban Land	54.5	51.0	45.0	40.5	50.9
Subtotal Urban	442.2	504.2	590.8	636.6	761.2
Nonurban					
Natural Areas					
Surface Water	71.6	74.0	76.2	76.9	77.4
Wetlands	274.3	270.3	266.6	268.7	275.7
Woodlands	186.8	184.3	181.9	185.9	182.7
Subtotal Natural Areas	532.7	528.6	524.7	531.5	535.8
Agricultural	1,637.1	1,564.7	1,475.4	1,395.4	1,259.4
Unused Rural and Other Open Land	77.2	91.6	98.4	126.0	133.5
Subtotal Nonurban	2,247.0	2,184.9	2,098.5	2,052.9	1,928.7
Total	2,689.2	2,689.1	2,689.3	2,689.5	2,689.9

[a]*Off-street parking is included with the associated land use.*

NOTE: As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change increases the precision of the land use inventory and makes it more useable to public agencies and private interests throughout the Region. As a result of the change, however, year 2000 land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the county and regional level, the most significant effect of the change is to increase the transportation, communication, and utilities category—the result of the use of actual street and highway rights-of-way as part of the 2000 land use inventory, as opposed to the use of narrower estimated rights-of-way in prior inventories. This treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories. Changes in total area may be due to this procedural change or to actual changes in the Lake Michigan shoreline.

Source: SEWRPC.

of the increase of 125 square miles in urban land indicated by the 1990 and 2000 inventories—is attributable to the referencing of land use delineations to real property boundaries in the 2000 inventory, particularly to the adjustment of estimated street rights-of-way to match actual rights-of-way. Thus, the actual increase in urban land uses in the Region during the 1990s, discounting the effect of procedural changes in the land use inventory, may be estimated at about 110 square miles, or 17 percent. This compares to increases of 46 square miles, or 8 percent, during the 1980s, and 87 square miles, or 17 percent, during the 1970s.

Environmental Corridors

One of the most important tasks completed under the regional planning program for Southeastern Wisconsin has been the identification and delineation of areas of the Region in which concentrations of the best remaining elements of the natural resource base occur. It was recognized that preservation of such areas is important to both the maintenance of the overall environmental quality of the Region and to the continued provision of amenities required to maintain a high quality of life for the resident population.

Under the regional planning program, seven elements of the natural resource base have been considered essential to the maintenance of the ecological balance, natural beauty, and overall quality of life in Southeastern Wisconsin: 1) lakes, rivers, and streams, and their associated shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils; and 7) rugged terrain and high-relief topography. In addition, there are certain other features which, although not part of the natural resource base per se, are closely related to, or centered upon, that base and are a determining factor in identifying and delineating areas with recreational, aesthetic, ecological, and cultural value. These five additional elements are: 1) existing park and open space sites; 2) potential park and open space sites; 3) historic sites; 4) scenic areas and vistas; and 5) natural areas and critical species habitat sites.

The delineation of these 12 natural resource and natural resource-related elements on maps results, in most areas of the Region, in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Regional Planning Commission.[9] Primary environmental corridors include a variety of the aforementioned important natural resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. Secondary environmental corridors generally connect with the primary environmental corridors and are at least 100 acres in size and one mile in length. In addition, smaller concentrations of natural resource base elements that are separated physically from the environmental corridors by intensive urban or agricultural land uses have also been identified. These areas, which are at least five acres in size, are referred to as isolated natural resource areas.

The preservation of environmental corridors and isolated natural resource areas in essentially natural, open uses yields many benefits, including recharge and discharge of groundwater; maintenance of surface and groundwater quality; attenuation of flood flows and stages; maintenance of base flows of streams and watercourses; reduction of soil erosion; abatement of air and noise pollution; provision of wildlife habitat; protection of plant and animal diversity; protection of rare and endangered species; maintenance of scenic beauty; and provision of opportunities for recreational, educational, and scientific pursuits. Conversely, since these areas are generally poorly suited for urban development, their preservation can help avoid serious and costly developmental problems.

Primary Environmental Corridors

As shown on Map 4, the primary environmental corridors in the Region are primarily located along major stream valleys, around major lakes, and along the Kettle Moraine. These primary environmental corridors contain almost all of the best remaining woodlands, wetlands, and wildlife habitat areas in the Region, and represent a composite of the best remaining elements of the natural resource base. The protection of the primary environmental corridors from additional intrusion by incompatible land uses, degradation, and destruction is one of the key objectives of the adopted regional land use plan.

As indicated in Table 12, primary environmental corridors encompassed about 462 square miles, or about 17 percent of the total area of the Region, in 2000. As indicated in Table 13, there was a small net increase of 0.7 square mile, or 0.2 percent, in primary environmental corridor lands in the Region between 1990 and 2000. The change in area is the net result of increases in primary environmental corridor lands in certain areas of the Region and decreases in other areas. Decreases in primary environmental corridor lands occur, for the most part, as a result of conversion to urban or agricultural use. Increases may occur as a result of managed restoration efforts (e.g., wetland, woodland, or prairie restoration) and as a result of situations where lands, such as farmed floodplains or wetlands, are simply allowed to revert to a more natural condition.

Secondary Environmental Corridors

As further shown on Map 4, secondary environmental corridors are generally located along the small perennial and intermittent streams within the Region. Secondary environmental corridors also contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive urban or agricultural purposes.

Secondary environmental corridors facilitate surface-water drainage, maintain pockets of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species.

In 2000, secondary environmental corridors encompassed about 75 square miles, or about 3 percent of the total area of the Region. There was a small net increase of 0.2 square mile, or 0.3 percent, in secondary environmental corridor lands in the Region between 1990 and 2000—also the result of increases in secondary environmental corridor lands in certain areas of the Region and decreases in other areas.

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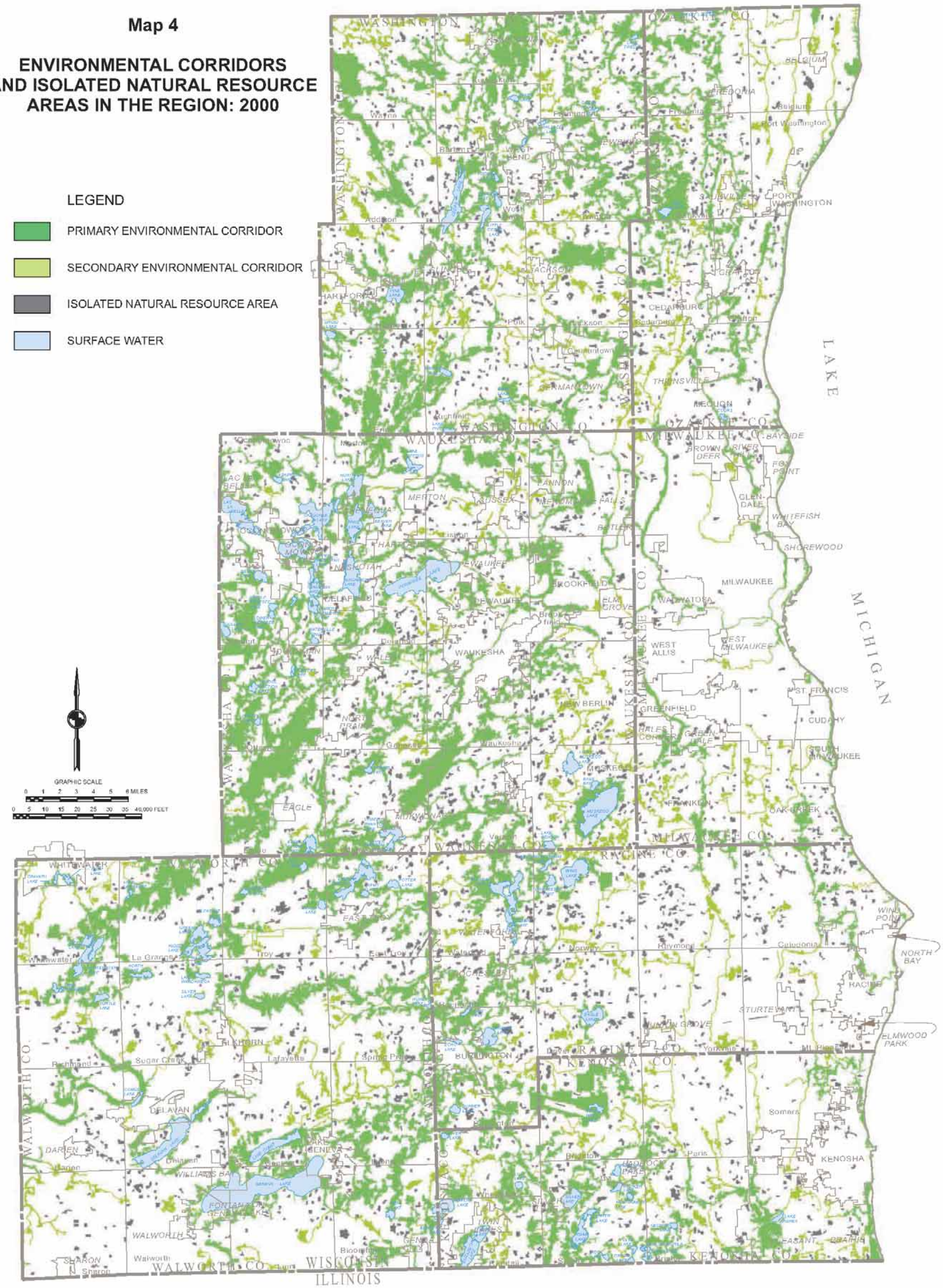
[9] *A detailed description of the process of delineating environmental corridors in Southeastern Wisconsin is presented in the March 1981 issue (Volume 4, No. 2) of the* SEWRPC Technical Record.

Map 4

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGION: 2000



Source: SEWRPC.

Table 12

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGION BY COUNTY: 2000

County	Primary Environmental Corridors		Secondary Environmental Corridors		Isolated Natural Resource Areas		Total Environmental Corridors and Isolated Natural Resource Areas	
	Square Miles	Percent of County/ Region	Square Miles	Percent of County/ Region	Square Miles	Percent of County/ Region	Square Miles	Percent of County/ Region
Kenosha	43.8	15.7	10.0	3.6	6.0	2.2	59.8	21.5
Milwaukee	14.5	6.0	5.2	2.1	3.3	1.4	23.0	9.5
Ozaukee	32.2	13.7	7.6	3.2	5.6	2.4	45.4	19.3
Racine	35.5	10.4	10.8	3.2	12.0	3.5	58.3	17.1
Walworth	99.2	17.2	14.6	2.5	12.9	2.3	126.7	22.0
Washington	94.2	21.6	15.4	3.6	10.1	2.3	119.7	27.5
Waukesha	142.8	24.6	11.2	1.9	13.0	2.3	167.0	28.8
Region	462.2	17.2	74.8	2.8	62.9	2.3	599.9	22.3

Source: SEWRPC.

Table 13

CHANGE IN ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGION: 1990-2000

Resource Feature	Existing 1990 (square miles)	Change: 1990-2000				Existing 2000 (square miles)
		Gains (square miles)	Losses (square miles)	Net Change		
				Square miles	Percent	
Primary Environmental Corridors	461.5	5.5	4.8	0.7	0.2	462.2
Secondary Environmental Corridors	74.6	1.9	1.7	0.2	0.3	74.8
Isolated Natural Resource Areas	63.3	3.0	3.4	-0.4	-0.6	62.9
Total Environmental Corridors and Isolated Natural Resource Areas	599.4	10.4	9.9	0.5	0.1	599.9

Source: SEWRPC.

Isolated Natural Resource Areas

In addition to the primary and secondary environmental corridors, other smaller pockets of wetlands, woodlands, surface water, or wildlife habitat exist within the Region. These pockets are isolated from the environmental corridors by urban development or agricultural use, and although separated from the environmental corridor network, these isolated natural resource areas have significant value. They may provide the only available wildlife habitat in an area, usually provide good locations for local parks, and lend unique aesthetic character and natural diversity to an area.

Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or about 2 percent of the total area of the Region, in 2000. There was a small net decrease of 0.4 square mile, or 0.6 percent, in isolated natural resource areas in the Region between 1990 and 2000.

AGRICULTURAL RESOURCE BASE

Agricultural land in the Region has decreased significantly over the past four decades. It is estimated that lands devoted to agricultural use decreased by 22 percent between 1963 and 2000, including a decrease of about 8 percent during the 1990s.[10] Despite this decrease, a large portion of the total area of the Region remains in agricultural use, and agriculture remains an important component of the regional economy.

Based upon the Commission's regional land use inventory, about 1,259 square miles, or 47 percent of the total area of the Region, were in agricultural use

[10] *These estimates are based upon the Commission's regional land use inventories and discount the effect of the procedural shifts made as part of the year 2000 inventory, described earlier in this chapter.*

in 2000. It should be noted that this figure includes lands actually used for agriculture—primarily cultivated lands and lands used for pasture—and excludes the wetland and woodland portions of existing farm units.

Map 5 shows the extent of agricultural land in the Region as identified in the year 2000 regional land use inventory and further identifies those areas which are covered by highly productive soils—comprised of soils in agricultural capability Class I and Class II, as classified by the U.S. Natural Resources Conservation Service. Agricultural lands covered by Class I and Class II soils encompassed about 945 square miles, or 75 percent of all agricultural land in the Region, in 2000. The adopted regional land use plan recommends the preservation of Class I and Class II soils insofar as practicable.

TRANSPORTATION FACILITIES AND SERVICES

Arterial Street and Highway System

The arterial streets and highways are defined as streets and highways that are previously intended to provide a high degree of traffic service, carrying relatively high volumes of traffic at relatively high operating speeds. The arterial street system may be divided into freeway facilities and nonfreeway, or standard arterial, streets and highways. A freeway is a special type of arterial providing the highest degree of mobility and the most limited degree of access. A freeway is defined as a directionally divided arterial highway with full control of marginal access and grade separation at all intersecting streets and highways. Standard arterial streets and highways may be directionally divided or undivided, with at-grade intersections, and partial or full control of marginal access to abutting property. Table 14 provides information on the mileage of arterials in the Region in 2001. Data on the existing and historic mileage of collector and land access streets and of the total street and highway system within the Region are also provided. Land access streets are primarily intended to provide access to abutting properties. Collector streets are intended primarily as connectors between the arterial and land access street systems. Streets and highways may also be classified according to jurisdiction. Jurisdictional classification establishes which level of government—State, county, or local—has responsibility for the design, construction, maintenance, and operation of each segment of the total street and highway system. Table 15 presents the distribution of existing arterial highway mileage within the Region in 2001 by State, county, and local jurisdictional classification. Map 6 shows the arterial street and highway system as it existed within the Region in 2001, by freeway and standard facility and by jurisdictional classification.

The location and configuration of the State Trunk Highway system, consisting of both freeway and nonfreeway facilities, has particular significance for telecommunications system planning. In order to provide public safety these facilities require good wireless telecommunications services.

Arterial Street and Highway System Traffic Volume

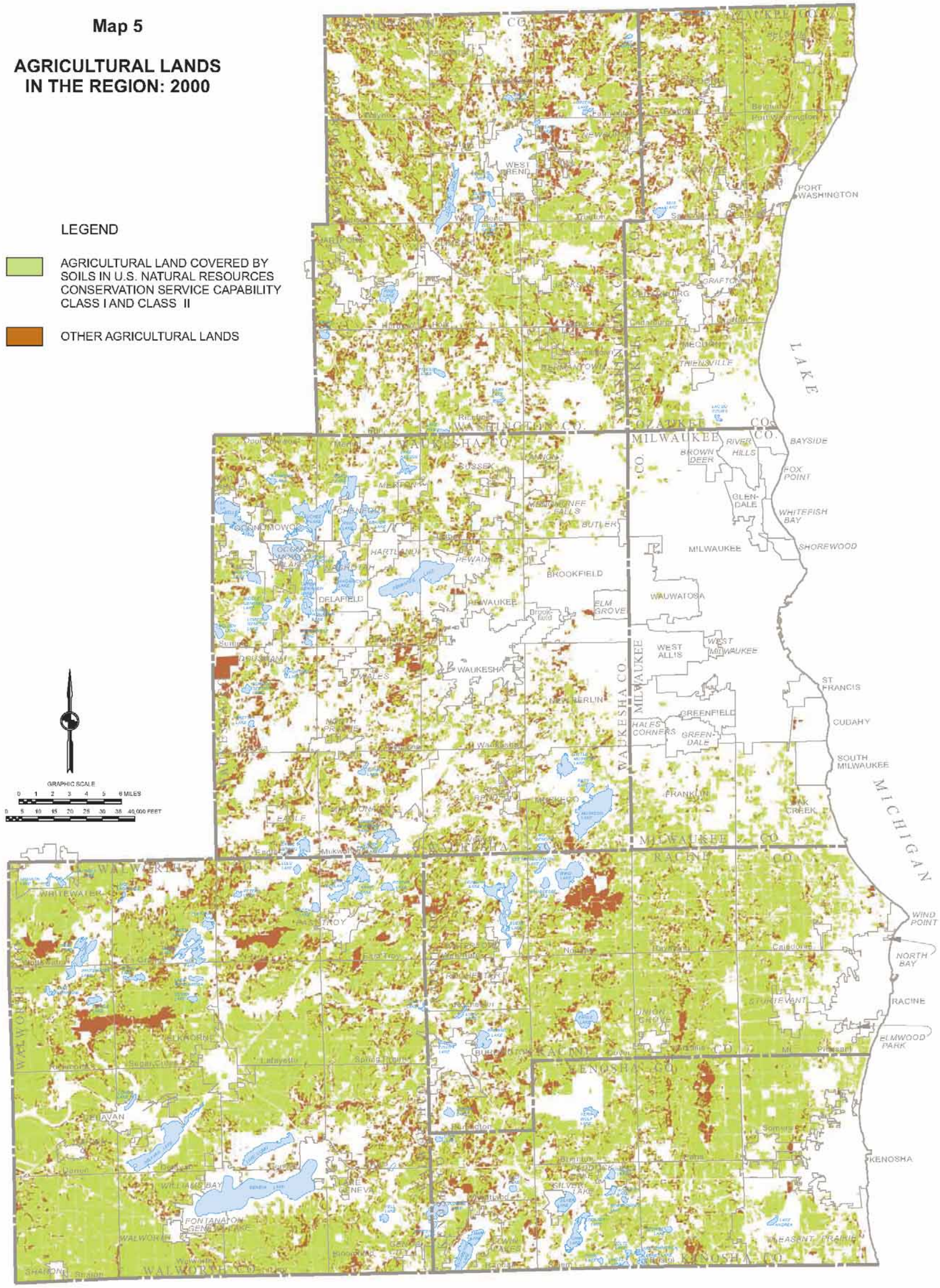
The average weekday traffic volume on each segment of the arterial street and highway system within the Region in 2001 is graphically displayed on Map 7. The magnitude of arterial street and highway traffic volume can also be measured in terms of total arterial system average weekday vehicle-miles of travel. About 40.0 million vehicle-miles of travel occurred on the arterial street and highway system within the Region on an average weekday in 2001. Freeways, which comprise about 8 percent of the total arterial street mileage, carried 37.2 percent of the total arterial vehicle miles of travel which took place within the Region on an average weekday in 2001.

Public Transit

Public transportation may be divided into service provided for the general public and service provided to special population groups. Examples of special group public transportation include yellow school bus service operated by area school districts, and fixed-route bus and paratransit van service provided by counties or municipalities for the elderly and disabled. Service to special population groups is considered only implicitly in the public transportation planning process, with the exception of paratransit operated within urban fixed-route transit service areas to meet the transportation needs of those persons who because of mental or physical disability are unable to use conventional transit service. Such service is required to be provided within fixed-route urban transit service areas under the Federal Americans with Disabilities act of 1990, and the needed configurations of such service is explicitly considered by the Commission in regional transportation system planning.

Map 5

AGRICULTURAL LANDS IN THE REGION: 2000



Source: SEWRPC.

Table 14

DISTRIBUTION OF TOTAL ARTERIAL STREET AND HIGHWAY SYSTEM MILEAGE AND VEHICLE MILES OF TRAVEL (VMT) WITHIN THE REGION BY COUNTY: 2001

County	Total Miles	Freeway System Miles	Nonfreeway System Miles
Kenosha	317.6	12.0	305.6
Milwaukee	781.8	67.8	714.0
Ozaukee	250.7	26.2	224.5
Racine	352.6	12.0	340.6
Walworth	436.6	48.9	387.7
Washington	406.5	42.8	363.7
Waukesha	746.0	60.0	686.0
Region	3,291.8	269.7	3,022.1

County	Total VMT in Thousands	Freeway System		Nonfreeway System	
		VMT in Thousands	Percent	VMT in Thousands	Percent
Kenosha	3,119.0	806	25.8	2,313	74.2
Milwaukee	16,666.0	6,895	41.4	9,771	58.6
Ozaukee	2,235.0	949	42.5	1,286	57.5
Racine	3,374.0	865	25.6	2,509	74.4
Walworth	2,338.0	763	32.6	1,575	67.4
Washington	3,091.0	1,369	44.3	1,722	55.7
Waukesha	9,160.0	3,237	35.3	5,923	64.7
Region	39,983.0	14,884	37.2	25,099	62.8

Source: SEWRPC.

Table 15

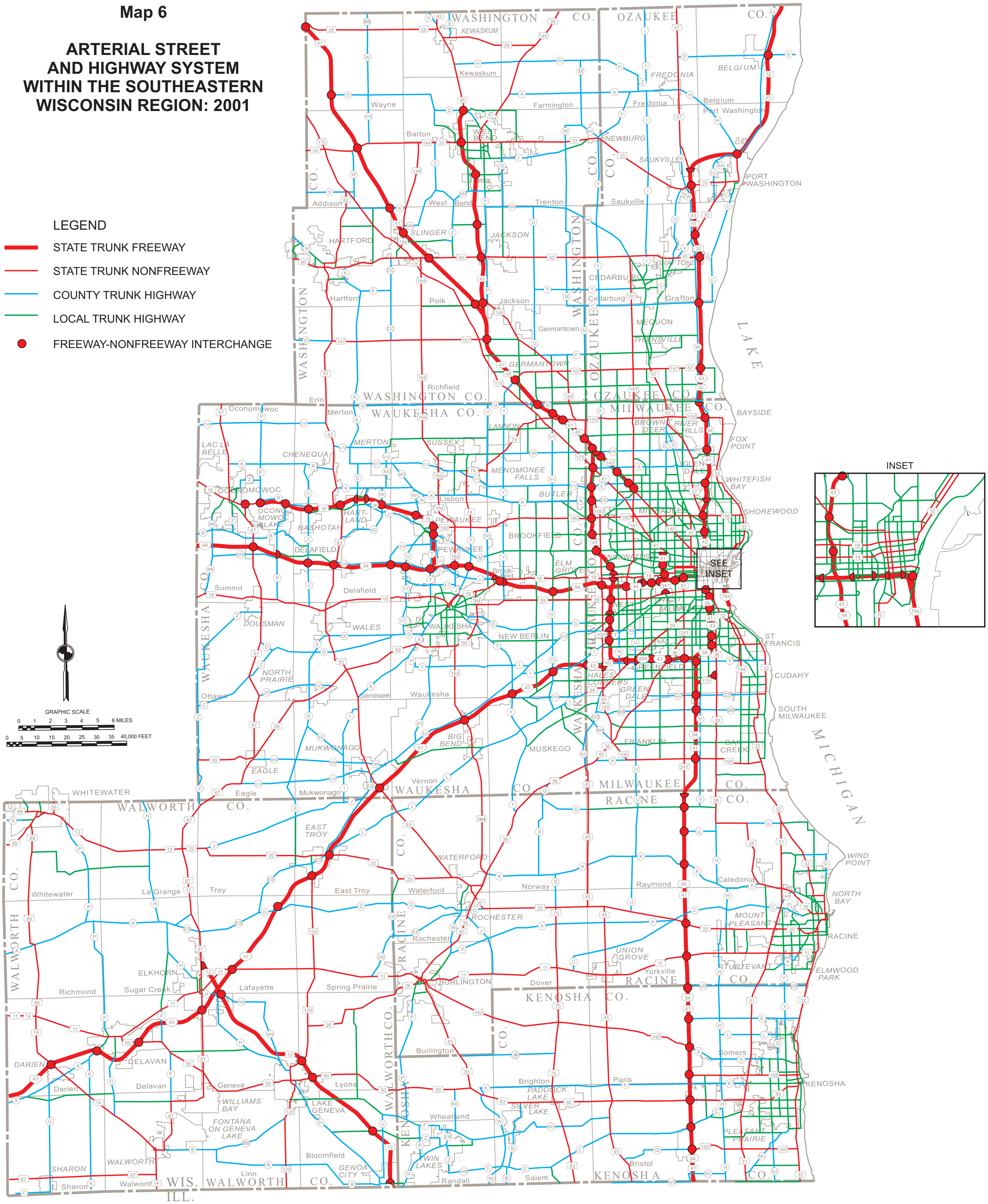
DISTRIBUTION OF EXISTING ARTERIAL STREET AND HIGHWAY MILEAGE WITHIN THE REGION BY COUNTY AND JURISDICTIONAL CLASSIFICATION: 2001

County	State			County		Local		Total	
	Trunk Highways (miles)	Connecting Streets (miles)	Percent of Total	Miles	Percent of Total	Miles	Percent of Total	Miles	Percent of Total
Kenosha	107.4	10.1	37.0	140.8	44.3	59.3	18.7	317.6	100.0
Milwaukee	175.3	87.3	33.6	87.7	11.2	431.5	55.2	781.8	100.0
Ozaukee	67.9	11.1	31.5	109.0	43.5	62.7	25.0	250.7	100.0
Racine	140.5	21.2	45.9	118.9	33.7	72.0	20.4	352.6	100.0
Walworth	193.0	18.4	48.4	168.9	38.7	56.3	12.9	436.6	100.0
Washington	173.3	14.4	46.2	149.8	36.9	69.0	16.9	406.5	100.0
Waukesha	220.5	18.4	32.0	351.7	47.1	155.4	20.9	746.0	100.0
Region	1,077.9	180.9	38.3	1,126.8	34.2	906.2	27.5	3,291.8	100.0

Source: Wisconsin Department of Transportation and SEWRPC.

Map 6

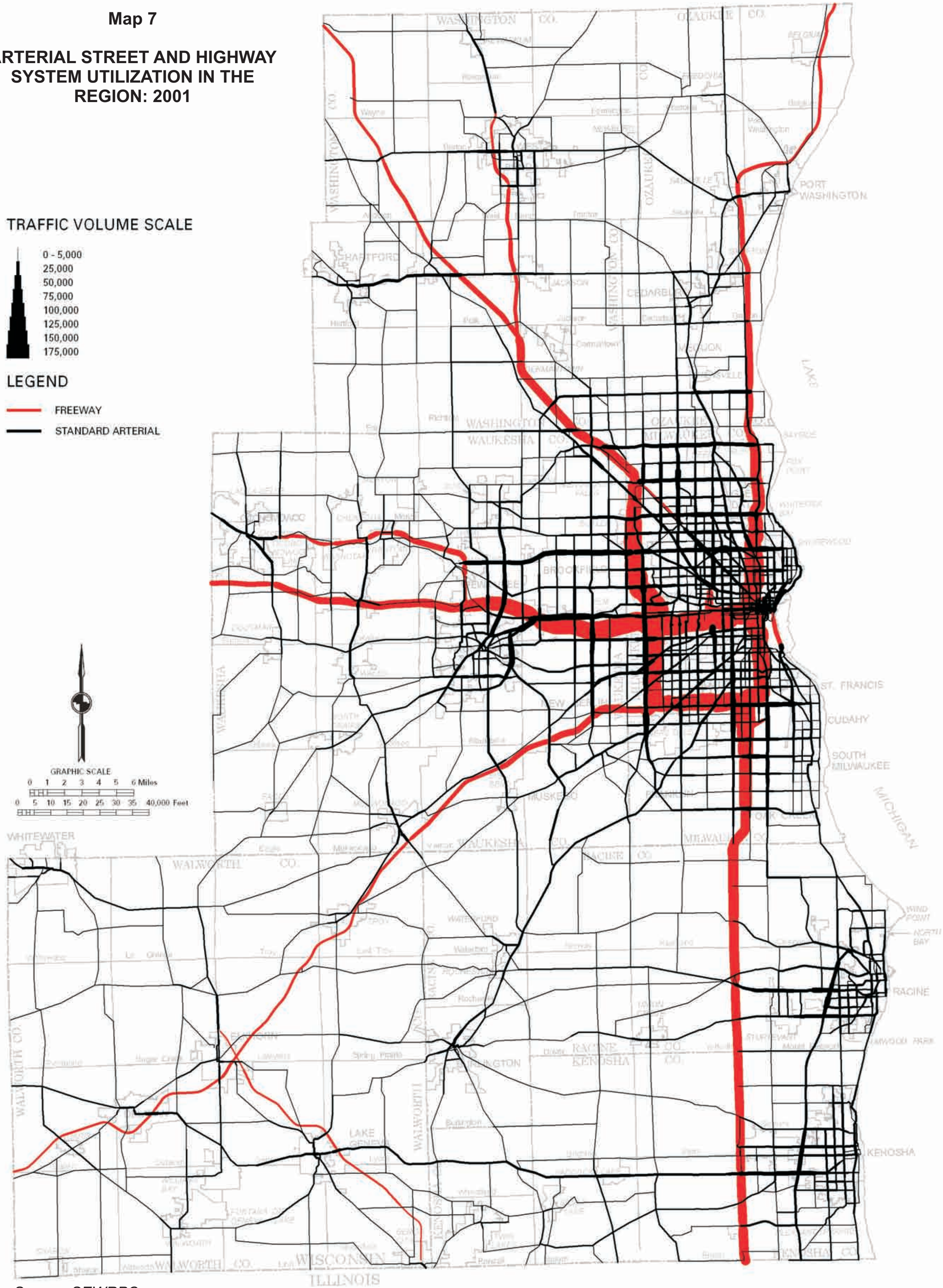
ARTERIAL STREET AND HIGHWAY SYSTEM WITHIN THE SOUTHEASTERN WISCONSIN REGION: 2001



Source: SEWRPC.

Map 7

ARTERIAL STREET AND HIGHWAY SYSTEM UTILIZATION IN THE REGION: 2001



Source: SEWRPC.

Public transit service to the general public may further be divided into three categories: intercity, urban, and rural. Intercity or interregional public transportation provides services across regional boundaries and includes Amtrak railway passenger service, interregional bus service, and commercial air travel. Rural—and small urban community—public transportation provides service in and between small urban communities and rural areas, and may provide connections to urban areas. Urban public transportation, commonly referred to as public transit, provide service within and between the large urban areas of the Region. Public transit is essential in any metropolitan area to meet the travel needs of persons unable to use personal automobile transportation; to provide an alternative mode of travel, particularly in heavily traveled corridors within and between urban areas and in densely developed urban communities and activity centers; and to provide choice in transportation modes as an enhancement of quality of life and to support and enhance the regional economy.

Urban public transit may be further divided into rapid express, and local levels of service. Rapid transit is intended to facilitate relatively fast and convenient transportation along heavily traveled corridors and between major activity centers and high- and medium-density urban centers and communities within the Region. Rapid transit has relatively high average operating speeds and relatively low accessibility, with station spacing one to three miles or more apart.

Rapid transit service can be provided by commuter, heavy, or light rail operating over exclusive, grade-separated rights-of-way or by motor buses operating over exclusive, grade-separated busways. Rapid transit can also be provided by motor buses operating in mixed traffic on freeways and by light rail operating over exclusive, though not fully grade-separated, rights-of-way.

Express transit service is provided over arterial streets and highways or on exclusive rights-of-way with stops generally one-quarter to two miles apart at intersecting transit routes, intersecting arterial streets, and major traffic generators. Express transit services trips of moderate length can be provided by motor bus or by light rail operating in mixed traffic on shared right-of-way, in reserved street lanes, or on exclusive rights-of-way. Express transit service provides a greater degree of accessibility at somewhat slower operating speeds than rapid transit and may provide "feeder" service to the rapid transit system.

Local transit service is characterized by a high degree of accessibility and low operating speeds. Local service is provided over arterial and collector streets with stops generally one-eighth to one-quarter miles apart. Such service can be provided by motor bus, electric trolleybus, or streetcar. Local transit service can also be provided on a demand-responsive basis, such as with automobiles or vans operating as a shared-ride taxi.

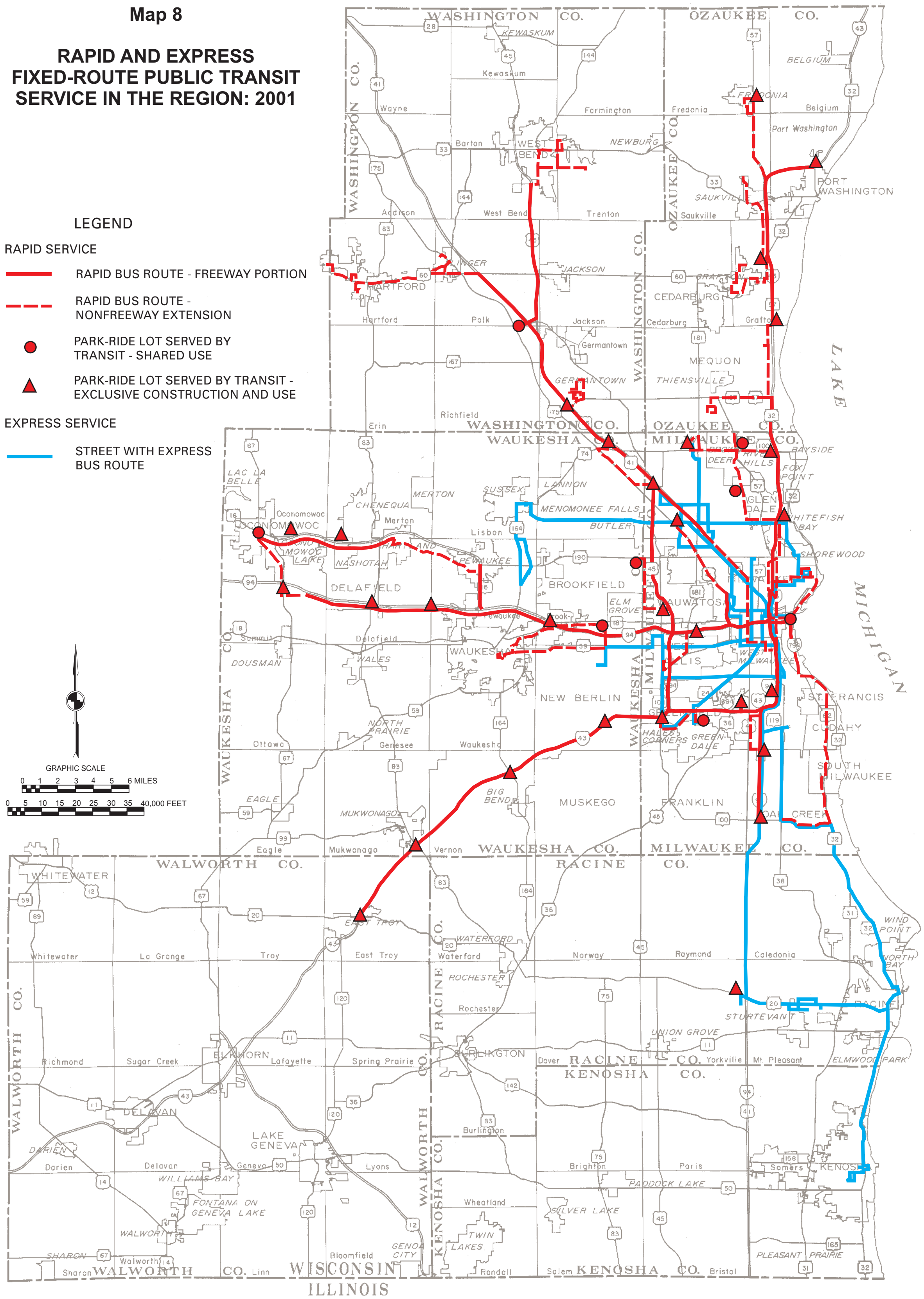
The extent of rapid and express fixed route transit service within the Region in 2001 is shown on Map 8.

Rural and Small Urban Community Demand-Responsive Transit Service

As shown on Map 9 demand-responsive rural public transit in the form of publicly operated shared-ride taxicab service was also provided in the Region in 2001. Shared-ride taxicab service was provided by the City of Port Washington Transport Taxi Service in Ozaukee County, and the Hartford City Taxi Service and City of West Bend Taxi Service in Washington County. These three systems served local travel in and immediately adjacent to the sponsoring municipality. In addition, both Ozaukee and Washington Counties provided shared-ride taxicab service on a countywide basis. The two county taxi systems principally served travel in the small urban communities and rural areas in each county and between the rural areas and all communities. The Ozaukee and Washington County taxi system did serve some communities located within the Milwaukee urban area including the communities of Germantown in Washington County and Mequon, Cedarburg and Grafton in Ozaukee County. These county taxi systems, however, do not serve trips that could be made on municipal systems in each county—Port Washington in Ozaukee

Map 8

RAPID AND EXPRESS FIXED-ROUTE PUBLIC TRANSIT SERVICE IN THE REGION: 2001



Source: SEWRPC.

Map 9

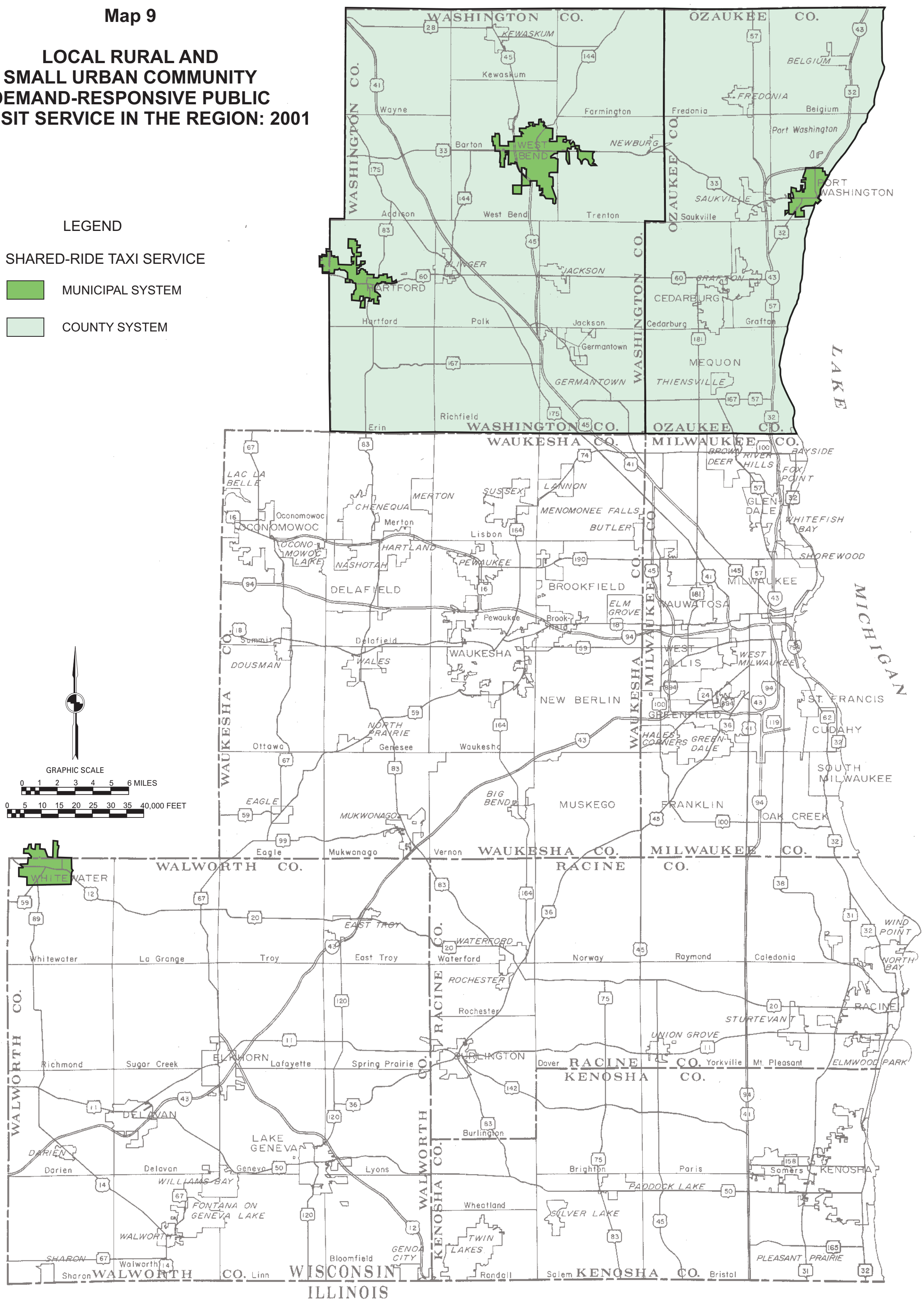
LOCAL RURAL AND SMALL URBAN COMMUNITY DEMAND-RESPONSIVE PUBLIC TRANSIT SERVICE IN THE REGION: 2001

LEGEND

SHARED-RIDE TAXI SERVICE

MUNICIPAL SYSTEM

COUNTY SYSTEM



Source: SEWRPC.

County and Hartford and West Bend in Washington County. Public shared-ride taxicab service was also provided in Walworth County by Browns Cab Service which served local travel in and immediately adjacent to the City of Whitewater.

PARK-RIDE FACILITIES

Park-ride facilities enable more efficient travel within southeastern Wisconsin through transfer of mode between private vehicle and public transit, and between single occupant or solo driver private vehicles and carpools. In 2001, there were 46 park-ride lots serving intra-regional travel within the Region, with 37 served by rapid or express transit bus service.

As already noted in 2001, rapid or express transit bus service was provided to 37 park-ride lots within the Region, as shown on Map 10. These intermodal parking facilities provided 6,120 parking spaces.

Also as already noted, in 2001, there were 9 park-ride lots not served by transit located within the Region containing 390 parking spaces as shown on Map 10. Most of these parking spaces, about 50 percent, were located within Waukesha County, with about another 29 percent within Washington County, and the remaining 21 percent in Walworth County.

SUMMARY

Reliable planning data are essential for the formulation of workable development plans. The critical nature and factual information in the planning process should be evident, since no reliable forecast can be made or alternate course of action formulated without the nature of the current state of the system being planned. Information regarding existing conditions and historical trends with respect to the demographic and economic base to certain elements of the natural environment, and to certain elements of the man made environment of the planning area is essential to the telecommunications planning process. This chapter presents a summary of the results of Commission inventories pertaining to the population, economy, land use pattern, natural and agricultural resource base and the transportation system within the Region. Inventory findings pertinent to telecommunications planning include the following:

Demographic and Economic Base

- The population of the Region increased by 120,800 persons, or 7 percent, from 1,810,400 persons in 1990 to 1,931,200 persons in 2000. Of the total population increase of 120,800 persons during the 1990s, 116,900 can be attributed to natural increase; the balance can be attributed to a modest net in-migration—about 3,900 persons—into the Region. The past decade saw a continuation of the long-term trend to decentralization of urban development within the Region. Milwaukee County's share of the total regional population decreased by about 4 percentage points during the 1990s, while the share of each of the other six counties increased.

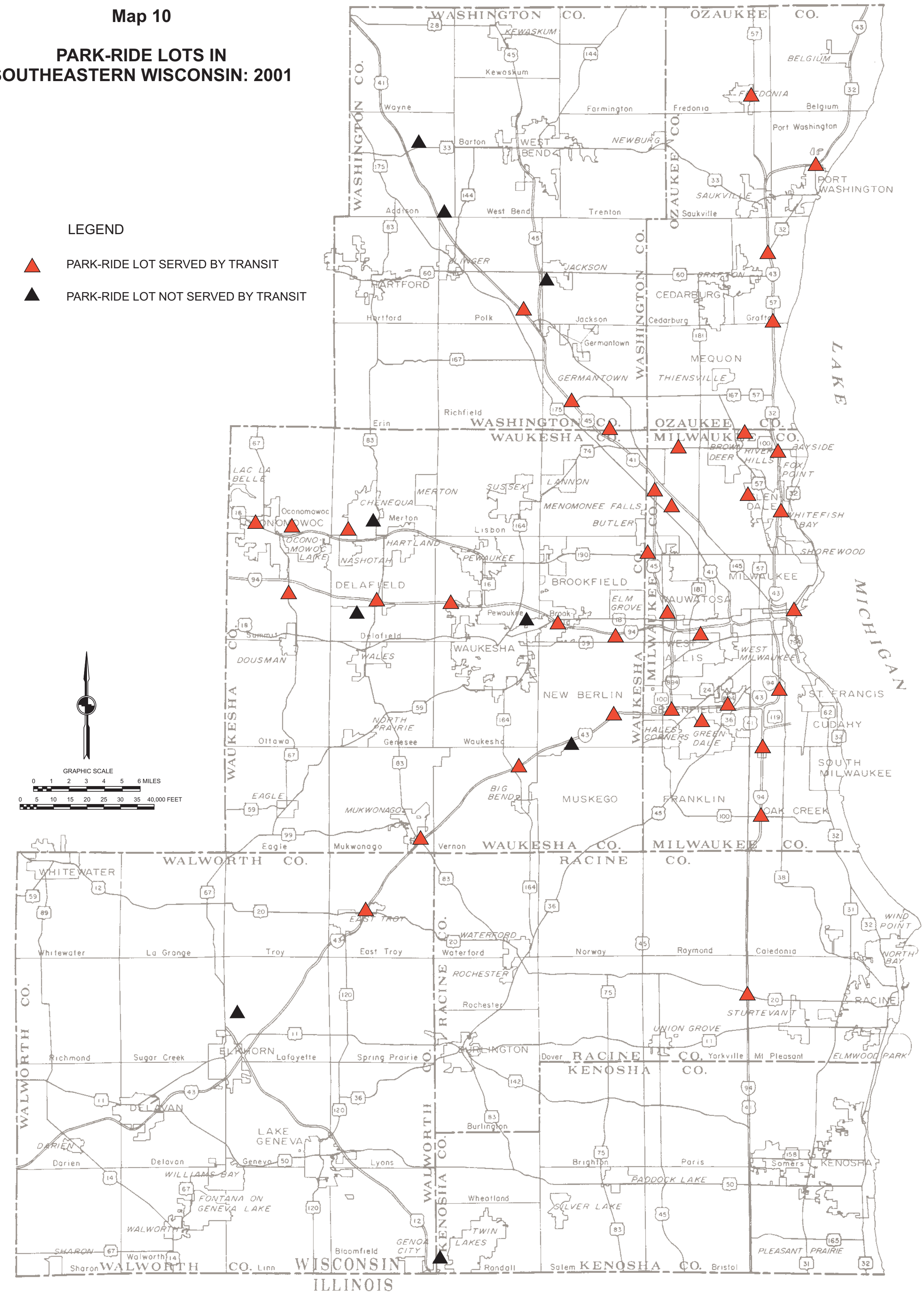
- The number of households, or occupied housing units, in the Region increased by 72,900, from 676,100 in 1990 to 749,000 households in 2000. In relative terms, the rate of growth in households, 11 percent, exceeded the rate of growth in total population, 7 percent. Similar patterns have been observed over each of the four previous decades. The differential growth rates in households and population are reflected in a declining average household size. During the 1990s, the average household size in the Region decreased by about 4 percent, from 2.62 persons in 1990 to 2.52 persons in 2000.

- Total employment in the Region increased by 160,200 jobs, or 15 percent, from 1,062,600 in 1990 to 1,222,800 jobs in 2000. Employment levels, both nationally and within the Region, tend to fluctuate in the short-term, rising and falling in accordance with business cycles. The long period of nearly uninterrupted job growth between 1980 and 2000 is unusual in this respect. Nationally and within the Region, total employment increased each year during that time, with the exception of a slight decrease in 1991.

- Each county in the Region experienced an increase in employment during the 1990s. Between 1990 and 2000, reflective of the trend to decentralization of urban development within the Region. Milwaukee and Racine

Map 10

PARK-RIDE LOTS IN SOUTHEASTERN WISCONSIN: 2001



Source: SEWRPC.

Counties decreased in their relative share of total regional employment while the share of each of the other five counties increased.

- The 1990s saw a continuation of a shift in the regional economy from a manufacturing to a service orientation. Manufacturing employment in the Region was virtually unchanged during the 1990s, following a 15 percent decrease during the 1980s, and a modest 4 percent increase during the 1970s. Conversely, service-related employment increased substantially during each of the past three decades—by 33 percent during the 1990s, 41 percent during the 1980s, and 53 percent during 1970s. Due to these differential growth rates, the proportion of manufacturing jobs relative to total jobs in the Region decreased from 32 percent in 1970 to 18 percent in 2000, while service-related employment increased from 18 percent in 1970 to 33 percent in 2000.

Land Use

- Urban land uses encompassed about 761 square miles, or 28 percent of the total area of the Region, in 2000. Residential land comprised the largest urban land use category, encompassing about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the Region. In combination, commercial and industrial lands encompassed about 63 square miles, or about 8 percent of all urban land and about 2 percent of the Region overall. Land used for governmental and institutional purposes encompassed 34 square miles, or 4 percent of all urban land and 1 percent of the Region overall. Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. Land devoted to transportation, communication, and utility uses—including areas used for streets and highways, railways, airports, and utility and communication facilities—totaled 201 square miles, or 26 percent of all urban land and 8 percent of the Region overall. Unused urban lands encompassed 51 square miles, or 7 percent of all urban land and 2 percent of the overall area of the Region.

- Areas considered "nonurban" under the land use inventory include agricultural lands, wetlands, woodlands, surface water, extractive and landfill sites, and unused rural lands. In 2000, nonurban lands as identified in the regional land use inventory encompassed about 1,929 square miles, or 72 percent of the total area of the Region. Agricultural land constituted the largest nonurban land use category, encompassing 1,259 square miles, representing about 65 percent of all nonurban land and about 47 percent of the overall area of the Region. Wetlands, woodlands, and surface water together encompassed 536 square miles, representing about 28 percent of all nonurban land and 20 percent of the Region overall. All other nonurban lands, including extractive, landfill, and unused rural lands, encompassed 134 square miles, representing about 7 percent of all nonurban land and 5 percent of the overall area of the Region.

- Commission inventories indicate a continued significant increase in urban land uses within the Region. Urban land uses increased by about 110 square miles from 1990 to 2000, or by about 17 percent.

- The population density of the urban portion of the Region has continued to decrease from 10,700 persons per square mile in 1940 to about 5,100 persons per square mile in 1970, 3,900 persons per square mile in 1980, and 3,500 persons per square mile in 2000. During the 1990s, the urban population density continued to decrease, but at a slower rate, to about 3,300 persons per square mile in 2000. A different density trend for the Region emerges when urban density is calculated based upon households rather than population. Since 1963, the relative decrease in urban household density has been much lower than the decrease in urban population density. Between 1963 and 2000, the urban household density decreased by 23 percent, compared to a 43 percent decrease in the urban population density.

- The most important elements of the natural resource base and features closely related to that base—including wetlands, woodlands, prairies, wildlife habitat, major lakes and streams and associated shorelands and floodlands, and historic, scenic, and recreational sites—when combined result in essentially elongated patterns referred to by the Commission as “environmental corridors.” “Primary” environmental corridors, which are the longest and widest type of environmental corridor, are generally located along major stream valleys, around major lakes, and along the Kettle Moraine; they encompassed 462 square miles, or 17 percent of the total area of the Region, in 2000. “Secondary” environmental corridors are generally located along small perennial and intermittent streams; they encompassed 75 square miles, or 3 percent of the Region, in 2000. In addition to the environmental corridors, “isolated natural resource areas,” consisting of small pockets of natural resource base elements separated physically from the environmental corridor network, have been identified. Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or 2 percent of the Region, in 2000.

- Agricultural land in the Region has decreased significantly over the past four decades. It is estimated that lands devoted to agricultural use decreased by 22 percent between 1963 and 2000, including a decrease of about 8 percent during the 1990s. Despite this decrease, a large portion of the total area of the Region remains in agricultural use, and agriculture remains an important component of the regional economy. About 1,259 square miles, or 47 percent of the total area of the Region, were in agricultural use in 2000. Of this total, about 945 square miles, or 75 percent, were covered by highly productive soils—agricultural capability Class I and Class II soils, as identified by the U.S. Natural Resources Conservation Service.

- As of 2001, there were approximately 11,937 miles of streets and highways—land-access, collector, and arterial—within the Region. Only 28 percent, or 3,292 miles, of the street and highway system were arterials with the principal function of moving traffic. The miles of arterials within the Region have increased from 3,188 in 1963 to 3,292 miles in 2001, an increase of 100 miles or 3 percent. The freeway system in 2001 of 270 miles accounted for 8 percent of the total arterial street and highway system and 2 percent of the total street and highway system yet carried over 37 percent of the arterial vehicle miles of travel on an average weekday, within the Region.

- The extent of fixed route public transit service in southeastern Wisconsin significantly increased from 1991 to 2001 from 63,300 vehicle-miles of service on an average weekday to 79,600 vehicle-miles of service, an increase of 26 percent. The extent of fixed route service provided in 2001 was also 24 percent greater than that provided in 1972 and only 6 percent less than that provided in 1963. Demand-responsive transit service in the Region also significantly increased from 1991 to 2001, from 1,800 vehicle-miles of service on an average weekday to 7,700 vehicle-miles of service. However, since 2001, the extent of fixed route transit service has significantly declined by about 10 percent to 71,900 vehicle-miles of service on an average weekday due to the economic downturn following September 11, 2001, reduced Federal funds, and State and local budget problems.

- The number of park-ride lots enabling the transfer of mode between private vehicles and public transit and from solo driver private vehicles to carpools has increased from 8 in 1972, to 37 in 1991, and to 46 in 2001. Of the 46 park-ride lots in 2001, 37 were provided with transit service. On an average weekday in 2001, about 38 percent of the approximately 6,500 spaces at the 46 park-ride lots were estimated to be in use.

The background inventory data presented in this Chapter is of both direct and indirect use in the wireless telecommunications planning process. Population and household estimates and forecasts in regional aggregate form and distributed by existing and proposed land use patterns will provide the basis for voice, data, and video traffic demand analyses. National traffic data from the Federal Communications Commission and the U.S. Bureau of Census will be allocated to the Region based on the regional share of the national population. These estimates will be verified and cross-correlated with data on state, regional, or industry levels so as to obtain the best estimate of current traffic and the framework for design year forecasts. The data to be allocated include: the number of subscribers, the average number of daily calls for each subscriber, and the average length of each call. From such data, it is possible to estimate existing and to forecast call generation for subregional areas down to the U.S. Public Land Survey system section. Most of the national call data relate to voice calls, but information on wireless data traffic is also becoming available. Wireless video traffic data, however, have not been available long enough to be meaningful. Employment data are also useful in forecasting wireless traffic from work locations. National traffic data can be allocated to the Region based on the regional share of national employment. Voice and data traffic by subregional area can be estimated and forecast based on regional employment and land use data. Land use data can also be used to differentiate as to whether population, employment, or a combination of both, should be used to determine traffic generation rates in a particular subarea of the planning Region. Areas designated as environmental corridors are generally excluded from consideration as potential antenna site locations.

A special aspect of wireless traffic generation relates to calls made during travel. Recent statistics released by the National Highway Traffic Safety Administration indicate that at any given time about 8 percent of automobile drivers are using cell phones. Therefore, data on arterial street and highway traffic volumes provides an important resource for estimating and forecasting wireless traffic in the Region. Vehicular traffic volumes segregated by street and highway segments will be an important input for wireless traffic level forecasts.

All of the above uses of background data relate to the demand side of telecommunications systems. On the supply side, relating to network infrastructure design, population density or more precisely household density is an important variable to be considered in the choice of communications technology. In geographic areas with low household densities, wireless infrastructures may be more cost effective for broadband communications than wireline systems. High household density areas favor use of fiber optic cable networks.

Overall, the background data on population, households, employment, land use and transportation traffic patterns facilitates wireless and wireline network designs, permitting alternative designs to be developed that can meet existing and probable future needs during the life of the network infrastructure.

Chapter V

TELECOMMUNICATIONS BROADBAND INFRASTRUCTURE INVENTORY FINDINGS

INTRODUCTION

Reliable planning data are essential for the formulation of workable development plans. Consequently, an inventory of existing conditions is the first step in the planning process. The crucial nature of factual information in the planning process should be evident, since no reliable forecasts can be made or alternative courses of action evaluated without knowledge of the current state of the system being planned. The necessary inventory not only provides data describing the existing conditions, but also provides a basis for identifying existing and potential problems in the planning area and opportunities for development. The inventory data are also crucial to the forecasting of future facility and service needs, formulating alternative plans, and evaluating such plans.

Chapter IV presented data on the existing demography and economy; the existing land use pattern; and the existing transportation system of the planning area. These factors provide the setting for the telecommunication facilities and services of an area, and affect the configuration of the demand upon those facilities and services, and the configuration of the facilities and services themselves. The sound development of a telecommunications facilities and services plan must also consider: telecommunications technologies currently employed within the Region; emerging technologies that may displace these current technologies; the planimetry and hypsometry of the Region that has a major impact on the deployment of wireless communications systems displayed as canopy data; and the existing telecommunications infrastructure within the Region. The performance of that existing infrastructure must also be monitored. The results of the monitoring are reported in a later chapter.

SEWRPC Planning Report Number 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin,* dated September 1, 2006 presented the findings of a wireless infrastructure inventory conducted by the Commission. The inventory consisted of a compilation of antenna sites that serve mobile cellular/PCS and fixed users within the Region. This inventory data will not be republished herein. This report will focus on an inventory of the geographic areas of the Region serviced by either wireless or wireline broadband communications services. Broadband wireline services were inventoried under four technology categories: (1) Digital subscriber line (DSL) services provided by telephone incumbent local exchange carriers (ILECs) and competitive local exchange carriers (CLECs) in the Region; (2) Hybrid fiber coaxial cable services provided by cable companies in the Region; (3) fiber-to-the-premises; and, (4) fiber-to-the-node.

Wireless broadband communication service may also be provided through high-speed, satellite-based, facilities. Although generally slower and more expensive than other available alternatives, satellite broadband service has the advantage of universal coverage. All areas in the Region may be serviced by satellite broadband. Such coverage is particularly important in rural areas where no other alternative broadband service is available. It is reasonable to expect however, that rural parts of Southeastern Wisconsin will eventually be offered other wireless, or wireline, broadband communication services. The satellite alternative is referenced here only to provide a comprehensive description of all of the broadband technologies available within the Region.

The inventory of interest in this chapter pertains only to the geographic coverage of each of the above technologies. The performance of these three classes of communications technology will be inventoried in a subsequent chapter based upon standard measurements of availability, throughput, response time, and accuracy. These same four performance parameters will be used to evaluate both the wireline and wireless networks.

Each of the service area inventories has its limitations based on the accuracy of the data sources used in its compilation. The broadband cable service area inventory is based on a combination of comprehensive infrastructure and service information for a single community—the Town of Ottawa, Waukesha County—an inventory of community cable service franchise agreements within the Region, and an historic urban growth map of the Region that indicates areas that meet widely accepted economic criteria for broadband cable deployment. This approach to the inventory of cable service deployment resulted from the refusal of either of the two cable service providers to make available maps of the areas in which they actually provide service, the providers regarding such maps as comprising confidential, competitive information. Having comprehensive cable service layout information for a typical urban fringe area community provided a check on the validity of the urban growth approach to defining cable service areas. The procedure also had the advantage that it can be used to forecast future potential broadband cable service deployments.

Telephone line-based digital subscriber line (DSL) broadband service areas were developed indirectly based on telephone company central office locations. A generally accepted service radius of 18,000 feet centered on the central office locations was used to define DSL service areas. DSL providers have extended their service areas beyond these radii by providing fiber-linked remote terminals. Requests for the location of these remote terminals were made by the Commission to all incumbent local exchange carriers and (ILEC) DSL service providers, but the requests were uniformly denied.

BROADBAND WIRELINE SERVICE AREA INVENTORY

There are four types of broadband wireline service networks deployed within the Region: hybrid fiber coaxial; provider based DSL broadband services; fiber-to-the-node; and fiber-to-the-premises.

Hybrid Fiber Coaxial Networks

In 2006, the technology for broadband services in Southeastern Wisconsin with the largest market share was hybrid fiber coaxial cable. This technology, as the name implies, involves a combination of fiber optic and coaxial cabling with the bandwidth capability necessary to achieve throughput as high as five megabits per second in the download direction, and 384 kilobits per second in the upload direction. Performance of these cable networks, however, varies significantly with network loading. The architecture of these cable networks requires a reduction of bandwidth to each user as more users access the medium. Current network performance is described in Chapter VI of this report.

Cable networks were originally designed to deliver broadcast television signals to subscribers' homes. To provide data services, cable operators have invested heavily to convert one-way cable television signal delivery systems into modern two-way networks to support broadband, high-speed Internet access. It is estimated that by 2004, cable operators within the United States had upgraded over 90 percent of the homes served to support Internet access. To provide broadband cable communications services to an area, the cable operator must deploy this advanced form of cable services to each subscriber.

Determining the broadband cable service areas for Southeastern Wisconsin required the multi-path approach described previously. Implementation of this approach involved the following activities:

1. <u>Franchise Area Mapping</u>
   The lists of the communities serviced by each of the two regional carriers operating within the Region, Time Warner Cable and Charter Communications, were obtained and mapped. It is important to note that the mapped areas represent potential service areas, not actual service areas, since the carriers are not legally obligated to serve all of their franchise areas.

2. <u>Comprehensive Analysis of a Franchised Cable Community</u>
   Since unserved, and under-served, subscribers located within the franchise areas tend to be concentrated in rural areas of the Region, a single cable service-franchised civil division, the Town of Ottawa in Waukesha County, was studied in some detail to determine the basis for broadband cable deployment by the major cable operator within the Region. More specifically, the Town was studied to determine the economic basis of new cable deployment in terms of population density. The decision rule concerned is set forth in Section 22.25 of the Town franchise agreement which reads as follows:

   Conditions of Required Line Extensions

   a. Grantee shall, within sixty (60) days of the acceptance of this franchise, file a plan with the Town for the initial installation of cable. Following such initial installation, the Grantee shall not be obligated to extend its cable network to additional subscribers, unless the proposed subscribers shall be located with-in thirty (30) feet of the existing network or at least nineteen (19) additional subscribers will be serviced per mile of cable extension required. It should be noted that the application of the aforereferenced criteria is community specific, and not universal, depending upon the existence and conditions of contracts entered into between cable service providers and the municipal governments concerned.

   b. In instances where the Grantee is not required to provide service pursuant to this section, the Grantee and subscriber may nevertheless contract to have service provided on terms and conditions agreeable to both the subscriber and Grantee.

Based upon the conditions set forth in the Town of Ottawa franchise agreement—conditions which further have been confirmed with a selected sample of fringe area civil divisions within the Region—indicated that similar decision rules were employed by the carriers concerned in approving areas of new cable deployment.

The regional broadband cable franchise areas for Time Warner Cable, Charter Communications, and Mediacom are shown on Map 11. Time Warner Cable is the dominant cable service provider in the Region. It is important to reemphasize that franchise areas do not equate with service areas. This disparity is illustrated in the Waukesha County Town of Ottawa where complete information on cable deployment is available for this community. Map 12 illustrates the urban growth pattern for the year 2000 as determined by Commission inventories within the Town of Ottawa together with the broadband cable deployment.

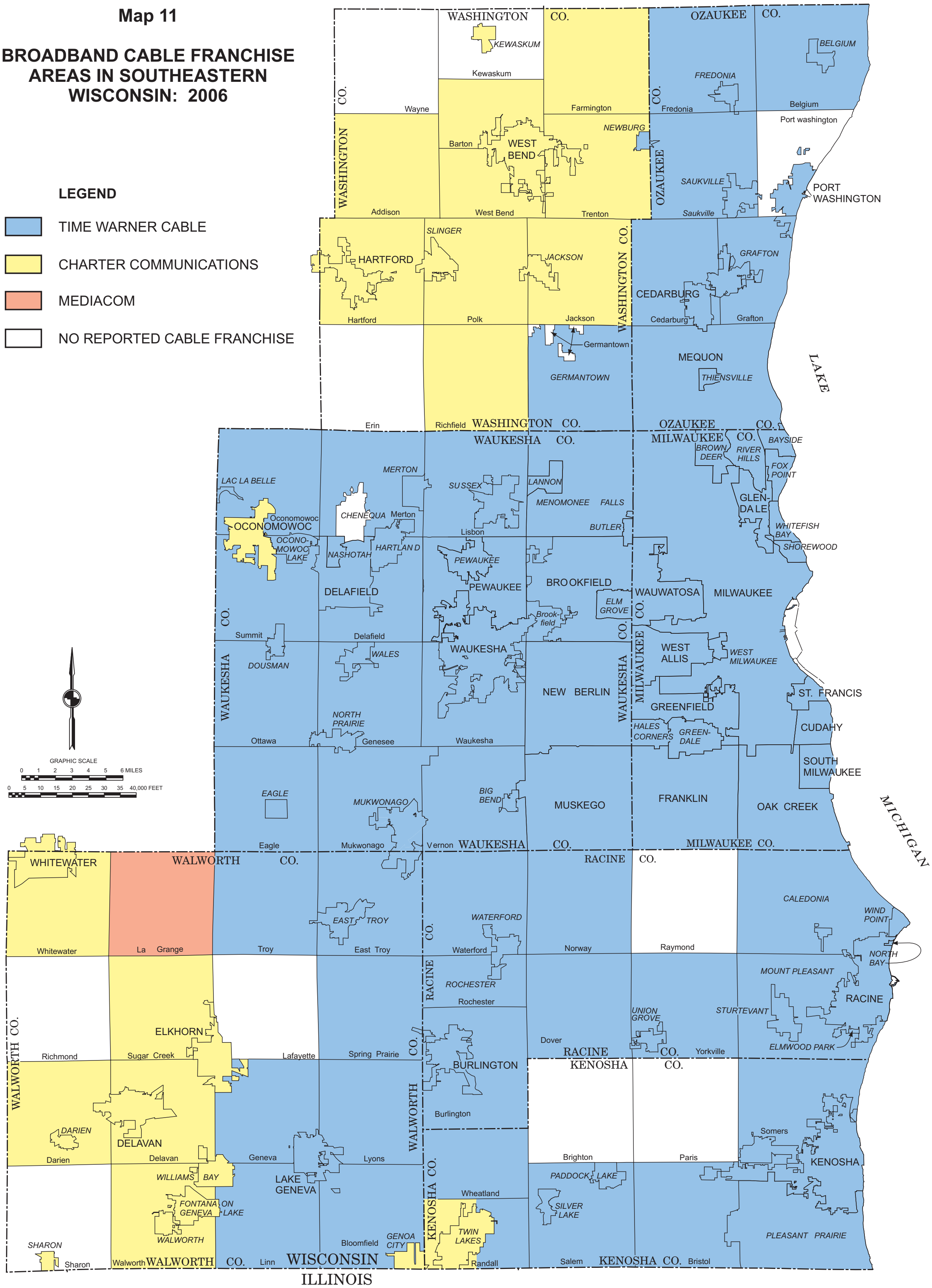
The growth pattern correlates well with the broadband cable service coverage in the Town. Lacking definitive service coverage information from the two regional cable providers, this correlation between urban growth patterns and broadband cable coverage was used as a basis for estimating the geographic extent of broadband cable coverage within the Region. Map 13 indicates the urban development pattern within the Region as of the year 2000, and is believed to represent an approximate delineation of the current areas served by broadband cable coverage within the Region. Whatever the precision and accuracy of these map estimations, it is evident that broadband cable did not provide universal broadband coverage for the Region. Provision of universal broadband communication service must therefore, look to other communication technologies.

Telephone Provider Based DSL Broadband Services

Regional telephone companies provide a broadband data communication service known as Digital Subscriber Line (DSL) of which the most common form is ADSL where the prefix A indicates asymmetrical data throughput. ADSL service, like

Map 11

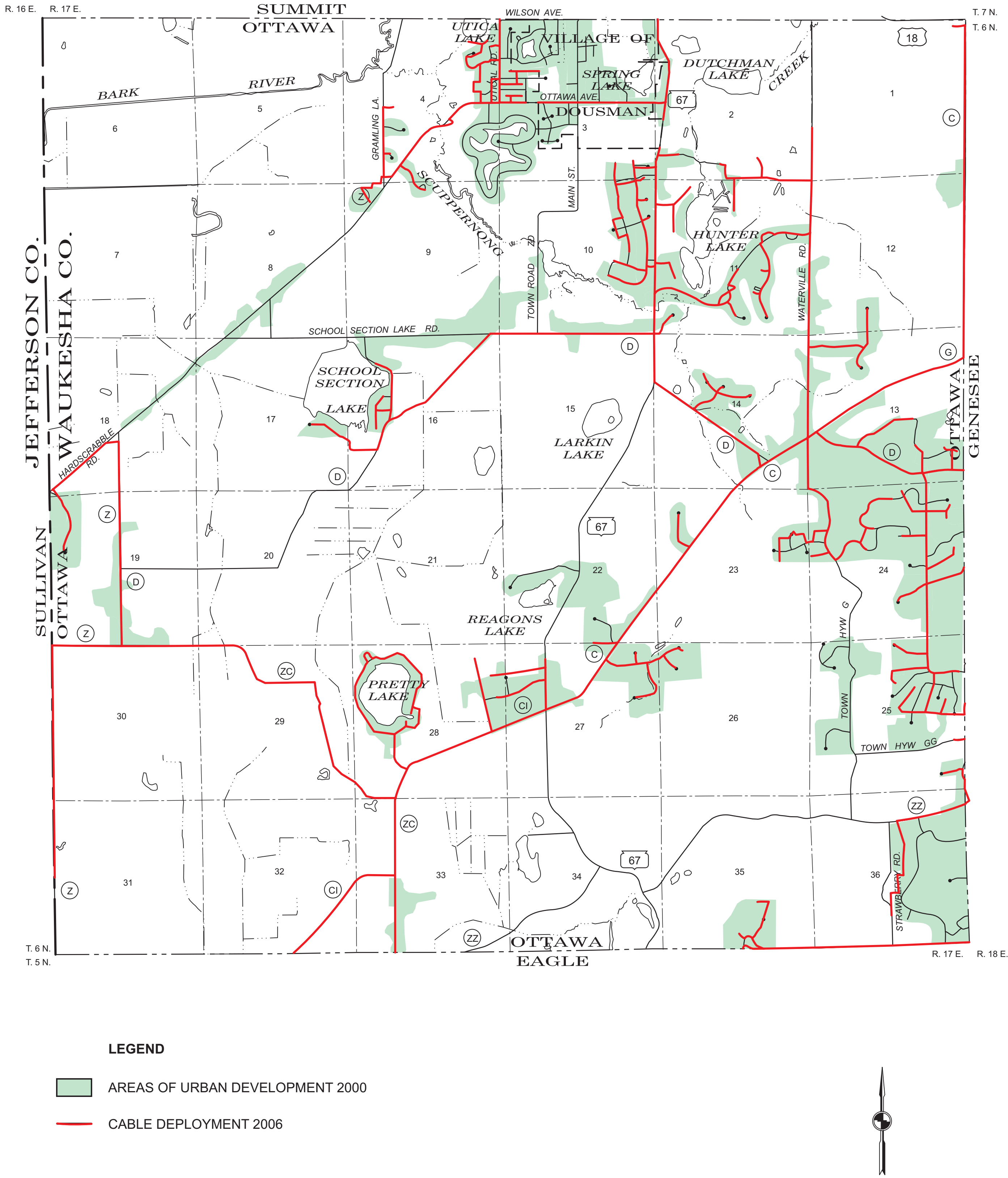
BROADBAND CABLE FRANCHISE AREAS IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 12

URBAN GROWTH PATTERN AND BROADBAND CABLE SERVICE DEPLOYMENT IN THE TOWN OF OTTAWA, WAUKESHA COUNTY, WISCONSIN: MAY 2000



LEGEND

AREAS OF URBAN DEVELOPMENT 2000

CABLE DEPLOYMENT 2006

Source: SEWRPC.

Map 13

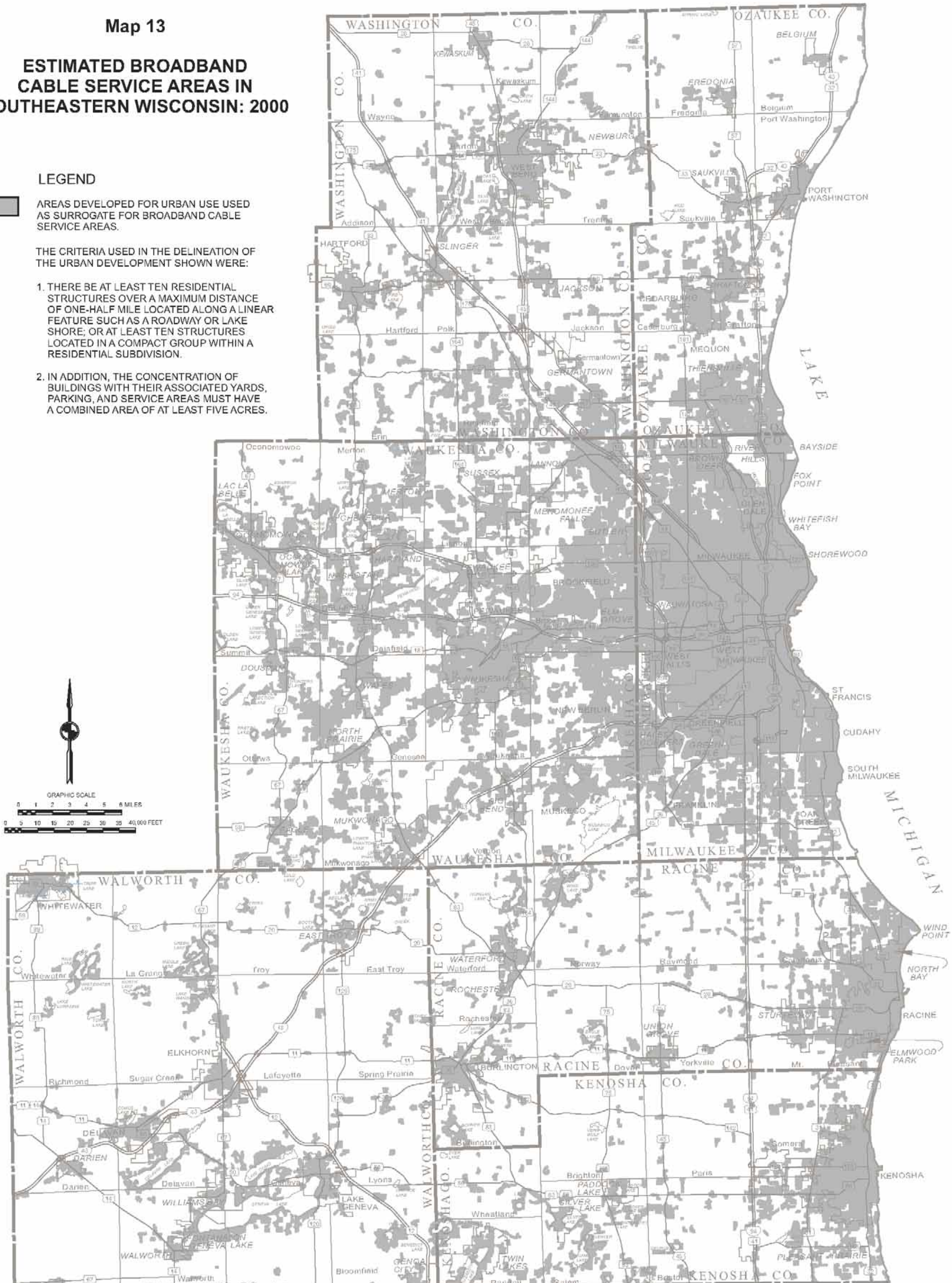
ESTIMATED BROADBAND CABLE SERVICE AREAS IN SOUTHEASTERN WISCONSIN: 2000

LEGEND

AREAS DEVELOPED FOR URBAN USE USED AS SURROGATE FOR BROADBAND CABLE SERVICE AREAS.

THE CRITERIA USED IN THE DELINEATION OF THE URBAN DEVELOPMENT SHOWN WERE:

1. THERE BE AT LEAST TEN RESIDENTIAL STRUCTURES OVER A MAXIMUM DISTANCE OF ONE-HALF MILE LOCATED ALONG A LINEAR FEATURE SUCH AS A ROADWAY OR LAKE SHORE; OR AT LEAST TEN STRUCTURES LOCATED IN A COMPACT GROUP WITHIN A RESIDENTIAL SUBDIVISION.
2. IN ADDITION, THE CONCENTRATION OF BUILDINGS WITH THEIR ASSOCIATED YARDS, PARKING, AND SERVICE AREAS MUST HAVE A COMBINED AREA OF AT LEAST FIVE ACRES.



Source: SEWRPC.

broadband cable service, is not symmetrical with download speeds much faster than upload speeds by a factor as high as ten to one.

Six Incumbent Local Exchange Carrier (ILEC) telephone companies provide broadband DSL services in the Region:

1. AT&T
2. Century Tel
3. Verizon North
4. Telephone and Data Systems, Inc.
5. State Long Distance Telephone Co.
6. Sharon Telephone Co.

AT&T is the major Incumbent Local Exchange Carrier (ILEC) telephone and DSL broadband service provider in the Region, providing service in parts or all of the seven counties, and in total, services about 61 percent of the land area of the Region. Citing concerns regarding making competitive information public, neither AT&T nor any of the other five regional ILECs agreed to provide maps of their DSL service coverage areas. Four of the six carriers—excluding Verizon and Telephone and Data Systems, Inc.—provided estimates of the percentage DSL coverage of their ILEC areas. Lacking DSL service area information from most ILECs, a Regional DSL coverage map was prepared as Map 14 which delineates the DSL coverage areas of all regional carriers based on 18,000 feet radius circles around each of the central offices of the various providers. DSL coverage for all providers based on central offices locations approximates 64 percent of the total area of the Region. For AT&T, central office-based DSL coverage is estimated at about 66 percent of the total AT&T service area, and about 40 percent of the total area of the Region. Map 15 provides additional graphic information concerning the AT&T service area.

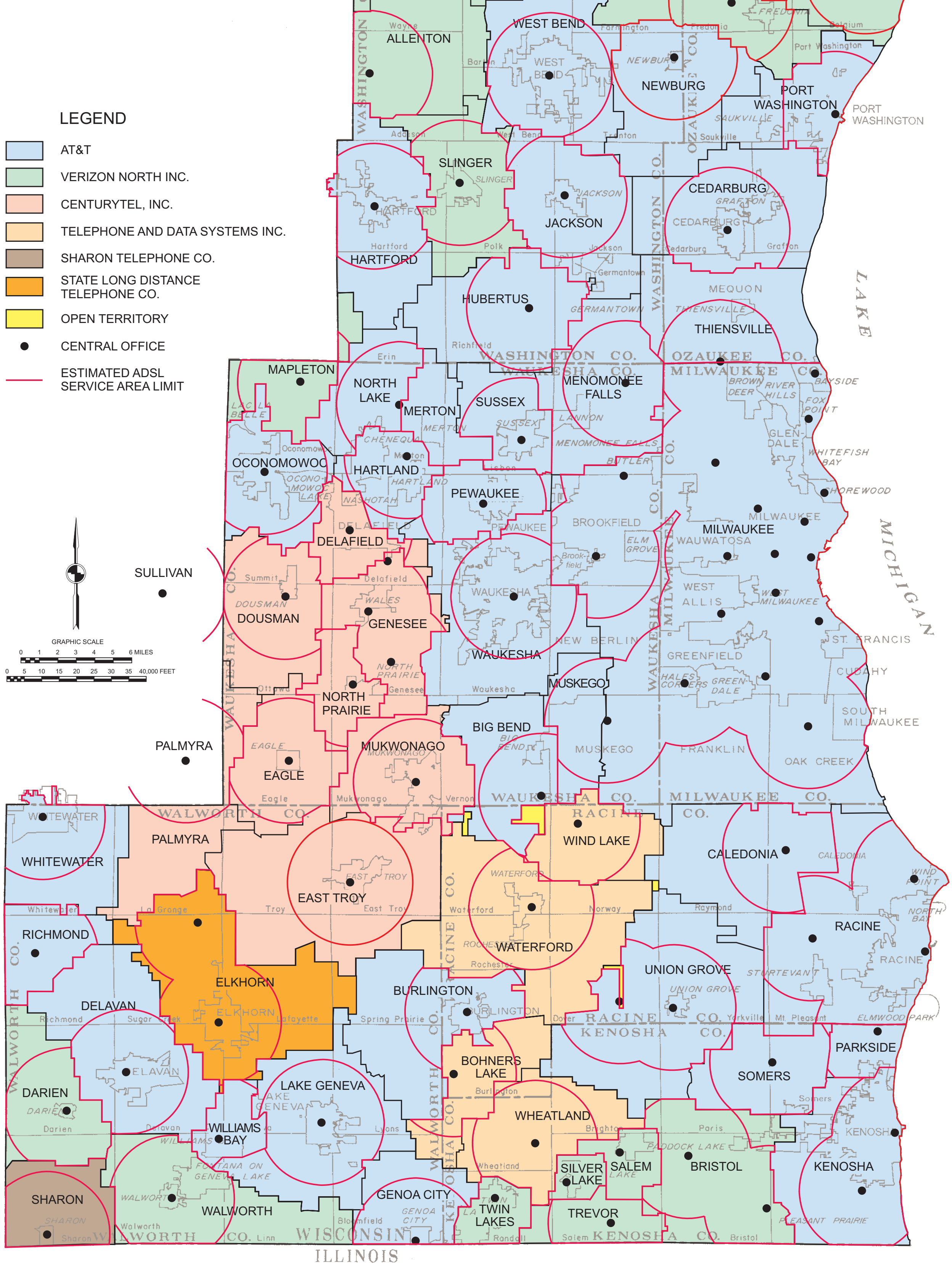
It is recognized that the 18,000 foot radius centered on central offices as a basis for the delineation of DSL service represents an over-simplification of the actual situation. Asymmetric digital subscriber line (ADSL), which represents the predominant version of DSL service, is a distance sensitive technology. Signal quality and throughput decrease as the connection length increases. The distance limit for DSL service, however, is typically defined as 18,000 feet to be consistent with the downstream speeds of 1.5 megabits per second generally offered to DSL users. At shorter connection lengths, signal levels will be elevated, and faster throughput speeds are possible. For example, at distances of about 6,000 feet, downstream data rates of 8 megabits per second may be achieved. ADSL performance is governed by the same Shannon's Law previously referenced in this report with respect to wireless communication links. This law identifies bandwidth and signal/noise ratio as the primary determinants of channel capacity. In DSL, as in wireless links, signal quality—signal-to-noise ratio—varies with link distance. The 18,000 feet link distance defines a level of signal quality consistent with upstream and downstream data rates defined as the service offering by the wireline carrier. Distances longer than 18,000 feet will result in signal quality levels and channel capacities below this service quality standard. Other versions of DSL are sometimes offered by wireline carriers. One version, very high bit rate digital subscriber line (VDSL) service, is capable of higher data rates but at reduced link distances. Other versions of DSL, such as rate-adaptive digital subscriber line, adjust link speeds depending on the length and quality of the connection.

Century Tel is the second largest ILEC DSL service provider in the Region, covering parts of Waukesha County and Walworth County. With their nine central offices in the region, the company covers over 65 percent of their ILEC area. Two additional central offices are located outside of the Region, one near Palmyra provides additional coverage in Walworth County and one in Sullivan provides additional coverage in Waukesha County. Based on information from Century Tel, DSL coverage has been extended to cover additional territory based on deployed fiber-linked remote terminals, known as Digital Subscriber Line Access Multiplexers (DSLAMs) that extend DSL coverage to previously unserviced areas. The company estimated that in 2006 about 81 percent of the Century Tel territory is eligible for DSL service. Uncovered areas are limited to parts of the Towns of Ottawa in Waukesha County, and the towns of Troy and East Troy in Walworth County.

Verizon North, Inc. is the ILEC service provider in many urban fringe areas located along the extreme north and south boundaries of the Region as shown on Map 14. Verizon purchased these properties from General Telephone and Electronics (GT&E) when Verizon was formed as part of the merger between Bell Atlantic and NYNEX in 1997. Operating 13 central offices in the Region, Verizon could offer DSL service in about 57 percent of 16 service areas concerned.

Map 14

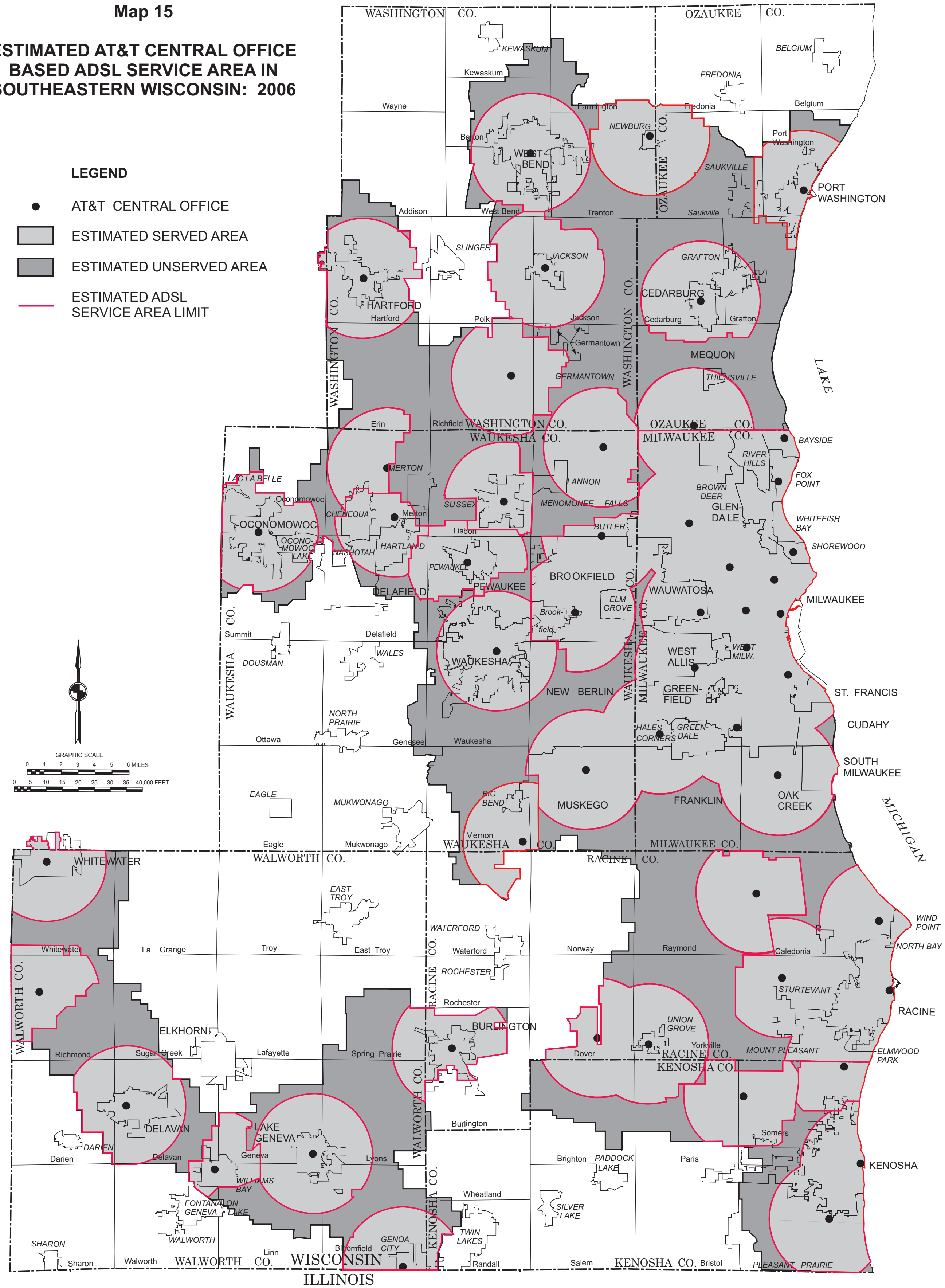
ADSL BROADBAND DEPLOYMENT IN SOUTHEASTERN WISCONSIN: 2006



Source: Wisconsin Department of Administration Office of Land Information Services and SEWRPC.

Map 15

ESTIMATED AT&T CENTRAL OFFICE BASED ADSL SERVICE AREA IN SOUTHEASTERN WISCONSIN: 2006



Source: Wisconsin Department of Administration Office of Land Information Services and SEWRPC.

Telephone and Data Systems, Inc. would not furnish any information for this inventory. Based on central office locations, TDS should offer service to about 57 percent of its ILEC area.

State Long Distance Telephone Company is a local provider headquartered in Elkhorn (Walworth County). It was cooperative in providing DSL coverage information for this inventory. Based on central office locations alone, the Company could offer service to about 73 percent of its ILEC area. Deployment of remote DSLAMs has increased coverage to about 95 percent of their ILEC area.

Sharon Telephone Company was also cooperative in providing information on their DSL deployment. As shown on Map 14, it is evident that this single central office of this provider is able to serve over 74 percent of their ILEC area. Company management stated that these unserved areas will be provided DSL service within the next six months.

The foregoing description of DSL deployment in Southeastern Wisconsin deals only with the services provided by Incumbent Local Exchange Carriers (ILECs). ILEC is an acronym derived from the Telecommunications Act of 1996 to describe existing local telephone companies such as AT&T, Century Tel or Verizon North. The term also includes smaller regional service providers such as the Sharon Telephone Company. ILEC service providers typically own the wireline network infrastructure with particular emphasis on the connections from the various central offices to DSL subscribers.

A second class of wireline service providers was created by the Telecommunications Act of 1996, the Competitive Local Exchange Carrier or CLEC. The CLEC concept involved the authorization of new local telephone companies that would compete with the incumbents in the telephone service market place. CLECs were granted access to the ILEC's infrastructure including the connections to each subscriber. This leased infrastructure was termed unbundled network element (UNE) and was intended to allow the CLEC to compete on an equal basis with the ILEC. The concept behind the Act also contemplated the development of new CLEC infrastructure as the CLECs prospered as economically viable local telephone and data service competitors. The reality in practice was quite different. CLECs found it very difficult to market an undifferentiated service with only a marginal price advantage. The end result was that most of the CLEC telephone companies failed, and CLEC competitive offerings are no longer a major factor in the regional end user communications marketplace. Some of the CLEC service providers created their own network facilities, while others operated as re-sellers of services using ILEC facilities. The former were generally more successful in the marketplace. Even those CLECs that provided their own central office facilities did not create any new access network infrastructure, the primary focus of this planning report.

Nevertheless, a competitive wireline infrastructure has been created in the form of core networks. Companies such as Time Warner Telecom and Norlight have deployed high capacity fiber optic networks that can serve as alternative Internet connection vehicles for new broadband wireless networks that may be developed within the Region.

Fiber to the Premises Broadband Deployment

Major wide area deployments of fiber to the premises broadband services are currently underway by Verizon Communications in the eastern parts of the United States. Such deployments are typically confined to metropolitan areas such as Boston, New York or Philadelphia. Some small communities in the Midwest, particularly in Minnesota, have deployed fiber to the premises networks. Reedsburg, Wisconsin deployed such a fiber network in 2003. The only known residential deployment of fiber to the premises in Southeastern Wisconsin is by AT&T in the new Pabst Farms Subdivision in the Oconomowoc area of Waukesha County. The company, however, is planning to deploy such access networks to an additional 24 land subdivision developments within the Region. Current services offer throughput performance of 2 to 4 megabits per second. This fiber network is based on architecture known under the designation PON—for passive optical network. Such networks provide faster service than cable networks that feature a tree-like architecture that requires primary fiber links to be shared with multiple users. Such fiber network architectures are in contrast with AON—active optical networks—topologies that provide a direct fiberlink to every subscriber.

Although the Pabst Farms development in Waukesha County may be the only publicly disclosed Fiber-To-The-Premises (FTTP) broadband access network service area in Southeastern Wisconsin, AT&T, the major ILEC in the Region, has initiated the deployment of FTTP and Fiber-To-The-Node (FTTN) access network service to other as yet undisclosed areas within Southeastern Wisconsin. Based on documents furnished by AT&T, this service provider is following a mixed FTTN-FTTP broadband deployment strategy within the Region. In the Fiber-To-The-Node approach being developed by AT&T, fiber optic cables are extended out to neighborhood locations providing nodes which can then service a significant number of copper wire-linked users with higher speed versions of DSL having throughputs as high as 25 megabits per second in a service area lying within a radius of approximately 3,000 feet of a node. The FTTN approach significantly reduces the capital investment required, while still offering the bandwidth necessary for high speed voice, data and various forms of video services. At the same time, an FTTN broadband deployment allows for later expansion to a full scale FTTP network in which fiber-based bandwidth is deployed directly to user premises. As of the date of publication of this report, AT&T is proposing to provide FTTN service through its Project Lightspeed to 44 of the 116 municipalities within Southeastern Wisconsin that AT&T serves.

Wireline Broadband Inventory Summary

DSL broadband wireline coverage of the Region is broad and comprehensive since all of the incumbent telephone-based carriers have offered DSL services in their respective ILEC areas. As already noted, potential coverage based on original central office locations is estimated at 64 percent of the total area of the Region. Deployment of DSLAM remote terminals is estimated to have expanded that coverage to an estimated 82 percent overall. Century Tel reports its DSL areal coverage at an estimated 81 percent. AT&T, the major ILEC in the Region also reports a current DSL coverage figure of 81 percent. Since their original central office coverage was estimated at 66 percent, the incremental addition from DSLAM deployment is about 15 percent. Smaller carriers such as Sharon and State (Elkhorn) tend to service their areas earlier and more completely than the larger carriers with both reporting coverage over 90 percent.

Cable service providers utilize a hybrid fiber coaxial (HFC) cable network topology, in which the user connection is provided by a coaxial cable link. Fiber optic lines are brought to a geographic area in the same manner as the telephone system Fiber-To-The Node (FTTN) configuration described above. The HFC cable method differs from the FTTN network structure in that it does not provide a direct nodal connection to each user in the manner of FTTN. Rather the HFC cable network deploys a bus type architecture in which a node—known as a "head-end"—is provided to serve a set of subscribers through an access line—known as a "bus"—serving a number of subscribers through coaxial cable connections from the bus. Such an architecture has the disadvantage of any shared medium in that performance degrades as more subscribers share the common lines – the bus. The fiber link serving the headend is also shared, but a fiber channel has such great capacity that it does not limit system performance. Cable service providers do not generally provide direct fiber links to individual subscribers.

Broadband cable coverage presents a much different situation. Ten townships representing about 324 square miles or about 12 percent of the land area of the region are without any cable service, lacking a franchise agreement with any cable provider. An additional 11 townships with population densities under 100 persons per square mile tend to be underserved even though they have franchise agreements. These underserved areas accrue to a total of about 700 square miles, or about 26 percent of the Region. Prospects for further broadband cable franchising and coverage depend on future residential urban development.

Referencing the fourth generation communications standards set forth in Chapter III of this report, none of the cable broadband networks are capable of achieving the throughput standard of 20 megabits per second. The hybrid fiber coaxial networks of the cable providers are, moreover, filling up and slowing down under a heavy load of users. A throughput standard of 20 megabits per second is still modest compared to Japan's 2008 target standard of 100 megabits per second for every potential user in that country. Current ADSL cable network technologies are reaching, or have reached, the limit of their performance capabilities. AT&T, however, has announced a new program called Project Lightspeed that is intended to upgrade ADSL technology in the form of VDSL technology which will provide throughput speeds of 20 megabits per second.

The next step in the wireline broadband access evolution may be expected to be a combination of fiber-to-the-node and fiber-to-the-premises technologies. Such deployments would represent major investments on the part of telephone and cable providers. If universal broadband coverage is to be achieved, as received by the standard set forth in Chapter III, then the Region must evaluate other broadband telecommunications alternatives to provide the desired universal coverage within the Region. The Region must take a proactive stance, and plan an aggressive broadband deployment program in both wireline and wireless broadband communications.

BROADBAND WIRELESS SERVICE AREA INVENTORY

The wireless service area inventories require explanation from two viewpoints:

1. Broadband Performance Standard
   The FCC defines broadband service as service providing a throughput exceeding 200 kilobits per second. Some of the wireless service areas do not meet this performance standard. All of the wireless carriers however, are either contemplating, or executing third generation (3G) conversion plans which will comply with the FCC broadband standard. These 3G conversions will be based primarily on existing antenna base station sites. For these reasons, the defined service areas will represent a mixture of 2G and 3G performance, trending, however toward broadband communications standards.

2. Network Parameters
   The wireless geographic service areas herein presented are based on radio propagation modeling. Accurate results from such modeling requires information on the power output and sectoral organization as well as the height and location of the antennae comprising the network. The height and location data are well known for the great majority of antenna sites. Technical data on radiated power and sectoral organization on specific sites are less well known and are guarded as confidential data by the cellular-PCS carriers. The wireless communications technologies are well understood, however, so that radio coverage maps prepared with estimated average power levels should closely approximate wireless carrier service areas.

Infrastructure Inventory Data Sources and Models

The comprehensive telecommunications infrastructure inventory compiled in this report is based on a combination of wireless and wireline telecommunications data sources. The original wireless data sources used in the antenna site and related infrastructure inventories presented in SEWRPC Planning Report No. 51 were also utilized in the geographic service inventory reported here. These sources include:

1. FCC Database
   This database provided the starting point for the antenna site inventory, particularly with respect to the cellular 800-900 MHz band. It was less useful and comprehensive for the higher 1900 MHz PCS band.

2. Local Units of Government
   The county and municipal governments provided the primary and most dependable source for antenna site location and height data. These sources, however, were not able to provide much data on the technical characteristics of the antenna and the supporting base station.

3. Wireless Service Providers
   Wireless service providers in general were unwilling to provide antenna site and related infrastructure data for their antenna base station sites. Exceptions were Sprint and Nextel. Sprint PCS furnished network sites for all counties except Kenosha, which is managed as part of their Chicago region. Nextel, which is now part of Sprint, furnished geographic site data but no attendant technical data on all of the Region.

Data from the aforereferenced sources were compiled into the antenna site and related infrastructure inventory reported in SEWRPC Planning Report No. 51. These data were then used in radio propagation simulation modeling to appropriate the geographic coverage provided by each of the antenna base station sites.

To understand the basis of the mapped wireless geographic service areas, it is necessary to understand radio propagation modeling in a functional sense with respect to the inputs, processes and outputs involved. Avoiding a technical discussion of the theory of radio wave propagation or the mathematical aspects, it is possible to appreciate basic model operation and to make judgments concerning the validity of the coverage maps produced.

The radio propagation modeling used was based on the EDX Signal Pro™ software package provided by EDX Wireless of Eugene, Oregon. This software package provides for a variety of radio propagation model-based area coverage, point-to-point path analysis and route studies for use in wireless network design. The area coverage studies were considered applicable for the generation of the geographic area maps developed for this planning report. To develop a geographic service area map for a set of wireless antenna base station sites, the following mathematical model and data inputs for that model were required.

1. Propagation model used:
   The Anderson 2Dv1.00 model was used. This is a physical model used by wireless communications engineers world wide.

2. Quality of service level selection
   This model input determines the percentage of time the signal level and the resulting quality of service that will be provided. The 90 percent level was selected.

3. Topographic database
   With a choice of terrain data, clutter loss data, or canopy data, the clutter database was selected for use with the model. This data base most realistically reflects the radio propagation environment, since it provides for signal attention due to trees and structures.

4. Transmitter site data
   The data required for each transmitter site—base station—included: site elevation; antenna height; site coordinates expressed in State Plane Coordinates, North American Datum of 1927; antenna type—sectoral or omnidirectional; antenna sectoral orientation; transmitter power; antenna pattern; and receiver parameters.

5. Remote site data
   The data required for each remote site—included: site elevation; antenna height; site coordinates expressed in State Plane Coordinates, North American Datum of 1927; antenna type—sectoral or omnidirectional; antenna sectoral orientation; transmit power; antenna pattern; antenna gain; and receiver parameters.

Based on the afore listed input data, the selected radio propagation model will generate a geographic service coverage area map for each antenna base station site. This coverage map will indicate the radio frequency signal level at various distances from the antenna site. Because of terrain and ground clutter variations, these signal levels will not be uniform in all directions from the antenna site. Areas characterized by dense woodlands or extensive building structures will attenuate signal levels within the areas concerned and beyond. In extreme circumstances, the signal level may drop below the noise floor preventing effective communication in a given area.

Employing the infrastructure data collected and analyzed in SEWRPC Planning Report No. 51, supplemented by estimates of data on antennae transmitter powers and patterns, the wireless service area maps herein presented were developed.

Mobile Cellular/PCS
Geographic Coverage Inventory
The mobile cellular geographic coverage inventory defines the signal level coverage of each of six wireless service providers operating within Southeastern Wisconsin. Based on these signal levels, the 90 percent availability and quality of service level and upon the capabilities of user cell phone devices, the border lines of service areas may be delineated. The defined coverage areas will provide the specified quality of service for both data and voice services. Based on earlier experience with both the Sprint and Nextel networks, estimated service levels were delineated showing levels of good service, marginal service and no service. These radio propagation maps together with the original signal level propagation maps for each provider defines cellular-PCS service levels in the Region.

Base station locations and antenna heights for all six cellular-PCS providers are fairly well known from the antenna site and related infrastructure inventory.

Technical data on radiated power levels and sectoral orientations are known only for Sprint. Estimated power levels and 120 degree sectoral orientations were used for the other five providers based on their individual technologies—CDMA, GSM or iDEN. A justification for the common treatment of all wireless providers with some modification for wireless lies in the limiting factor present in all wireless networks – the user equipment, here the cellphone. Limited in both receiver sensitivity and transmitter power, the cellphone establishes the limits of cellular coverage. While there are differences in cell phone technology and performance, transmitter power is limited by FCC regulation to 0.6 watts and receiver sensitivity differences are believed to be small.

Regional Wireless Service Coverage—Sprint

Sprint was selected first for evaluation because Commission staff had access to definitive network information for this carrier, has worked with the Company on an antenna site location project, and understands some of carrier's criteria for site selection. Sprint employs CDMA technology and operates in the 1931 to 1935 MHz frequency band. A transmit power of 2.4 watts was used in the modeling for all base stations with antenna gains of minus 15.5 to minus 22.5 dBi. Map 16 indicates the regional signal level coverage starting with an initial signal level over minus 76.9 dBmW and ending with a signal level less than minus 109.1 dBmW. The color pattern on Map 16 indicates the signal level range within the Region. Map 17 provides a simplified view of service quality at three levels:

1. Green for good service
   Signal over –91.9 dBmW

2. Yellow for marginal service
   Signals between –91.9 dBmW and –109.1 dBmW

3. White for no service
   Signals below –109.1 dBmW

A review of Map 17 indicates the presence within the Region of some areas of marginal performance, and some areas of no coverage. Operating in the 1900 MHz frequency band, results in greater radio path attenuation, than operating in the 800 to 900 MHz band.

Regional Wireless Service Coverage—Nextel

Although Nextel was acquired by Sprint in 2005, it still operates as a separate network with a different technology, iDEN, which features push-to-talk communications and is especially popular with public safety agencies and with industries having mobile employees. iDEN, which is an acronym for Integrated Dispatch Enhanced Network, was developed by Motorola for dispatch-oriented communications, but has become a popular wireless network for a variety of users. It employs a TDMA modulation method which is becoming obsolete for third generation wireless communications. Nextel service coverage within the Region is robust with few areas of marginal performance. Maps 18 and 19, display signal level and service quality performance respectively for the provider.

Regional Wireless Service Coverage—Verizon Wireless

Map 20 displays the radio propagation signal levels of Verizon's network, and Map 21 the three levels of service indicated by these signal levels. Like Sprint, Verizon employs CDMA technology so similar antenna output parameters to those used for the Sprint system were used in the radio propagation modeling for the Verizon system. Map 21, indicates that Verizon provides a good level of service to a higher proportion of its service area than does Sprint with the same technology. Verizon, however, lacks a good level of service coverage of major areas in western Walworth and Waukesha County, and of some of the northern areas of Ozaukee and Washington Counties. Some lack of good rural coverage also exists in parts of Kenosha County.

Regional Wireless Service Coverage—Cingular Wireless

Maps 22 and 23 constitute the radio coverage maps for Cingular Wireless. The uniformly high quality signal levels—above minus 76.9 dBmW—are evident throughout the Region. Consistent with GSM base station practice, the power levels were set at 45 watts in each 120 degree sector. Marginal service quality areas were found to be limited to the extreme southwest corner of Waukesha County, and to small areas of Washington and Ozaukee Counties. The GSM technology used by Cingular is the standard technology used throughout most of the world.

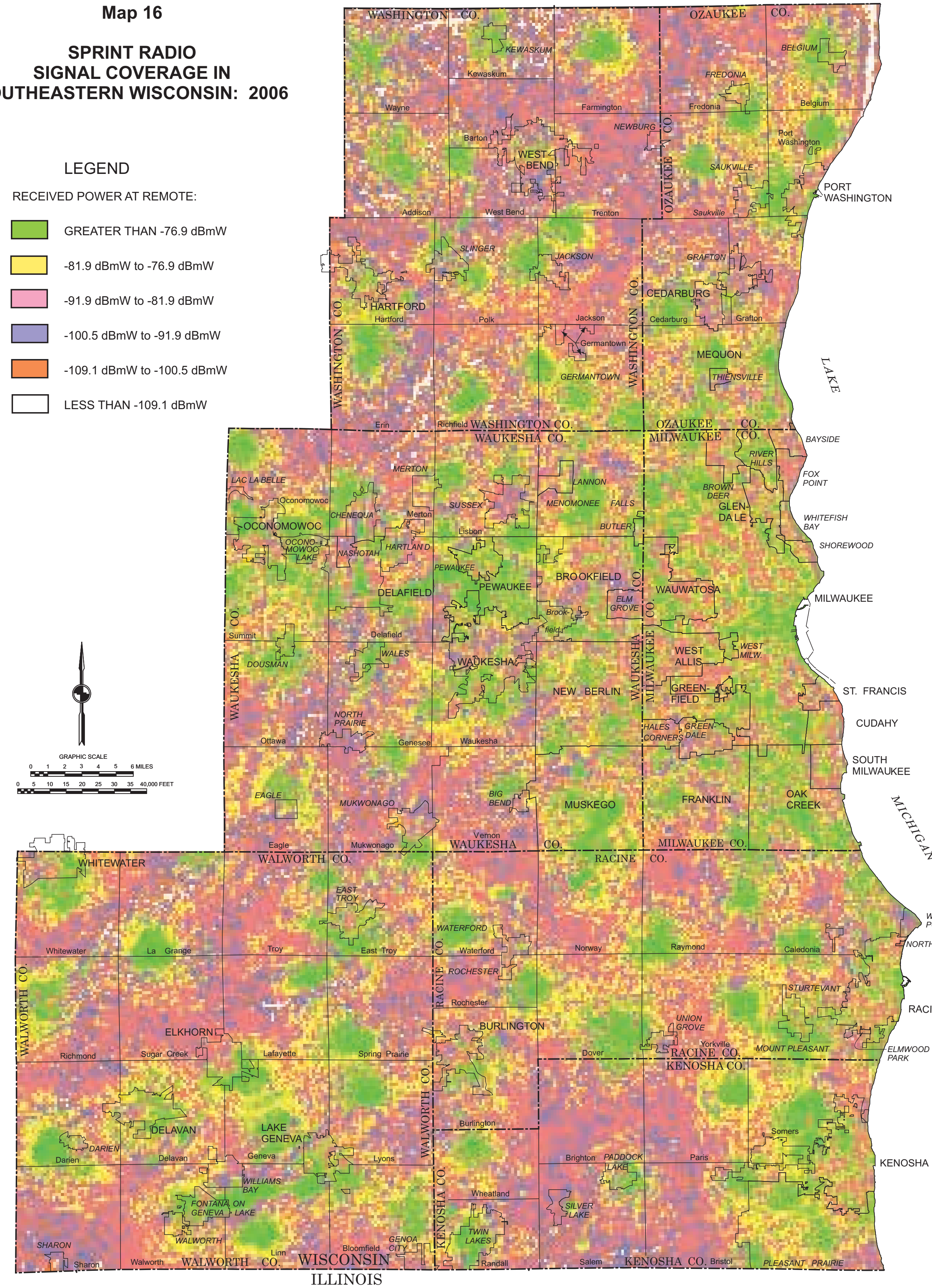
Map 16

SPRINT RADIO SIGNAL COVERAGE IN SOUTHEASTERN WISCONSIN: 2006

LEGEND

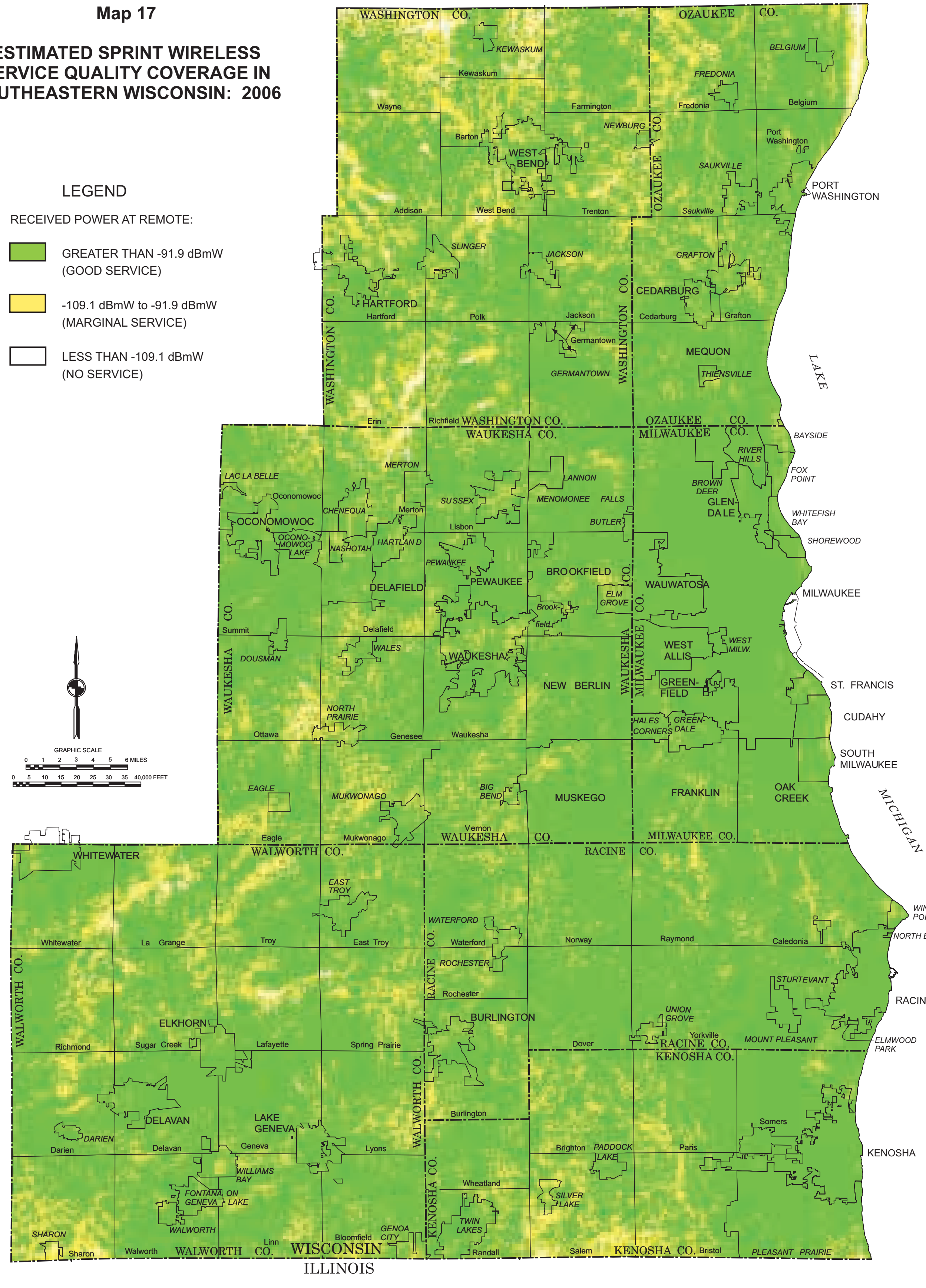
RECEIVED POWER AT REMOTE:

- GREATER THAN -76.9 dBmW
- -81.9 dBmW to -76.9 dBmW
- -91.9 dBmW to -81.9 dBmW
- -100.5 dBmW to -91.9 dBmW
- -109.1 dBmW to -100.5 dBmW
- LESS THAN -109.1 dBmW



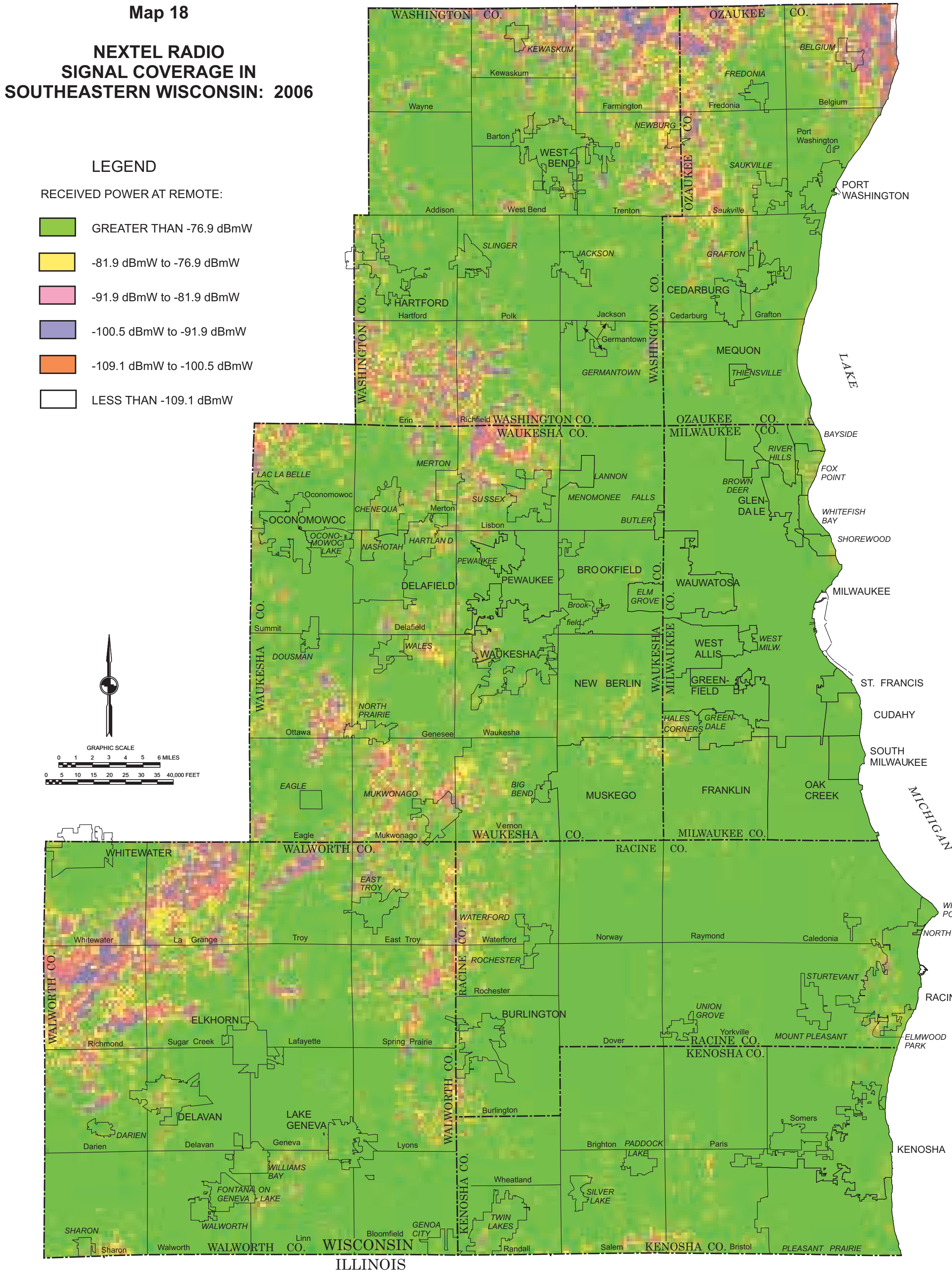
Map 17

ESTIMATED SPRINT WIRELESS SERVICE QUALITY COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Map 18

NEXTEL RADIO SIGNAL COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

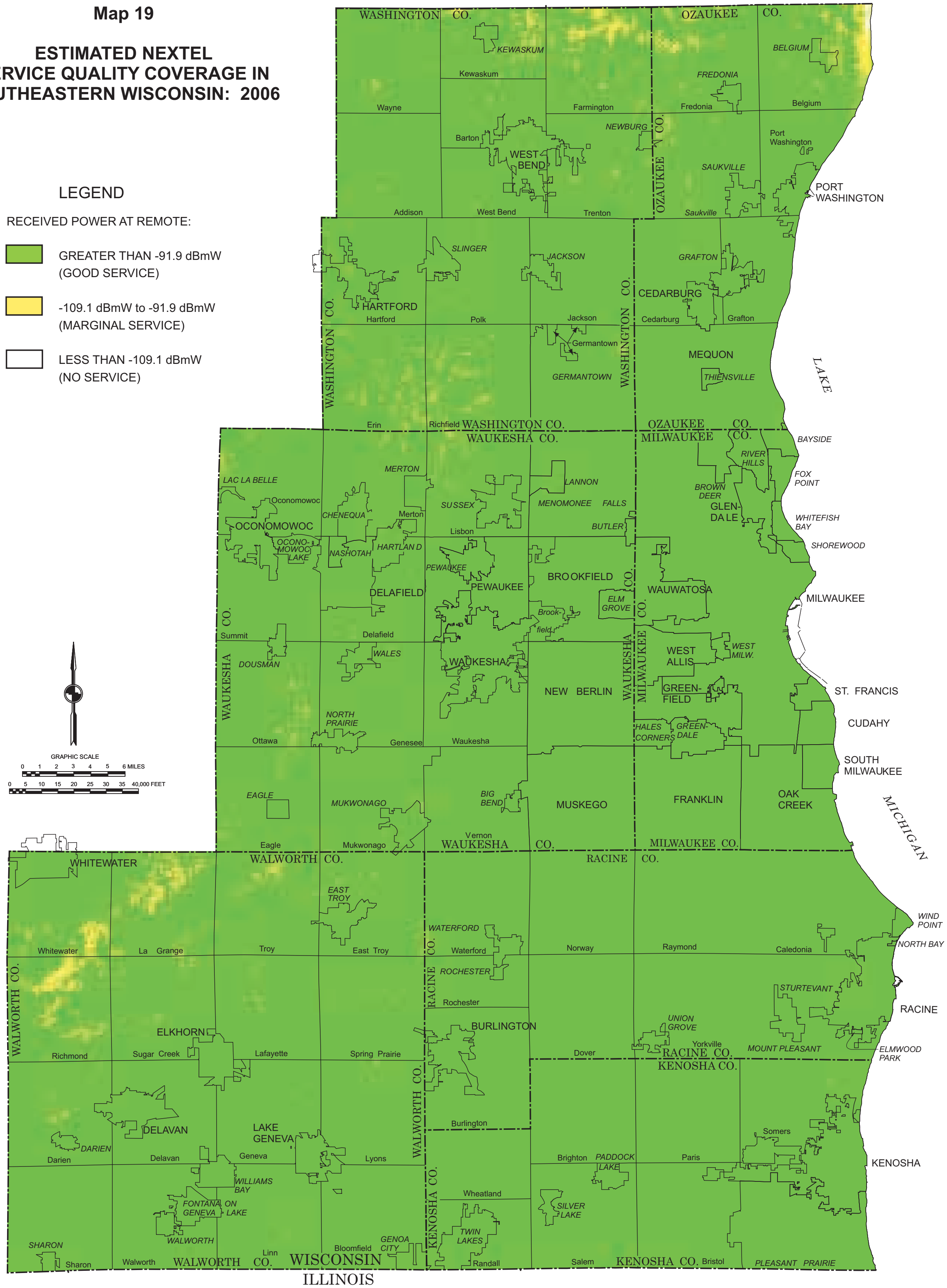
Map 19

ESTIMATED NEXTEL SERVICE QUALITY COVERAGE IN SOUTHEASTERN WISCONSIN: 2006

LEGEND

RECEIVED POWER AT REMOTE:

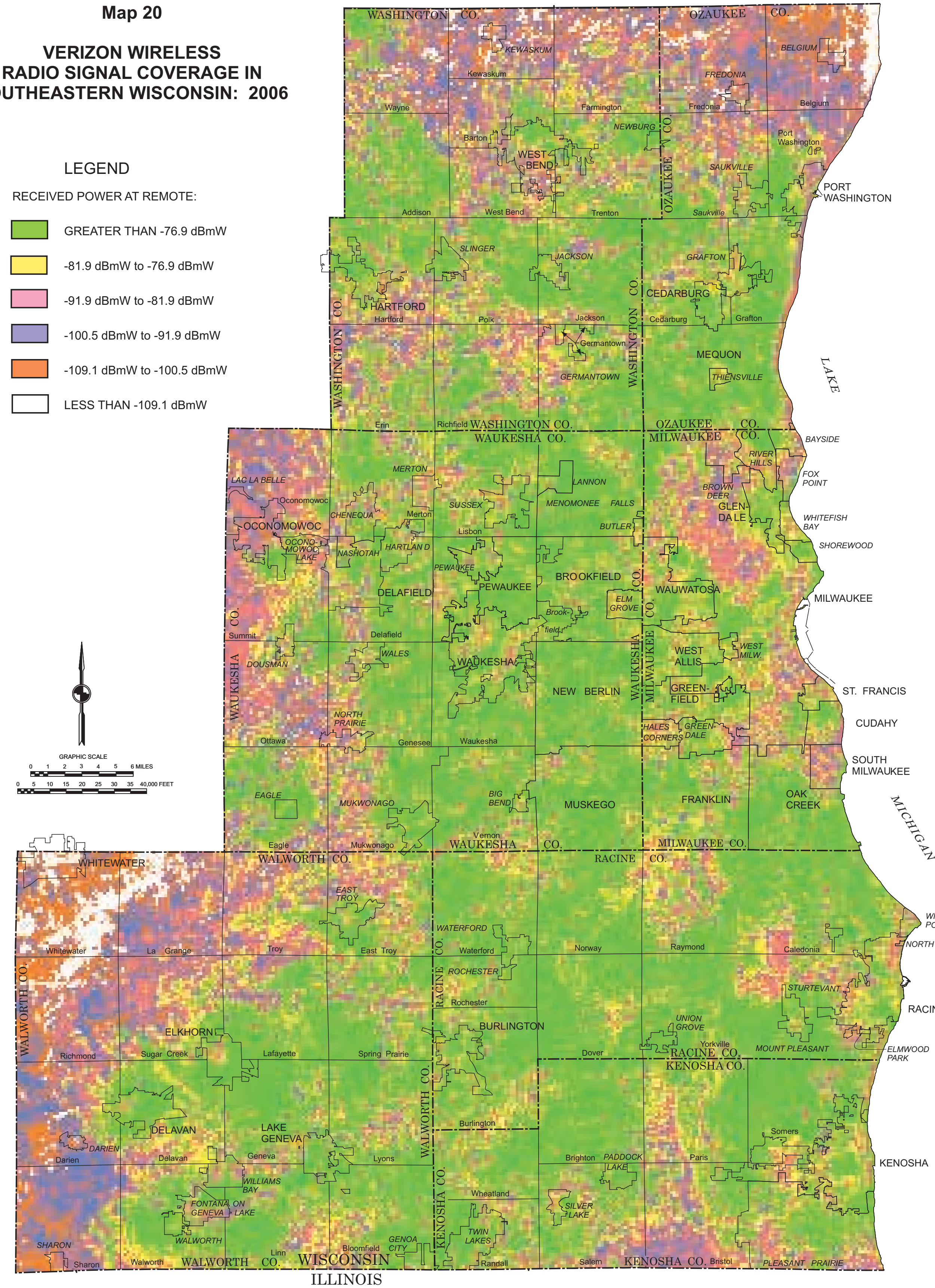
- GREATER THAN -91.9 dBmW (GOOD SERVICE)
- -109.1 dBmW to -91.9 dBmW (MARGINAL SERVICE)
- LESS THAN -109.1 dBmW (NO SERVICE)



Source: SEWRPC.

Map 20

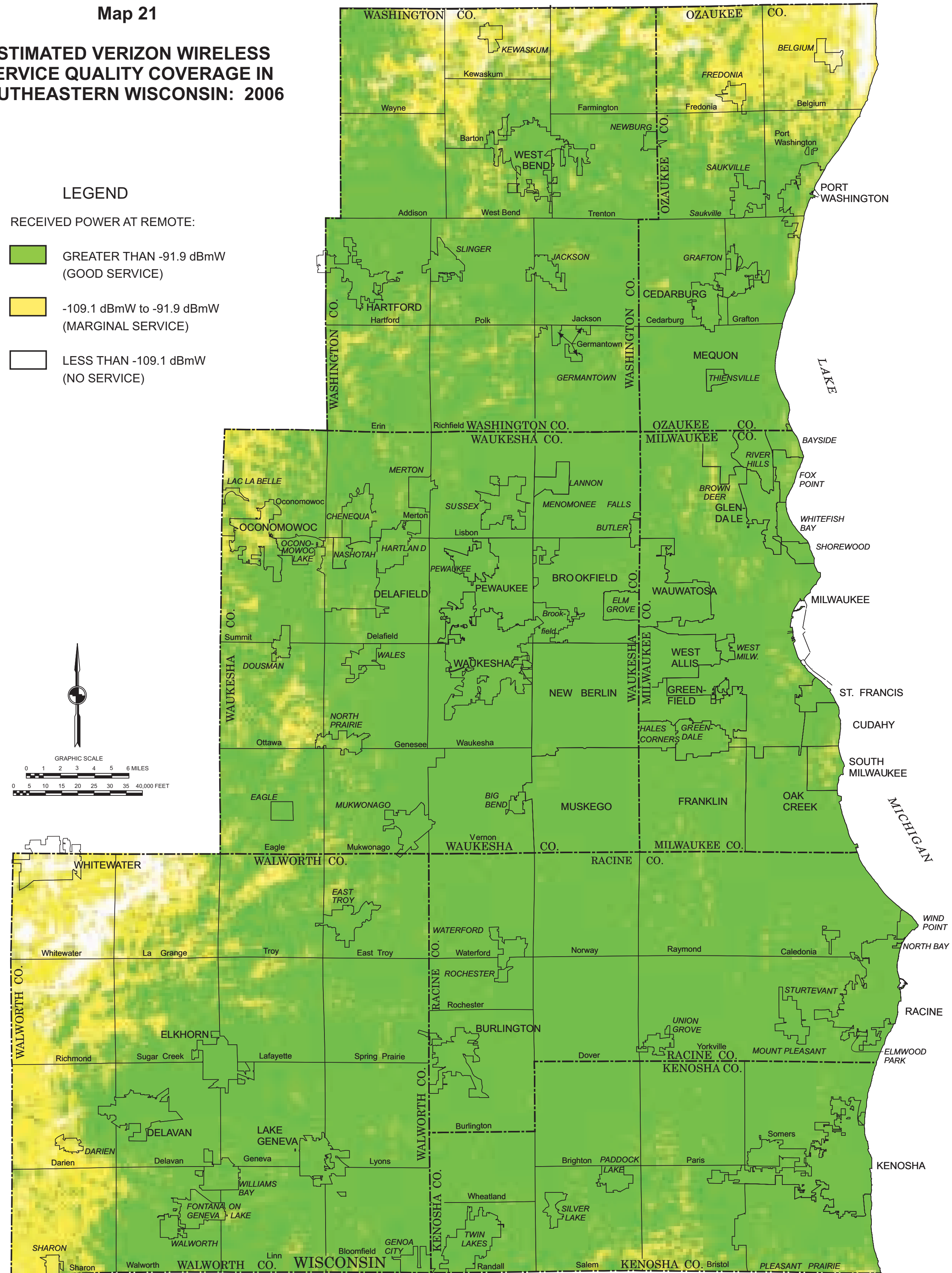
VERIZON WIRELESS RADIO SIGNAL COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 21

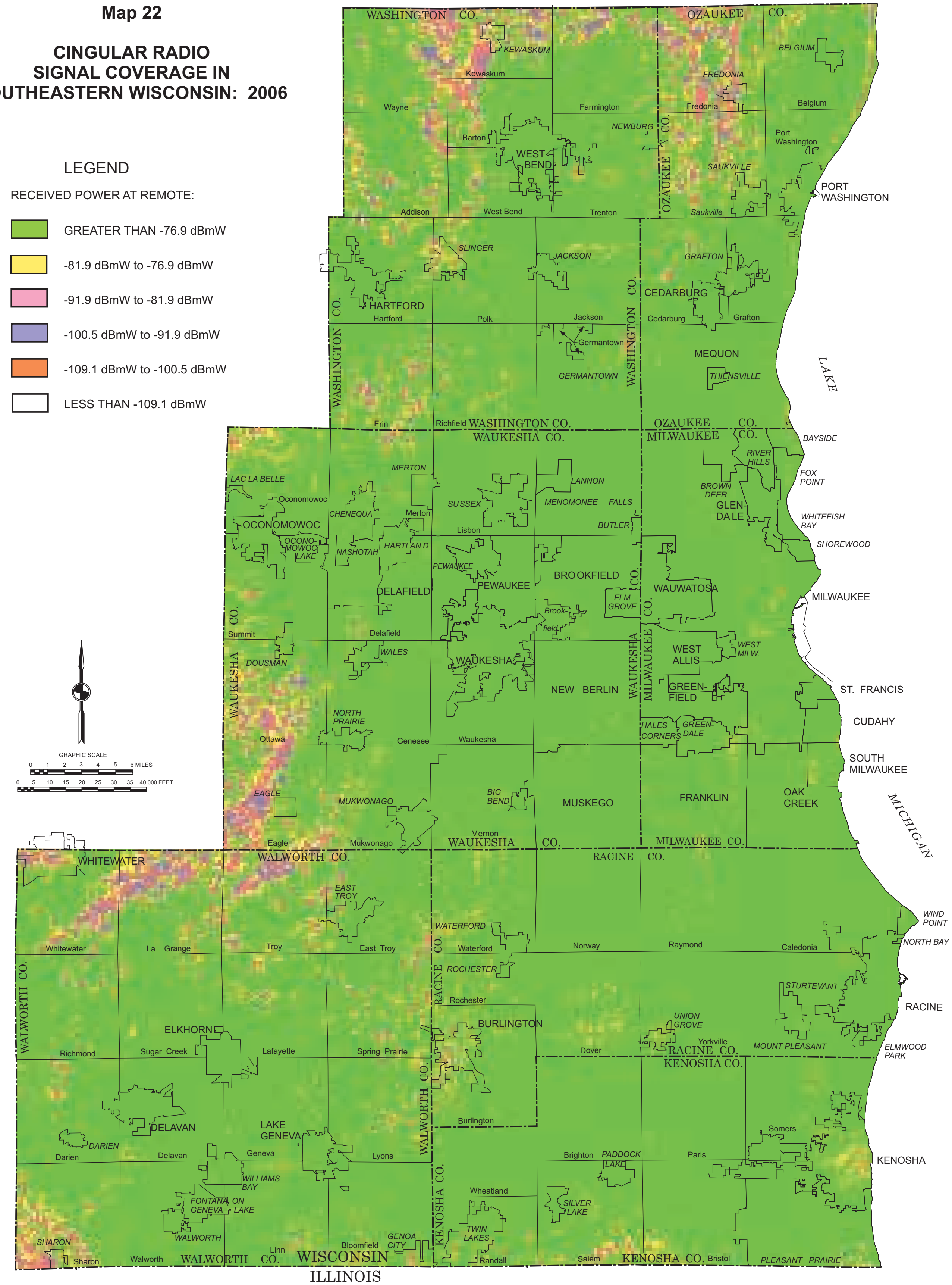
ESTIMATED VERIZON WIRELESS SERVICE QUALITY COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 22

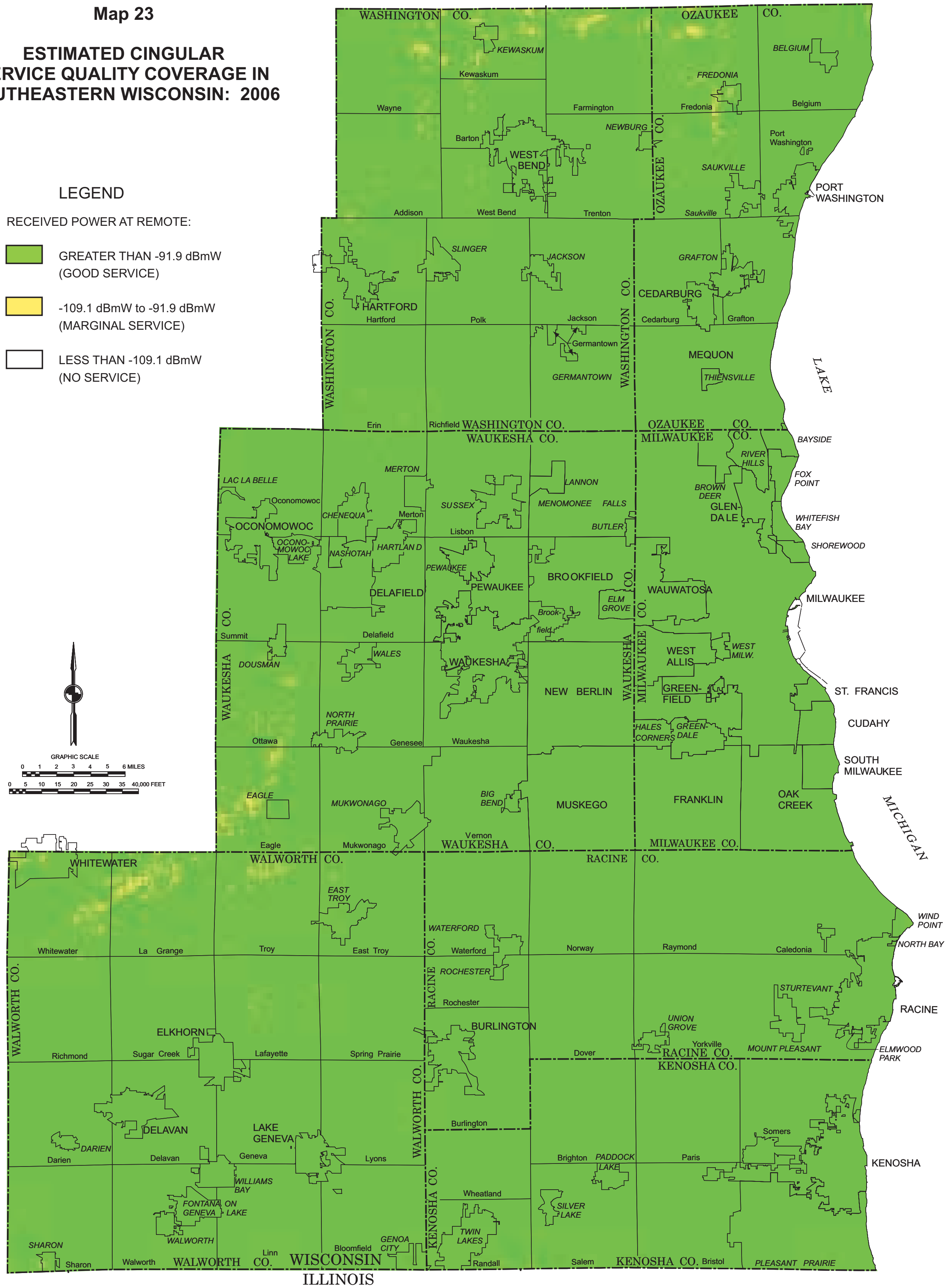
CINGULAR RADIO SIGNAL COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 23

ESTIMATED CINGULAR SERVICE QUALITY COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Regional Wireless Service Coverage—U.S. Cellular

U.S. Cellular is the third CDMA network provider within the Region considered. This provider is unique in having no circuit-switched component in its network. Maps 24 and 25 constitute the radio coverage maps for this provider. The maps indicate that there are numerous areas with marginal coverage located throughout the Region, with particular areas of deficiencies in Ozaukee, Washington, and Walworth Counties. The reasons for such scattered marginal performance apparently relates to network layout since U.S. Cellular has one of the largest number of base stations in the Region. U.S. Cellular consistently showed the lowest availability rate of any of the six regional wireless service providers in recent performance monitoring by the Commission.

Regional Wireless Service Coverage—T-Mobile

The coverage provided by T-Mobile, a second GSM wireless carrier operating within the Region, differs significantly from that provided by the first, Cingular, in the marginal nature of its coverage in many areas of the Region. This carrier provides poor or no coverage, in most of Walworth County and southwestern Waukesha County. The service also has significant gaps in Washington and Ozaukee Counties despite the fact that common power levels were used for all providers in radio propagation modeling. The radio signal coverage is shown in Map 26 and the service quality coverage in Map 27.

Summary – Wireless Service Area Inventory

The cellular-PCS wireless service inventory reveals a Region geographically well covered for mobile wireless voice communications. Five of the six regional wireless carriers provide mobile wireless services in all seven counties of the Region. The sixth carrier, T-Mobile, operates in six of the seven counties, with very limited service in Walworth County. Two of the carriers, Cingular and Nextel, have few areas with marginal coverage, and the remaining carriers provide quality service in the majority of the Region.

Data communications performance, however, is far below the objectives for fourth generation mobile wireless technologyset forth in Chapter III of this report. The previous seven-county regional wireless network performance inventory recorded download perfor-mance of only 178.2 kilobits per second, and upload performance of 63.3 kilobits per second for 2G networks. 3G networks improved to 336.0 kilobits per second for download, and 78.9 kbps for upload. Only the 3G download throughput qualifies for "little broadband" status based on the Federal Communications Commission standard of 200 kilobits per second. Many developed nations of the world have a higher broadband standard of 1.5 megabits per second. All of these performances are far below the throughput objective of 20 megabits per second set forth in Chapter III.

None of the three mobile wireless technologies employed in the Region—GSM, CDMA or iDEN—is suitable for upgrade to 4G performance levels. The two current competing 4G-class mobile technologies are WiMAX (802.16e), an emerging industry standard, and P2P, a proprietary Qualcomm technology now under development. Sprint is the only Regional mobile wireless carrier to announce field trials with WiMAX. It is fair to assume that deployment of any fourth generation mobile wireless network in Southeastern Wisconsin is at least three to four years in the future.

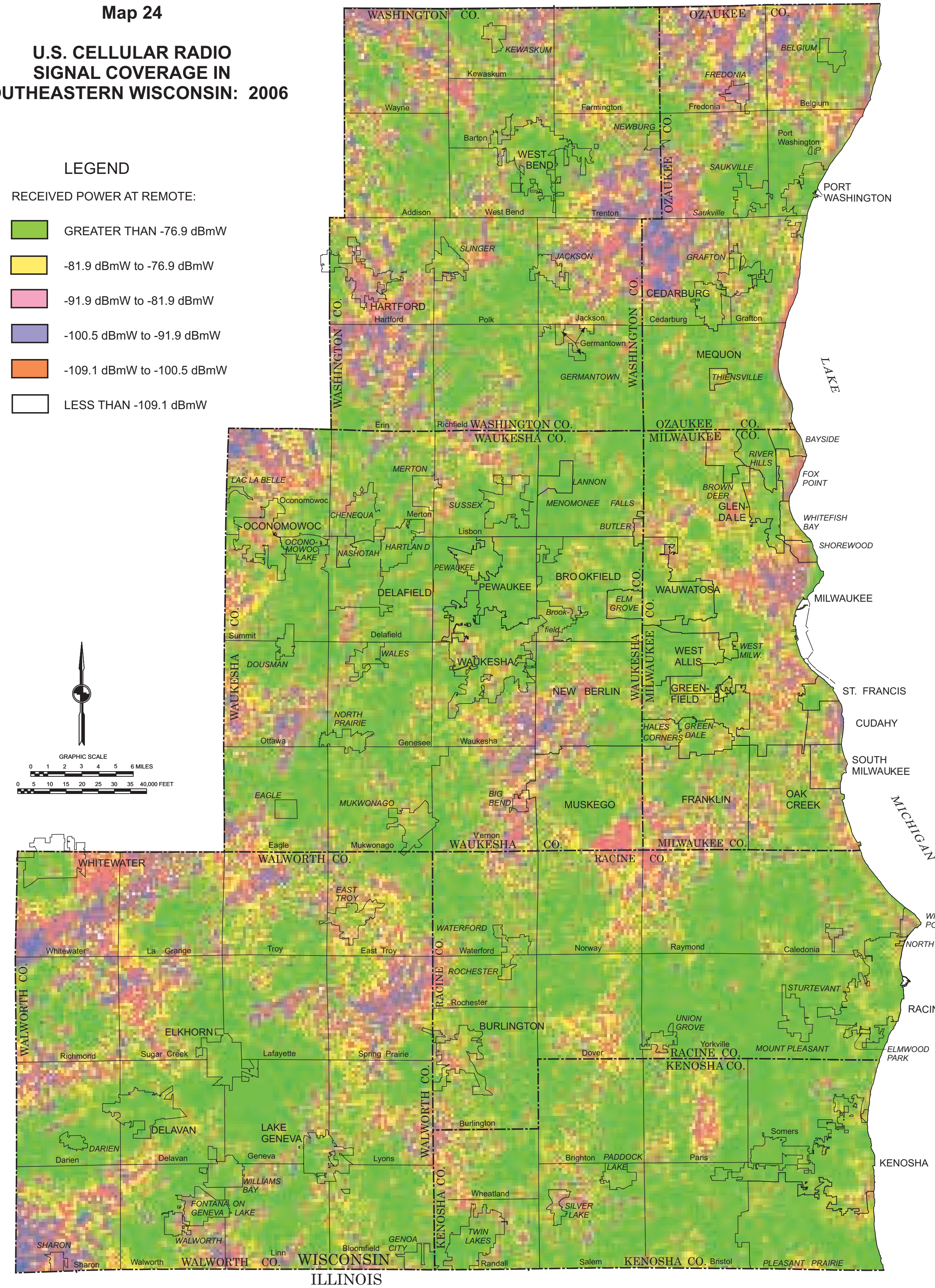
CORE NETWORK INVENTORY

Historically, points of presence (POPs) were the interexchange carriers' (IXC) equivalent of the local telephone company central offices. All long distance calls were routed through the IXC's POP facilities. In a traditional circuit-switched network, local exchange carrier calls would be provided a line—or channel—for the duration of the call. In the packet-switched networks of concern here, the POP provides an Internet connection to a fiber optic cable network capable of transporting the packet set to its destination. For incumbent local exchange carriers, the POP point is often located at a central office. The decentralized nature of packet-switched networks, and the ability of such networks to access outside of the POP locations makes traditional points-of-presence less important to advanced wireless communications systems as described below.

A partial core network inventory of existing points of presence (POP) locations was originally envisioned as a part of the regional telecommunications planning effort. Such POP points constitute important elements of any future broadband wireline or wireless communications system in the Region since they provide fiber optic connection

Map 24

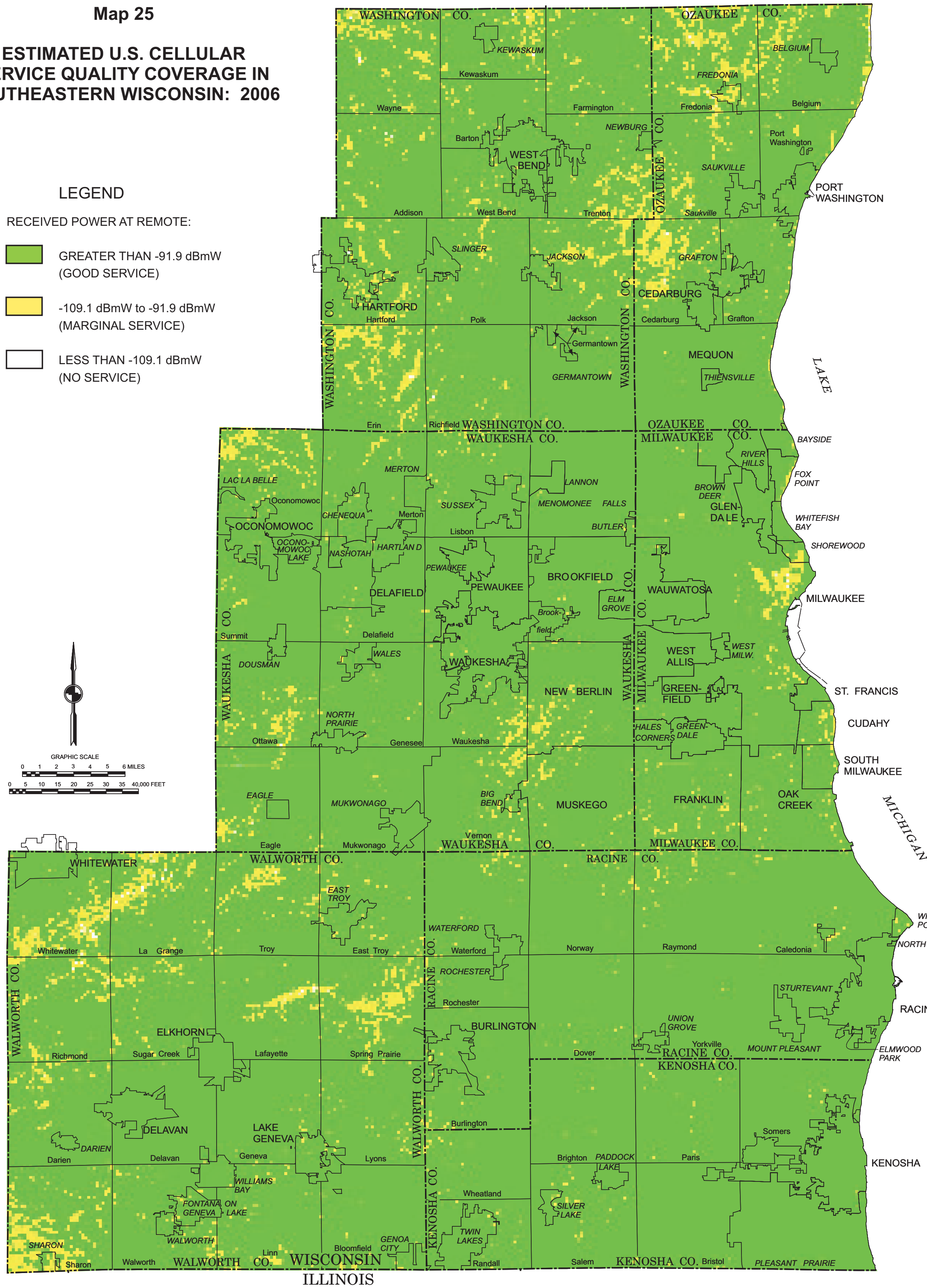
U.S. CELLULAR RADIO SIGNAL COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 25

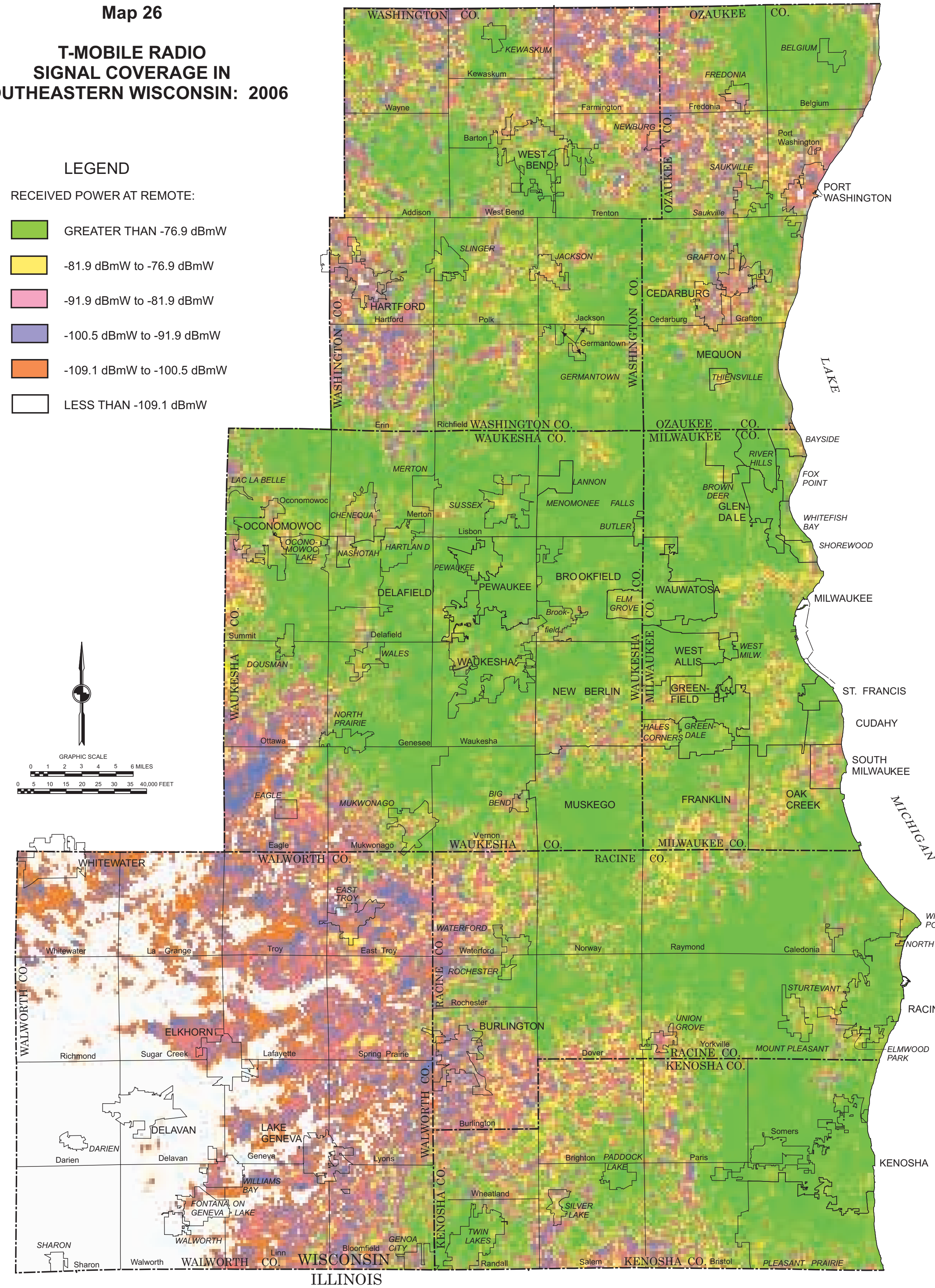
ESTIMATED U.S. CELLULAR SERVICE QUALITY COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 26

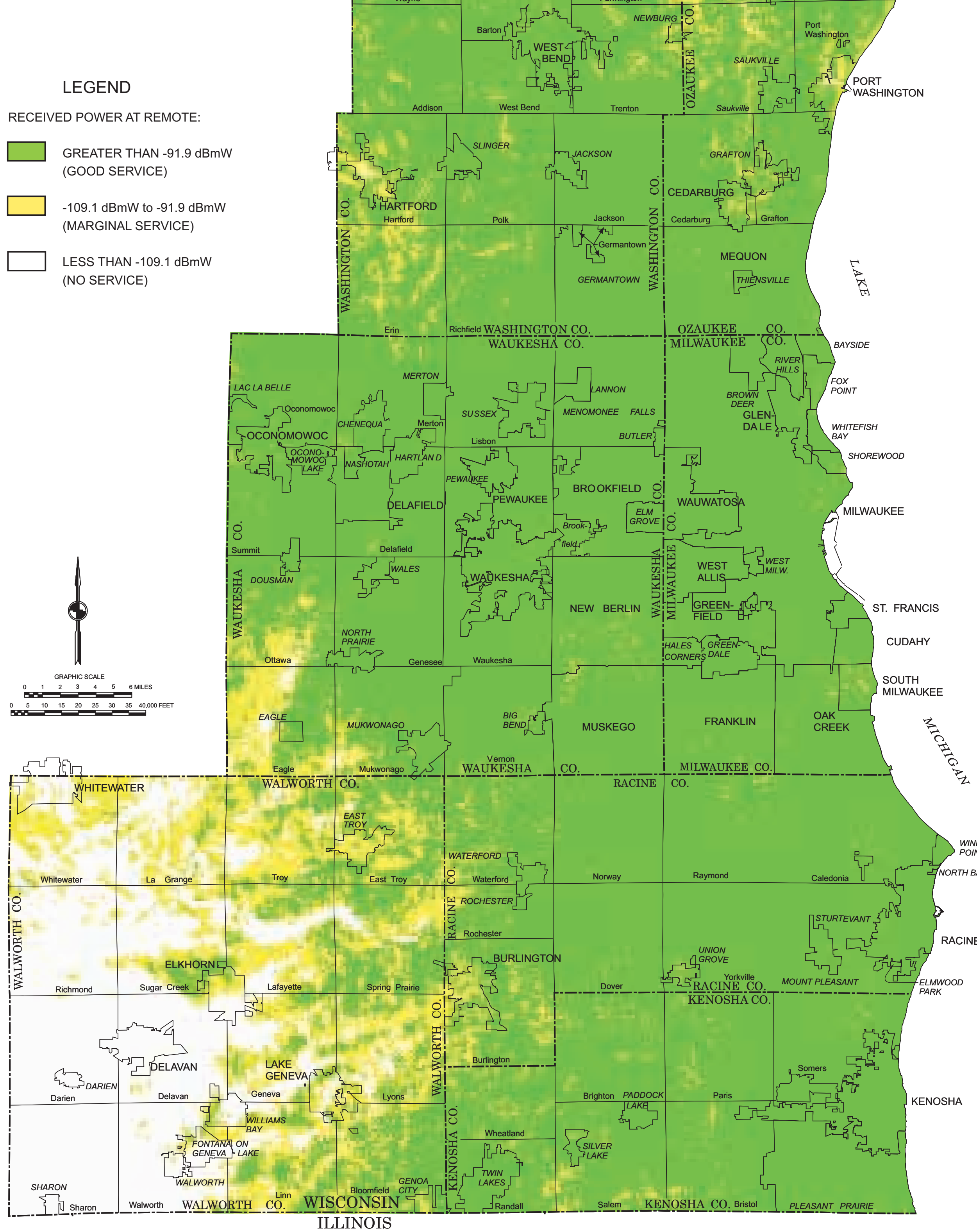
T-MOBILE RADIO SIGNAL COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

Map 27

ESTIMATED T-MOBILE SERVICE QUALITY COVERAGE IN SOUTHEASTERN WISCONSIN: 2006



Source: SEWRPC.

to the Internet. There are numerous broadband fiber optic core networks in the Region with each having its own POP locations for interconnection with other networks. Some of these POP point locations are known and available for Internet gateway connection to existing or new broadband wireline or wireless networks. Others are not publicly available and are useable only by special private arrangements with the carrier. For a new broadband communications system to interconnect at a POP point, it must provide a wireline or wireless link to that POP point. Such links, particularly for fiber optic wireline links, can be quite costly. The initial and continuing costs of such links can significantly change the economics of network deployment. For this reason, a search was carried out for an alternative to established POP point Internet gateway access.

One such an alternative is found in the hybrid fiber coaxial networks of the two regional cable companies—Time Warner Cable and Charter Communications. Internet access through these cable networks can be implemented with an average link distance of about one-half mile. For this reason, the concept of a POP gateway has little meaning in fiber coaxial cable networks. Both Time Warner Cable and Charter have literally thousands of "POP points" available wherever their networks are deployed in the Region. One possible key to future new broadband access network deployment, therefore, rests with connection to the hybrid fiber optic coaxial cable networks. Other alternatives for Internet connection may exist in the core fiber optic cable facilities deployed by other service providers within the Region, such as AT&T, Norlight and Time-Warner Telecom. For this reason, a detailed inventory of fiber network POP points for noncable networks as originally envisioned was not pursued.

SATELLITE BROADBAND COMMUNICATION SERVICES

A number of service providers offer broadband satellite based Internet access communications within the Region and throughout the United States.

Download speeds vary from 500 kilobits per second, to 3 megabits per second while upload speeds are much slower in the range of 128 kilobits per second to 1.5 megabits per second. Monthly service fees extend from $50 per month at the low end to $1,000 per month at the high end. Megabit per second performance generally calls for charges exceeding $500 per month. For this reason, broadband satellite services can not compete with other broadband service alternatives when and where they are available. Most current satellite broadband service users reside in rural areas lacking other forms of broadband communications services.

Operating in the super high frequency SHF—2.5 to 22 GHz—bands, satellite communications has the advantage of significant bandwidth allocation which generally allow for high throughput rates. This bandwidth must be shared, however, with a large body of other users to support the costs of launching and maintaining communications satellites in orbit. These low earth orbiting satellites to be effective on a 24-hour basis, must be continuously available on a line-of-sight basis throughout the service area. Such availability requires a large fleet of satellites for continuing coverage.

A geosynchrous (GEO) satellite is a satellite whose orbital track on the Earth repeats regularly over points on the Earth over time. If such a satellite's orbit lies over the equator, it is called a geostationary satellite. Such satellites to be geosynchronous must orbit at an altitude of 22,369 miles so as to have an orbital period of 23 hours and 56 minutes, the same as the Earth's rotation period.

A geostationary satellite appears to be fixed in one location above the equator. Other GEO satellites are stationary over other locations on the earth's surface. All GEO satellites have an inherent time delay of about 0.25 seconds for a round trip to and from the satellite. Such delays preclude their use in voice communications. GEO systems also require the use of expensive, bulky directional antennas that must be pointed and calibrated to acquire a satellite. Low earth orbit (LEO) satellites, in contrast, use small omnidirectional antennas that do not require calibration. GEO satellites also do not interface well with the Internet and its TCP/IP protocol. For all of these reasons, GEO satellites are best used for television broadcasting and high-speed data transmission.

ENTERPRISE NETWORKS

Modern communications networks in the United States and worldwide take two forms by way of organizational structure and clientele served; utility networks and enterprise networks. Utility networks such as those operated by AT&T, Verizon, Time-Warner Cable and Charter Communications are organized to serve the general public. These networks are owned and managed by the private service providers and offer a wide range of voice, video and data communications services to consumers, businesses, government entities and other organizations. Enterprise networks, in contrast, are owned and operated by individual enterprises to serve the needs of the enterprise. Enterprise networks do not typically offer communications services to the general public. Enterprise networks serve medium and large businesses, government, health care and educational institutions and other private and public enterprises. In developing and deploying their enterprise networks, organizations may lease facilities, particularly land line facilities, from service providers in lieu of constructing all elements of their networks. They also typically purchase other network equipment such as switches, routers and multiplexers for their exclusive network use. The key difference, however, is that enterprise networks are owned and operated by the enterprise to serve enterprise functions.

The regional telecommunications planning program was originally envisioned to address only telecommunications networks that either performed governmental functions, such as public safety, or offered services to the general public. Enterprise networks were not intended to be addressed except peripherally. Maintaining the economic viability and competitiveness of the Southeastern Wisconsin Region, however, was a major objective of the planning program. And, the availability of fiber optic cable core network facilities is an important factor in regional economic development. For this reason, an attempt was made in the planning program to map the location and geographic availability of the existing fiber optic cable core network serving in the Region.

In this respect, it is important to note the somewhat divergent needs of small, medium and large scale businesses and industries within the Region. Small businesses generally rely on residential telecommunications networks for reasons of cost, scale and geographic availability. For this reason, universal geographic availability of broadband communications is an important factor in regional economic development. Data published by the U.S. Small Business Administration (SBA) indicate that over 50 percent of all small businesses may be expected to be home-based and therefore widely distributed geographically. Other small business enterprises also tend to be similarly widely dispersed geographically throughout an urban region. Small businesses play a vital role in the growth of the regional economies. Data published by the SBA indicate that from 1996 to 2006, 60 to 80 percent of net new jobs created annually at the national level were created by small business enterprises. Many of these businesses are based on new technologies. SBA data also indicate that small businesses produce 13 to 14 times more patents per employee than larger businesses that are active in patenting. An increasing number of these small businesses are information-oriented, and have need for high performance broadband communications. Given their home-based, or small facility-based, nature and their wide dispersion throughout an urban region, small businesses may be expected to benefit from broadband communications networks that cover the entire Region. Accordingly, the Commission telecommunications planning effort focused on services provided to the general public.

The importance of small business enterprises to economic development within the Region is confirmed by the following excerpts from the *Jobs in the New Millennium* report of the Wisconsin Policy Research Institute for the period 1999 through 2003.

1. Small Business
   In the Metropolitan Milwaukee area—Milwaukee Waukesha, Ozaukee and Washington Counties—small business employs 76.6 percent of all of the 799,690 private sector employees in the area. In Racine and Kenosha counties, the corresponding small business percentages are 78.7 percent, and 83.9 percent respectively. Nationally, small business provides about 50 percent of all private sector jobs.

2. Employment gains from 1999 through 2003 were confined to establishments with under 100 employees. Large businesses—over 500 employees—accounted for 60 percent of the employment losses even though they represented only 21.3 percent of the workforce.

The relatively higher percentage of small business employees in Southeastern Wisconsin along with their recent position as the only source of job growth, make wide coverage regional broadband communications a high economic priority.

Medium and large-scale organizations present a somewhat different set of telecommunication requirements than small businesses. Such medium and large-scale organizations typically design and operate their own enterprise networks. The trend toward enterprise networks began with the breakup of the Bell System in 1984, and accelerated with the growth of large-scale national and international data networks. Although enterprise networks are typically designed and installed in cooperation with communications equipment vendors such as Cisco or Nortel Networks, all such networks have the need for land-line fiber optic cable links that provide the required bandwidth capacity to serve the communication needs concerned. Such core network service is typically arranged with core network carriers such as AT&T, Time Warner Telecom, Norlight Communications, or others within the Region. The capacity of the optical fiber cable network generally is not an issue. Most fiber core networks within the United States and the Region are underutilized. The real issue is geographic availability. Fiber optic cable core facilities do not exist in many parts of the Region. For this reason, a definitive, comprehensive map of the Regional fiber optic core network within the Region would provide a valuable resource.

The acquisition of such network layout information requires the cooperation of the core network providers themselves. At the small business level, broadband communications is synonymous with the residential networks. The telephone system Incumbent Local Exchange Carriers (ILECs), and the two regional cable companies, Time Warner Cable and Charter Communications, own the majority of the fiber optic cable facilities required for broadband connection. Although earlier attempts under the regional planning program to obtain detailed information on the core fiber optic cable networks were unsuccessful, the Commission in February 2007 determined to again seek the cooperation of the core optic cable facility providers in mapping those facilities.

In 2007, the major carriers serving the enterprise network fiber optic core network market within the Region included the following: 1.) AT&T; 2.) Time Warner Telecom; 3.) Norlight Telecommunications; 4.) TDS Metrocom; and 5.) Midwest Fiber Networks. The latter firm provides inactive or "dark", rather than electronically activated fiber optic cable facilities that must be equipped and activated by the user.

The remaining core networks service providers are smaller ILEC carriers that offer core network services only in their own ILEC service areas. These in 2007 included: 1.) Verizon North; 2.) Century Tel; 3.) State Long Distance (Elkhorn); and 4.) Sharon Telephone Company.

An unsuccessful search was made of the Federal Communication Commission, and Wisconsin Public Service Commission data bases to obtain definitive information on the location of the core optic fiber facilities within the Region. The Commission on February 21, 2007, sent letters to all known fiber optic core network carriers operating within the Region requesting definitive information on the cable networks locations. As of March 21, 2007, replies were received only from Verizon, politely declining cooperation. Apparently—barring State legislation—the necessary information will become publicly available only when the carriers see it to be in their own interest to cooperate with public bodies such as the Commission in developing a core network infrastructure inventory.

Lacking comprehensive fiber optic core network location information for the Region, the Commission selected to work with core network providers in plan design and implementation on a project-by-project basis. Such an approach allows for the implementation of specific advanced broadband communications system plans based on core network connections specified for a given geographic area. In such a working relationship, the core network carrier would typically offer a number of possible Internet locations, so that a selection could be made that would maximize the performance versus cost of the new network infrastructure design. To date, two core network carriers, Charter Communications and Time Warner Telecom, have demonstrated a willingness to cooperate in this critical aspect of plan implementation. Attempts will be made to expand this group of carriers so that all parts of the Region will achieve broadband communications coverage.

SUMMARY AND CONCLUSIONS

Broadband wireline communications services in the Region are currently offered primarily by the major incumbent telephone company, AT&T, and the leading cable services provider, Time-Warner Cable. Other incumbent telephone companies, such as Century Tel and Verizon North also offer broadband communications services in some parts of the Region. Charter Communications, the other regional cable services provider, has deployed broadband cable networks in areas of Washington and Walworth counties and in the City of Oconomowoc in Waukesha County.

Telephone-based service providers utilize a technology known as DSL—digital subscriber line—which transmits high speed data over twisted pair copper wires originally used for voice communications. Cable companies employ a hybrid communications technology that combines fiber optic cable links with traditional coaxial cable connections to deliver high speed data services.

None of the existing wireline broadband services networks in the Region offer throughput data rates that meet the Commission recommended performance standard of 20 megabits per second. All of the current wireline services are extremely asymmetrical, with upload speeds of 20 percent or less of download speeds. AT&T, the leading DSL service provider, is in the process of deploying a Fiber-to-the-Node technology (FTTN) that is designed to achieve the Commission recommended broadband service standard of 20 megabits per second. Advanced broadband service plans of the two cable service providers, Time-Warner Cable and Charter Communications, have not been revealed at this time. Similarly, the other DSL service providers have not announced plans for technologies designed to meet the 20 megabits per second throughput standard.

None of the major current wireline broadband service providers offer the universal geographic coverage objective recommended by the Commission. Cable services in many communities serve the large majority of the population, but there are still areas of the Region that do not meet the Commission recommended standards for extension of broadband cable services. DSL broadband services from telephone service providers are also not universally available from the wireline carriers in the Region. Furthermore, as of the date of publication of this report, AT&T's plans for expanded broadband services target only 44 of the 116 local municipalities within Southeastern Wisconsin that AT&T serves. Although AT&T's post-2008 plans may expand this number, there was no information available on these plans at the time of publication of this report.

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Chapter VI

TELECOMMUNICATIONS BROADBAND PERFORMANCE INVENTORY FINDINGS

INTRODUCTION

Chapter V presented the findings of an inventory of the current broadband telecommunications infrastructure within the Region expressed in terms of geographic coverage and types and levels of service. This chapter deals with the performance of the existing broadband communications networks, particularly with regard to throughput speed—the primary parameter for evaluating system performance under the regional telecommunications planning program. Performance data were collated from a variety of Internet websites that routinely collect throughput performance data from within the United States and worldwide. Performance data are analyzed and published by country, state or province, local community, down to the postal service zip code area level in the United States. Data are also summarized by technology—DSL, cable, wireless—carrier, and type of connection. Performance data, of course, are more readily available for larger geographic areas such as nations or states than for smaller areas. At the zip code area level, many areas have no recorded data available. For purposes of performance analyses, however, the type of technology and the individual service provider or carrier are of primary interest for planning purposes.

PERFORMANCE MONITORING CATEGORIES

The performance herein reported emphasizes wireline, rather than wireless, networks. This emphasis is based on two major considerations:

1. Wireless performance within the planning area was monitored by the Commission, and the findings were reported in SEWRPC Planning Report No. 51; and

2. The higher levels of performance typically provided by the wireline networks as compared to mobile wireless networks. Fixed wireless networks provide better throughput performance than mobile, but these networks do not serve all areas within the Region.

Broadband wireless performance is, however, herein reported to the extent that data are available for the Region through the Commission's monitoring effort. Also of interest are satellite wireless communications in rural areas. Throughput data rate is the only measure of broadband performance herein considered. Data on the other major performance measure considered in the previous Commission wireless monitoring—availability—are not readily available for wireline networks. Moreover, availability performance in wireline networks is generally high—approximating 99 percent or more—so that availability is not a useful differentiator in wireline broadband service evaluations.

The performance data as herein reported are limited to data on data transmission rather than voice communications, since broadband capabilities are not generally relevant to circuit-switched voice traffic. Voice over internet protocol (VoIP) communications does share bandwidth with data traffic on packet switched networks, but performance quality is more dependent on network response time—latency—than on bandwidth or throughput. Also, regional use of VoIP is still at a relatively low level within this Region.

Based on website-based performance data, broadband throughput data are herein tabulated and analyzed by the following categories:

1. Technology—with emphasis on hybrid fiber coaxial cable and DSL technologies;

2. Service Provider—with emphasis on the major carriers operating within the Region;

3. Geographic Area—broadband performance data availability becomes limited as the geographic areas concerned are reduced in size, but to the extent feasible, performance information is provided for counties and municipalities as geographic areas.

The end objective of the performance monitoring as herein reported is to determine the status of broadband communications within the Region as the foundation for developing future regional broadband communications systems.

Wireline Performance Data
Sources and Parameters

A number of broadband communications websites were searched and evaluated prior to selecting two websites that provided higher quality and quantities of broadband wireline performance data. These two sites and the rationale for their selection are described below.

1. <u>TCP/IQ Line Speed Meter</u>
   This website provides data on download speed, upload speed, and latency—response time—by county, state, community and postal service zip code area; and by service provider, technology and class of service.

2. <u>Bandwidth Place</u>
   This website provides data only by state and technology type, but reports based upon a relatively large number of performance tests, e.g., over 30,000 for Time Warner Cable and over 48,000 for Charter Communications in Wisconsin alone.

The TCP/IQ website provides the most extensive categorization of the data, but sample quantities are low and nonexistent for some categories. The Bandwidth Place website has high sample volume, but categorizations are coarse with no areal categories below the state level.

The TCP/IQ website was developed and is managed by Sigma Solutions, Inc. based in San Antonio, Texas. The company was formed in 1998 and has grown to 85 employees. The company develops database, server and internetworking software for businesses, government and institutional users, typically on a custom basis. The TCP/IQ website for network performance measurement was developed as a promotional tool to attract potential customers to the Company. The primary question relating to the use of the data concerns its accuracy. TCP/IQ line speed data are collected from Internet user volunteers who wish to measure their broadband performance in terms of download and upload throughput and latency time. In return for their cooperation, the volunteers receive free access to the performance data base. TCP/IQ maintains the high accuracy of its Internet performance reporting using the following measures.

1. <u>Multiple Time Series Measurement</u>
   When a user registers and contracts for the free service offered, the user agrees to allow collection of additional performance data which permit the averaging of link performance over time, thereby reducing the standard errors of the applicable means and allowing for measurement of performance variability.

2. <u>Detection of Erroneous Data</u>
   A registered user must specify the service levels received in terms of maximum download and upload speeds. Performance data outside of these service ranges are ignored.

3. <u>Three Month Moving Average</u>
   Each registered user's performance data are maintained as three month moving averages. Such a moving average provides a more accurate estimate of link performance than single readings.

Bandwidth Place is a small website company operating out of Calgary, Alberta, Canada. It differs from TCP/IQ and its sponsor, Sigma Solutions, in that it charges fees for its broadband communications measurement services. Users pay fees from $10 to $220 per year to receive network performance data on a continuing basis. The Version 1 of the program was placed online in early 2000. The data acquisition software system is now in its fourth version, and over 100 million test runs have been compiled.

Bandwidth Place data were used herein only to summarize performance at the State level. All other performance data referenced in this Chapter are from TCP/IQ.

Using a combination of data from these two websites, it is possible to approximate the performance characteristics of the major broadband communications technologies currently operating within the Region. Performance data were collated, tabulated, and analyzed by technology and service providers starting at the national level, and moving down to state, region and community levels as data availability permitted.

Service Specifications
Most broadband communications services are based on a service package offering that states the maximum download and upload speeds permissible on that link connection. For example, a Time Warner Cable service offering of 3000/768 specifies a maximum download speed of 3000 kilobits per second and a maximum upload speed of 768 kilobits per second. These figures represent the results of bandwidth allocations made by the service provider. They do not represent a quality of service guarantee, and they are not typically incorporated in any service agreement. These specifications do, however, represent the maximum throughput possible for a given network service.

National Level Broadband Communications Performance
Since the same broadband wireline and wireless communications technologies are deployed throughout the United States, it was deemed advisable to first review broadband performance at the national level, and then compare it with State and local level performances. The larger sample counts available at the national level also improve the accuracy and reliability of the data.

The current overall performance of broadband communications in the United States is portrayed in Figure 9 which displays the means and standard deviations of the download and upload speeds of all Internet service providers over the time period from January 2003 to November 2006. The disparity between the faster download speeds and the slower upload speeds is quite apparent. Download speeds cover the one to two megabits per second range, while upload speeds are generally no more than 300 kilobits per second.

A display of the performance provided by the two primary wireline technologies used in the United States is provided in Figure 10. Broadband cable and DSL throughput performance for two different service levels are shown.

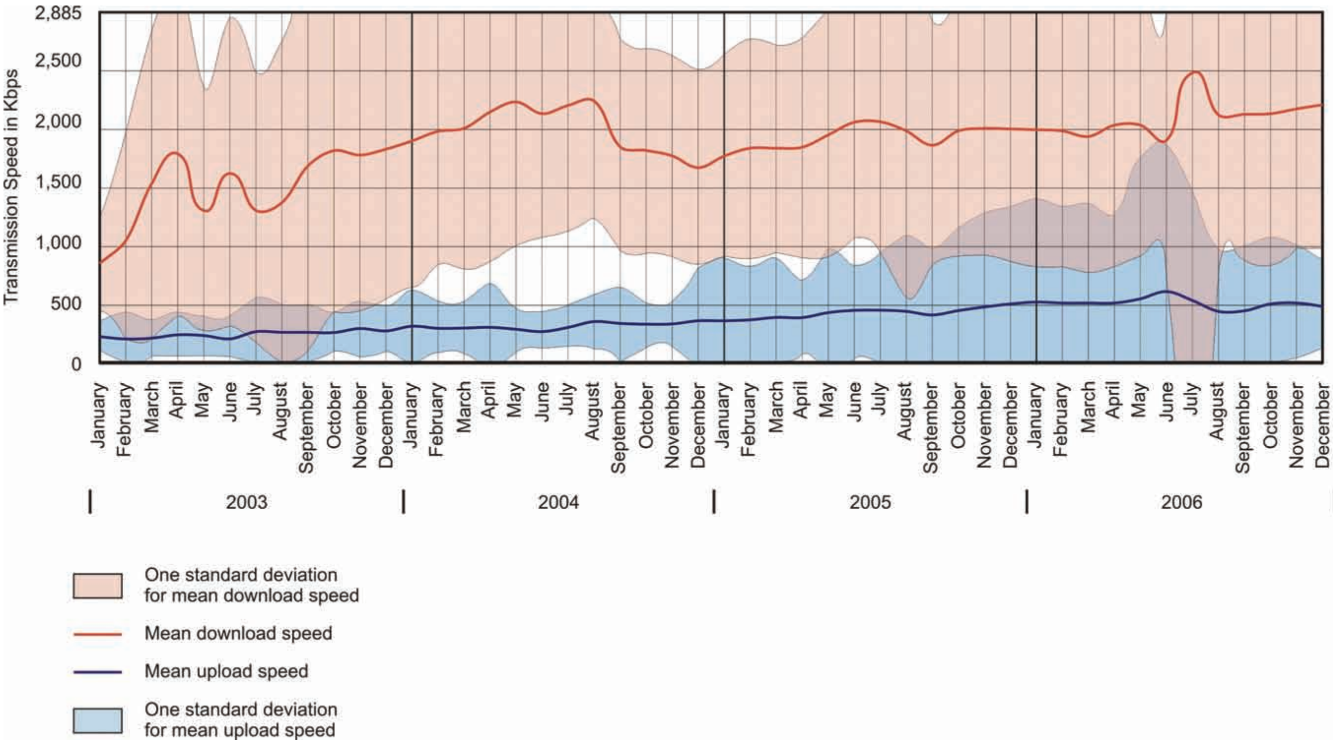
Although Comcast does not operate in Southeastern Wisconsin, its technology is similar to that of Time Warner and Charter, the primary cable service providers in the Region. Again, the slower upload speeds are graphically shown. A higher download throughput level of cable is indicated, but this performance also comes with a higher level of service and an associated higher cost.

The performance of Time Warner Cable is shown in Figures 11, 12 and 13 over the same 2003 through 2006 time period. Variations by the day of the week and hour of the day are also shown. The relatively slow upload speeds are again evident.

Time Warner Cable performance for a higher level of service offering is shown in Figures 14, 15, and 16. The 5000/512 service package promises a higher download speed than the previous 3000/768 service

Figure 9

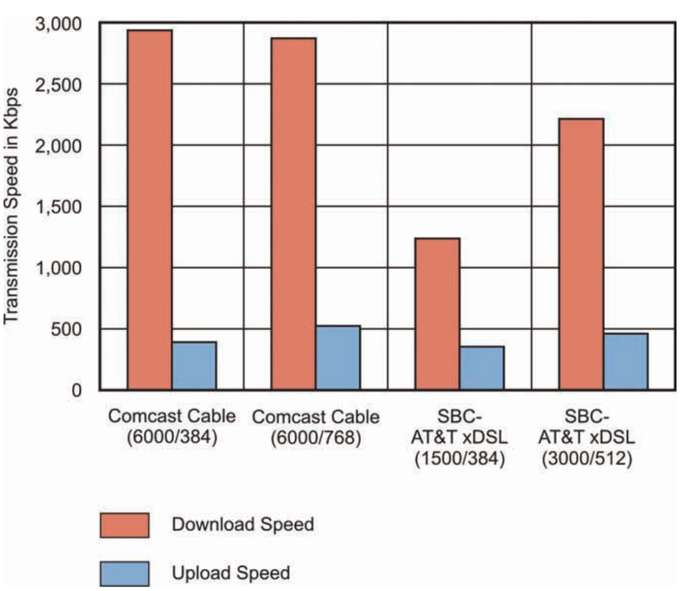
COMPARISON OF DOWNLOAD AND UPLOAD TRANSMISSION RATES FOR ALL INTERNET SERVICE PROVIDERS IN THE UNITED STATES: 2003 - 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 10

COMPARISON OF BROADBAND AND DSL PERFORMANCE FOR THE TWO PRIMARY SERVICE PROVIDERS IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

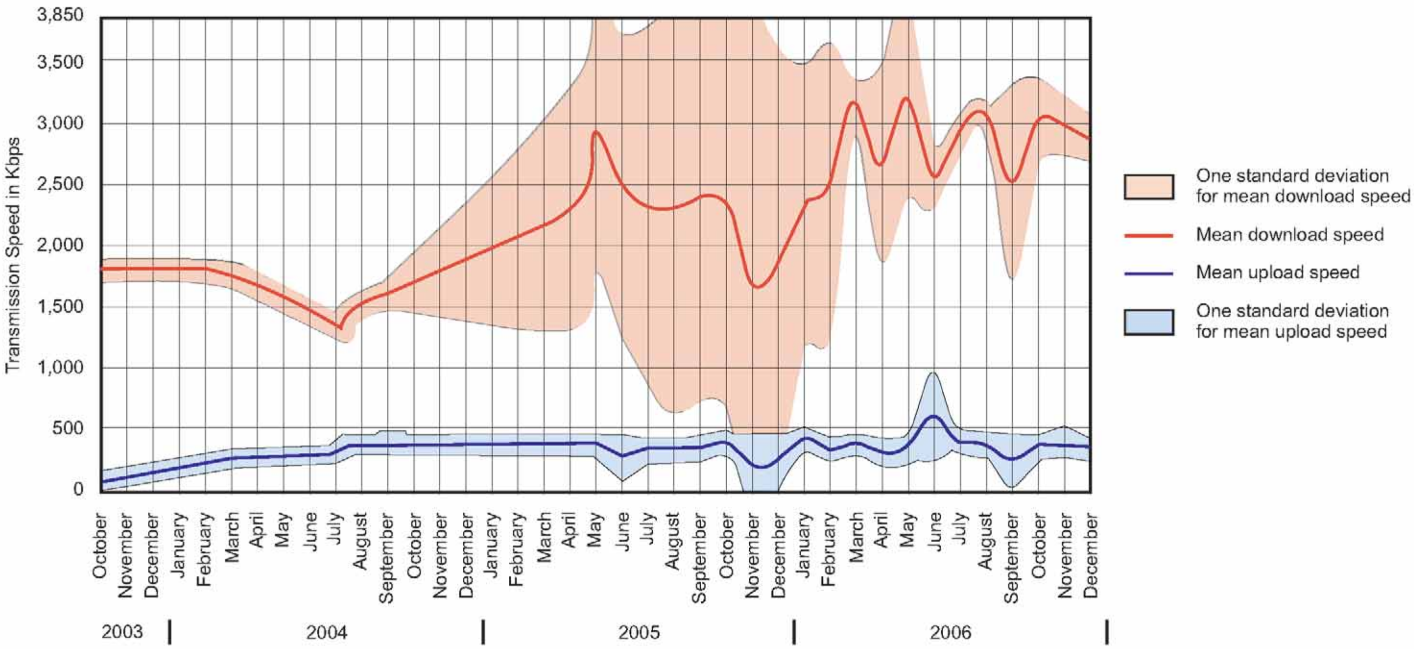
package but with a slower upload speed. The graphs actually indicate a slower download throughput but a slightly higher upload speed performance. Residential service agreements provide no quality of service guarantees. The higher throughput value represents only a maximum throughput speed allowed and not a guaranteed level of service.

An equivalent performance record for Charter Communications, the other regional cable service provider, is shown in Figures 17, 18 and 19. Throughput speeds are significantly slower than the equivalent service offering of Time Warner.

AT&T DSL performance at a higher service level—6,000/608—in the United States is plotted in Figures 20, 21 and 22. The significantly higher level of both download—over four megabits per second—and upload speeds—approximately 500 kilobits per second—is noteworthy. The DSL category, however, is xDSL meaning higher level versions of DSL such as VDSL could be included in the data

Figure 11

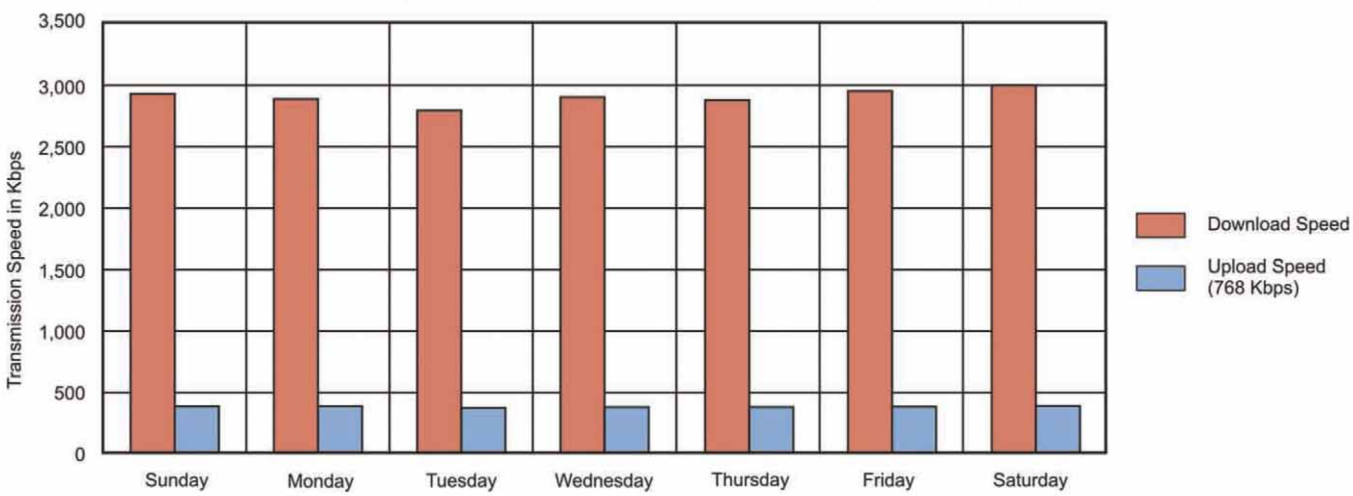
ROAD RUNNER (TIME WARNER CABLE) SERVICE (3000 Kbps/768 Kbps)
IN THE UNITED STATES: OCTOBER 2003 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 12

UNITED STATES-ROAD RUNNER (TIME WARNER CABLE) CABLE (3000 Kbps/768 Kbps) SPEED VS DAY OF WEEK



Source: Sigma Solutions Group, LLC, and SEWRPC.

summary. Because deployment of VDSL by AT&T in the United States has not been extensive, most of the data in this summary is believed to represent ADSL technology.

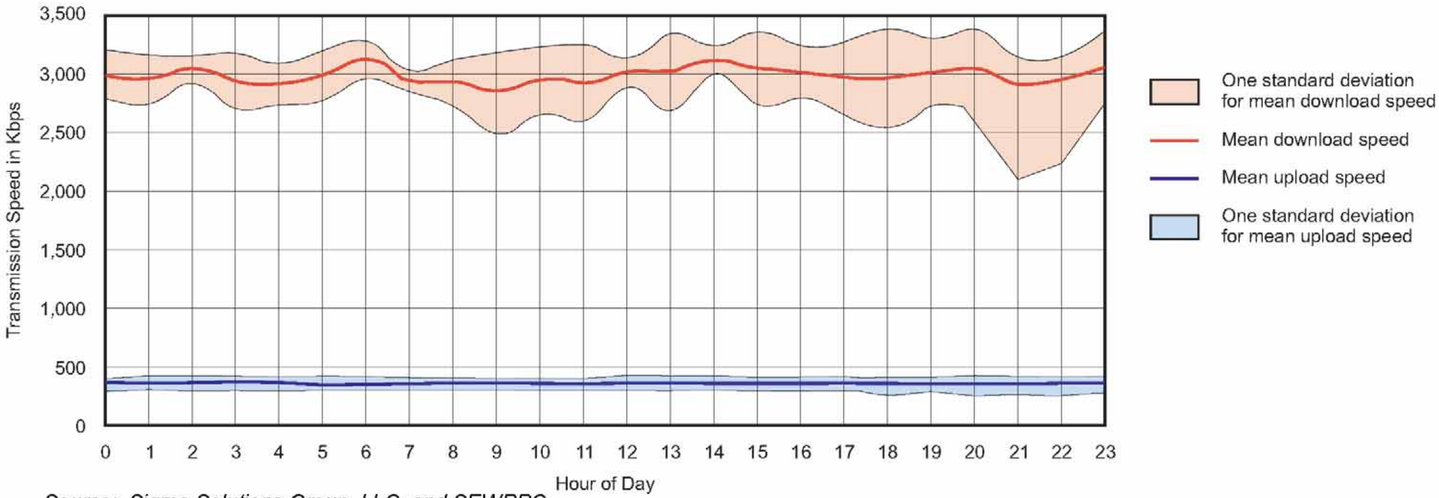
A similar data summary for CenturyTel, a regional DSL service provider is displayed in Figures 23, 24 and 25. The level of service portrayed, however, is much lower at 1,500/256. It is significant that actual performance is very close to the service specified.

Wireless Broadband Performance

Performance data on wireless broadband networks even at the national level are not widely available. The cellular/PCS wireless monitoring data reported in SEWRPC Planning Report No. 51 provided a greater volume of data than most other publicly available reports even at the national level. The data collected by the Commission were for mobile rather than fixed wireless service. Some of the wireless

Figure 13

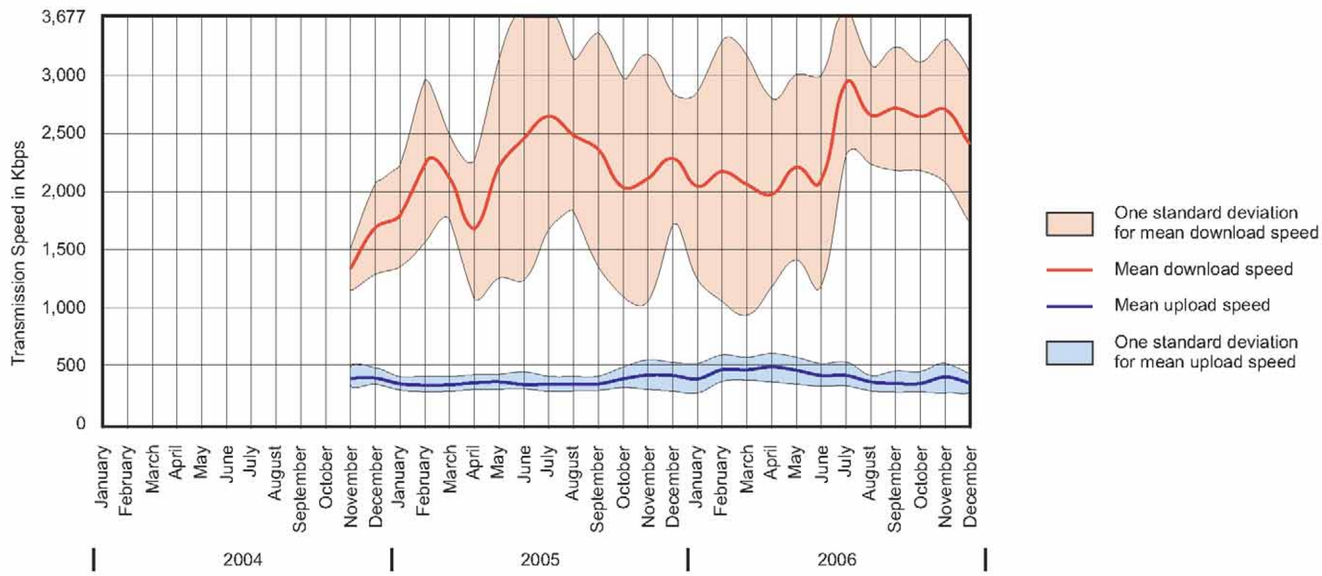
ROAD RUNNER SERVICE (3000 Kbps/768 Kbps) IN THE UNITED STATES VS HOUR OF DAY (+1000)



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 14

COMPARISON OF DOWNLOAD (5000 Kbps) AND UPLOAD (512 Kbps) TRANSMISSION RATES BY MONTH FOR TIME WARNER CABLE ROAD RUNNER SERVICE IN THE UNITED STATES: NOVEMBER 2004 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

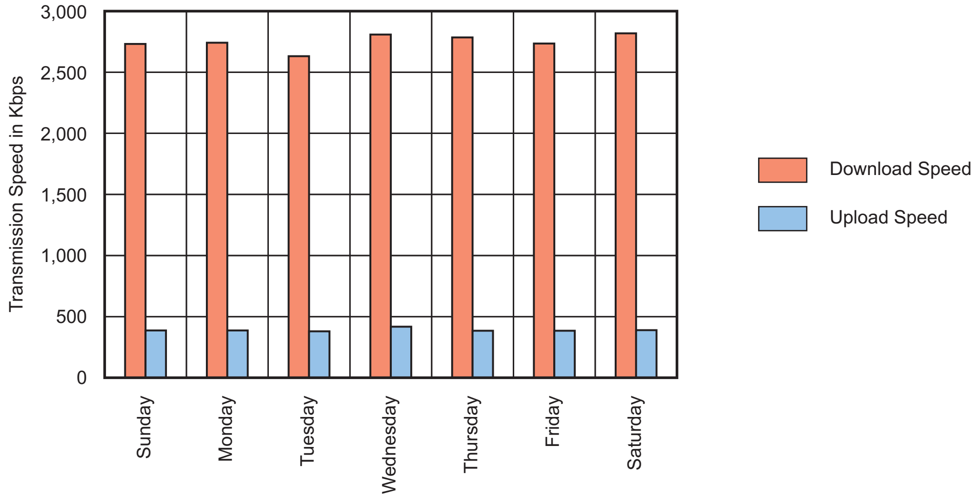
performance data relate to standard technologies such as WiFi (IEEE 802.11), but most relate to a variety of proprietary technologies.

An interesting WiFi performance study is illustrated in Figure 26 for a 3600/3000 service level typical of mesh networks. Initially, upload throughput exceeds download throughput, an unusual situation for any current day broadband network. Although WiFi networks are basically symmetrical, ISPs typically allocate more bandwidth to download traffic than upload traffic because most applications are download oriented.

Some rare data on broadband mobile wireless are shown in Figures 27, 28 and 29. All of the cellular/PCS broadband data collected and presented in SEWRPC Planning Report No. 51 were based on 3G CDMA technology as deployed by Verizon Wireless and Sprint. The new data presented in

Figure 15

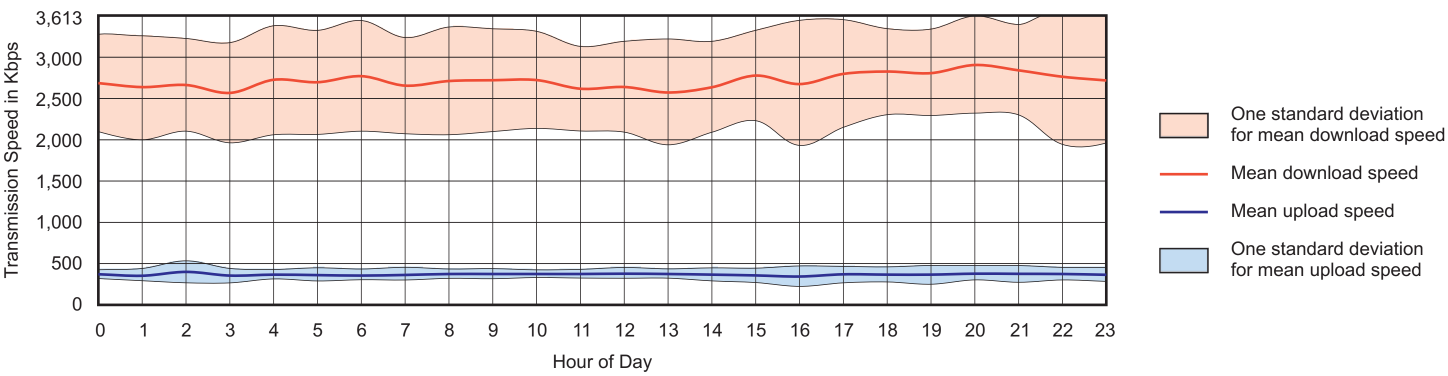
COMPARISON OF DOWNLOAD (5000 Kbps) AND UPLOAD (512 Kbps) TRANSMISSION RATES BY DAY OF WEEK FOR TIME WARNER CABLE ROAD RUNNER SERVICE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 16

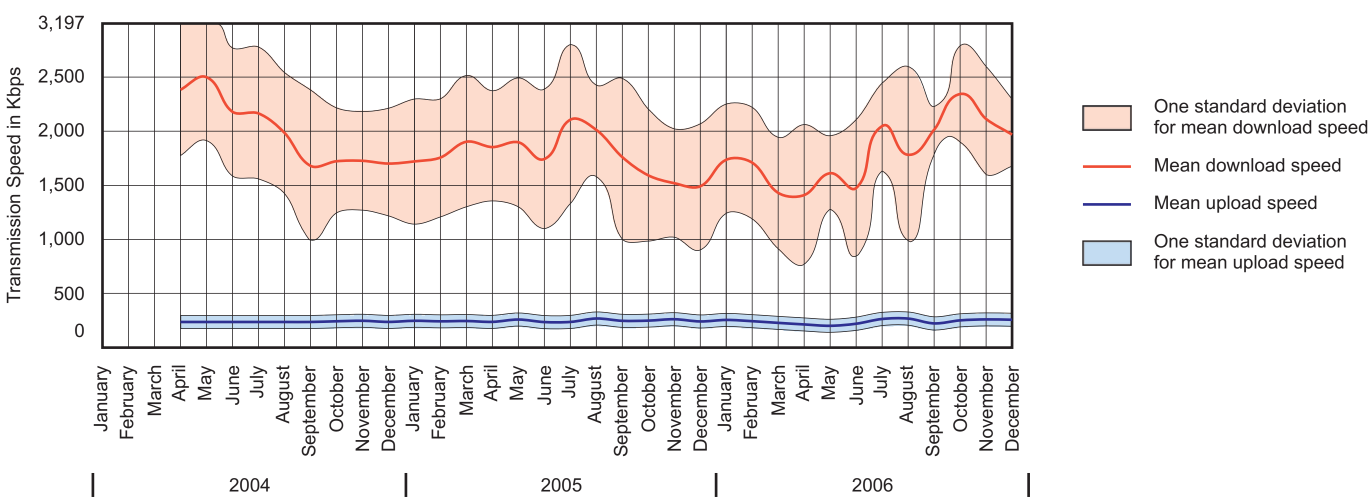
COMPARISON OF DOWNLOAD (5000 Kbps) AND UPLOAD (512 Kbps) TRANSMISSION RATES BY HOUR OF DAY FOR TIME WARNER CABLE ROAD RUNNER SERVICE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 17

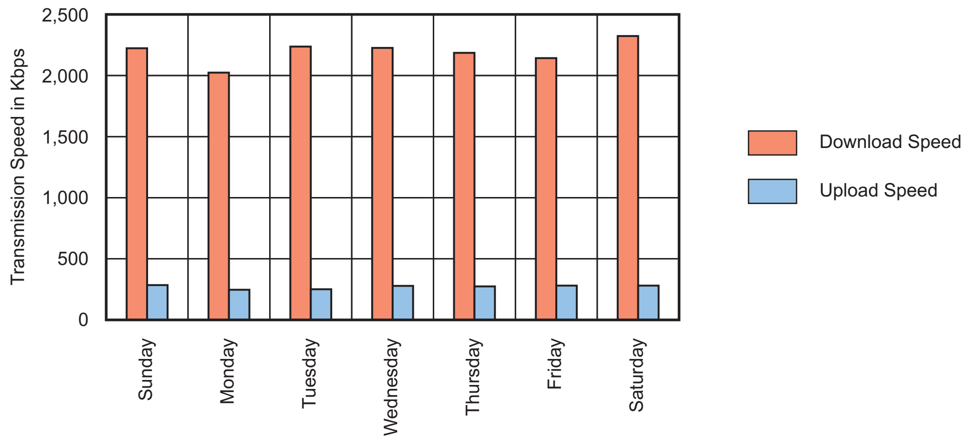
COMPARISON OF DOWNLOAD (3000 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY MONTH FOR CHARTER CABLE IN THE UNITED STATES: APRIL 2004 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 18

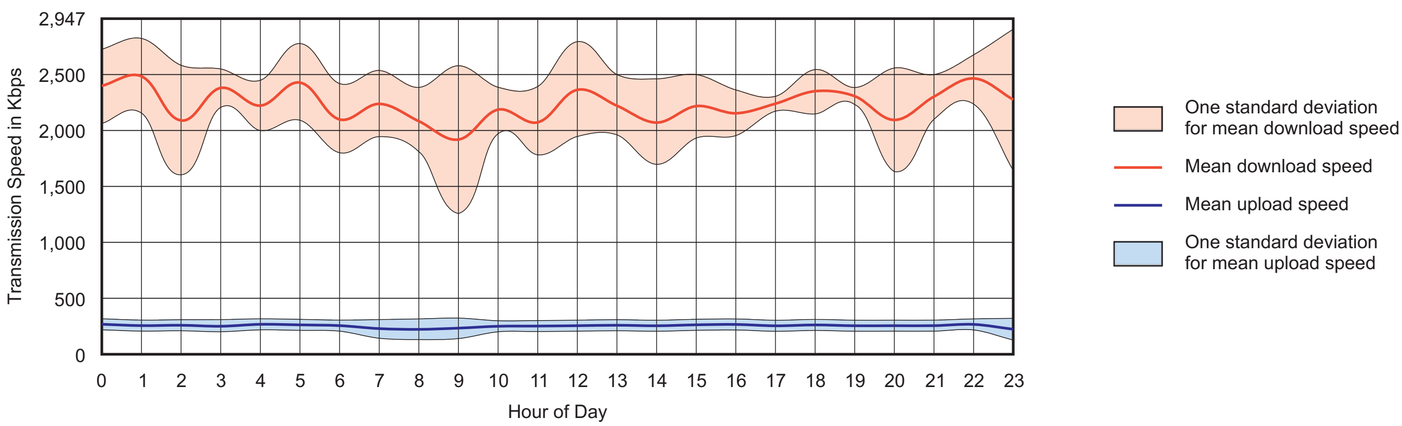
COMPARISON OF DOWNLOAD (3000 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY DAY OF WEEK FOR CHARTER CABLE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 19

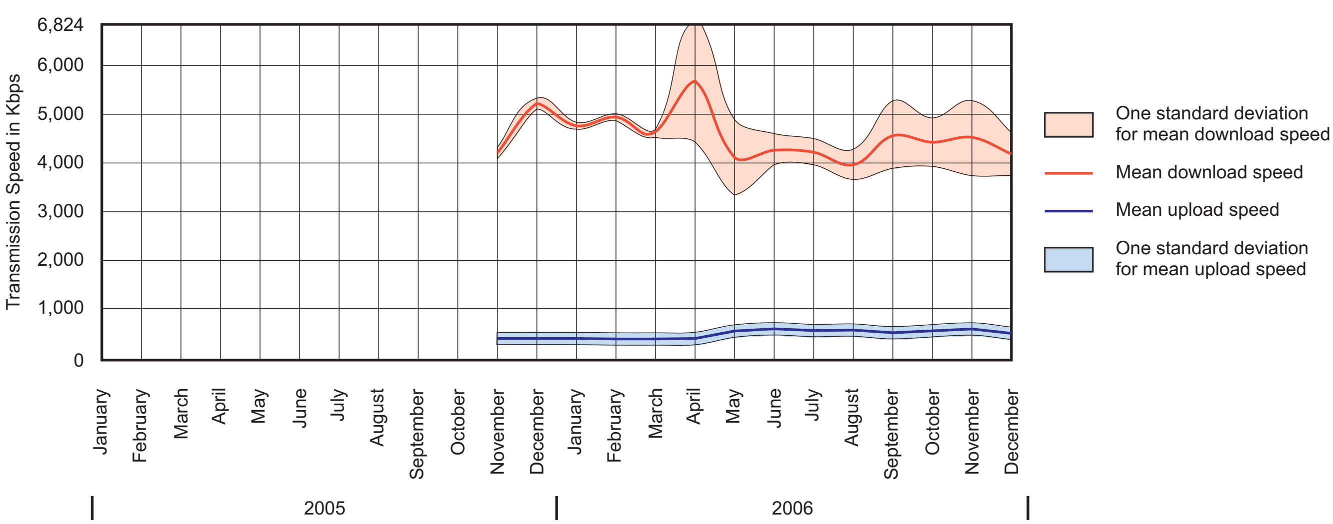
COMPARISON OF DOWNLOAD (3000 kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY HOUR OF DAY FOR CHARTER CABLE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 20

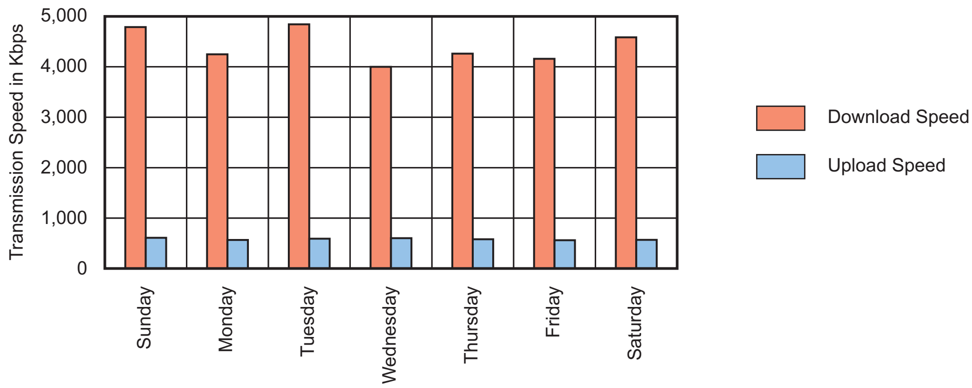
COMPARISON OF DOWNLOAD (6000 Kbps) AND UPLOAD (608 Kbps) TRANSMISSION RATES BY MONTH FOR SBC - AT&T xDSL SERVICE IN THE UNITED STATES: NOVEMBER 2005 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 21

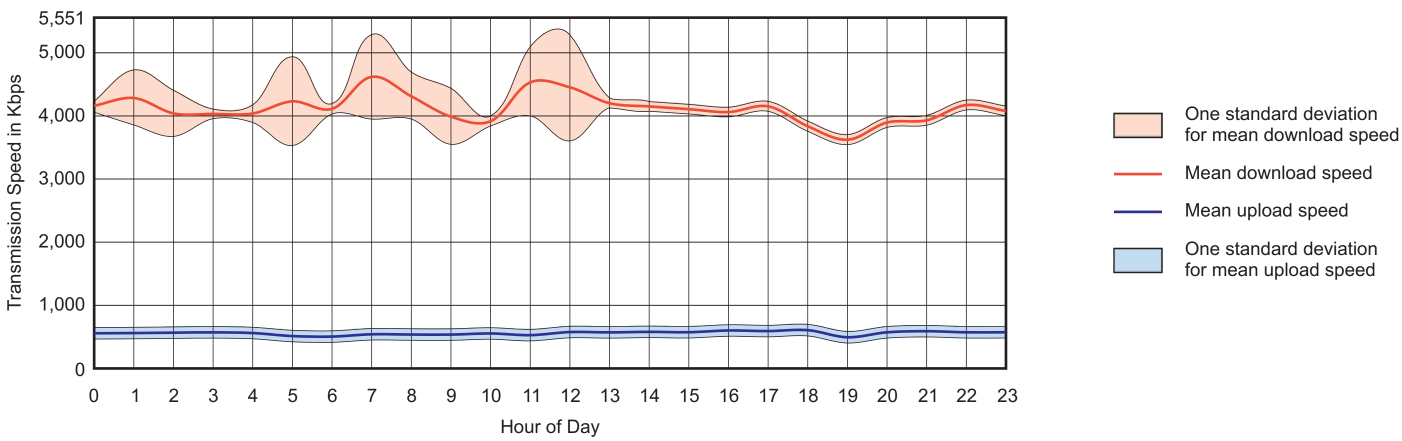
COMPARISON OF DOWNLOAD (6000 Kbps) AND UPLOAD (608 Kbps) TRANSMISSION RATES BY DAY OF WEEK FOR SBC - AT&T xDSL IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 22

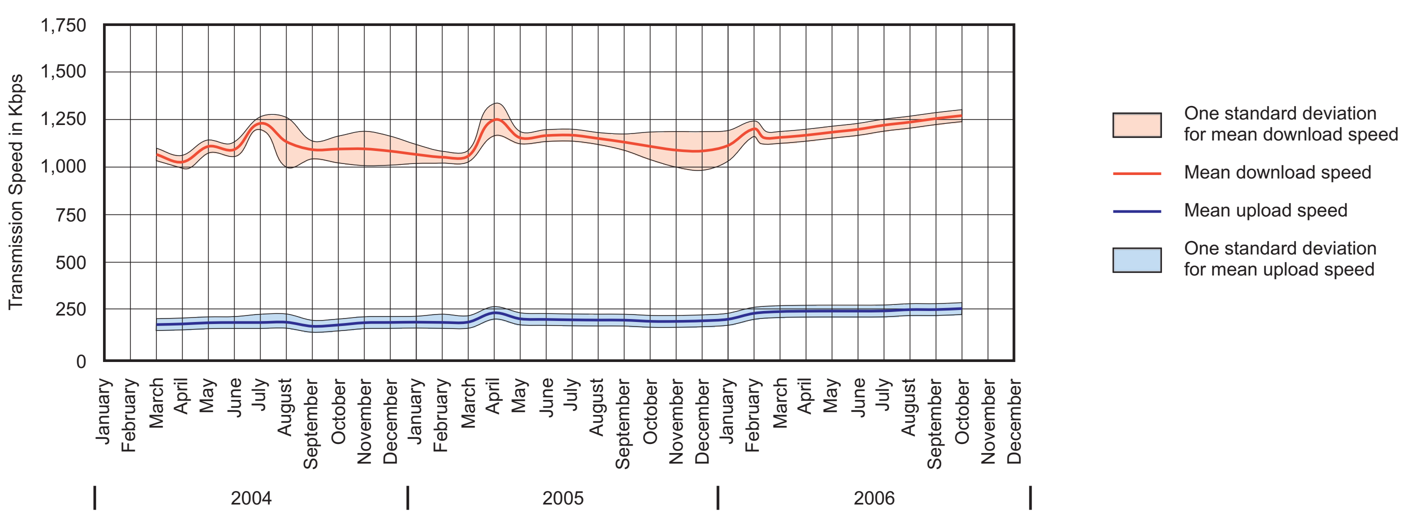
COMPARISON OF DOWNLOAD (6000 Kbps) AND UPLOAD (608 Kbps) TRANSMISSION RATES BY HOUR OF DAY FOR SBC - AT&T xDSL IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 23

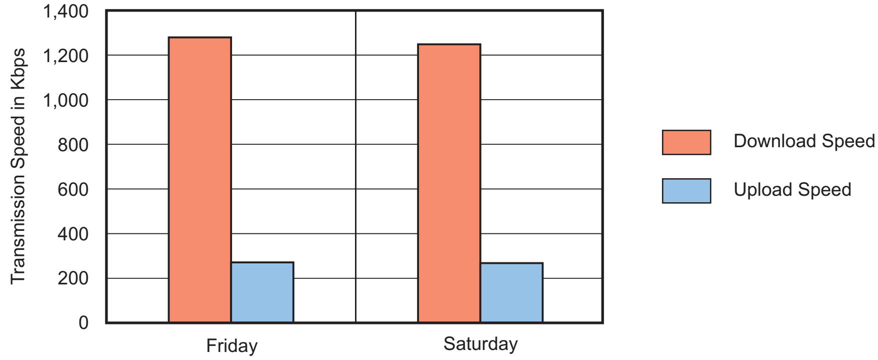
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY MONTH FOR CENTURYTEL xDSL IN THE UNITED STATES: MARCH 2004 THROUGH OCTOBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 24

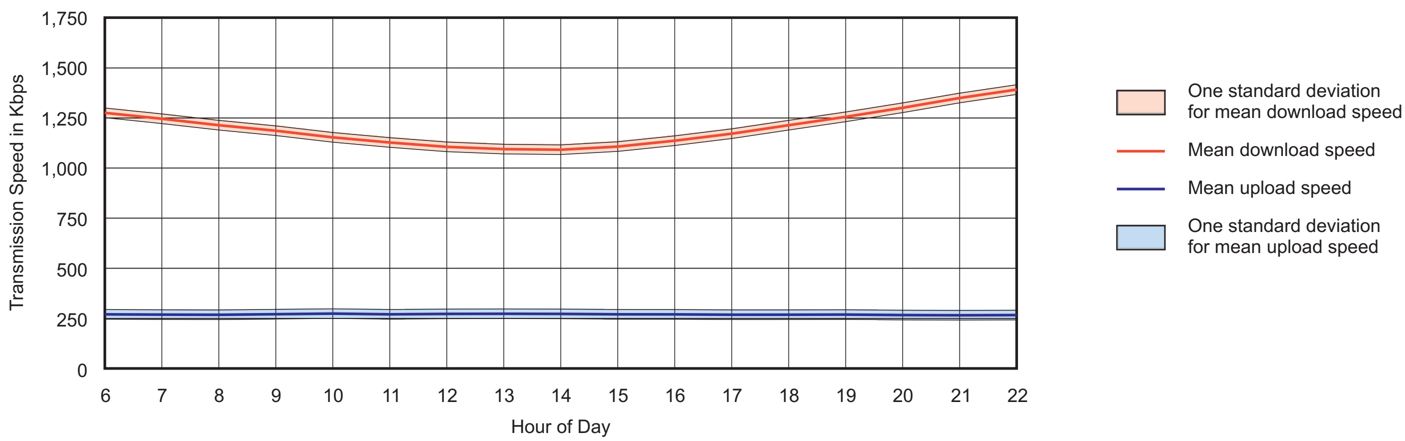
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES ON FRIDAYS AND SATURDAYS FOR CENTURYTEL xDSL SERVICE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 25

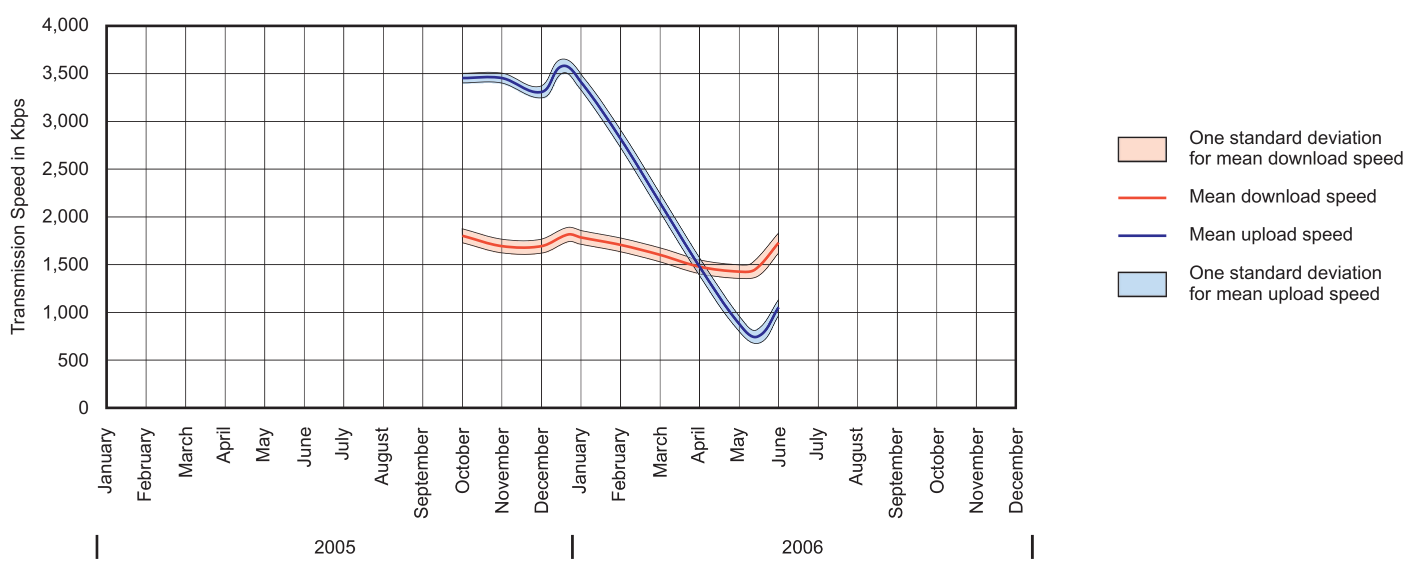
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY HOUR OF DAY FOR CENTURY TEL xDSL IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 26

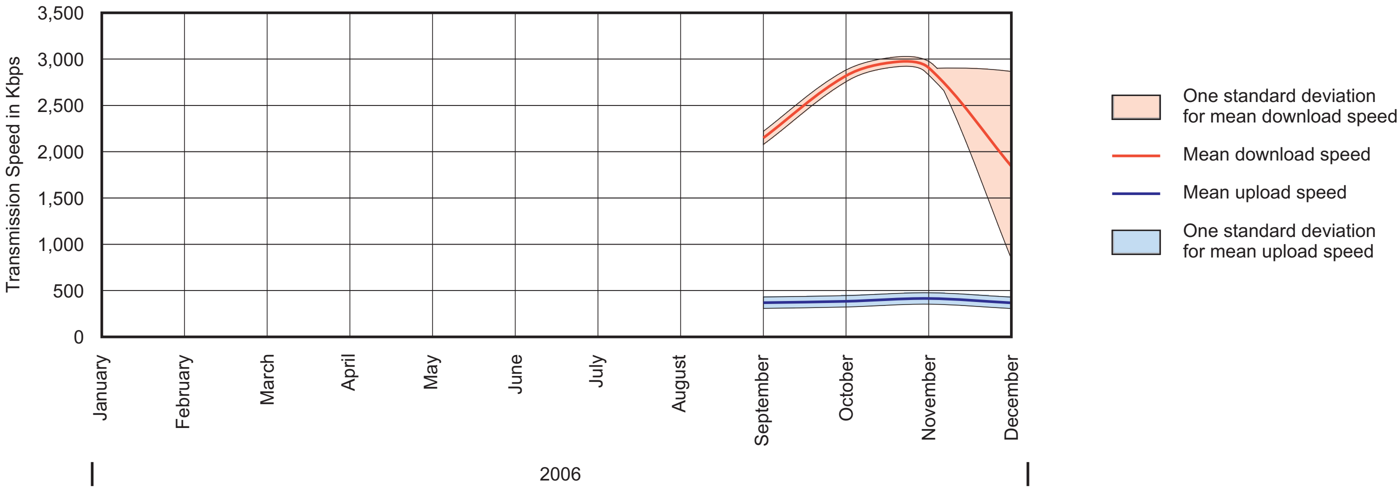
COMPARISON OF DOWNLOAD (3000 Kbps) AND UPLOAD (3000 Kbps) TRANSMISSION RATES BY MONTH FOR WIRELESS BROADBAND INTERNET ACCESS WiFi 802.11a/b/g/n/x IN THE UNITED STATES: OCTOBER 2005 THROUGH JUNE 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 27

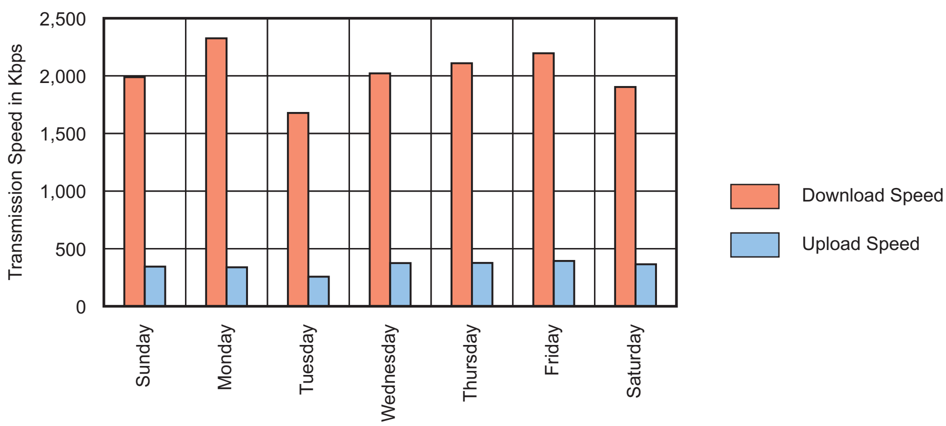
COMPARISON OF DOWNLOAD AND UPLOAD TRANSMISSION RATES BY MONTH FOR CINGULAR WIRELESS GSM GPRS IN THE UNITED STATES: SEPTEMBER 2006 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 28

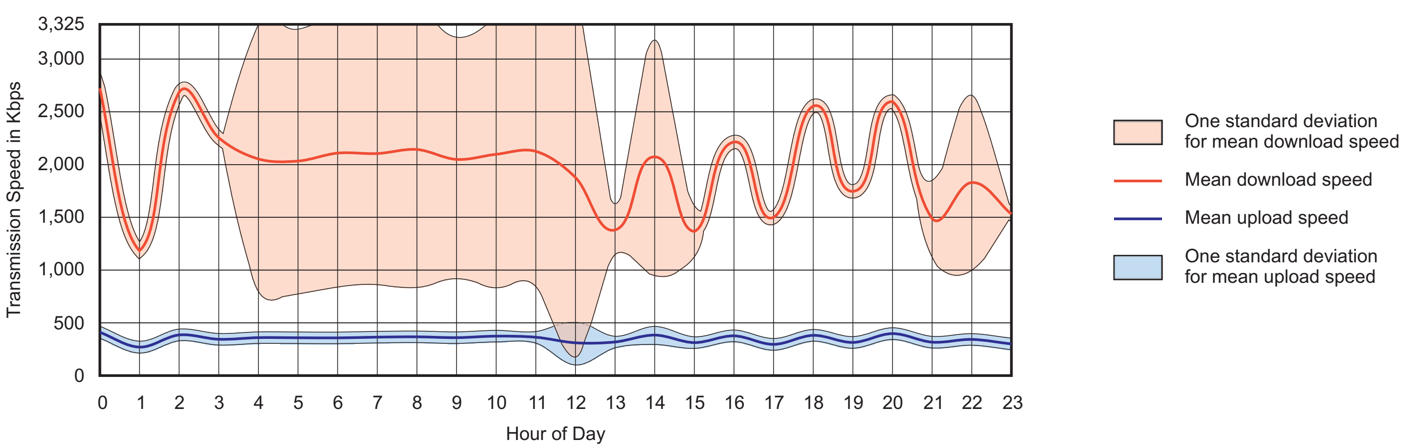
COMPARISON OF DOWNLOAD AND UPLOAD TRANSMISSION RATES BY DAY OF WEEK FOR CINGULAR WIRELESS GSM GPRS IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 29

COMPARISON OF DOWNLOAD AND UPLOAD TRANSMISSION RATES BY HOUR OF DAY FOR CINGULAR WIRELESS GSM GPRS IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figures 27, 28, and 29 relate to the GSM/GPRS technology employed by Cingular Wireless. A 3G version of GSM wireless technologies has not been deployed in Southeastern Wisconsin, but these results indicate that the technology is potentially capable of achieving the 3G throughput objective of two megabits per second. This objective, however, is still below the 4G standard of 20 megabits per second of interest here, but also far above the regional CDMA 3G performance recorded in SEWRPC Planning Report No. 51 which averaged only 336 kilobits per second in download performance, and 79 kilobits per second in upload performance.

Clearwire Wireless is a national broadband wireless service provider that employs a proprietary wireless technology (Alvarion) and WiMAX to provide broadband communications services in certain areas of the United States, including Wisconsin. The Company has deployed networks in the states of Washington, Oregon, California, Texas, North Carolina and Florida as well as a network in the Eau Claire/Chippewa Falls, area of Wisconsin. The performance graphs presented in Figures 30, 31 and 32 indicate performance levels in the 1.0 to 1.5 megabits per second range, which are probably typical of most fixed wireless networks in the United States.

The performance of fixed wireless service providers can vary widely, however, as indicated by the performance graphs for Communicomm Wireless (Texas) and Keyon Wireless (Nevada) shown in Figures 33 and 34. As shown in Figure 33, a 1500/200 service offering Communicomm provides a throughput level below 500 kilobits per second in the download direction. Keyon Wireless for a 2048/512 service offering averages half of that level as shown in Figure 34.

Finally, wireless satellite performance data on a comparable graphical basis are recorded in Figures 35, 36 and 37 for SATNOW Satellite with a service offering of 1000/56. The upload service is essentially dial-up level throughput performance. Download performance, consistent with the service offering, is around 800-900 kilobits per second.

State of Wisconsin Broadband Communications Performances

A comparison of throughput performance of all ISPs for the United States as presented in Figure 9, and for Wisconsin, as presented in Figure 38, indicates general parity between these geographic areas. Wisconsin performance is more volatile, but that may be due to by the smaller sample sizes involved at the State level. For both the United States and for Wisconsin, overall broadband communications performance is currently in the one to two megabits per second range.

Available performance data for Time Warner Cable Road Runner broadband cable service within Wisconsin appeared to contain serious errors and therefore constituted an unusable data set. Accordingly, no comparison could be made between national and Wisconsin performance levels.

Charter Cable also appears to offer a lower throughput performance in Wisconsin than nationally as indicated by a comparison of Figure 39 with Figures 17, 18, and 19. The national level performance is significantly above two megabits per second, while the performance within Wisconsin generally ranges under two megabits per second and at times below one megabit per second.

The DSL performance provided within Wisconsin by the three ILEC carriers—AT&T, TDS and Verizon—shows quite similar performance in Figures 40, 41, and 42.

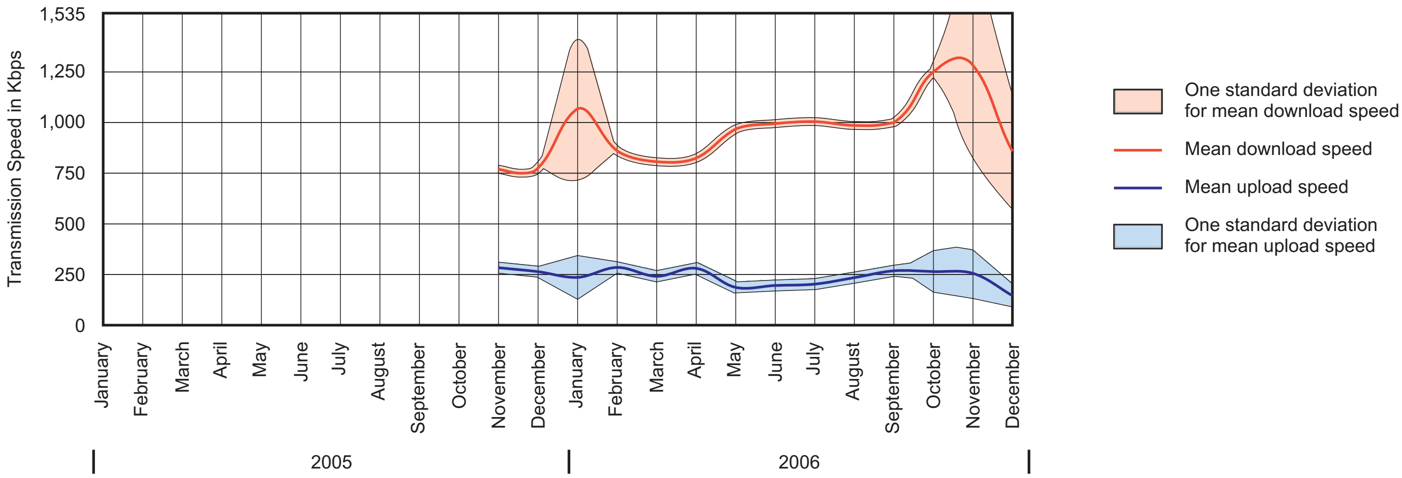
A composite tabulation of wireline broadband communication performance within Wisconsin is presented in Table 16.

Local-Level Broadband Performance Within Southeastern Wisconsin

While national and State level broadband performance data provide a comparative evaluation of the wireline broadband communications technologies in use within the Southeastern Wisconsin Region, it is instructive to investigate equivalent network performance at local levels to verify the consistency of broadband performance on a Regional basis. If local level broadband performance data are consistent with national and State evaluation data, then regional performance is likely to match the throughput performance of the same technologies in other states and regions of the United States. In the future, when performance data at the postal zip code level become more readily available, it will become possible to map regional broadband performance in some detail.

Figure 30

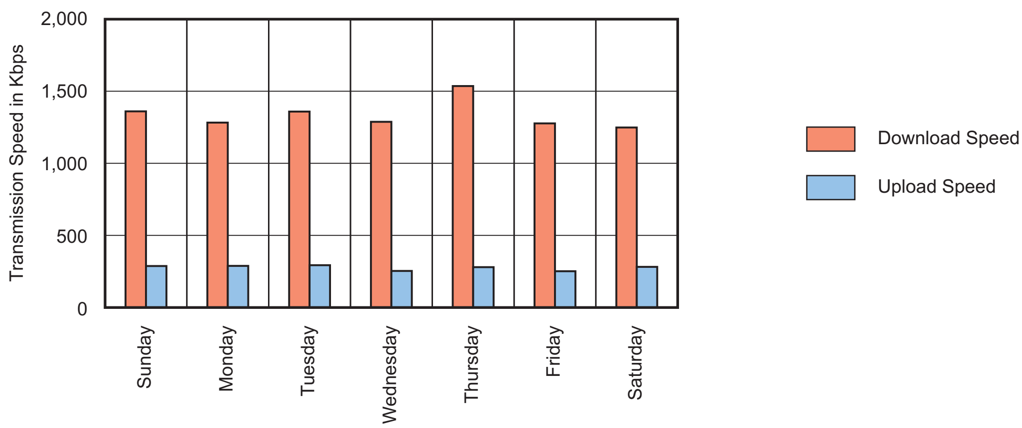
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY MONTH FOR CLEARWIRE WIRELESS - PROPRIETARY IN THE UNITED STATES: NOVEMBER 2005 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 31

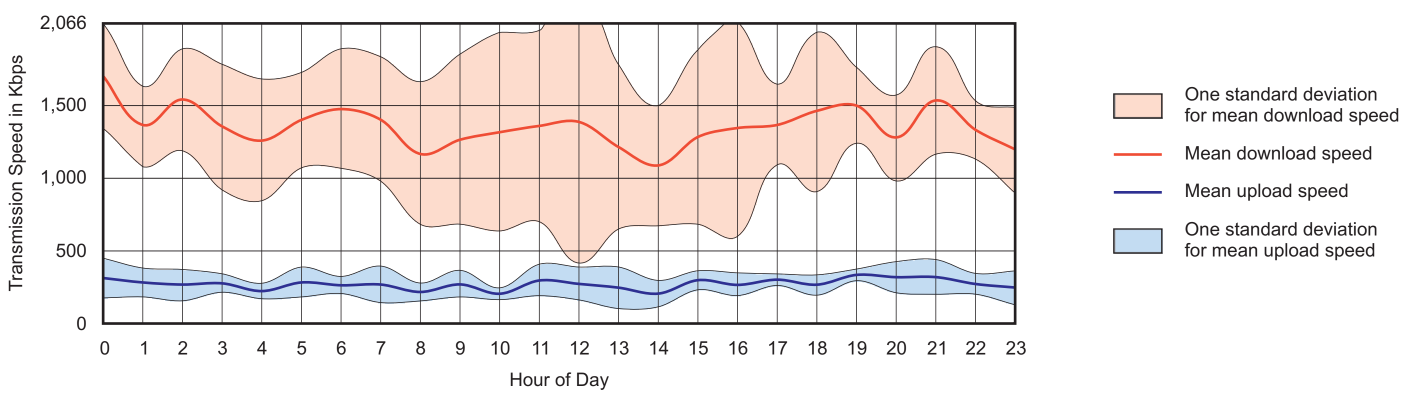
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY DAY OF WEEK FOR CLEARWIRE WIRELESS - PROPRIETARY IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 32

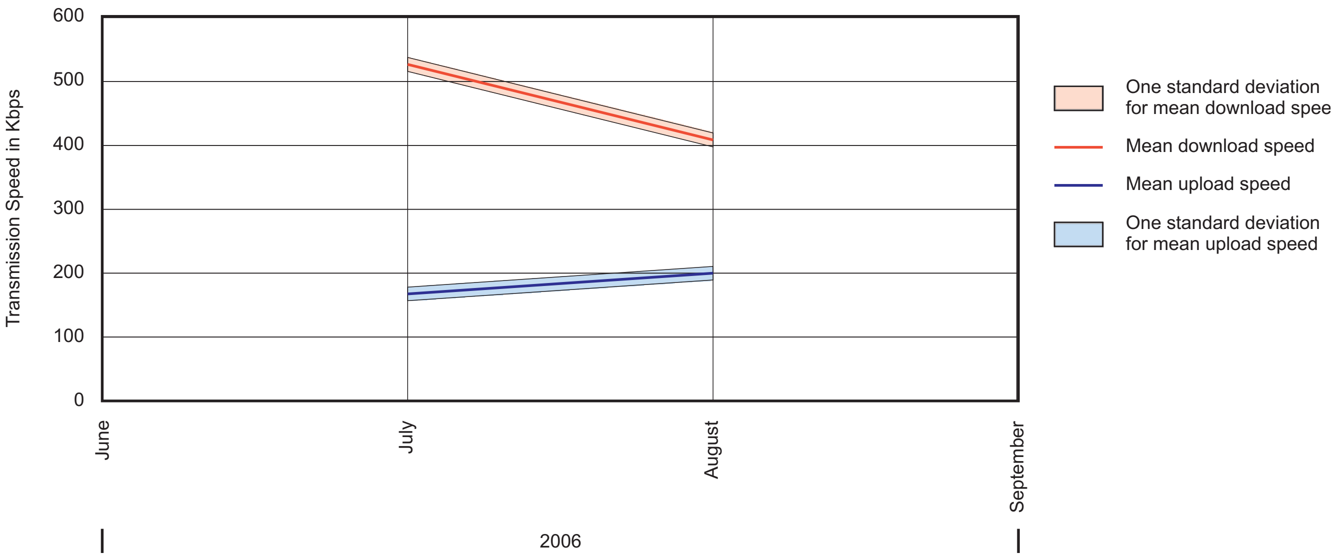
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (256 kbps) TRANSMISSION RATES BY HOUR OF DAY FOR CLEARWIRE WIRELESS - PROPRIETARY IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 33

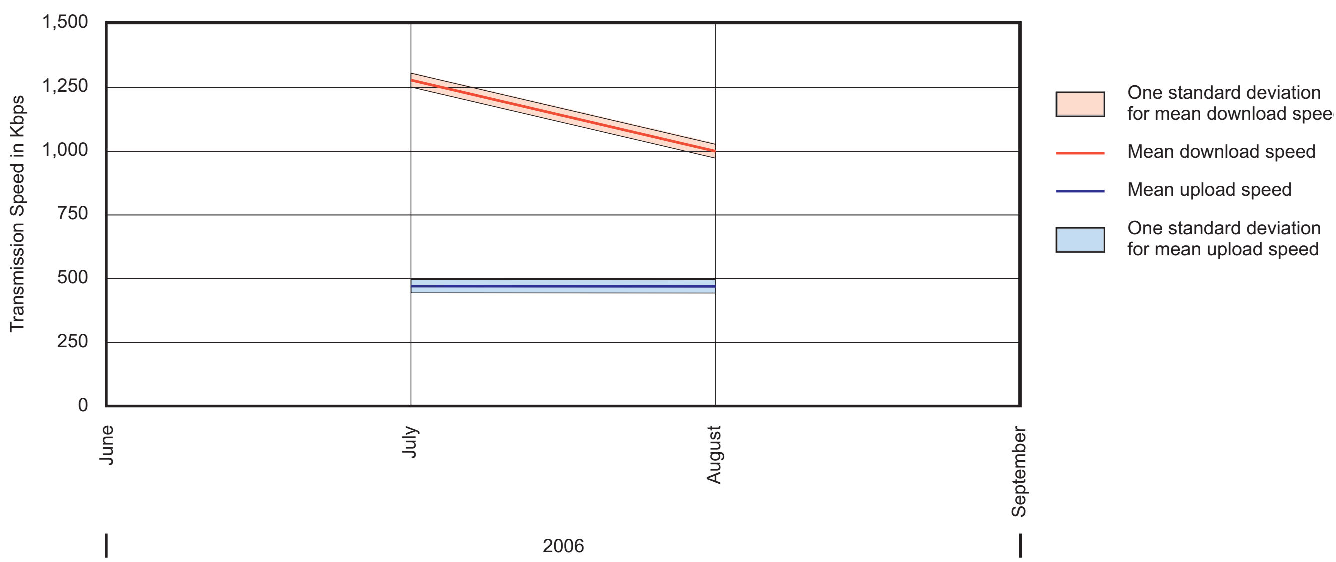
COMPARISON OF DOWNLOAD (1500Kbps) AND UPLOAD (200Kbps) TRANSMISSION RATES BY MONTH FOR COMMUNICOMM WIRELESS – PROPRIETARY IN THE UNITED STATES: JULY 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 34

COMPARISON OF DOWNLOAD (2048Kbps) AND UPLOAD (512Kbps) TRANSMISSION RATES BY MONTH FOR KEYON WIRELESS – PROPRIETARY IN THE UNITED STATES: JULY 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

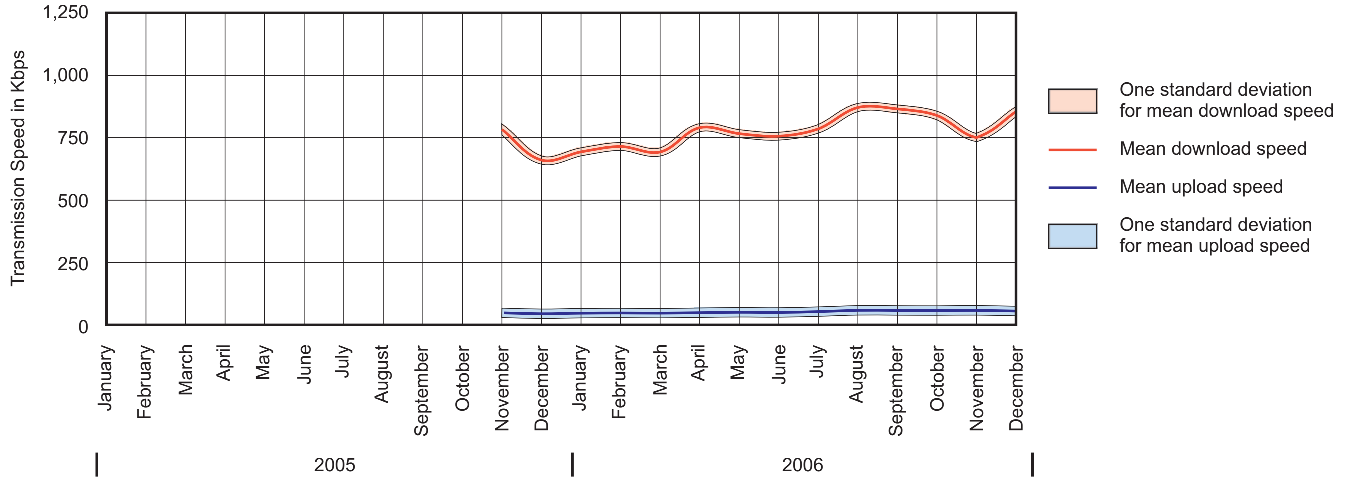
Currently, it is possible only to verify performance equivalency with national and State performance levels.

The next level of source data below the state category for the TCP/IQ website is the postal zip code. Source data at the zip code level is sparse with many zip code areas having no data reported. For this reason, the performance data herein presented for smaller geographic areas, was severely constrained.

Broadband cable performance in the City of Lake Geneva, Walworth County—zip code 53147 shown on Map 28—in Figure 43, evaluates the same downward trend as exhibited at the State level

Figure 35

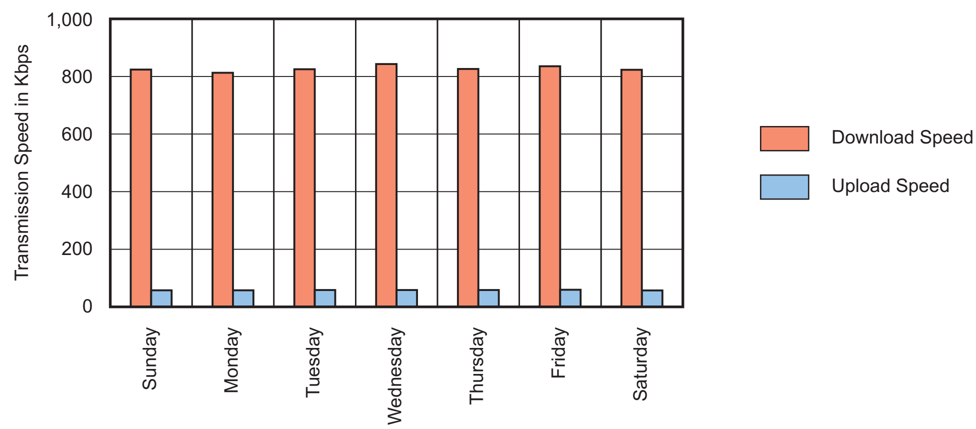
COMPARISON OF DOWNLOAD (1000 Kbps) AND UPLOAD (56 Kbps) TRANSMISSION RATES BY MONTH FOR SATNOW SATELLITE INTERNET SATELLITE + PHONE IN THE UNITED STATES: NOVEMBER 2005 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 36

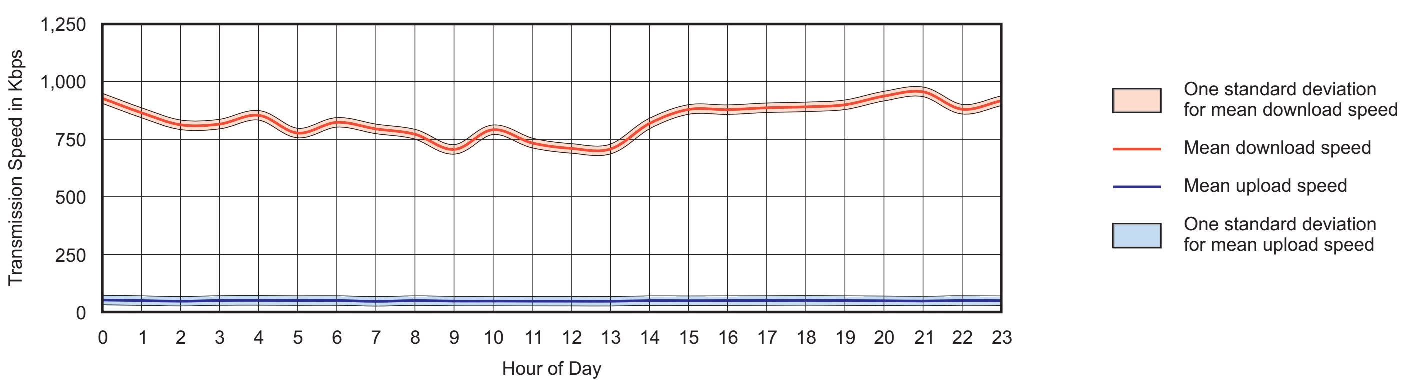
COMPARISON OF DOWNLOAD (1000 Kbps) AND UPLOAD (56 Kbps) TRANSMISSION RATES BY DAY OF WEEK FOR SATNOW SATELLITE INTERNET SATELLITE + PHONE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 37

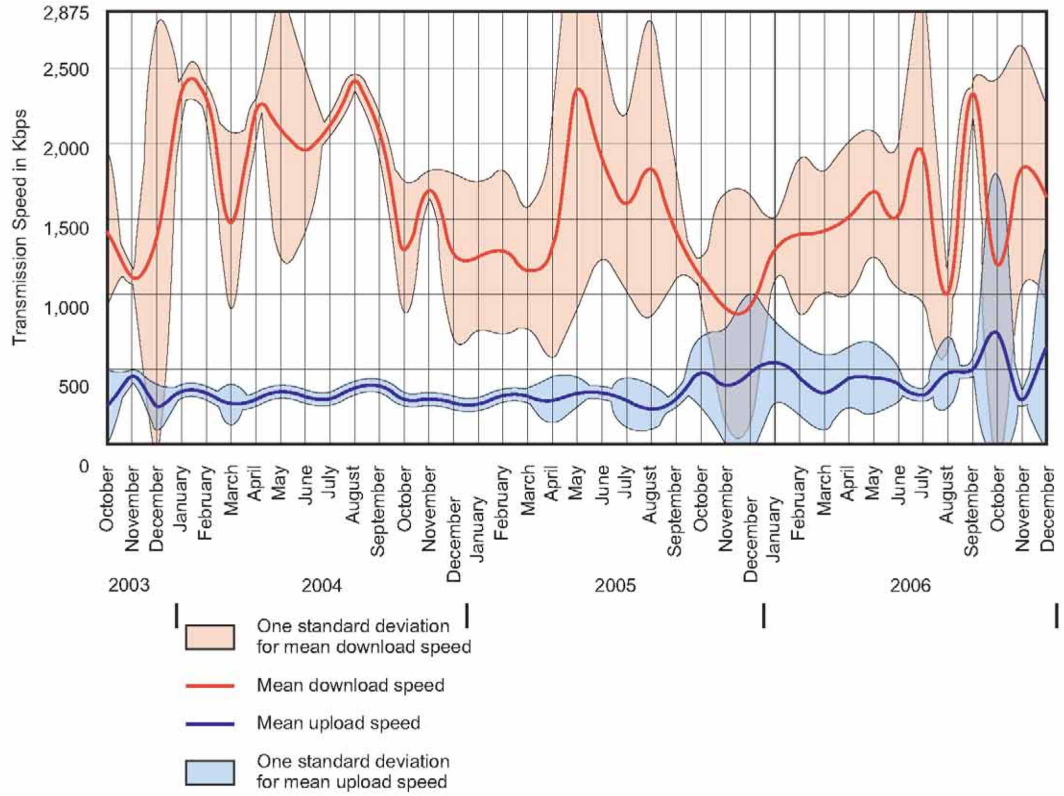
COMPARISON OF DOWNLOAD (1000 Kbps) AND UPLOAD (56 Kbps) TRANSMISSION RATES BY HOUR OF DAY FOR SATNOW SATELLITE INTERNET SATELLITE + PHONE IN THE UNITED STATES



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 38

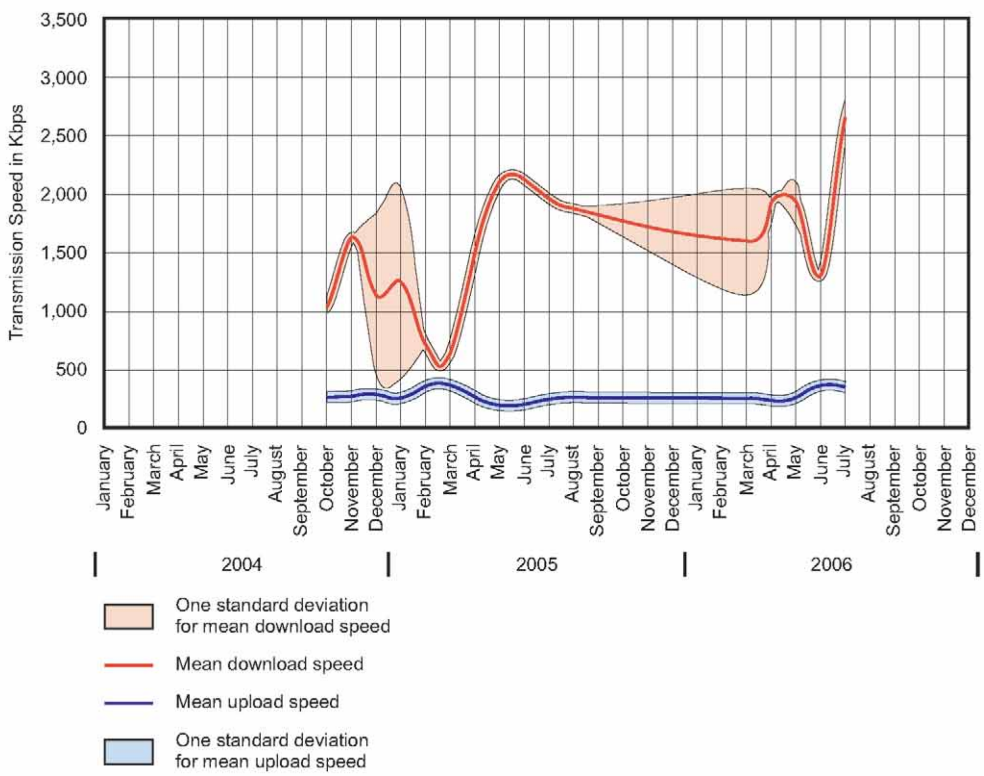
COMPARISON OF DOWNLOAD AND UPLOAD TRANSMISSION RATES FOR ALL INTERNET SERVICE PROVIDERS IN WISCONSIN: OCTOBER 2003 - DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 39

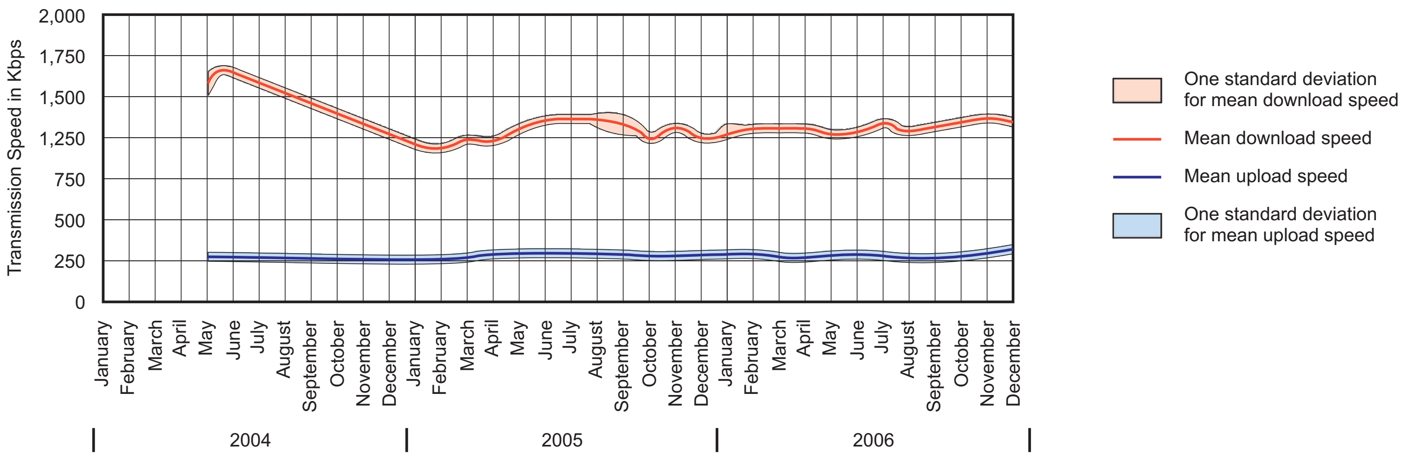
COMPARISON OF DOWNLOAD (3000 Kbps) AND UPLOAD (256 Kbps) TRANSMISSION RATES BY MONTH FOR CHARTER CABLE IN WISCONSIN: OCTOBER 2004 THROUGH JULY 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 40

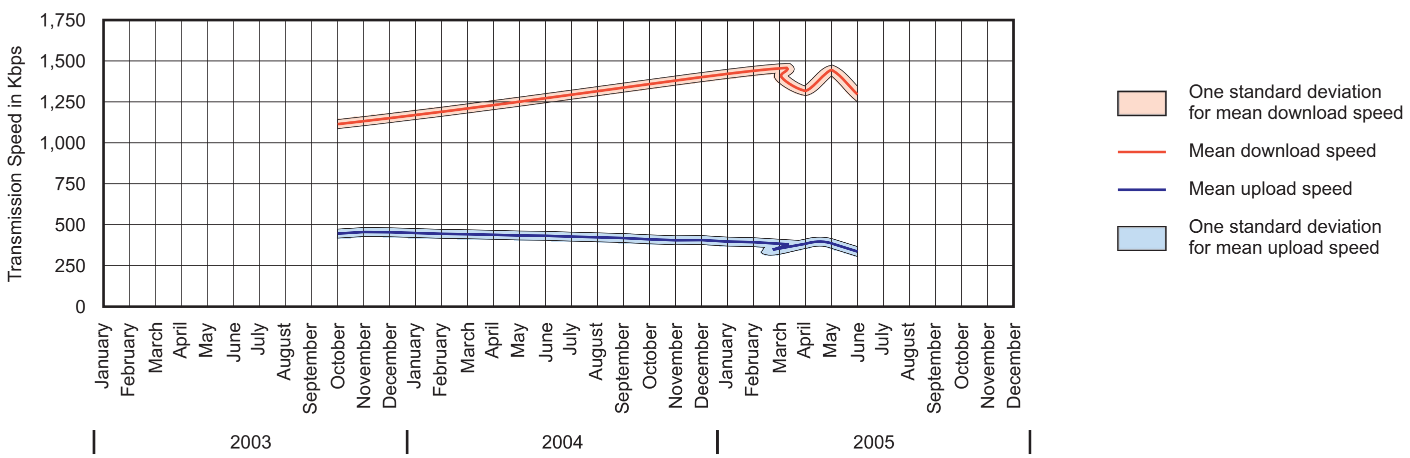
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (384 Kbps) TRANSMISSION RATES BY MONTH FOR SBC - AT&T xDSL IN WISCONSIN: MAY 2004 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 41

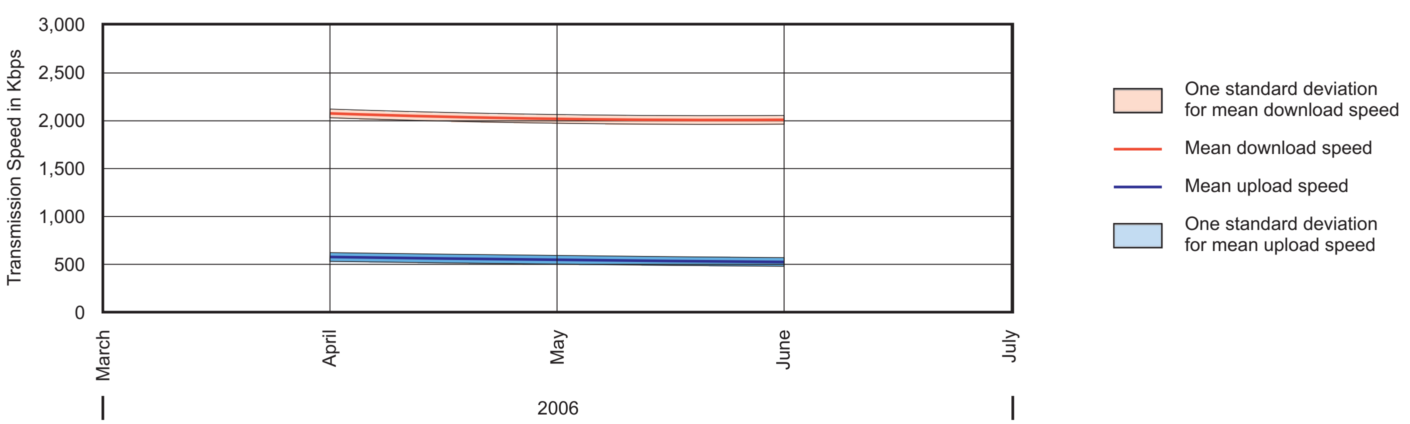
COMPARISON OF DOWNLOAD (1500 Kbps) AND UPLOAD (512 Kbps) TRANSMISSION RATES BY MONTH FOR TDS.net xDSL IN WISCONSIN: OCTOBER 2003 THROUGH JUNE 2005



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 42

COMPARISON OF DOWNLOAD (3000 Kbps) AND UPLOAD (768 Kbps) TRANSMISSION RATES BY MONTH VERIZON xDSL IN WISCONSIN: APRIL 2006 THROUGH JUNE 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

Table 16

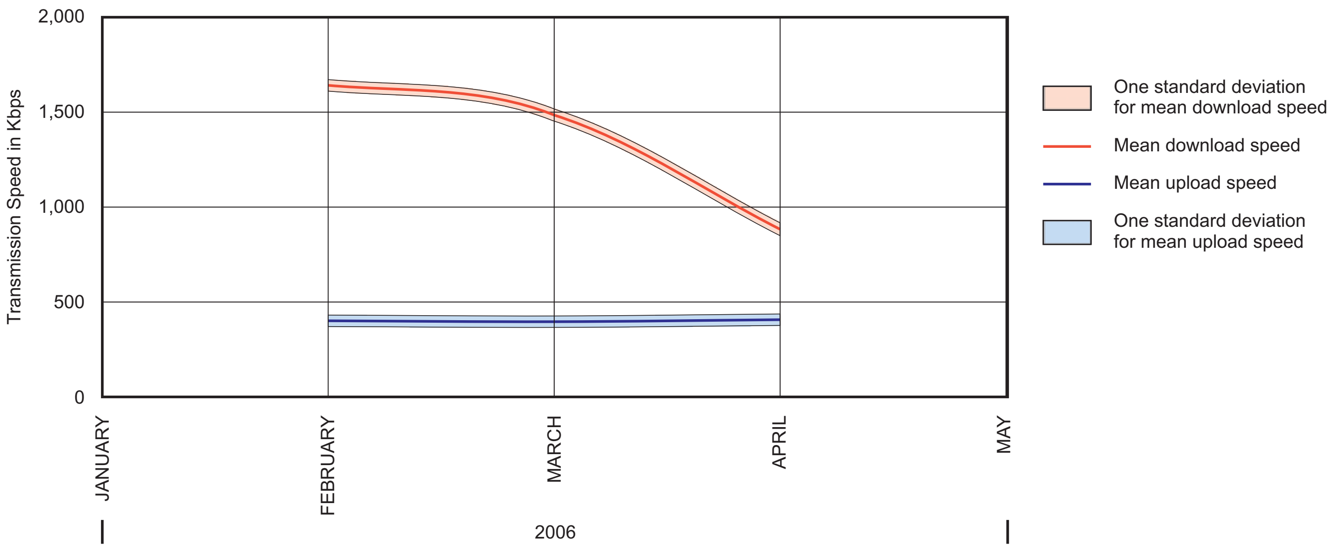
COMPARATIVE WIRELINE BROADBAND COMMUNICATIONS PERFORMANCE WITHIN WISCONSIN: 2006

Provider	Technology	Samples	Average Download Throughput (Mbps)
Time Warner Cable.................................	Cable	30,111	2.59
Charter Communications	Cable	48,773	1.91
AT&T..	ADSL	12,100	1.01
CenturyTel	ADSL	2,491	0.72
TDS..	ADSL	2,725	0.47
Netwurx..	Fixed / Wireless	130	1.19

Source: SEWRPC.

Figure 43

COMPARISON OF DOWNLOAD (5000Kbps) AND UPLOAD (768Kbps) TRANSMISSION RATES BY MONTH FOR TIME WARNER CABLE ROAD RUNNER SERVICE IN THE U.S. POSTAL ZIP CODE 53147 AREA OF THE CITY OF LAKE GENEVA, WALWORTH COUNTY AND ENVIRONS: FEBRUARY 2006 THROUGH APRIL 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

shown in Figure 40.Initial average download transmission rates in 2006 exceeded 1.5 megabits per second but declined over the first half year to average rates under 0.8 megabit per second. This decline in performance as a function of subscriber load is inherent in the hybrid fiber coaxial architecture cable. Upload throughput, though much lower in value, is remarkably stable. It is of interest to note that the offered service level of 5000/768 is significantly above actual performance.

A remarkably different performance trend for broadband DSL is indicated for AT&T DSL as shown in Figure 44 for West Bend, Washington County—zip code area 53095 as shown on Map 28. Transmission rates are stable near the offered service level of 1500/384 with no apparent downtrend in either download or upload throughput over time.

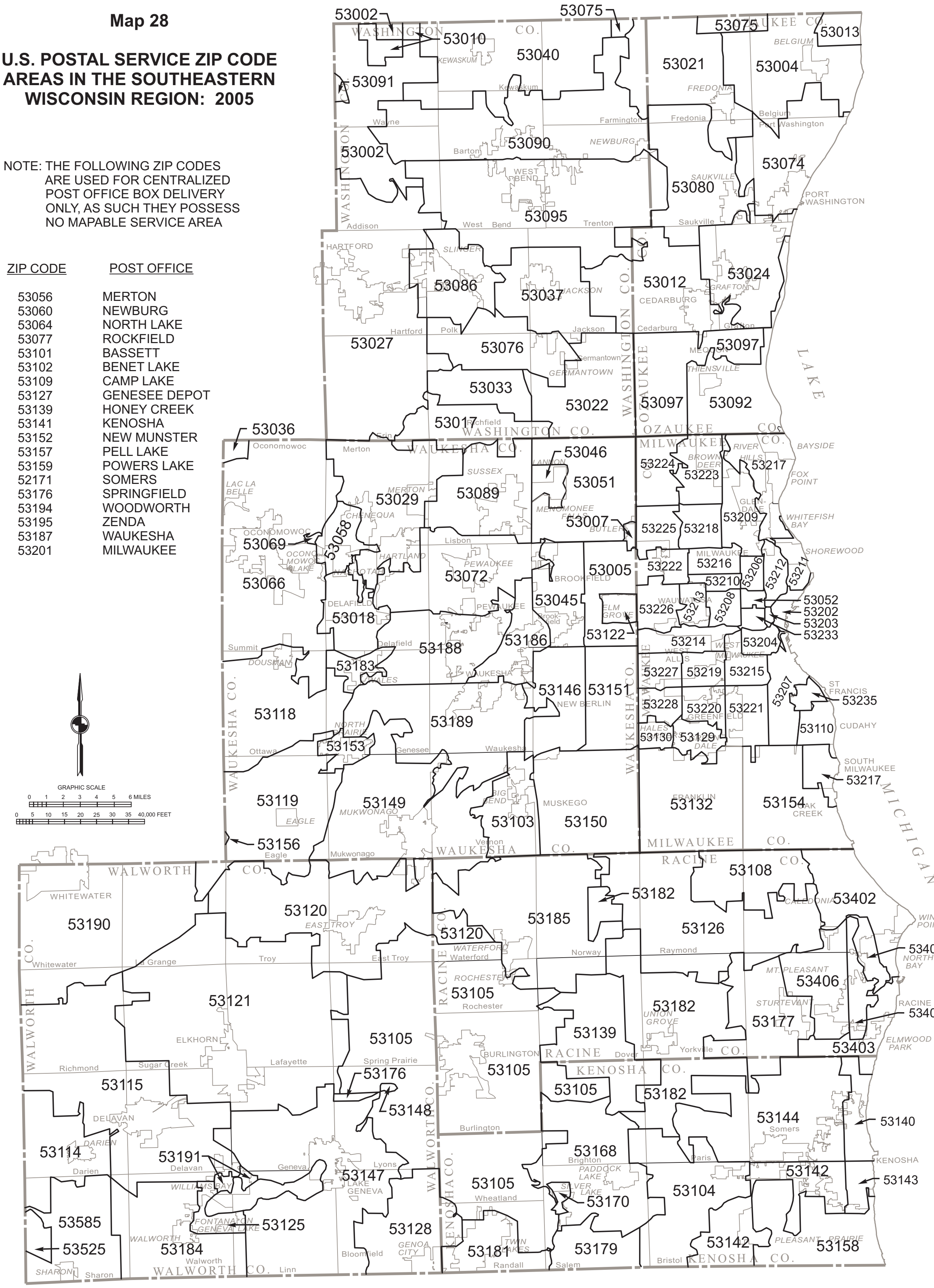
Data for zip code area 53207 as shown on Map 28 representing an area in the south side of the City of Milwaukee as given in Figure 45 indicates a lower level of performance than another AT&T site in West Bend. Comparing the performance provided in the south side of Milwaukee with that provided for West Bend as given in Figure 44, performance in the West Bend area is about 30 percent faster than in the selected area of Milwaukee using the same broadband DSL technology. This performance difference is probably best explained by the presence of multiple remote terminals in the West Bend area because of its size and newly developed subdivisions. Remote terminals enhance performance by bringing greater fiber optic bandwidth closer to the user. DSL performance degrades with distance from either the Central Office or fiber-linked terminals.

Map 28

U.S. POSTAL SERVICE ZIP CODE AREAS IN THE SOUTHEASTERN WISCONSIN REGION: 2005

NOTE: THE FOLLOWING ZIP CODES ARE USED FOR CENTRALIZED POST OFFICE BOX DELIVERY ONLY, AS SUCH THEY POSSESS NO MAPABLE SERVICE AREA

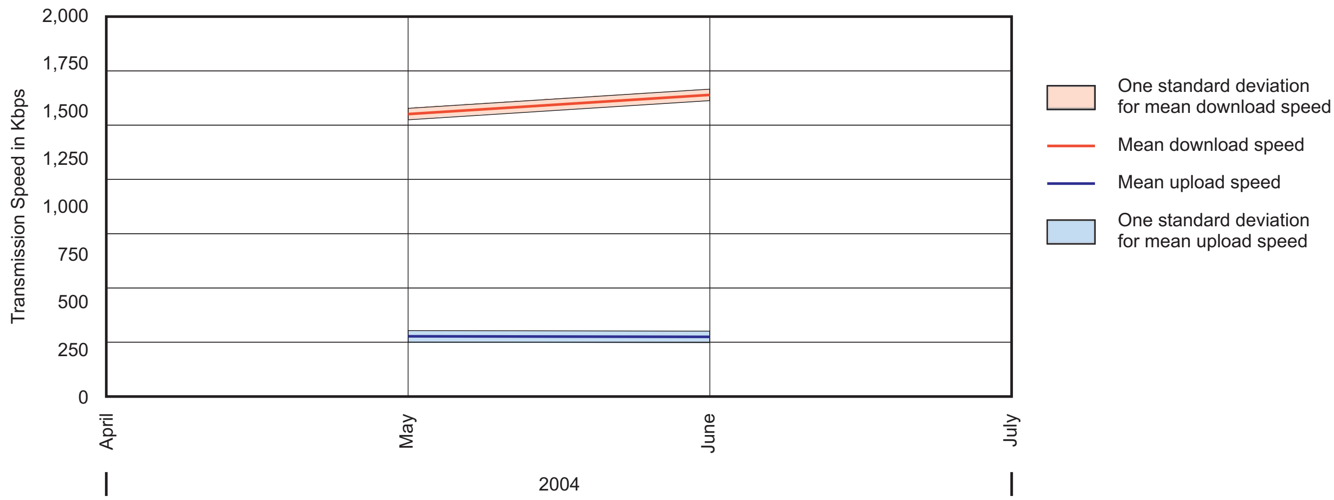
ZIP CODE	POST OFFICE
53056	MERTON
53060	NEWBURG
53064	NORTH LAKE
53077	ROCKFIELD
53101	BASSETT
53102	BENET LAKE
53109	CAMP LAKE
53127	GENESEE DEPOT
53139	HONEY CREEK
53141	KENOSHA
53152	NEW MUNSTER
53157	PELL LAKE
53159	POWERS LAKE
52171	SOMERS
53176	SPRINGFIELD
53194	WOODWORTH
53195	ZENDA
53187	WAUKESHA
53201	MILWAUKEE



Source: U.S. Census Bureau and SEWRPC.

Figure 44

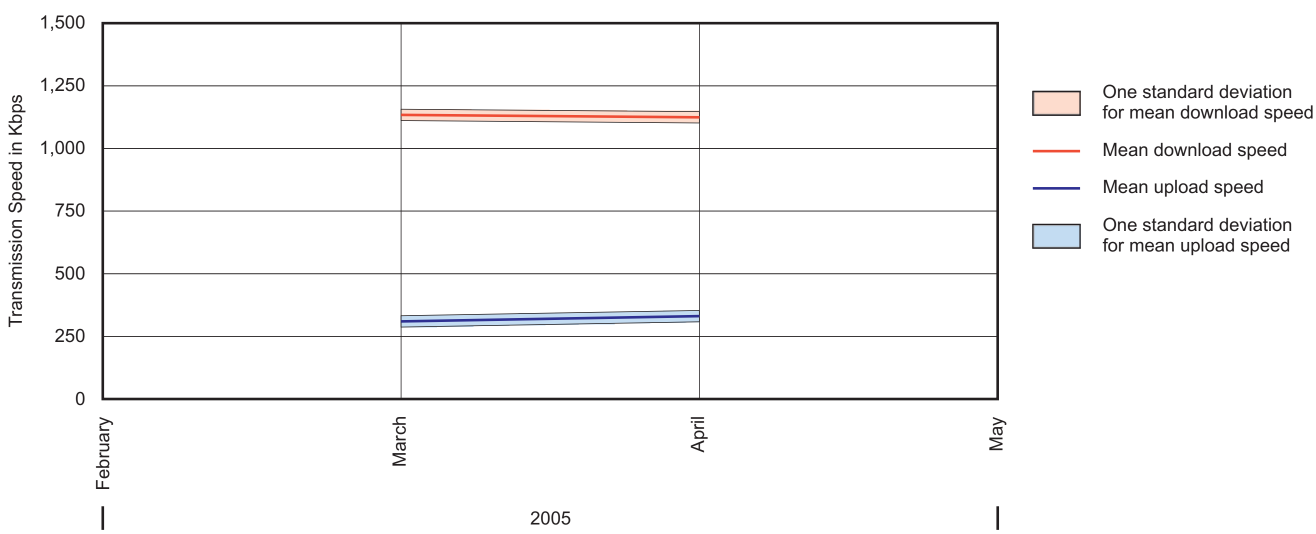
COMPARISON OF DOWNLOAD (1500Kbps) AND UPLOAD (384Kbps) TRANSMISSION RATES BY MONTH FOR SBC – AT&T xDSL IN THE U.S. POSTAL ZIP CODE 53095 AREA OF THE CITY OF WEST BEND, WASHINGTON COUNTY AND ENVIRONS: MAY 2004



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 45

COMPARISON OF DOWNLOAD (1500Kbps) AND UPLOAD (384Kbps) TRANSMISSION RATES BY MONTH FOR SBC – AT&T xDSL IN THE U.S. POSTAL ZIP CODE 53207 AREA OF THE NEAR SOUTHSIDE OF THE CITY OF MILWAUKEE: MARCH 2005



Source: Sigma Solutions Group, LLC, and SEWRPC.

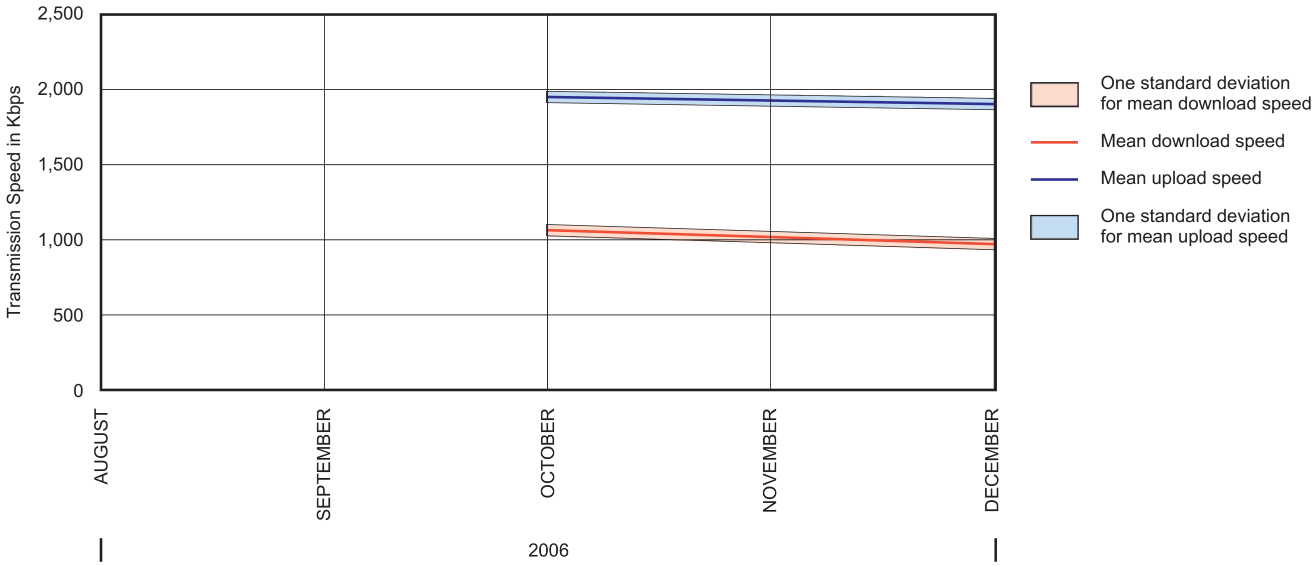
An unusual level of broadband cable network performance is illustrated for the City of Greenfield, Milwaukee County—zip code area 53228 as shown on Map 28—in Figure 46 where the service offering is reversed with greater bandwidth allocated to upload than download transmission (750/3000). Through-put performance appears to be stable over time.

Broadband Communications, Performance Summary

National broadband download wireline throughput performance as measured in megabits per second averages in the 1.0 to 2.5 range in the United States. Upload performance is much slower with recordings around 0.25 to 0.50 megabit per second. This disparity in download versus upload speeds occurs

Figure 46

COMPARISON OF DOWNLOAD (750Kbps) AND UPLOAD (3000Kbps) TRANSMISSION RATES BY MONTH FOR EARTHLINK CABLE IN THE U.S. POSTAL ZIP CODE 53228 AREA OF GREENFIELD, MILWAUKEE COUNTY AND ENVIRONS: OCTOBER 2006 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

primarily because more bandwidth is generally allocated by the carriers to download traffic. Most user applications such as web search heavily favor download volume. If more bandwidth were allocated to upload traffic, download transmission speeds would be reduced.

Depending on service agreements in terms of maximum download and upload speeds, DSL and cable broadband services are generally equivalent in the one to five megabits per second range at the national level. DSL performance can vary significantly with individual carriers and with the distance of the subscriber from the telephone central office or extended remote terminal. Cable performance also varies between carriers and tends to decline as more subscribers share a common channel in the hybrid fiber coaxial cable network architecture.

Fixed wireless generally offers more symmetrical service offerings in terms of download and upload speeds. Standards based WiFi networks also perform in the one to three megabits per second range. Mobile wireless networks resemble wireline networks in their bias toward much faster download speeds

Although the field measurement studies conducted by the Commission recorded 3G mobile network throughputs well below the two megabits per second targets at 336 kilobits per second, some national data for GSM networks supports throughput above two megabits per second.

Overall, measures of broadband throughput at the State level indicate performance levels in the same range as nationally. Time series recordings of Time Warner Cable, however, display a statewide downward trend in throughput for download traffic. This trend appears to be consistent with the network architecture limitations of hybrid fiber coaxial cable networks. However, Charter Cable performance, while more volatile, does not confirm this downward trend. DSL networks though sensitive to central office distances, do not show this performance reduction from network loading.

Overall measurements of broadband communications networks as provided in Table 16, with thousands of samples, indicate significantly higher performance for cable networks. Average download throughputs for Time Warner and Charter Cable networks are more than double those of telephone DSL networks. It may be concluded from the data summary that broadband cable has an inherently greater bandwidth capability than the current ADSL version of DSL. A smaller sample data summary for a Regional fixed wireless service provider, Netwurx using the Motorola Canopy technology, appears to confirm the broadband capability of fixed wireless in the over one megabit per second range.

Local broadband performance data at the postal zip code area level, where available, are generally consistent with national and Statewide broadband throughput performance data.

Overall, currently available wireline and wireless broadband communications technologies do not provide the throughput performance levels specified in the regional telecommunications service objectives and standards set forth in Chapter III of SEWRPC Planning Report No. 51, and in Chapter III of this report. In addition, only one of the technologies, DSL, has a current infrastructure development plan aimed at achieving these objectives. AT&T with its Project Lightspeed has targeted line speeds exceeding 20 megabits per second based on a fiber-to-the-node (FTTN/VDSL) technology. Deployment plans, however, currently involve only 25 of the 147 municipalities in the Region, and there is no commitment to serve all of the geographic areas of these communities. There are no publicly available higher throughput broadband plans for the Time Warner or Charter Cable networks.

Fixed wireless in its WiFi version is currently focused on mesh networks which have demonstrated throughput only in the one to three megabits per second range with little upward prospects. Proprietary fixed wireless systems as manufactured by Motorola and Alvarion are operating in the same performance range with no known plans for upward scaling.

WiMAX has been advanced as the standards-based answer to higher performance wireless broadband but current focus in WiMAX is on the mobile version of the technology for licensed spectrum with little activity for the unlicensed bands which provide the basis for most fixed wireless networks. Sprint Nextel has announced plans for the introduction of WiMAX in the United States as a major upgrade of its mobile network with 2008 as a target year. Service level determinations of throughput for the carrier’s WiMAX technology are still in the experimental stage.

Chapter VII

DESIGN OF ALTERNATIVE REGIONAL BROADBAND TELECOMMUNICATIONS PLANS

INTRODUCTION

Previous chapters of this report have presented information pertinent to the development of alternative fourth generation (4G) broadband telecommunications plans for Southeastern Wisconsin. The objectives and standards set forth in Chapter III of this report provide the criteria for judging the relative merits of the alternative plans considered, and the rationale for the selection of a recommended plan.

The findings of the existing wireless antennae base station sites within the Region set forth in Chapter V of SEWRPC Planning Report No. 51 provide the basis for selecting antennae station sites for the alternative regional wireless plan. The findings of the service area coverage inventories documented in Chapter V of this report provide the geographic basis for plan design and implementation. The findings of the performance inventory set forth in Chapter VI of this report reveal both the capabilities and shortcomings of current wireline and wireless networks in the Region. These findings also describe the state of current plans for broadband service within the Region, indicating that no single service provider or group of providers have plans for networks that would satisfy the objectives and standards set forth in Chapter III.

Six alternative broadband communications plans were developed and are described and evaluated in this chapter as a basis for the selection of a recommended plan. The recommended plan set forth in Chapter VIII of this report, is a composite of the best features of the alternative plans considered, since no single wireline or wireless communications technology can cost effectively satisfy the needs of all areas of the Region. It is important to understand in this respect, that private sector service providers or governmental organizations could develop different regional broadband communications plans that would satisfy the objectives and standards of Chapter III. The alternative plans presented herein are not intended to impede the development or implementation of plans prepared and put forth by private providers, or by counties or municipalities within the Region, that would move the existing level of telecommunication service within the Region toward the achievement of the agreed upon objectives and standards set forth in Chapter III of this report. It is hoped, however, that the plans herein presented would serve as a point of departure for further telecommunication planning by private providers and public agencies.

The alternative telecommunications plans presented in this chapter represent a mixture of wireline and wireless communications technologies. In designing these alternative plans the cost effectiveness of deploying each technology concerned was taken into account. The alternative plans presented emphasize the access element of communications networks, since this element represents the primary constraint in delivering broadband capability to users. Beyond the direct access networks are the backhaul networks which link primary access networks to core networks which carry the bulk traffic throughout the United States and the remainder of the world. All access communications networks require a core network in order to link with subscribers beyond their immediate areas. The placement of access network node locations is often heavily influenced by the availability of fiber optic gateway locations.

Preparation of a comprehensive broadband regional communications plan involves a sequence of steps that include:

1. Selecting a set of basic communications technologies for consideration in the preparation of alternative plans;

2. Identifying and defining the equipment requirements for both network infrastructure and users to implement the selected technologies;

3. Developing performance data for the various technologies as necessary to determine the estimated performance of alternative plans;

4. Developing capital and operating cost data for the same technologies sufficient to estimate the costs of alternative plans;

5. Preparing geographic network layouts of alternative broadband communications systems with base stations, access points, points of presence, distribution networks and Internet-connecting gateway stations indicated;

6. Specifying the expected performance, benefits and costs associated with each alternative broadband communications system plan; and

7. Evaluating the ability of each alternative plan to meet the objectives and standards set forth in Chapter III of this report as a basis for selecting a recommended broadband communications system plan for the Region.

The end result of this sequence of design activities is a proposed regional broadband communications network infrastructure, set forth in the succeeding chapter of this report, that will support a wide variety of broadband users with a fourth generation (4G) communications deployment.

TECHNOLOGICAL ALTERNATIVES

Five separate but related technological alternatives were considered in formulating alternative broadband telecommunications plans for the Region:

1. <u>Community-Based Advanced WiFi Wireless Networks</u>
   This plan is based on extended range versions of IEEE Standard 802.11g operating in the 2.40 to 2.48 GHz band, and is intended to serve fixed and nomadic users.

2. <u>Regional Advanced WiFiA Wireless Network</u>
   This plan is based on IEEE Standards 802.11a (WiFiA) operating in the 5.8 GHz band, and is intended to serve fixed and nomadic users.

3. <u>Regional Mobile WiMAX-based Wireless Network</u>
   This plan is based on IEEE Standard 802.16e and is intended to serve mobile users.

4. <u>Regional Fiber-to-the Node Wireline Network</u>
   This plan would provide fiber optic cable from telephone system central offices to remote nodes, and twisted pair copper wires from the nodes to each user. The plan would be based on VDSL technology.

5. <u>Localized Fiber-to-the Premises, Wireline Network</u>
   This plan would provide fiber optic cable to each premise in areas with sufficient population and/or enterprise densities to justify the investment required.

Advanced WiFi Wireless and WiMAX Technologies

Information on the history and general background of IEEE Standard 802.11 (WiFi for Wireless Fidelity) were provided in SEWRPC Planning

Report No. 51, and will not be repeated here. It is important however, to emphasize the advanced high performance version of the WiFi technology proposed to be employed in the plans. Traditional WiFi networks operate around very short range—300 feet radius—access points—hot spots—in homes, coffee shops, hotels, schools and other designated locations. The WiFi networks planned here feature a sectoral cellular network topology and high gain active antennas at each fixed user premise. This combination of network structure and augmented user transceiver equipment allows for 4G levels of network throughput performance exceeding 20 megabits per second. Community-level WiFi access networks would operate using the 802.11g standard at 2.4 GHz with 802.11a backhaul at 5.8 GHz, while regional networks would operate with the 802.11a standard and for backhaul.

Initial releases of WiMAX equipment are expected to be in the licensed bands such as 2.5 GHz and 3.5 GHz. Such bands are available only to licensed carriers who have purchased radio spectrum from the Federal Government. Such licensed bands are expected to be used primarily for mobile communications. Succeeding WiMAX equipment releases, however, are expected to be at 5.8 GHz, an unlicensed band suitable for backhaul communications as defined here. WiMAX equipment for backhaul infrastructure deployment will be more costly of equivalent WiFiA (802.11a) equipment operating in the 5.8 GHz band. The improved quality of service features and traffic handling capability of WiMAX is expected to justify the increased cost.

Mobile WiMAX Technologies

The WiMAX technology referenced in the previous section is specified for fixed backhaul networks. Another version of WiMAX 802.16e is being developed for mobile use. This WiMAX version differs in its ability to serve users in moving vehicles rapidly crossing sectoral boundaries and requiring rapid handoffs to adjacent access points. This version of WiMAX is also able to service fixed and nomadic users, but generally at slower data rates than fixed WiFi/WiMAX networks. In mobile application, the potential advantage of WiMAX over current 3G versions of GSM/UMTS and CDMA/EV-DO technologies is the provision of higher data rates with the potential at least of 4G-level performance of 20 megabits per second or better. Early deployments of mobile WiMAX are expected to be data centric to take advantage of the higher throughput performance of this technology. WiMAX also will have more advanced quality of service (QOS) capabilities with a more sophisticated media access protocol than current WiFi networks.

Because mobile WiMAX technology will be available, at least initially, only in licensed bands such as 2.5 GHz and 3.5 GHz, regional deployment of mobile WiMAX will depend on the selection of this technology by licensed American wireless carriers. To date, Sprint/Nextel is the only American wireless carrier committed to WiMAX. WiMAX plans, then, must be based on a Sprint/Nextel regional deployment. The timing of such a Southeastern Wisconsin mobile WiMAX deployment will depend upon corporate priorities concerned. Sufficient information on both WiMAX technology and the current Sprint/Nextel base station infrastructure, however, is available to prepare a 802.16e WiMAX plan for the Region. In fact, the antenna site information obtained from Sprint and Nextel was considered to be complete and of high quality. These two service providers were the only providers that cooperated in the Commission regional antenna site inventory.

Fiber-to-the-Node Wireline Technologies

The Fiber-to-the-Node (FTTN) technology to be employed in the broadband wireline communications plan of the same name is the Alcatel-based technology currently being used by AT&T to deploy the U-Verse system as part of Project Lightspeed in Southeastern Wisconsin. The reasons for selecting the particular version of FTTN are two:

1. State of the Art Technology
   This particular Alcatel-based version of FTTN is a current, well-conceived and carefully reviewed technology.

2. AT&T – Major Incumbent Local Exchange Carriers (ILEC) in the Region
   As the dominant ILEC in Southeastern Wisconsin, AT&T owns most of the copper lines required to implement any FTTN wireline plan. Under Federal law, AT&T must make these copper lines available to other facilities-based service providers. The

AT&T must lease space in AT&T central offices to other providers; those providers may then install their own fiber optic cable connections from the central offices concerned to remote nodes; and the AT&T must then make their copper line distribution facilities available for use by the other providers under appropriate lease agreements. Any FTTN plan applying to areas beyond the AT&T service areas must be based on ILEC carriers that own copper distribution lines to homes, businesses, and institutions. FTTN extensions beyond AT&T service areas were, therefore, presumed to be deployed by other ILEC's operating within the Region such as Century Tel and Verizon North.

The AT&T FTTN broadband communications network is based on Alcatel's 7330 Intelligent Services Access Manager, ISAM. The 7330 ISAM is connected by fiber optic cable with the local central office and serves as a remote distribution point for broadband traffic to users over existing twisted pair copper links. Each ISAM can service subscribers located within a 3,000 feet radius of the node. High speed throughput is possible because the signal-to-noise ratio (SNR), which decreases with distance from the node, is still high enough to support throughputs exceeding 20 megabits per second.

A pictorial diagram of a U-Verse network is shown in Figure 47. Supporting the node and local central offices are a series of special central offices that manage Internet access and Voice over IP as well as video. Regional IP video hub offices store and distribute video content to end users through local central offices.

Physically, the U-Verse network takes the form of a set of outdoor cabinets as shown in Figure 48. Three cabinets are typically located at each node location:

1. Fiber Conversion Cabinet
   This cabinet houses the Alcatel 5330 ISAM, with 200, 400 or 800 line connections, the corresponding cabinets being designated as 52 BP, 52B or 52E respectively.
2. Power Cabinet
   This cabinet houses power line connections, power supply equipment and power metering.
3. Cross Connection Cabinet
   This cabinet serves as a cross-connection point for subscriber twisted pair copper lines.

It should be emphasized that U-Verse represents a further stage upgrade to AT&T's original Digital Subscriber Line (DSL) broadband offering as shown in Figure 49. The original ADSL deployment was based on copper line connections to a central office. The central office is able to serve DSL subscribers within a radius of about 18,000 feet of a central office. The first upgrade, shown just below the all-copper existing network in Figure 49, deployed fiber-linked remote terminals that extended DSL range to a new radius of 18,000 feet from the remote terminal. This upgrade brought DSL services to areas previously located too distant from central offices. The second upgrade, shown in the lower part of Figure 49, is the U-Verse upgrade now part of the current Project Lightspeed (VDSL). Because the new high speed VDSL technology is limited to a 3,000 foot radius, this upgrade will require a much higher density of remote nodes than the original ADSL remote terminals.

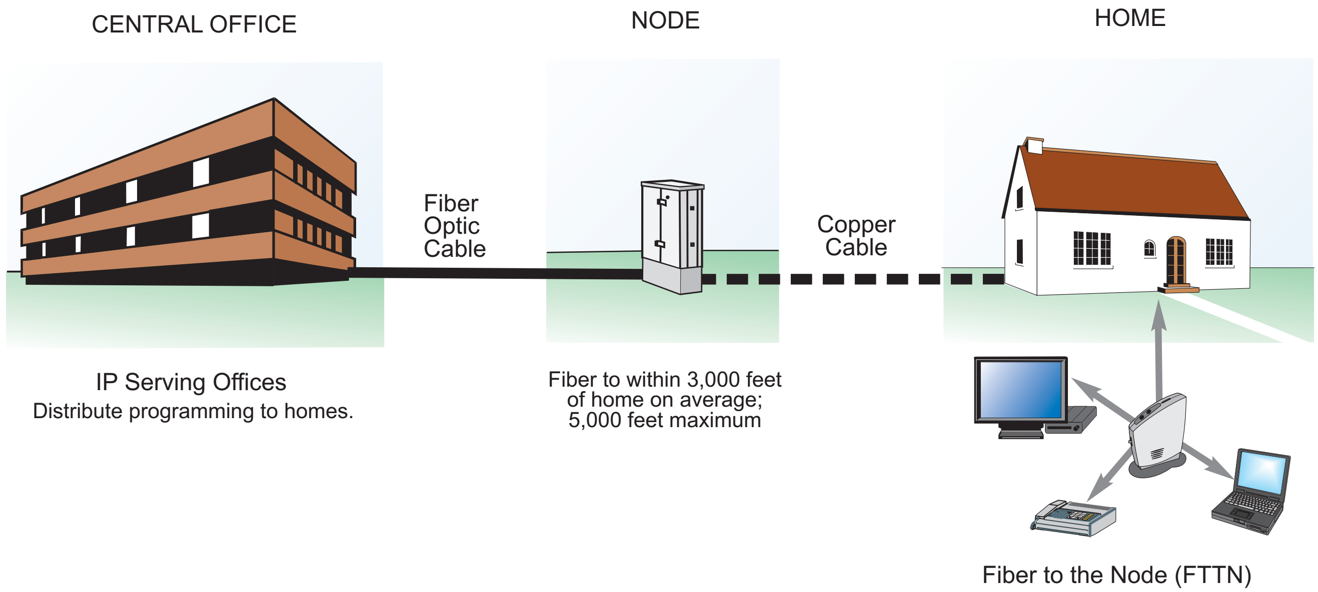
Achieving the data rates of 20 to 25 megabits per second needed for high definition television represents a significant challenge for copper-based networks. An important component in achieving these high data rates is video compression technology. Alcatel and AT&T are relying on significant improvements in the current MPEG-4 video compression technology to satisfy their target markets.

Localized Fiber-to-the-Premises (FTTP) Wireline Technology

Fiber optic cable technology represents the ultimate in bandwidth for broadband communications systems. A single-mode fiber strand using the most sophisticated fiber transceiver technology has currently an ultimate demonstrated capacity of 14 terabits per second, where a terabit per second is equal to 1,000 gigabits per second. A gigabit per second in turn represents a 1,000 megabits per second. Fiber optic transmission systems of such

Figure 47

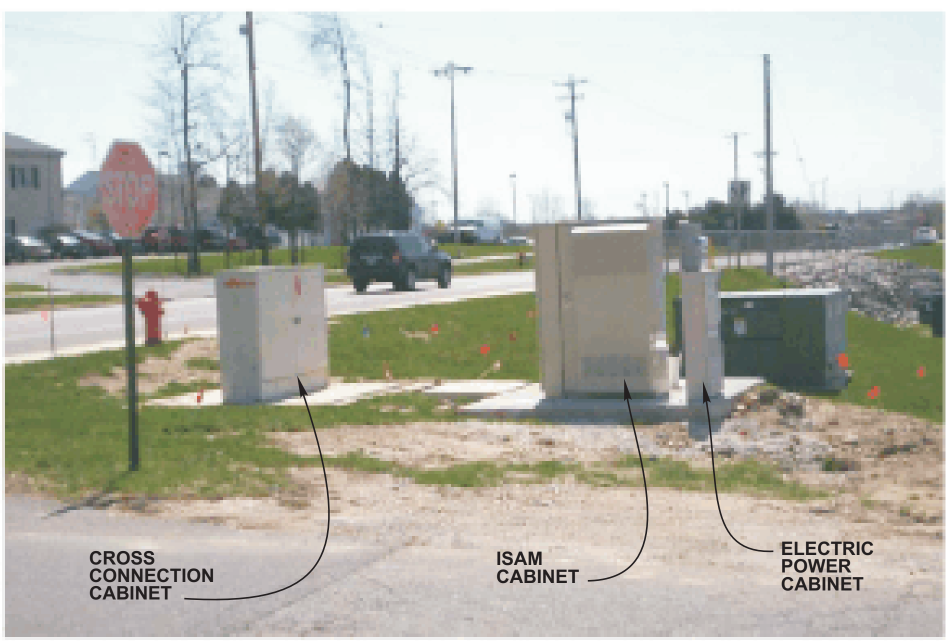
FIBER TO THE NODE WIRELESS TELECOMMUNICATION TECHNOLOGY



Source: AT & T and SEWRPC.

Figure 48

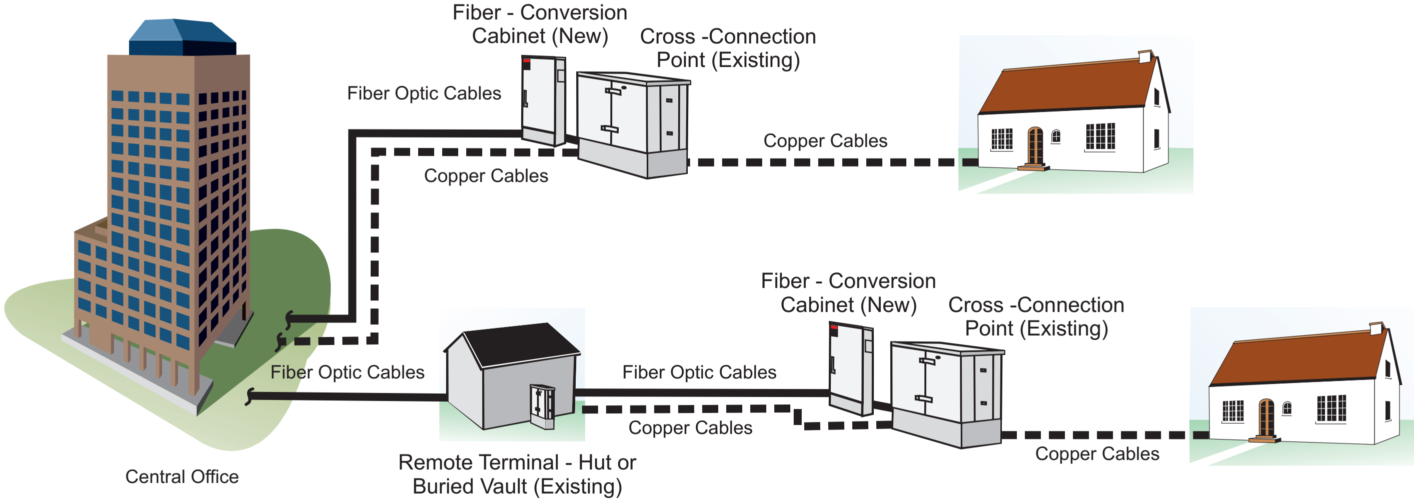
TYPICAL INTELLIGENT SERVICE ACCESS MANAGER (ISAM)



Source: AT & T and SEWRPC.

Figure 49

EVOLUTION OF NETWORK FROM DIGITAL SUBSCRIBER LINE (DSL) SERVICE TO FIBER TO THE NODE SERVICE



Source: AT & T and SEWRPC.

capacity are deployed only on major trunk lines such as transoceanic links. Economic cost and need considerations result in lower capacity networks for user broadband access.

Two major technologies are utilized in fiber optic access networks; Active Optical Networks (AONs) and, Passive Optical Networks (PONs).

Active optical networks require a dedicated fiber from a central office to each user with transceiver electronic equipment at both ends of the connection. In an AON network, throughput is limited only by the cost and complexity of the transceiver equipment at both ends of the connection. The fiber strand itself, as already noted, has essentially unlimited bandwidth. Cost considerations, however, do limit the capacity of the transceiver equipment to data rates in the lower gigabit range.

Passive optical networks share both optical fiber and transceiver equipment. With the Alcatel 7340 Fiber-to-the-Premises (FTTP) System employed regionally by AT&T, a single fiber connects multiple users to a single transceiver located at a central office. The single fiber is split, using a passive optical splitter, to serve up to 32 users. The PON approach reduces not only the amount of fiber required, but also the electronic transceiver equipment, lowering both capital and operating costs for the service provider. AT&T Wisconsin has selected the PON design alternative to take advantage of these lower capital and operating costs. The disadvantage of this determination is in the lower throughput potential of a PON as compared to an AON system configuration. The Alcatel 7340 PON system selected by AT&T will provide Internet access data rates up to 100 megabits per second. While this data rate is significantly above data rates possible with AT&T's ADSL service, or even Fiber-to-the-node (FTTN) technology, it is also below the ultimate potential of fiber optic broadband service which lies well into the gigabit per second range. Broadband service of 100 megabits per second however, complies with the 4G objective and standards set forth in Chapter IV of this report. In the future, this network capacity may be challenged by the needs of video-on-demand. A network diagram of the Alcatel 7340 FTTU System is shown in Figure 50. The system is comprised of the following functional components:

At the Central Office

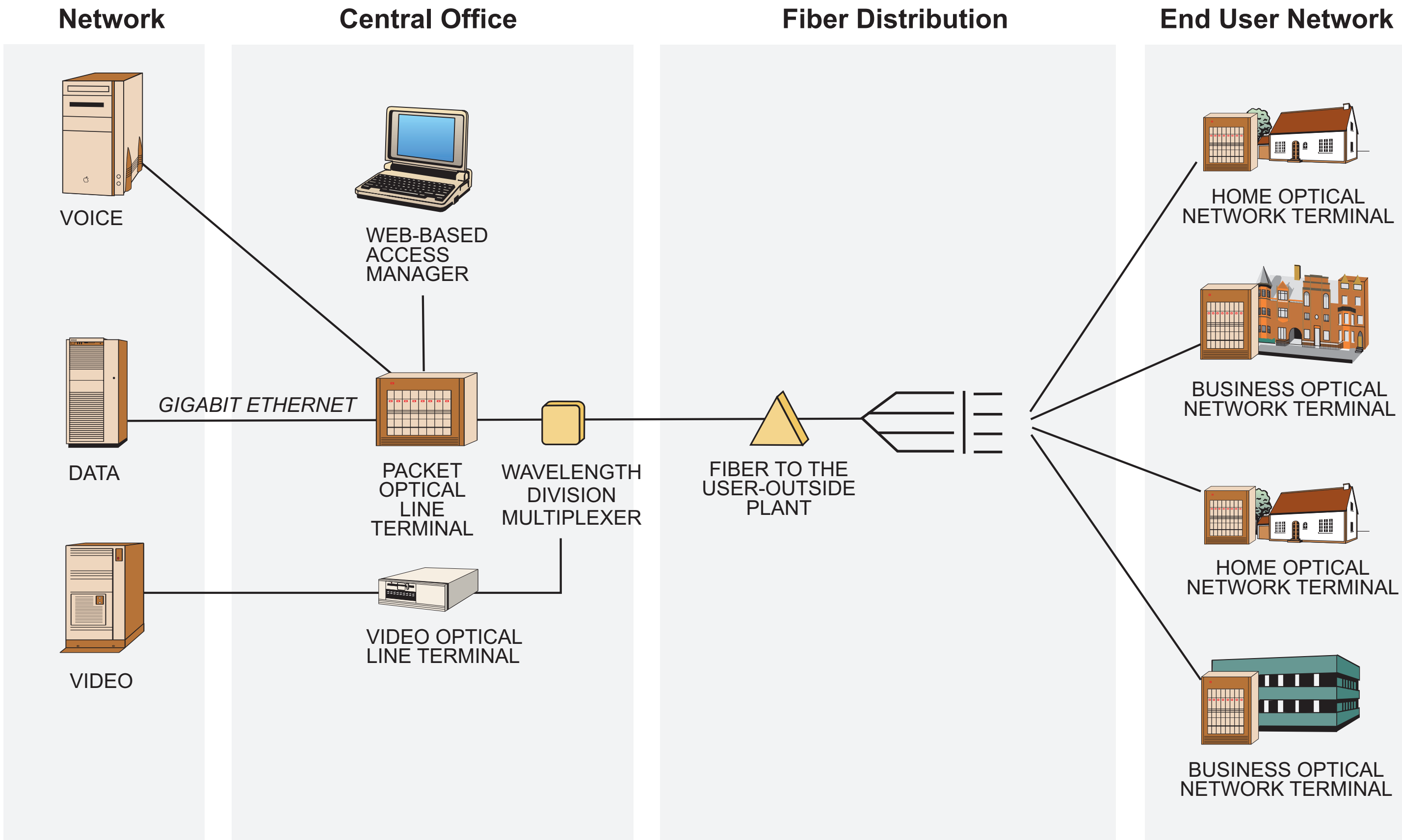
1. <u>Packet Optical Line Terminal (P-OLT)</u>
   This component serves data and voice traffic.

2. <u>Video Optical Line Terminal (V-OLT)</u>
   This component serves video traffic.

3. <u>Web – based Access Manager (WAM)</u>
   This component provides local network management.

Figure 50

FIBER TO THE PREMISES NETWORK DIAGRAM



Source: ALCATEL and SEWRPC.

4. Wavelength – Division Multiplexer
   This component provides frequency multiplexing on the fiber optic link.

In the Field

1. Alcatel 6620 Outside Plant
   This component consists of fiber optic cable, splicing enclosures for patching, coupling and optical splitters.

User Premises

1. Home Optical Network Terminal (H-ONT)
   This component terminates the PON fiber optic cable at the residence and provides voice, data and video interfaces.

2. Business Optical Network Terminal (B-ONT)
   This components terminates the PON fiber optic cable at the business site and provides voice, data and video interfaces.

The Alcatel 7340 FTTU System supports a long distance reach of up to 12.4 miles from the central office. The P-OLT collects voice traffic and routes it to a voice gateway. Data traffic is accrued and routed to a broadband switch or router also by the P-OLT at the central office. In a similar manner, video traffic is directed through the V-OLT where it is amplified for downstream or upstream transmission.

For reasons similar to those presented for the fiber-to-the-node wireline technologies, this particular version of Alcatel FTTU technology was selected for the regional wireline plan. It is the choice of AT&T, the major ILEC in the Region. While legacy home or business copper lines are no longer involved in this technology, the major capital commitments required to implement the technology makes the technology of the major ILEC an important consideration.

ALTERNATIVE PLANS

Employing the wireless and wireline technologies just described, six alternative broadband telecommunications plans were developed as candidates for the recommended regional plan. Four of these plans employ wireless broadband technologies and two employ fiber optic wireline technologies. Since no one technology is likely to fulfill all of the functional needs—fixed, nomadic and mobile users—and all of the geographic constraints—urban, suburban and rural area—the final regional comprehensive broadband telecommunications plan is a composite of the functional capabilities and geographic components of a number of the alternative wireless or wireline broadband communications plans.

The following six alternative broadband communications plans are presented in this chapter:

1. Community-Based Wireless Plan
   Under this plan advanced WiFi/WiMAX wireless networks would be provided on a community-by-community basis with the option of a WiMAX-based backhaul network for fixed and nomadic users. With some minor changes in associated hardware and software, this alternative is the wireless plan presented in SEWRPC Planning Report No. 51.

2. Regional Wireless Plan
   Under this alternative plan all areas of the Region would be served by an integrated WiFiA wireless network with fiber optic gateways provided at each base station site for fixed and nomadic users.

3. Mobile WiMAX-based Wireless Plan
   This plan is based on IEEE Standard 802.16e, and would use licensed frequency bands in the 2.5 or 3.5 GHz spectral regions to provide high data rate cell phone service to the entire Region.

4. Mobile Wi-Fi-based Wireless Plan
   This plan is based upon IEEE Standard 802.11a and 802.20, and would use unlicensed frequencies in the 5.8 GHz band to provide high data rate cell phone service as an extension of the Alternative Plan 2, the Regional Wireless Plan.

5. Regional Fiber-to-the-Node (FTTN) Wireline Plan
   This plan is based upon Alcatel 7330 FTTN technology, and would extend fiber optic cable from telephone system central office locations to remote sites for copper line transmission to users. The plan would employ very high speed VDSL technologies.

6. Regional Fiber-to-the-Premises (FTTP) Wireline Plan
   This plan is based on Alcatel 7340 FTTU technology, and would extend fiber optic cable to each user's premises using Passive Optical Network (PON) technology.

Community-Based Wireless Plan

As already noted, the community-based wireless plan is substantially the plan presented in SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin,* September 2006. Differences relate only to additional equipment and related software options for the end user and an alternative approach to servicing nomadic users in community-based wireless networks. These additions and alternatives are described below as a part of a brief review of the structure of this plan as presented in SEWRPC Planning Report No. 51.

The regional community-based wireless plan consists of two major mutually supportive networks: a regional wireless backhaul network and a set of community level wireless service plans.

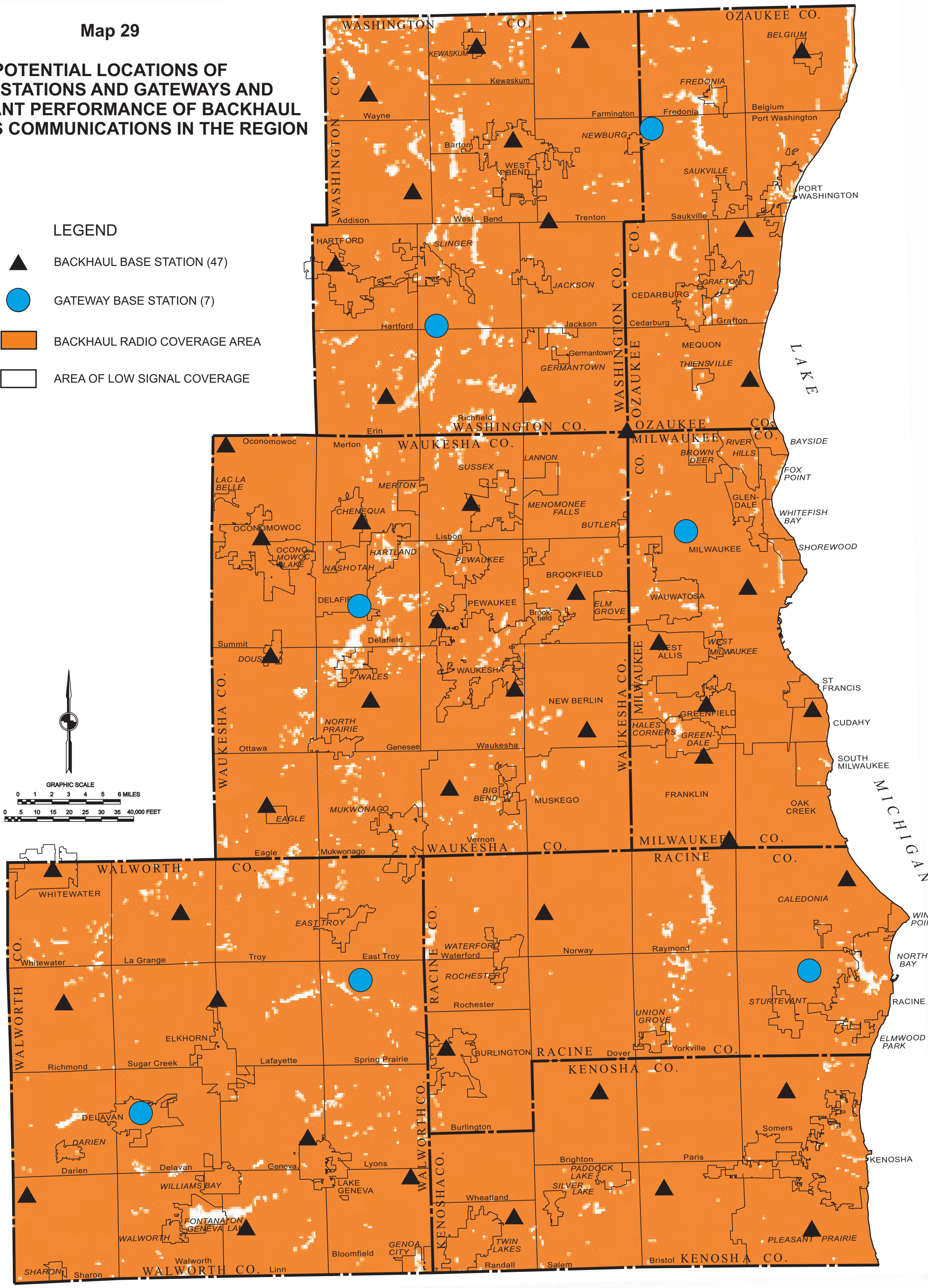
The Regional Wireless Backhaul Network Plan is fully described on pages 195 to 199 of SEWRPC Planning Report No. 51 previously referenced. The description includes Map 60 on page 196 which shows all 47 backhaul base stations and the 7 recommended gateway stations required to service all potential community-based wireless networks in the Region. This Plan map is provided as Map 29 in this Chapter. While all communities will have the option of arranging for their own Internet gateway connections, most would benefit financially by interconnecting to a regional wireless backhaul network. The alternative WiFiA and WiMAX technologies to be used in building the wireless backhaul infrastructure are also described in SEWRPC Planning Report No. 51.

Map 29

POTENTIAL LOCATIONS OF BASE STATIONS AND GATEWAYS AND ATTENDANT PERFORMANCE OF BACKHAUL WIRELESS COMMUNICATIONS IN THE REGION

LEGEND

- ▲ BACKHAUL BASE STATION (47)
- ● GATEWAY BASE STATION (7)
- BACKHAUL RADIO COVERAGE AREA
- AREA OF LOW SIGNAL COVERAGE



Source: SEWRPC.

Summary costs for deploying the backhaul network infrastructure are provided on page 197 of SEWRPC Planning Report No. 51 and detailed in Appendix F of that report. Costs are provided for both new and existing co-located sites. Estimated operating costs of the regional backhaul network are detailed in Appendix G of that report.

Individual community level wireless plans would be prepared by the Commission, or by consultants or potential providers, upon request of the local unit or units of government concerned. An example of a community wireless plan for an urban area of the Region—for the City of Cedarburg and Village of Grafton area of Ozaukee County—is presented in SEWRPC Planning Report No. 51. This plan is based on advanced WiFi 802.11g technology included in the detailed plan description on pages 199 to 204 of the report. Maps 61 and 62 on pages 200 and 201 of that report depict a 41 access point structure with 18 in the City of Cedarburg and 23 in Village of Grafton servicing both fixed and nomadic users. Map 61 on page 200 of that report indicates anticipated performance levels for nomadic users and Map 62 on the page following for fixed users. These plan maps are provided as Maps 30 and 31 in this Chapter. Table 67 on page 202 lists all of the recommended access points for the Cedarburg-Grafton community wireless plan. This table is provided as Table 17 in this Chapter. Infrastructure capital costs and system operating costs are provided in Appendices F and G respectively of SEWRPC Planning Reporting No. 51. These appendices are provided as Tables 18 and 19 in this Chapter.

Since the publication of SEWRPC Planning Report No. 51 the Commission has been asked by several municipalities to prepare second level plans as envisioned in the plan implementation procedure set forth in SEWRPC Planning Report No. 51. The requests have involved both rural and urban communities. The preparation of these second level plans has involved the conduct of extensive field tests of the initially proposed networks, and the findings of these tests have resulted in some changes to and enhancements of the original network plans for the areas concerned. These changes and enhancements include:

1. <u>User Premises Equipment</u>
   Previously, potential users were offered the option of installing either a directional antenna or a directional antenna with a high gain preamplifier.

2. <u>Repeater Sites and Nomadic Users</u>
   Previously, the wireless network plans were prepared separately for two classes of users—fixed users and nomadic users. Plans servicing nomadic as well as fixed users typically required a larger number of access points to provide the same level of performance. A new wireless network design approach using lower cost repeater sites will significantly lower the overall cost of a system configured to serve nomadic users. A repeater site is estimated to cost about 30 percent of the cost of a primary access point, and the repeaters can be selectively placed in locations where nomadic user performance upgrades are required. This repeater-based network enhancement can be accomplished without changing the network access point structure originally placed to serve only fixed users.

With the exception of the afore listed changes and enhancements, Alternative Plan One is identical to the community-based wireless plan described in SEWRPC Planning Report No. 51 and is intended to be used as a model for any community-based wireless plans that may be prepared.

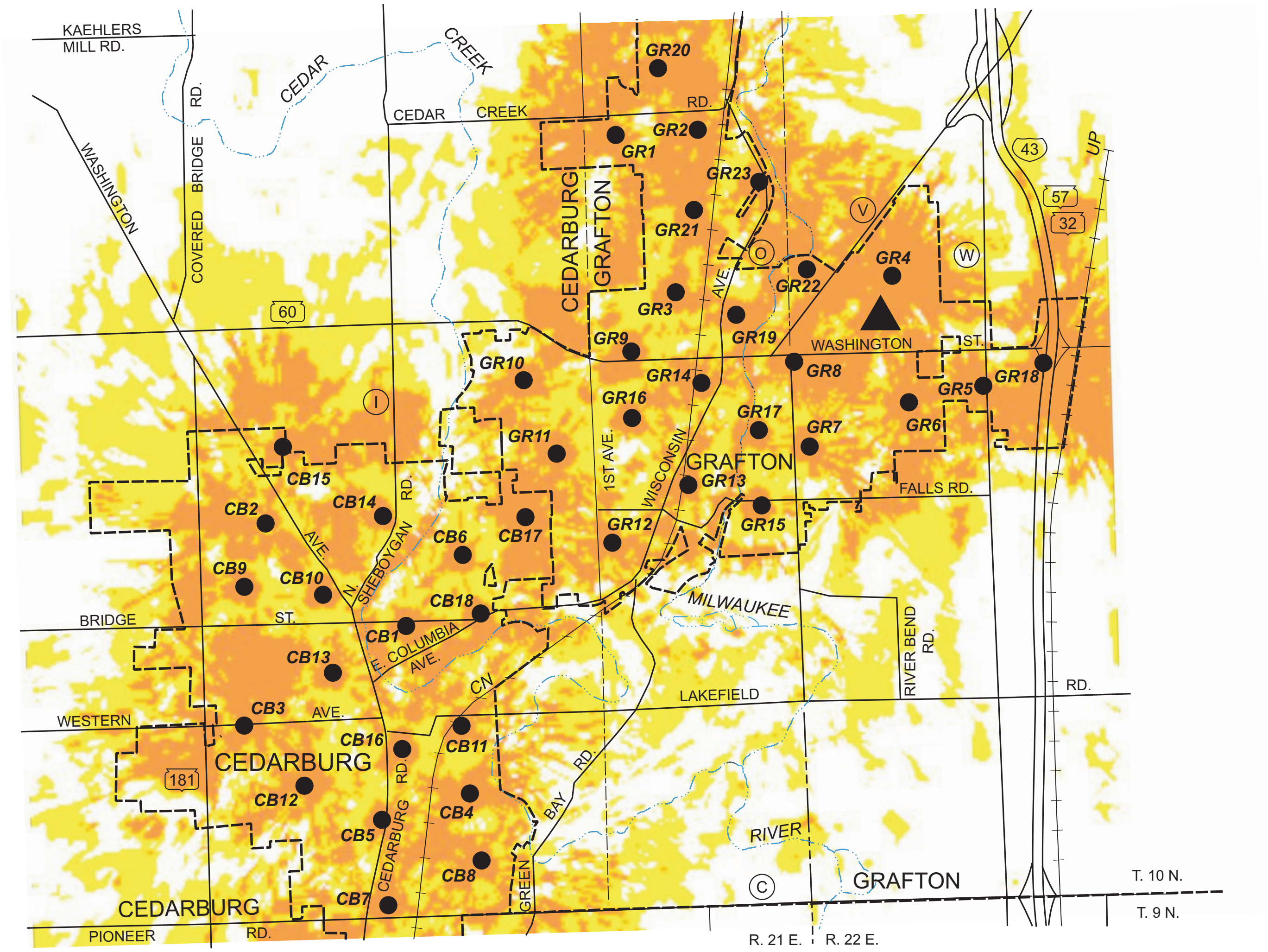
Costs

The infrastructure capital cost for an urban community wireless plan are typified by the wireless plan for the Cedarburg-Grafton area of Ozaukee County. The cost of the access infrastructure of this plan is estimated at $353,000 for 41 access points in the required network. Operating costs for each access point, as detailed in Table 19, are estimated at about $37 per month per station, or about $1,500 per month for all 41 access points.

To estimate the cost of providing the access infrastructure for the Region as a whole, the cost for the Cedarburg-Grafton area were expanded utilizing a regional multiplier of 57.5. This multiplier represents the ratio of the Cedarburg-Grafton urban service area to the total urban service area within the Region, the urban service areas being approximated by the adopted sanitary sewer service areas within

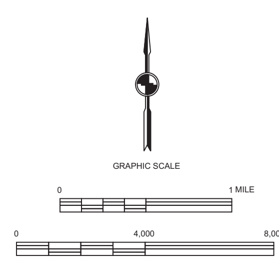
Map 30

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR NOMADIC USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO USER



LEGEND

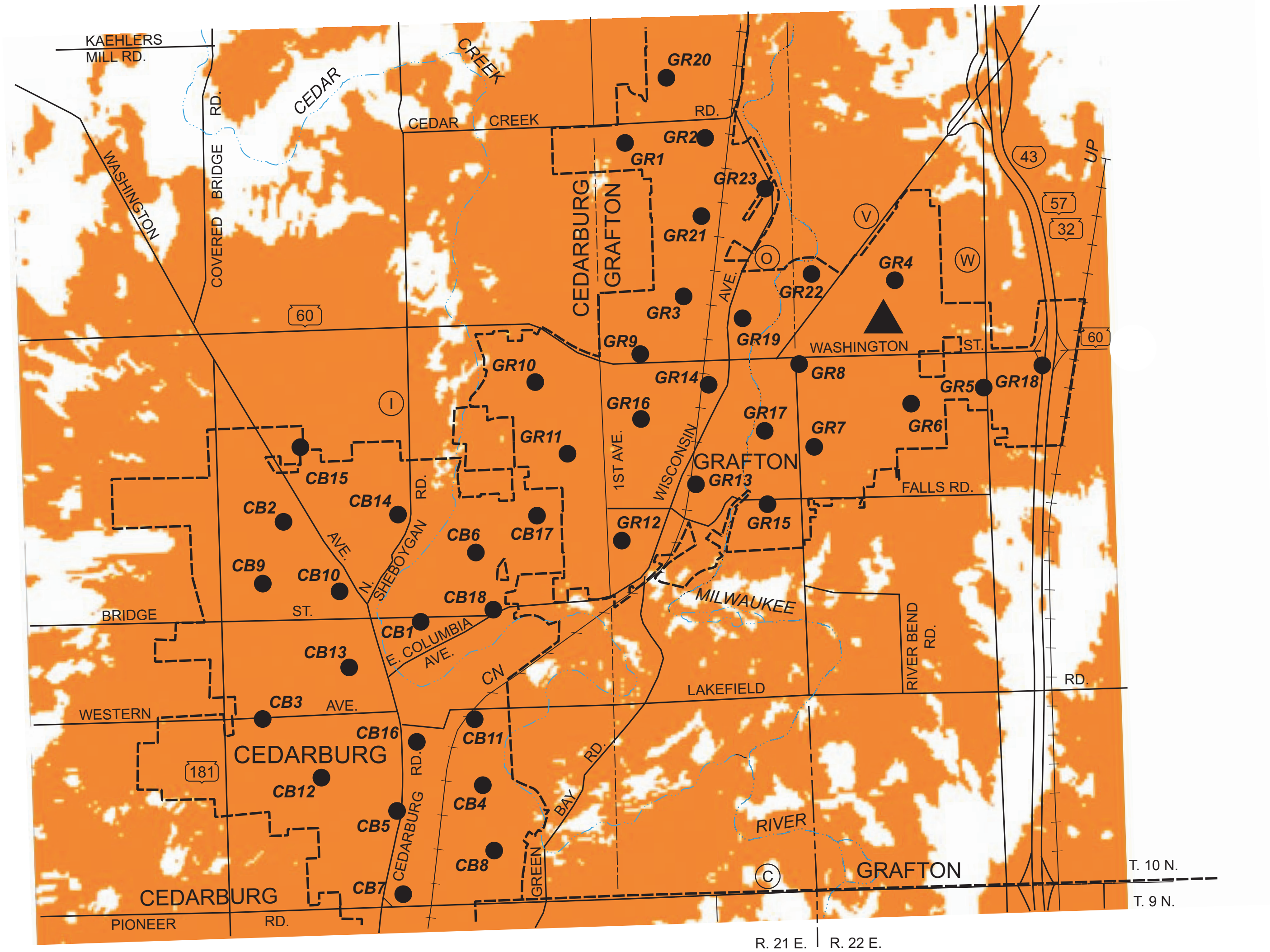
- ▲ EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION
- ● RECOMMENDED LOCATION OF WiFi ACCESS POINT
- *GR3* IDENTIFICATION NUMBER (SEE TABLE 17)
- (orange) RECEIVED POWER AT REMOTE: -70dBmW TO -79dBmW, THROUGHPUT: 24 Mbps to 54Mbps
- (yellow) RECEIVED POWER AT REMOTE: -79dBmW to -87dBmW, THROUGHPUT: 6 Mbps to 24 Mbps
- (white) AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Map 31

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR FIXED USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO REMOTE



LEGEND

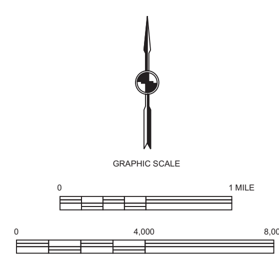
▲ EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION

● RECOMMENDED LOCATION OF WiFi ACCESS POINT

GR3 IDENTIFICATION NUMBER (SEE TABLE 17)

RECEIVED POWER AT REMOTE: -70dBmW TO -87dBmW, THROUGHPUT: 24 Mpbs to 54Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Table 17

LOCATIONS OF RECOMMENDED WIRELESS ACCESS POINTS TO BE USED FOR WiFi PURPOSES IN THE CITY OF CEDARBURG AND VILLAGE OF GRAFTON, OZAUKEE COUNTY, WISCONSIN

Site Number (See Maps 30,31, and 37)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
GR1	493,567	2,542,022	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GB2	488,807	2,545,318	T. 10 N., R. 21 E. Sec.13	Village of Grafton
GR3	489,372	2,543,603	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GR4	489,971	2,549,446	T. 10 N., R. 22 E. Sec. 18	Village of Grafton
GR5	486,743	2,551,950	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR6	486,450	2,549,905	T.10 N., R. 22 E. Sec. 19	Village of Grafton
GR7	485,296	2,547,322	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR8	487,628	2,546,826	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR9	487,928	2,542,530	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR10	487,149	2,539,665	T. 10 N., R. 21 E. Sec. 23	Village of Grafton
GR11	485,188	2,540,599	T. 10 N., R. 21 E. Sec. 23	Village of Grafton
GR12	482,694	2,541,918	T. 10 N., R. 21 E. Sec. 25	Village of Grafton
GR13	484,267	2,544,017	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR14	487,002	2,544,322	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR15	483,683	2,545,926	T. 10 N., R. 21 E. Sec. 25	Village of Grafton
GR16	485,980	2,542,482	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR17	485,633	2,545,878	T. 10 N., R. 21 E. Sec. 26	Village of Grafton
GR18	487,463	2,553,785	T. 10 N., R. 21 E. Sec. 26	Village of Grafton
GR19	488,807	2,545,318	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR20	495,301	2,543,229	T. 10 N., R. 21 E. Sec. 12	Village of Grafton
GR21	491,564	2,544,215	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GR22	490,090	2,547,290	T. 10 N., R. 22 E. Sec. 18	Village of Grafton
GR23	492,355	2,546,028	T. 10 N., R. 21 E. Sec. 13	Village of Grafton

Site Number (See Maps 30,31, and 37)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
CB1	480,488	2,536,424	T. 10 N., R. 21 E. Sec.26	City of Cedarburg
CB2	483,338	2,532,805	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB3	477,856	2,532,271	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB4	475,954	2,538,218	T. 10 N., R. 21 E. Sec. 25	City of Cedarburg
CB5	475,207	2,535,812	T.10 N., R. 21 E. Sec. 24	City of Cedarburg
CB6	482,317	2,537,883	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg
CB7	473,063	2,535,915	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB8	474,070	2,538,428	T. 10 N., R. 21 E. Sec. 35	City of Cedarburg
CB9	481,530	2,532,094	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB10	481,367	2,534,206	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB11	477,791	2,537,969	T. 10 N., R. 21 E. Sec. 35	City of Cedarburg
CB12	476,276	2,533,937	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB13	479,193	2,534,415	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB14	483,477	2,535,790	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB15	483,417	2,533,281	T. 10 N., R. 21 E. Sec. 22	City of Cedarburg
CB16	477,206	2,536,337	T. 10 N., R. 21 E. Sec. 24	City of Cedarburg
CB17	483,309	2,539,755	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg
CB18	480,689	2,538,419	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg

[a]*State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

Source: SEWRPC.

Table 18

ANTENNA AND RELATED INFRASTRUCTURE COST ESTIMATES FOR THE CEDARBURG-GRAFTON AREA WIRELESS NETWORK PLAN

COMMUNITY WiFi NETWORK (802.11) ACCESS POINT EQUIPMENT

WiFi (802.11 a,g) Access Point	
1. Transceiver Modules	
2 at $1,500 =	$3,000
2. Sectorized Antenna	995
3. Auxiliary Equipment	841
4. Installation and Testing	
17 hours at $80 =	1,360
Total	$6,196

WiFi Network Summary-Cedarburg-Grafton Area	
1. Access Points	
41 at $6,196 =	$254,036
2. Gateway Stations	
2 at $17,300 =	34,600
3. Network Monitoring System	10,000
4. Project Management and Engineering	55,000
Total	$353,336

For rural wireless network, add:
Three sets of preamplifier, connectors and power injectors - $645

BACKHAUL WiMAX/WiFi NETWORK (802.11, 802.16) BASE STATION EQUIPMENT

Co-located Site	
1. Site Preparation and Cleanup	$1,000
2. Enclosures	200
3. Utility Connection	2,000
4. Power Conditioning and Backup	7,020
5. 21 dBi Antenna	150
6. 16 dBi Sectorized Antenna	1,404
7. Transceiver Modules	
WiFi (802.11) (2)	2,800
WiMAX (802.16) (1)	3,000
8. Installation and Testing	
40 hours at $80=	3,200
9. Miscellaneous	
(Freight, cabling, and travel)	2,250
Total	$23,024

New Site		
1. Items 1-9 of co-located site above		$23,024
2. Tower Erection		
100 foot tower	$7,200	
Foundation	4,100	
Labor	2,200	
Climb Shield	1,000	14,500
Total		$37,524

Gateway Station	
1. Site Preparation and Cleanup	$ 1,000
2. Enclosures	10,850
3. Utility Connection	2,000
4. Power Conditioning and Backup	7,020
5. 31.2 dBi Antenna	3,874
6. 16 dBi Sectorized Antenna	1,404
7. Transceiver Modules	
WiFi (802.11) (2)	2,800
WiMAX (802.16) (1)	3,000
8. Internet Interconnection	
MPLS Router	30,420
Fiber Interconnect Equipment	20,000
9. Installation and Testing	
80 hours at $80=	6,400
10. Miscellaneous	
(Freight, cabling, and travel)	2,750
Total	$91,518
Additional if new tower is required	14,500
Total if new tower is required	$106,018

Backhaul Network Cost Summary – Co-Location	
1. Antenna Base Stations	
47 at $23,024=	$1,082,128
2. Gateway Stations	
7 at $91,518=	640,626
3. Project Management and Engineering	350,000
Total	$2,072,754

Backhaul Network Cost Summary – New Tower Sites	
1. Antenna Base Stations	
47 at $37,524=	$1,763,628
2. Gateway Stations	
7 at $106,018=	742,126
3. Project Management and Engineering	350,000
Total	$2,855,754

Source: SEWRPC.

Table 19

OPERATING AND MAINTENANCE COST ESTIMATES FOR THE CEDARBURG-GRAFTON AREA WIRELESS NETWORK PLAN

ACCESS POINT COMMUNITY WIFI NETWORK

1. Electric Power 50 watts at $0.05/kwh	$ 1.80 per month
2. Maintenance and Network Management	25.00 per month
3. Pole Rental	10.00 per month
Total	$ 36.80 per month

BACKHAUL BASE STATION WIFI/WIMAX NETWORK – CO-LOCATION

1. Electric Power 200 watts at $0.05/kwh	$ 7.20 per month
2. Maintenance and Network Management	100.00 per month
3. Base Station Rental $4/foot/month 100 foot tower	400.00 per month
4. Internet Connection Costs (100 Mbps) 74 x 100 =	7,400.00 per month
Total	$ 7,907.20 per month

BACKHAUL BASE STATION WIFI/WIMAX NETWORK – NEW TOWERS

1. Electric Power 200 watts at $0.05/kwh	$ 7.20 per month
2. Maintenance and Network Management	100.00 per month
3. Land usage fee	1,060.00 per month
4. Transport Costs (100 Mbps) 74 x 100 =	$7,400.00 per month
Total	$8,507.20 per month

Note: The base station costs do not include any costs of land acquisition for site. Base station operators are often required to have liability insurance in the range of one million to three million dollars for each base station site, and may be required to post performance bonds for the potential removal of structures upon abandonment. The base station costs do not include these insurance or removal contingency costs.

Source: SEWRPC.

the Region as those areas that are shown on Map 32. As delineated on Map 32, the Cedarburg-Grafton area encompasses an area of 16.9 square miles, while the aggregate total area of all such urban service areas within the Region, encompasses an area of 975.4 square miles. Utilizing this multiplier, the total access infrastructure cost for urban community wireless areas within the Region approximates $20.3 million. Similarly, the attendant operating costs would total approximately $87,000 per month.

The infrastructure capital cost of the backhaul network for the Region, consisting of 47 base stations and seven gateway stations, as shown on Map 29, totals $2.1 million dollars, assuming the use of co-located sites. The operating cost of a backhaul station may be expected to range from $7,900 to $8,500 per month depending upon the type of installation, for a total operating cost of about $459,000 per month for all 47 base stations and seven gateway stations required.

The infrastructure capital cost for a rural community wireless plan are typified by such a plan for the Town of Wayne, Washington County. As shown on Map 33, four access points are required to serve the entire approximately 36 square mile area of the Town. The cost of the access infrastructure plan is estimated at about $82,000 for the four access points in the required network. Operating costs for each access point are estimated at about $37 per month, per station, or about $148 per month for all four access points. Applying a regional multiplier of 47.6[1] the total access infrastructure cost for rural community wireless areas within the Region approximates $3.9 million. Similarly, the attendant operating costs total about $7,000 per month. Since the access points would utilize the same backhaul station as would the urban community access station, no additional backhaul station capital or operating costs would be entailed.

Thus, the total capital cost of the community based wireless plan would approximate $26.3 million for the Region. The total operating cost would approximate $553,000 per month.

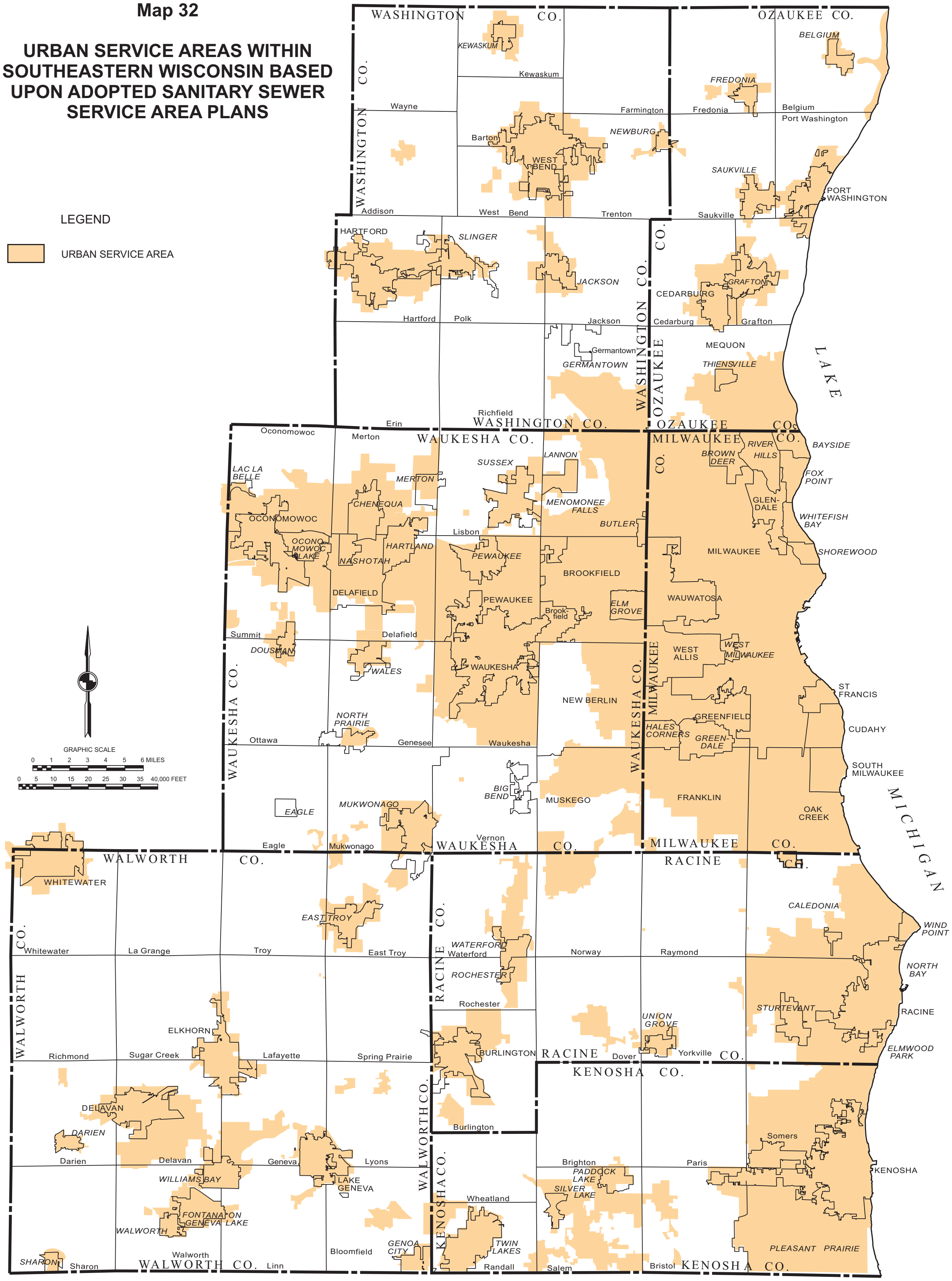
Regional Wireless Plan

A major shortcoming of the community-based wireless plan is its dependence upon community-by-community action for implementation. This may result in the creation of residual areas of the Region without broadband service. Since a major objective of the broadband regional wireless plan is universal service, an alternative regional

[1] *Derived by subtracting the aggregate total regional urban service area of 975.4 square miles from the total area of the Region of 2,689.8 square miles and dividing the remainder by 36 square miles.*

Map 32

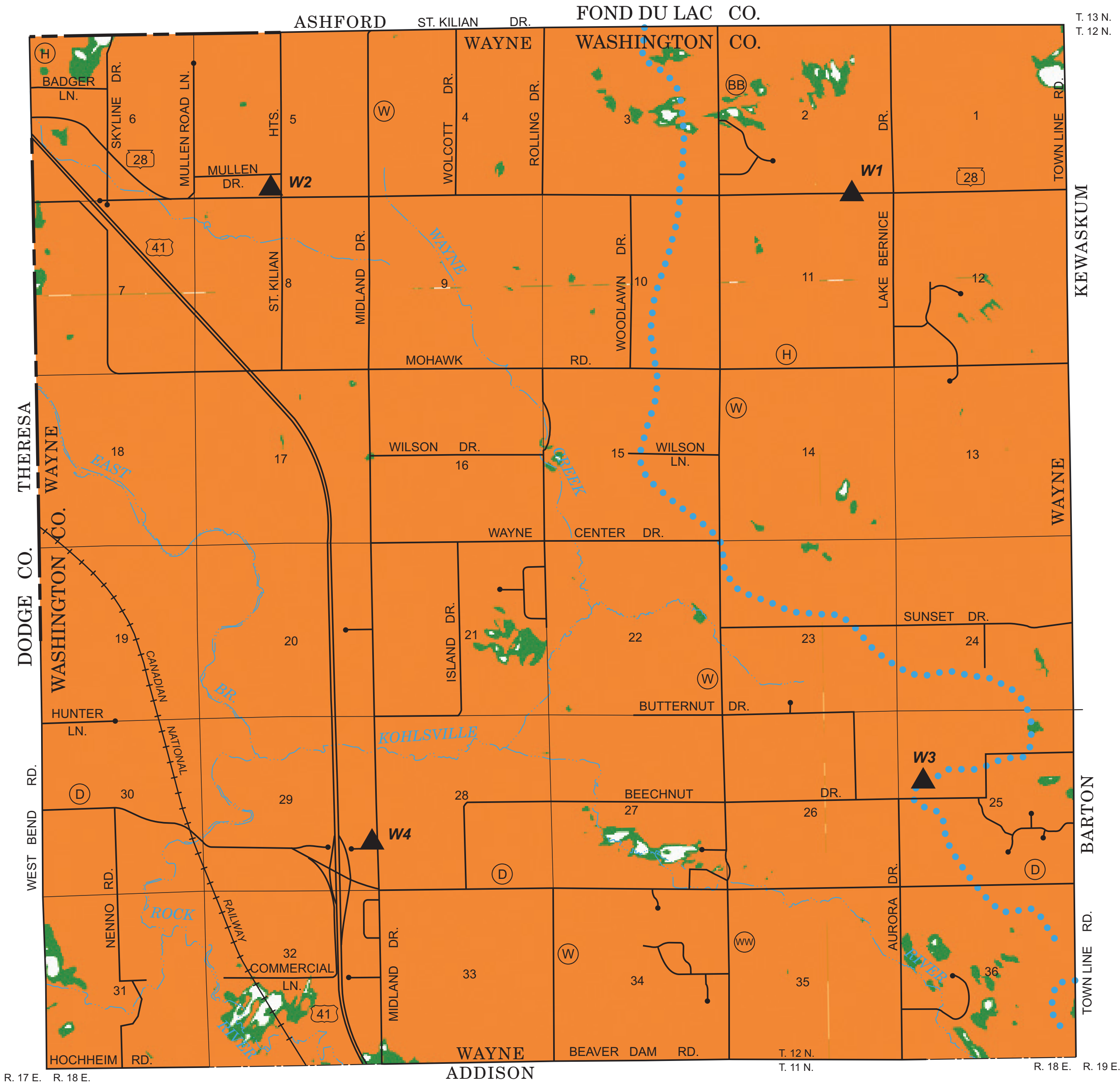
URBAN SERVICE AREAS WITHIN SOUTHEASTERN WISCONSIN BASED UPON ADOPTED SANITARY SEWER SERVICE AREA PLANS



Source: SEWRPC.

Map 33

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR FIXED USERS IN THE TOWN OF WAYNE: ACCESS POINT TO REMOTE



LEGEND

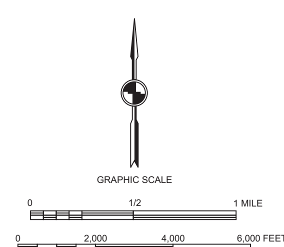
▲ ACCESS POINT LOCATIONS

W3 IDENTIFICATION NUMBER

RECEIVED POWER AT REMOTE: GREATER THAN -113.0 dBmW, THROUGHPUT: 24 Mpbs TO 54 Mbps

RECEIVED POWER AT REMOTE: -121.0 TO -113.0 dBmW, THROUGHPUT 6 TO 24 Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

wireless plan was developed. This broadband WiFiA-based system is designed to serve fixed and nomadic users in all geographic areas of the Region from the inner city of Milwaukee to the most rural areas of Walworth and Washington Counties. This plan would be specified to offer the following features:

1. Frequency Band
   The regional wireless system would operate in the unlicensed 5.8 GHz band separate and noninterfering with the 2.4 GHz community wireless band.

2. Technology
   System operation would be based on IEEE 802.11a WiFiA OFDM technology.

3. Antenna Base Stations Sites
   The network infrastructure would be based on 141 existing antenna tower sites installed on a co-location basis. An antenna height of 30 meters was assumed although that height could vary from site to site. A four sector antenna configuration is employed.

4. Antenna Site Density
   The antenna site density, as shown in Map 34, would vary with higher densities provided in urban service areas. This variation is required, in part, because of the higher building "clutter" in urban areas, and in part to serve the heavier traffic volume that may be expected in areas with higher population density.

5. Internet Gateway Connections
   Because of the expected high network traffic volume, fiber optic gateway interconnections would be made at each antenna base station site. Such interconnection implies fiber optic cable availability at each site. Since these co-location sites already serve other cellular/PCS wireless networks, there is a high likelihood that fiber optic accessibility is already present at each site.

6. Repeater Sites for Nomadic Users
   Enhanced service for nomadic users would be provided under this plan with repeater sites located at 6 meter—lamp pole—heights in areas requiring such service. With 141 base station sites each having four 90 degree sectors, there are 564 possible sector sites for repeater stations. Many of these sectors may be expected to be in areas unsuitable for extensive nomadic user service.

   Furthermore, with advancing antenna and electronic technology in laptop computers, the need for repeaters may be expected to decline over time as fixed and nomadic transceivers become more similar in performance characteristics.

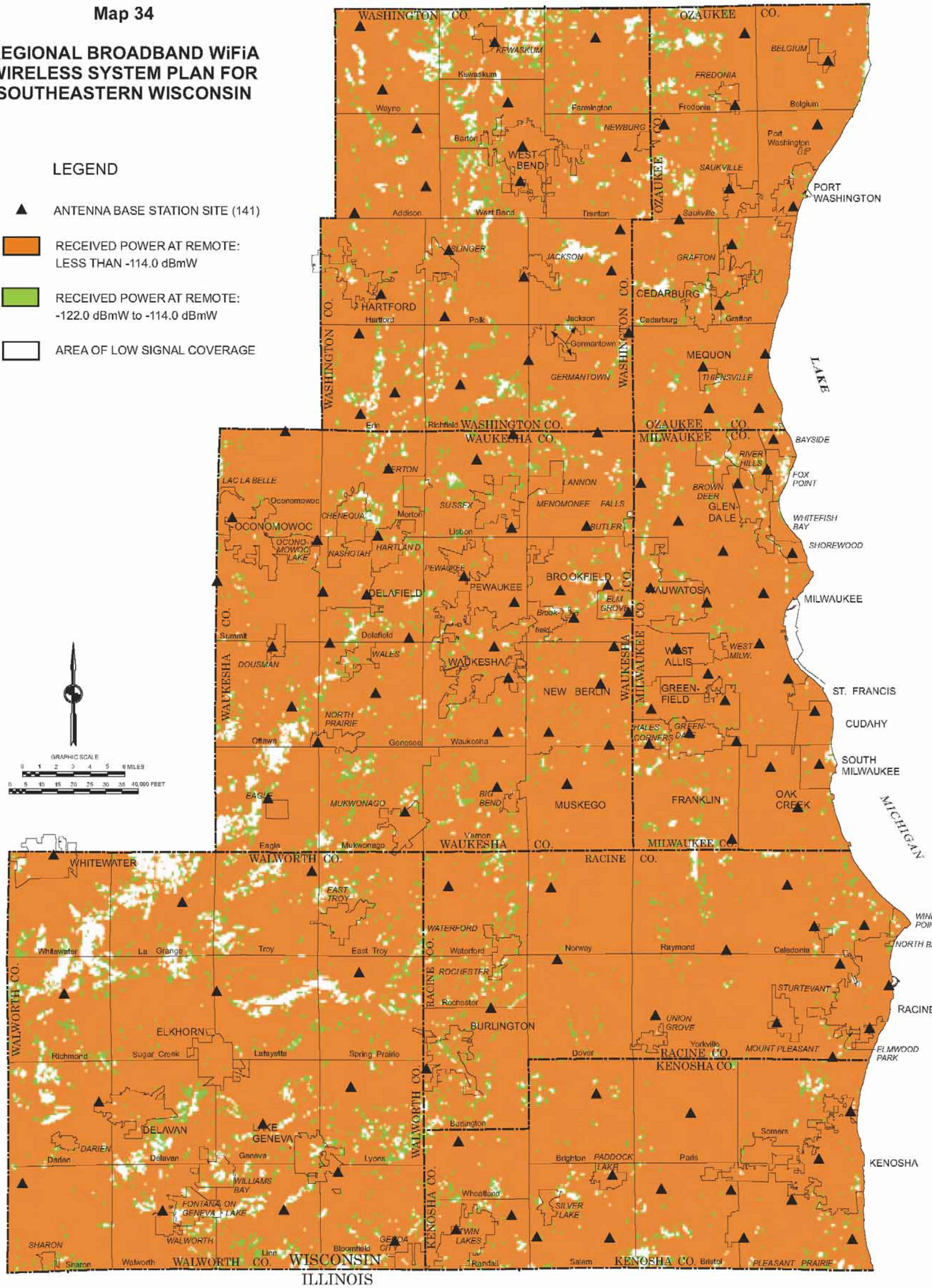
7. Cost Structure
   The cost structure of the regional wireless plan as it relates to base station infrastructure equipment would be virtually identical to that estimated for the regional wireless backhaul network. The same 802.11a WiFiA equipment would be applicable to both networks. Both provide for four sector operation. This similarity allows for use of the backhaul cost data in estimating the costs of the regional wireless access plan. The regional wireless access plan of necessity has a higher base station site density—141 versus 54. The higher density requirement results from the assumed height of the serviced user. In the backhaul plan, it is a six meter—approximately 20 feet—access point while in the access plan, it is a two meter—approximately six feet—user site. While the number of base station sites is larger in the access plan, the unit base station cost is the same.

8. Performance
   The network layout as shown in Map 29 is designed to provide 24 megabits per second throughput performance to fixed users for the entire Region. The few sub-performance areas noted on the map may also be upgraded using the same repeaters employed to enhance the service to the nomadic users.

9. County Representation
   The 141 antenna base sites are represented in each of the seven counties as follows: Kenosha 15, Milwaukee 24, Ozaukee 14, Racine 15, Walworth 14, Washington 23, and Waukesha 36.

Map 34

REGIONAL BROADBAND WiFiA WIRELESS SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN



Source: SEWRPC.

Costs

The antenna base station equipment costs are detailed in Table 18. Separate cost summaries are provided for both co-location and new sites. Since the plan herein presented is based upon co-located sites, only co-located site cost data were used in the cost estimate. Some of the selected co-location sites may encounter difficulties in arranging with site owners for co-location. There are, however, 1,010 cellular/PCS antenna base station sites in the Region. With this large number of sites, substitute sites should be available in almost all areas so as not to significantly affect the cost of this plan estimate.

The only addition to the Table 18 site cost summary is a $2,500 fiber optic interconnection which was adjudged as the typical connection charge if fiber optic cable is available at the site. With 141 planned sites in the regional wireless plan and with an estimated site cost of approximately $25,500, the total estimated capital cost for the required wireless communications infrastructure equipment is approximately $3.6 million including the cost of fiber optic interconnections. Additional systems infra-structure costs relate to the cost of bringing fiber to each of the 141 sites. These costs, estimated in cooperation with Time Warner Telecom and Charter Communications, approximate $2.8 million. Thus, the total capital cost of this alternative plan is estimated to be $6.4 million. Operating costs are estimated at $987,000 per month based on a rate of $7,000 per month for a capacity of 100 megabits per second at each site.

Fiber-to-the-Node (FTTN)
Alternative Wireline Plan

The Fiber-to-the-Node (FTTN) Alternative Plan is based upon the previously described Alcatel 7330 Intelligent Services Access Manager (ISAM). The early stages of this planned network are being deployed by AT&T in its ILEC territory within the Region as part of its Project Lightspeed. The alternative plan covered would extend the network into other ILEC areas within the Region. The envisioned FTTN network deployment is based upon the location of the ILEC central offices, as documented in Chapter V of this report. Each central office would support a set of remote nodes that in turn would service users within a radius of about 3,000 feet – comprising an approximately one square mile service area. The extent of the envisioned FTTN network deployment would depend upon the household density pattern within the Region. A threshold household density of 150 households per square mile was selected as the minimum density for service under the FTTN alternative plan since this standard results in an average density in the service area of about 1,343 households per square mile. Such an average household density coupled with a 20 percent "take-rate" assumption would provide for about 200 users per square mile which is the capacity of the smallest ISAM equipment unit. Larger take-rates could be supported by the installation of 400 or 800 line ISAM units, but the plan would provide for efficient utilization of even the smallest 200 nodal infrastructure.

The areas of the Region which may be expected to have a household density of 150 households per square miles or more in the year 2035, the design year of the adopted regional land use plan, are shown on Map 35. These areas, in aggregate, en-compass a total of 953 square miles, or about 35 percent, of the total area of the seven-county Region. The areas meeting or exceeding the minimum household density standard as shown on Map 35 include areas of such density existing in the inventory base year 2000, as well as such areas expected to exist in the plan design year 2035. The mapped areas therefore include a number of small scattered and discontinuous areas meeting the minimum density standard. Such small, scattered, and discontinuous areas may be expected to be located beyond the reasonable service area of a FTTN wireline telecommunication system. Map 35 also includes a delineation of the planned urban service areas within the Region, the same areas as those shown on Map 32 of this report. These areas may be expected to accommodate anticipated urban development within the Region to the adopted regional land use plan design year 2035; and represent those areas of the Region which the adopted land use plan envisions being provided with a full range of urban facilities and services, including sanitary sewerage, public water supply, mass transit, and high speed broadband telecom-munications. The urban service areas in aggregate encompass a total of 975 square miles or about 36 percent of the total area of the seven-county Region. In the base year of the plan – 2000 – about 477 square miles of this planned urban service area were actually devoted to urban development. This area is expected to increase to about 639 square

Map 35

PROPOSED SERVICE AREA ALTERNATIVE PLAN 3 - FIBER OPTIC CABLE TO THE NODE

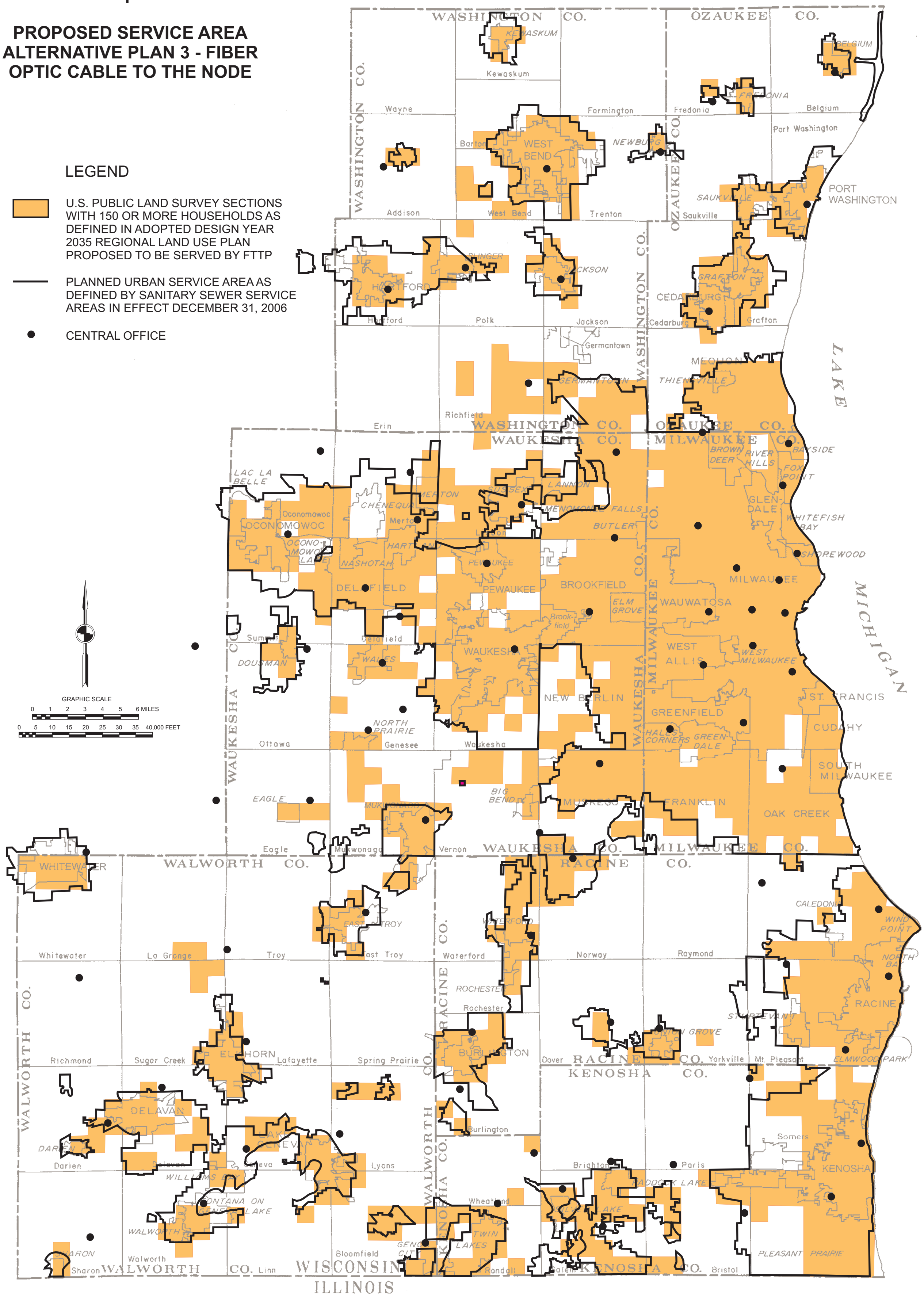
LEGEND

- U.S. PUBLIC LAND SURVEY SECTIONS WITH 150 OR MORE HOUSEHOLDS AS DEFINED IN ADOPTED DESIGN YEAR 2035 REGIONAL LAND USE PLAN PROPOSED TO BE SERVED BY FTTP
- PLANNED URBAN SERVICE AREA AS DEFINED BY SANITARY SEWER SERVICE AREAS IN EFFECT DECEMBER 31, 2006
- CENTRAL OFFICE

GRAPHIC SCALE

0 1 2 3 4 5 6 MILES

0 5 10 15 20 25 30 35 40,000 FEET



miles by the year 2035. The latter area, however, may be expected to contain about 92 percent of the anticipated year 2035 resident population of the Region of 2.8 million persons; about 93 percent of the 27,600 acres of land anticipated to be devoted to commercial use; and about 90 percent of the land anticipated to be devoted to industrial use in that year.

The FTTN Alternative Plan is central office oriented, so that the deployment must consider proximity to central office locations as well as housing density. These central offices, previously displayed in Map 32 of the report, are also shown on Map 35 in conjunction with the envisioned service area of the FTTN Alternative Plan. Although AT&T is the only regional wireline carrier that is known to be committed to the deployment of an FTTN network within the Region, the envisioned service area of the FTTN Alternative Plan includes other areas of the Region serviced by ILEC carriers located within the delineated service area of the plan.

The FTTN plan has the following features:

1. Technology
   An advanced version of DSL technology known as VDSL—for very high speed DSL—is the basis of the proposed FTTN Alternative Plan. Also known as International Telecommunications Union (ITU) Standard G.993, VDSL currently exists in two forms: VDSL—ITU Standard G.993.1, and VDSL2 ITU Standard G.993.2. VDSL has a maximum downlink transmission rate of 13 to 55 megabits per second, while VDSL2 has a maximum downlink transmission rate of 10 to 100 megabits per second. This asymmetrical nature of all forms of DSL constitutes an important limitation of the technology. Currently, the uplink transmission rates are limited to one megabit per second. Such a bandwidth allocation, while unimportant to many users, does limit certain applications such as video-conferencing, or the need to transmit large data files, where symmetrical data transmission rates are essential to quality video communications. Most of ILEC service providers offer a range of other high speed data equipment and services for symmetrical communications such as OC-1 (also called T3 or DS-3) lines, but these services are typically offered at much higher cost rates than the contemplated FTTN network services.

   The FTTN networks currently being deployed by ILEC service providers are primarily aimed at the residential entertainment (television) market. Bandwidth allocation heavily favors downstream broadcasting and website downloading. Such networks are not particularly supportive of industrial and commercial communication which require more balanced symmetric communications channels.

   It is of interest to note that DSL in all of its forms transmits data using discrete multi-tone (DMT), a wired version of orthogonal frequency division multiplexing (OFDM), that is widely used in wireless standards such as WiFi and WiMAX. The data signal to be transmitted is divided into multiple low speed data paths. These paths are modulated on hundreds or thousands of adjacent carriers over a broad spectrum. The medium from the central office to the node is fiber optic cable. The medium from the node to the user is the twisted wire pair telephone cable made with Number 24 or 26 gauge copper long used for voice telecommunications systems.

2. Range
   Although a radius of 3,000 feet is the most frequently quoted range of VDSL, network performance varies with the distance from the local node. Maximum data transmission rates depend upon the signal-to-noise ratio (SNR) which declines with distance from the node. Users located closer to the node with a higher SNR will experience higher transmission rates. The range of VDSL can extend as far as approximately 4,500 feet from the node, and VDSL2 as far as approximately 5,000 feet.

3. Cost Structure
   The deployment costs of the FTTN Alternative Plan include the central office, node, fiber optic cable link and user premise

installation costs. Infrastructure costs are primarily nodal and fiber applicable link costs—the cost of the ISAM equipment installation and the fiber link to that node. Allowing for a proportionate share of central office augmentation costs allocated to each node, the estimated cost per node approximates $83,000 of which $48,000 is for nodal equipment and $35,000 for the fiber optic cable link. This assumes an average fiber optic link of one mile from the central office to each node, and a weighted average cable installation cost of $35,000 per mile. The basis for the calculation of this weighted average cost is set forth below under the description of the cost structure for the Fiber-to-the-Premises alternative plan.

User acquisition costs for the FTTN Alternative Plan include the equipment and installation labor costs associated with the startup of service to a new user. Based upon an estimated four to eight hour installation time, and a typical user equipment cost of $150, the total new user equipment and installation cost may be estimated at about $600. Initially, service providers may absorb this cost to expedite the early growth of the network, but essentially this cost will have to be paid by each new user, either as an installation cost, or as a user cost to be absorbed as part of the monthly charges for the service. For these reasons, user equipment and installation costs were not considered in the comparative evaluation of alternative regional broadband communications plans.

4. Performance

The Alcatel 7330 FTTN technology may be configured to provide a minimum target throughput of 25 megabits per second at each user location. The allocation of this bandwidth lies with the wireline service provider. Since television is the primary driving force behind the current FTTN network deployments, a sizable bandwidth allocation to video may be expected. A typical allocation might be 19 mbps for video, and 6 megabits per second for Internet data communications. As previously noted, a very small portion of the bandwidth is allocated to upload throughput.

Costs

As already noted, the FTTN Alternative Plan is envisioned to be deployed within an aggregate service area of 975 square miles—the planned design year 2035 urban service area within the region—or about 36 percent of the total area of the seven-county Region. This regional area is currently supported by 77 central offices each covering an approximate 12 square mile service area requiring 12 nodes per central office. At the previously estimated cost of $83,000 for each FTTN node, the cost attendant to the implementation of the FTTN alternative plans may be estimated at $77.7 million.

Cable Networks and the Fiber-to-the-Node (FTTN) Plan

Parallels exist between proposed ILEC-based FTTN networks and existing Hybrid Fiber-Coax (HFC) Networks employed by cable service providers. Both networks integrate combinations of fiber optic and copper wire linkages. Since cable networks now offer the same or equivalent services that are the primary target of the new FTTN network, it is reasonable to conclude that such cable networks could also offer fourth generation (4G) communications performance at throughput rates of 20 megabits per second and higher. Such upgrades to current HFC networks with download data rates as high as 100 Mbps have been reported. Charter Communications offers data rates as high as 30 megabits per second over its current HFC network. The structural topology of these HFC networks however, is also asymmetric and very downstream oriented in bandwidth allocation. Their geographic coverage, like FTTN, is also limited by the high costs of cable deployment.

Fiber-to-the-Premises (FTTP) Alternative Wireline Plan

The Fiber-to-the-Premises (FTTP) Alternative Plan is based upon the previously described Alcatel 7340 Fiber-to-the-Premises System which uses Passive Optical Network (PON) technology to reach new subscribers. A single fiber originating in a central office is split at a remote site using an optical splitter to connect up to 32 end users into the fiber network. Since there is no active electronic equipment between the central office and the user, the infrastructure deployment costs consist primarily of the cost of laying the fiber cable to the user's premises. The cost per user will depend on the household density in a given area. Since the costs of laying fiber cable per mile in various urban, suburban or rural settings are essentially fixed, the economic viability of FTTP depends on the population density of an area. Based on an average fiber optic cable deployment cost of $35,000 per mile, and an estimated 11 miles of cable required typically to serve one square mile of urban development area, the cost of installing the fiber optic cable would approximate $385,000 per square mile. The FTTP plan was assumed to serve the same area within the Region as the FTTN plan. This assumption was made to ensure comparability between the FTTN and FTTP alternative plans, although return on investment analyses would lead to smaller and different service areas for each plan.

The FTTP plan, like the FTTN plan, is central office oriented, so that deployment must consider the availability of central office locations as well as housing density. The long reach, however, of the Alcatel 7340 System—up to 12.4 miles—along with the ready availability of central offices to 400 household per square mile density areas should not seriously restrict the deployment of FTTP networks.

The FTTP plan has the following features:

1. Technology
   The Alcatel 7340 FTTP System is a second generation PON (passive optical network) platform that distributes voice, data and video transmissions through a passive (no electronic or electro-optic components) optical fiber network in which each fiber terminated at the central office (CO) can be split into 32 fiber lines at a remote Optical Splitter (OSP) for servicing up to 32 optical network terminals in homes or businesses. A PON network is selected in preference to an active optical network (AON) which provides for a direct fiber connection between each user and the CO. The AON has much greater potential capacity than a PON, but it also has a higher initial investment cost and higher operating and maintenance costs.

2. Range
   The Alcatel 7340 FTTP supports a range of up to 12.4 miles from the central office to the end user. At some intermediate distance, each co-originated fiber is split into 32 fibers, each one serving an individual.

3. Cost Structure
   The infrastructure costs of the FTTP Alternative Plan include the central office, fiber optic deployment and user premises installation costs. Infrastructure costs embrace only the first two of the cost elements since user premises installation costs occur only when a resident or business elects the service. User premises installation costs include the equipment and installation labor costs associated with the structure of service to a new user. These costs are absorbed by the user either in terms of an initial fee or as part of fees over the life of the service.

   The cost of laying fiber optic cable will vary widely with the type of area traversed—various urban, suburban, or rural settings—and with the design of the installation. For example, the City of Milwaukee installs its own fiber optic cables in ducts laid to line of grade properly related to the horizontal and vertical location of other utilities and to established street grades. The ducts typically consist of 4 inch diameter plastic tubing laid in groupings of one by two to four and four, and encased in a concrete slurry. Manholes are provided at junctions and at approximately 600 feet spacing between junctions. This represents the best municipal engineering practice, and should be followed for the installation of cable along arterial streets and in areas developed with high density urban uses, and therefore in which the street rights-of-way must accommodate a multiplicity of utility structures. The cable ducts are normally installed using trenching. In lower density urban, suburban and rural areas, the fiber optic cables are usually installed without benefit of duct work, utilizing cheaper plowing and directional boring techniques. The costs entailed may therefore range from a low of less than $20,000 per mile, to a high exceeding $250,000 per mile.

In the base year of the plan – 2000 –, there were a total of about 8,500 miles of public streets and highways within the planned urban service areas of the Region, of which 2,240 miles consisted of arterial streets and highways, and 6,260 miles consisted of collector and land access streets. As already noted, the collector and land access street network served a total of about 477 square miles of actual urban development within the 975 square miles of planned urban service area. Therefore, an average of 13 miles of collector and land access streets were required to serve one square mile of urban development together with an attendant two miles of peripheral arterial streets. Assuming that, typically, fiber optic cable would be installed only in about 67 percent of the collector and land access street mileage, about nine miles of cable would be required per square mile of urban development, plus an attendant two miles of cable in peripheral arterial streets. Assuming that duct installation would be required only for the fiber optic cable located in newly reconstructed arterial streets, and that 50 percent of the arterial streets in the urban service area will require reconstruction over the plan design period, duct installation would be required on average for about one mile of arterial street per square mile of development over the plan design period. Thus, for regional systems planning purposes, the cost of providing fiber optic cable service to the individual premises was estimated at $385,000 per square mile, with a weighted average cost for laying cable of about $35,000 per mile.

4. Performance
   The Alcatel 7340 offers high speed Internet access service up to 100 megabits per second. This data rate is far below the ultimate optical fiber capacity, but is constrained by the topology of the inactive PON network which has some of the same upload traffic limitations as hybrid fiber coaxial cable networks.

It is important to understand that a PON FTTP System is a shorter term solution that may in the future limit the full potential of fiber optics telecommunications in the coming years. An active optical network (AON) would have higher initial costs for both optical fiber and electro-optical equipment. It would also have higher operating costs in the form of equipment maintenance. It would, however, have essentially unlimited bandwidth and the ability to expand in service capability with future advances in electro-optical technology. This future potential would warrant consideration in the final step of an FTTP broadband wireline telecommunications plan.

Costs
The FTTP Alternative Plan is envisioned to be deployed within the same aggregate service area of 975 square miles or 36 percent of the seven-county Region as the FTTN plan, of which, as already noted, about 639 square miles would be devoted to actual urban development. Given the areal cost of about $385,000 per square mile, the infrastructure cost attendant to the implementation of the FTTP plan may be estimated at about $246 million.

ALTERNATIVE ADJUNCT PLANS

The primary alternative system plans herein presented serve only fixed and nomadic users. A complete telecommunications system for the Region would, therefore, require an adjunct network to serve mobile users. Although competing networks designed to serve mobile users currently exist within the Region, none is currently able to meet the objectives and standards set forth in Chapter III of this report. Therefore, each of the primary telecommunications system plans herein presented must be accompanied by an adjunct plan to provide mobile users with service meeting the objectives and standards set forth in Chapter III of this report.

Two technologies could be used to provide such adjunct service: WiMAX technology based on IEEE Standard 802.16e, or WiFi technology based on IEEE Standard 802.11a or g. The former technology employs licensed frequency bands primarily owned by existing wireless mobile service providers. The latter technology employs unlicensed frequency bands, and may be deployed as an extension of the primary community-based and the regional wireless system alternative plans. Deployment of the former technology is envisioned in Alternative Adjunct Plan A as herein presented, while deployment of the latter technology is envisioned in Alternative Adjunct

Plan B as herein presented. Alternative Adjunct Plan A is a potential supplement to all of the primary wireless or wireline plan alternatives; while Alternative Adjunct Plan B is a potential supplement only to the two primary fixed wireless plans—the community-based and the regional wireless system plans.

The technical limitations of mobile and nomadic user service rest primarily with the user's communications device. Both the laptop computer and the cell phone currently suffer from low performance radio receivers and low transmitter powers. Although transmitter power, particularly for unlicensed radio bands, is limited by the Federal Communications Commission, receiver technology is limited only by technical innovation. Such innovation may be expected to improve the wireless telecommunications performance of both cell phones and laptop computers. Each of the alternative adjunct broadband wireless telecommunications plans herein considered depend upon the continued advance of the state-of-the-art of wireless telecommunications technology.

Alternative Adjunct Plan A

Recognizing the dynamic evolving state of mobile wireless telecommunications technology, the formulation of Alternative Adjunct Plan A was based upon the assumption that the range of mobile wireless WiMAX antenna base stations will be extended from the current range of about 0.5 mile to at least 1.0 mile. It was further assumed that these assumptions will be met through the use of a combination of increased transmitter power and improved cell phone receiver sensitivity by equipment manufacturers.

Since it involves the use of licensed frequency bands, Alternative Adjunct Plan A must be deployed and operated by a wireless carrier with ownership of licensed frequency bands. Since Sprint-Nextel Communications is the only known national wireless service provider currently operating in Southeastern Wisconsin that has selected WiMAX technology for its next generation deployment, the antenna sites of this service provider within the Region as shown on Maps 12, 13, 19, 20, 26, 27, 33, 34, 40, 41, 46, 47, 53, and 54 of Chapter V of SEWRPC Planning Report Number 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin,* September 2006, were used in the design of this adjunct plan. Extensive and accurate base station site data are available for Sprint and Nextel sites in Southeastern Wisconsin. The use of such base station sites in the plan design is not intended to imply that this alternative plan represents a recommended network layout for Sprint-Nextel Communications. Rather, use of the base station sites concerned allows for the preparation by the Commission of a meaningful and practical alternative plan that can be considered as a part of a final recommended comprehensive regional broadband telecommunications plan.

Alternative Adjunct Plan A was designed to offer the following features:

1. <u>Frequency Band</u>
   Alternative Adjunct Plan A would operate in the licensed 2.5 GHz frequency band with sub-bands selected based on Sprint-Nextel band assignments.

2. <u>Technology</u>
   System operation would be based on IEEE Standard 802.16e WiMAX technology.

3. <u>Antenna Base Station Sites</u>
   The network infrastructure would be based on 380 existing antenna base station sites, and 363 new antenna sites necessary to provide universal service coverage within the Region.

4. <u>Antenna Site Layout</u>
   The antenna site layout for Alternative Adjunct Plan A shown on Map 36 was based upon radio wave propagation modeling. The modeling assumed that the antennas would be mounted at a height of about 100 feet above the base of the antenna base station masts. Variations in the antenna site density shown result from both the higher building "clutter" and higher traffic volumes expected for urbanized areas of the Region.

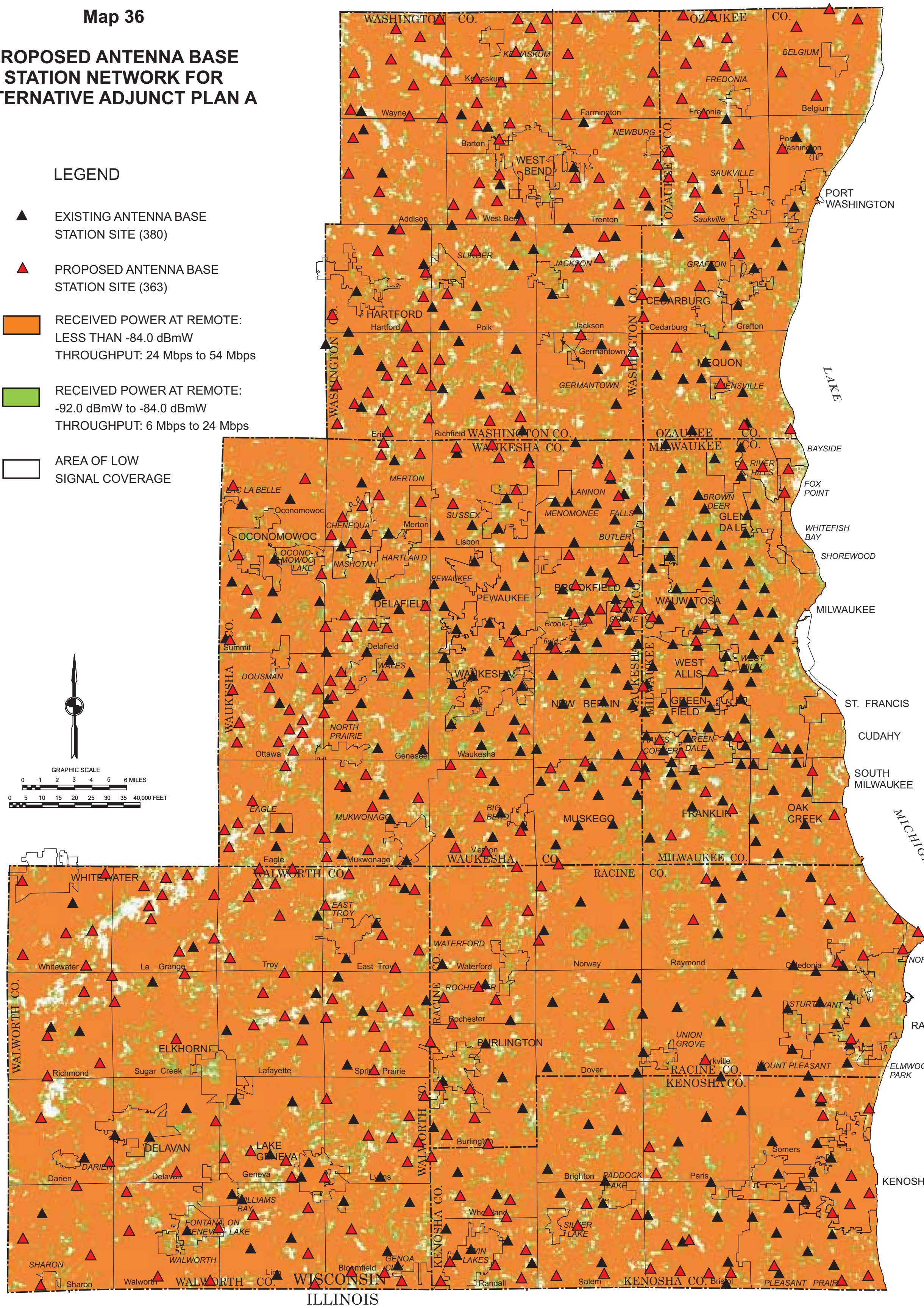
5. <u>Internet Gateway Connections</u>
   Consistent with the regional wireless system plans for fixed and nomadic users, the plan was based upon the provision of fiber optic gateway interconnections at each antenna base station site. Some of the current base stations have interconnections with a wire-

Map 36

PROPOSED ANTENNA BASE STATION NETWORK FOR ALTERNATIVE ADJUNCT PLAN A

LEGEND

- ▲ EXISTING ANTENNA BASE STATION SITE (380)
- ▲ PROPOSED ANTENNA BASE STATION SITE (363)
- RECEIVED POWER AT REMOTE: LESS THAN -84.0 dBmW THROUGHPUT: 24 Mbps to 54 Mbps
- RECEIVED POWER AT REMOTE: -92.0 dBmW to -84.0 dBmW THROUGHPUT: 6 Mbps to 24 Mbps
- AREA OF LOW SIGNAL COVERAGE



Source: SEWRPC.

line network, but such interconnections may consist of either coaxial copper cable or fiber optic cable. The broadband nature of the proposed WiMAX based wireless network will require fiber optic cable interconnections.

6. Cost Structure

   The cost structure of the plan will be similar to that of the regional wireless plan for fixed and nomadic users except that costs will be increased to reflect the higher price WiMAX infrastructure equipment. The number of antenna base stations required for the plan reflects the conflicting effects of higher base station transmitter power versus low receiver sensitivity. Accordingly, the plan proposes the use of 743 antenna base stations to serve the Region.

7. Performance

   The network layout on Map 36 is designed to provide a minimum service level of six megabits per second throughput to mobile users within the Region.

Costs

WiMAX-based antenna base station costs may be expected to be similar to those shown in Table 18 for co-located backhaul base stations, except that WiMAX transceiver equipment would fully replace all WiFi equipment. Three WiMAX 802.16e transceiver modules would replace the WiFi-WiMAX combination given in Table 18 at an estimated cost of $15,000 per base station. This cost replaces the $5,800 of transceiver equipment cost listed in Table 18. Adding the needed fiber optic interconnections would entail an estimated cost of $2,500. Accordingly, the cost of a co-located WiMAX antenna base station site may be expected to total $25,000 and a new base station $37,500. With 743 base stations required, of which 363 would be new stations and 380 would be co-located stations, the estimated capital cost of the required base stations would total $23.1 million. The cost of the needed fiber optic cable connections would add an estimated $20,000 per site. Thus, the total capital cost of Alternative Adjunct Plan A is estimated to be $38 million. Operating costs are estimated at $5.6 million per month, based on a rate of $7,000 per month for a capacity of 100 megabits per second at each site and $500 for other expenses.

Alternative Adjunct Plan B – Advanced WiFi and WiFiA

Alternative Adjunct Plan B can serve as an adjunct to either of the two proposed primary wireless service plans—the Community-Based Wireless Plan and the Regional Wireless Plan. As an adjunct to the Community-Based Wireless Plan, Plan B would provide mobile telecommunication service using IEEE Standard 802.11g technology. As a subsidiary to the Regional Wireless Plan, Plan B would provide service using IEEE Standard 802.11a technology. Alternative Adjunct Plan B would utilize the unlicensed spectrum, thus allowing WiFi network users an alternative compatible with their fixed and nomadic communications needs.

As already noted, wireless communications systems performance is limited in part by the sensitivity of the remote cell phone device. A typical cell phone antenna gain is only –2.0 dB. Such a low overall gain means that the cell phone antenna and any supporting amplifier actually attenuates rather than amplifies incoming voice or data signals. A gain of –2.0 dB means that the cell phone captures only 63 percent of an incoming signal. Such a low gain—coupled with the high signal-to-noise ratios required for data transmission severely limits the range of the broadband mobile communications antenna base stations concerned. Early high data rate WiMAX mobile telecommunications networks have antenna base station ranges of only about 800 meters—or approximately one-half mile. Such a system would require over 3,400 antenna sites to cover the seven-county Region. An expanded range of one mile may be expected to be provided by a later version of mobile WiMAX, and this would reduce the number of base station sites required to 856—a feasible maximum since there are currently 1,010 cellular/PCS wireless antenna sites within the Region. Increasing the range, and thereby decreasing the antenna base station density, depends primarily on the provision of either increased transmitter power or improved cell phone sensitivity or gain. In licensed frequency bands, transmitter power can be increased almost at the discretion of the service provider; given, however, technical limits on increased transmitter power due to potential interference in other cellular sectors of the network concerned. For the unlicensed frequency bands proposed to be used in Alternative Adjunct Plan B, transmitter power would be limited to about 4.0 watts. Such a limitation leaves improved receiver sensitivity as the only means for range improvement.

Another technology available for use with both WiFi and WiMAX to increase the range of base stations, is known as Multiple Input Multiple Output, or MIMO, technology. MIMO technology involves the use of multiple—from two to four—base station antennas and complex digital signal processing. Pre-certified WiFi versions of MIMO in the form of IEEE Standard 802.11n are now available in retail outlets. Early versions of mobile WiMAX will also incorporate MIMO. Experience to date, however, indicates range extensions have been modest, particularly if high data transmission rates are also required. Given the evolving nature of broadband 4G mobile wireless communications technology, Adjunct Plan B is based on the following assumptions in that the FCC limitations on transmitter power for the unlicensed 2.4 GHz and 5.8 GHz frequency bands will remain in force and that WiFi, and WiFiA mobile cellphone sensitivity enhancement—gain—may be expected to improve the current gain level of –2.0 dB to 10 dB. WiFi and WiFiA cellphone transmitter power may be expected to remain at the current level of 23 dB.

Based on the above assumptions, Alternative Adjunct Plan B has been specified to offer the following features:

1. Frequency Band
   Alternative Adjunct Plan B would utilize the 2.4 GHz frequency band in conjunction with the community-based primary wireless network plan; and the 5.8 GHz frequency band in conjunction with the regional based primary wireless network plan.

2. Technology
   The plan operation would be based on IEEE Standard 802.11g wireless technology in conjunction with the community-based primary wireless networks plan; and IEEE Standard 802.11a technology in conjunction with the regionally-based primary wireless network plan.

3. Antenna Access Points
   The adjuncts to the community-based wireless systems would use the same access points as the primary fixed and nomadic user service community wireless networks.

4. Example Community-Based Mobile WiFi Wireless Network
   As an example, a WiFi mobile wireless network plan was developed using the Cedarburg-Grafton fixed wireless infrastructure. This network employs the same access point locations as the fixed and nomadic user service network. It differs, however, in the sensitivity of the user device, a cell phone in this application. The network differs in the throughput performance levels which are indicated on Map 37 for a receiver sensitivity enhancement of 10 dB.

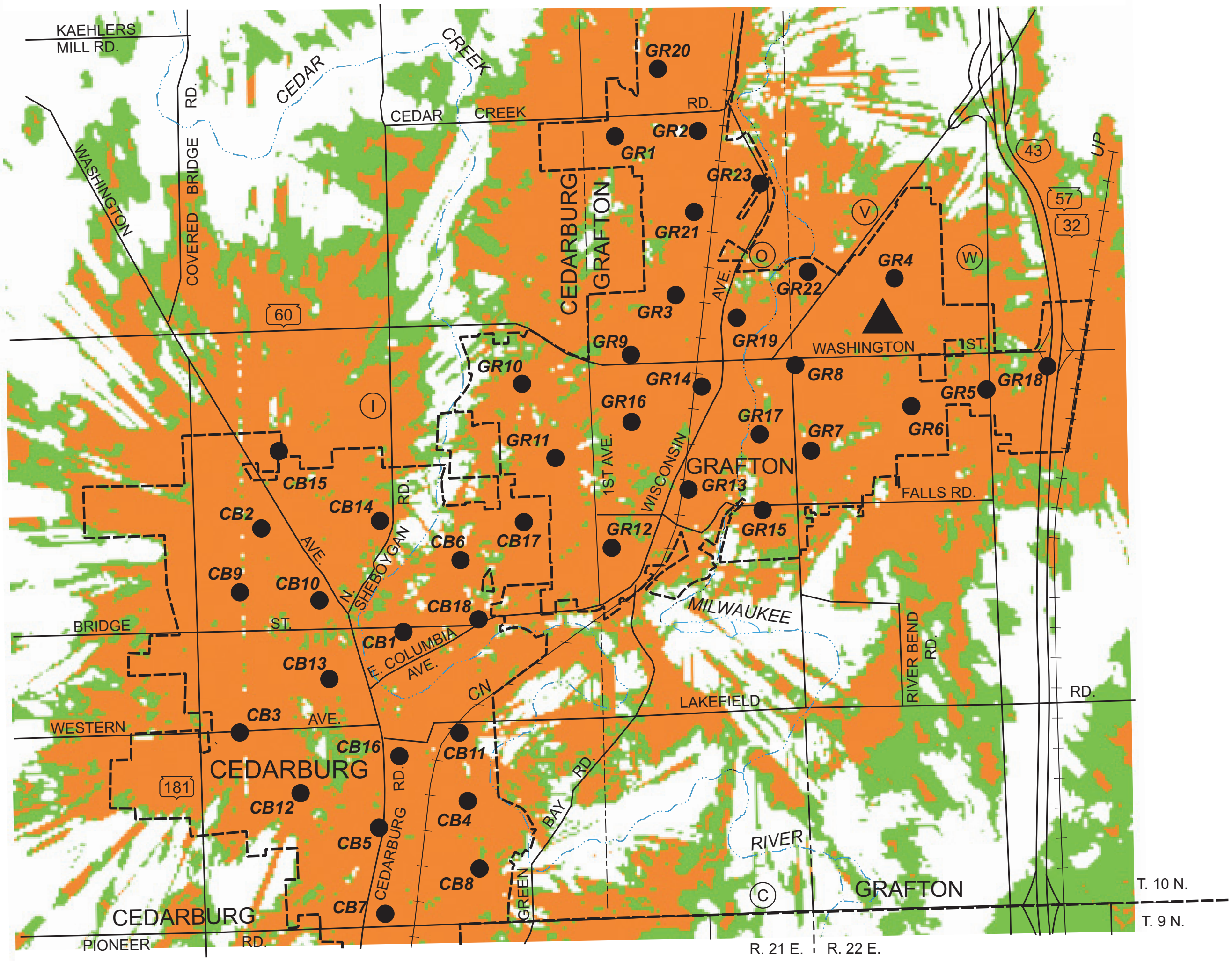
5. Regional Mobile WiFiA Wireless Network
   The Alternative Adjunct Plan B network would employ an infrastructure configuration taken from the primary service Regional Wireless Plan. It would differ in the areal performance levels possible as a function of receiver sensitivity. Based upon radio wave propagation modeling, Map 38 illustrates the mobile data rates possible for a cell phone antenna gain of 10 dB. Although data communications performance is emphasized as the primary criterion in all of the broadband mobile wireless plans, all of these networks would be able to provide for voice communication which has only modest bandwidth requirements.

6. Internet Gateway Connections
   The mobile wireless networks would be based on the same Internet gateway connections as the host fixed user networks. The community-based networks would generally have wireless backhaul to central gateway locations. The regional wireless network would have a fiber optic cable connection Internet gateway at each antenna base station site.

7. Cost Structure
   The cost structures of the community-based and regional network mobile wireless plans are identical to their host fixed wireless networks since they employ the same access points and base stations.

Map 37

SERVICE COVERAGE PROVIDED BY ALTERNATIVE ADJUNCT PLAN B COMMUNITY WiFi NETWORK



LEGEND

EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION

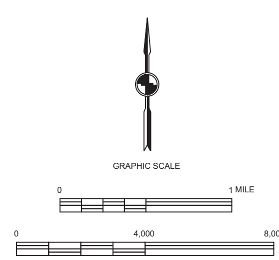
RECOMMENDED LOCATION OF WiFi ACCESS POINT

GR3 IDENTIFICATION NUMBER (SEE TABLE 17)

RECEIVED POWER AT REMOTE: -84dBmW TO -92dBmW, THROUGHPUT: 24 Mbps to 54Mbps

RECEIVED POWER AT REMOTE: GREATER THAN -92dBmW THROUGHPUT: 6 Mbps to 24 Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Map 38

SERVICE COVERAGE PROVIDED BY ALTERNATIVE ADJUNCT PLAN B REGIONAL WiFiA NETWORK

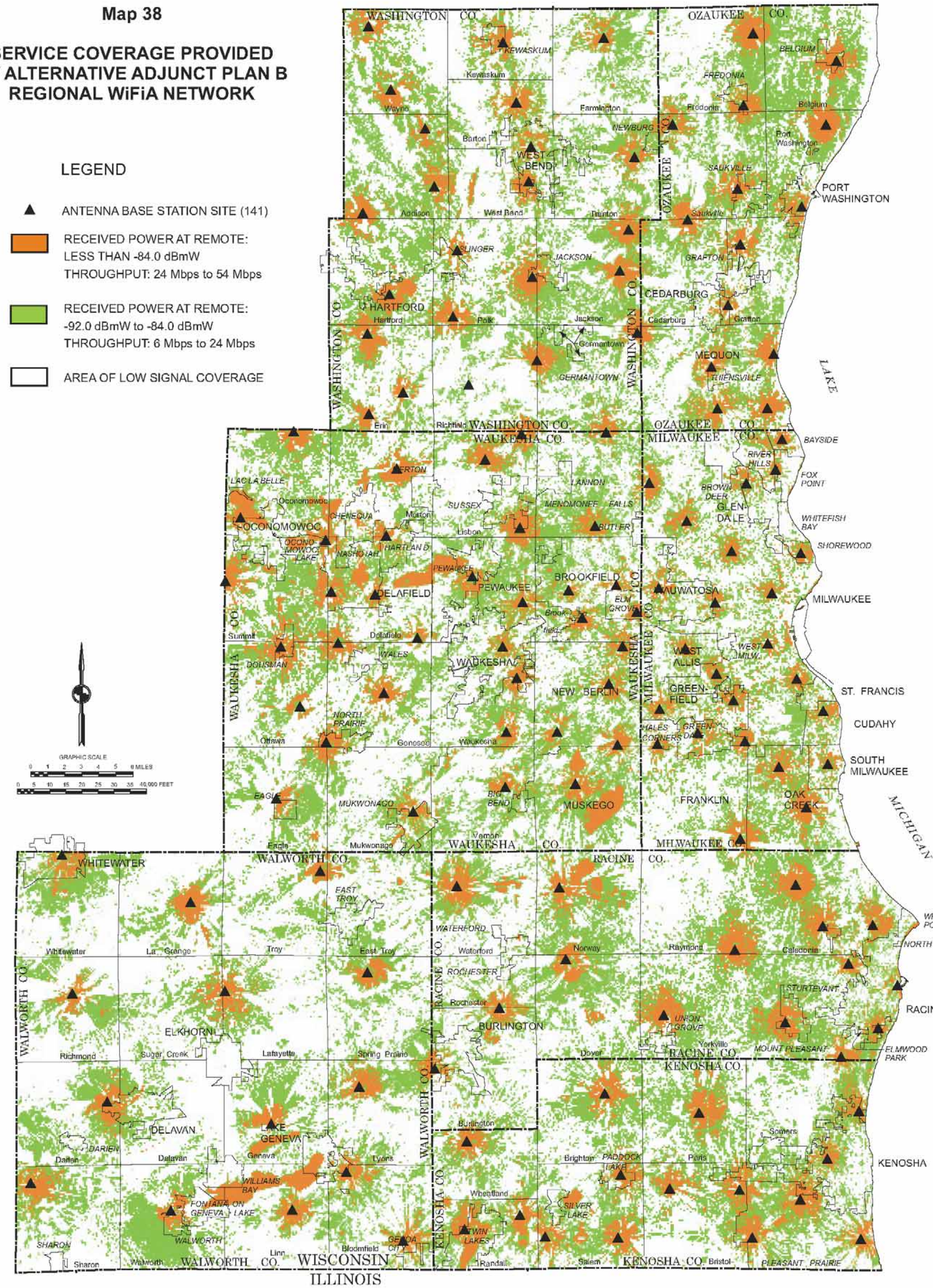
LEGEND

▲ ANTENNA BASE STATION SITE (141)

RECEIVED POWER AT REMOTE: LESS THAN -84.0 dBmW THROUGHPUT: 24 Mbps to 54 Mbps

RECEIVED POWER AT REMOTE: -92.0 dBmW to -84.0 dBmW THROUGHPUT: 6 Mbps to 24 Mbps

AREA OF LOW SIGNAL COVERAGE



Source: SEWRPC.

8. <u>Performance</u>
   As already noted, the performance levels of the two versions of Adjunct Plan B are shown in Maps 37 and 38. The prevailing data rate throughput is estimated to be in the 6 megabits per second range or better. It should be emphasized that laptop computer and WiFi cell phone active antenna gains were increased to the 10 dBi level from the current 5 dBi for laptop, and—2 dBi for WiFi cell phone equipment to achieve the indicated performance level. These remote devices constitute the "bottleneck" in extended range nomadic/mobile broadband communications. Remote device receiver sensitivity technology levels will need to be improved to achieve 4G performance objectives.

Alternative Adjunct Plan B Costs
As previously stated, there are no new infrastructure costs for either the community-based or the regionally-based mobile wireless networks. Both versions utilize fixed wireless host networks. Thus the capital cost of Alternative Adjunct Plan B when used in conjunction with a community-based fixed and nomadic user host network for the example Cedarburg-Grafton service area would approximate $353,000. The operating costs would approximate $4,600 per month.

The capital cost of Alternative Adjunct Plan B when used in conjunction with the regional wireless system host network would approximate $6.4 million. The operating costs would approximate $987,000 per month.

SUMMARY

The preparation of alternate regional broadband communications plans involved a seven step process:

1. Selecting a set of communications technologies for use in formulation of the plans;

2. Identifying infrastructure and user equipment requirements;

3. Developing performance data on the various technologies;

4. Developing cost data on the various technologies;

5. Preparing geographic network layouts of alternate plans;

6. Specifying the expected performance and costs of alternate plans; and

7. Evaluating each alternate plan in terms of the previously established objectives and standards.

The WiFi (IEEE 802.11g and 802.11a) and WiMAX (IEEE 802.16) standards were selected as the technologies for use in formulating the alternate wireless plans because they were the only technologies correctly specified to achieve the fourth generation performance targets. As IEEE standards technologies, they were also significantly lower in cost than competitive technologies. The Alcatel Fiber-to-the-Node (FTTN) and Fiber-to-the-Premises (FTTP) wireline technologies were selected for use in formulating the alternative wireline plans as typical of fiber communications technology today—Alcatel Lucent is the leading world provider of fiber communications systems. The current versions of these technologies, Alcatel 7330 and Alcatel 7340, may be expected to be electronically upgraded over the coming years, but the necessary basic fiber or fiber/copper infrastructures will remain essentially unchanged. The deployment costs—particularly of the FTTP technology—all more dependent on the construction costs of laying fiber than on the specific electronic equipment employed.

Having selected the basic technologies to be used in formulating the alternative plans, it was then necessary to specify equipment configurations for both the network infrastructure and the service users. The wireless equipment required special high gain antennas at both infrastructure access points and end users in order to achieve the performance standards previously established. Wireless plans were also based on a sectoral cellular topology to take advantage of the high gain active directional antennas. A conventional mesh network topology requires the employment of lower gain omni-directional antennas which do not have the gain performance necessary to achieve the 4G throughput standards. Performance estimates for a wireless network were based on manufacturers specifications,

Table 20

SUMMARY OF SALIENT CHARACTERISTICS OF ALTERNATIVE REGIONAL TELECOMMUNICATIONS PLANS

Plan	Universal Geographic Coverage	Performance	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Community-Based Wireless Plan	Geographic coverage depends on a community-by-community plan implementation	Meets the throughput standard but may have less speed improvement potential than fiber-based systems	Plan is much lower in cost than fiber-based systems $20.3 million	Built-in redundancy is possible using peer-to-peer communications feature to be field tested as part of the regional wireless plan	Joint 4.9 GHz frequency operation for public safety communications is possible as an added feature in a community network	Plan is not designed for broadcast video services but is well suited to video con-ferencing
Regional Wireless Plan	Plan specifies coverage for the entire Region, but implement-ation depends on a county-by-county deployment	Meets the throughput standard but may have less speed improvement potential than fiber-based systems	Plan is the lowest in infrastructure cost by a wide margin $6.4 million	Plan will have inherent redundancy for both alternative transmission paths and for failure of infrastructure base stations	Plan has specific separate network for public safety	Plan is not designed for broadcast video services but is well suited to video conferencing
Fiber-to-the-Node (FTTN) Wireline Plan	Plan will cover only 35 percent of the geographic areas of the Region	Plan will meet throughput standards in the downstream but not the upstream direction	For a third of the geographic coverage, plan is more than 10 times the cost of the Regional Wireless Plan $77.7 million	Plan has no explicit redundant transmission paths	Plan does not specifically provide for public safety communications except for priorities in times of public emergency	Plan emphasizes the video broadcast application. Slow upstream throughput is not compatible with video conferencing
Fiber-to-the-Premises (FTTP) Wireline Plan	Plan, like the FTTN plan, covers only 35 percent of the Region	Plan will have the greatest throughput potential of any plan	It is the most costly of all of the plans $246.0 million	Plan has no explicit redundant transmission paths	Plan does not specifically provide for public safety communications except for priorities in times of public emergency	Plan is well suited to both broadcast video and video con-ferencing
WiMAX Mobile Wireless Plan A	Economic considerations will limit coverage in low density rural area	Plan provides for 4G throughput performance	The cost far exceeds that of the WiFi mobile wireless plan $38.0 million	There is no provision for network redundancy	There are no specific public safety features in this plan	Videoconferencing is supported in this plan
WiFi Mobile Wireless Plan B	Operating with both the regional and community-based wireless networks, this plan provides for full regional coverage	Plan provides for 4G throughput performance	Infrastructure costs are minimal and relate to augmentations of the other two wireless plans $1.0 million	Plan calls for redundancy using peer-to-peer transmission paths	Plan allows for integration with 4.9 GHz public safety wireless network	Video conferencing is supported in this plan

Source: SEWRPC.

radio propagation modeling and extensive field testing with the specified equipment. Wireless cost data were collected from manufacturer price schedules. The estimated geographic coverage of wireless network plans was based primarily on radio propagation modeling verified by field testing.

Fiber-to-the-node (FTTN) and fiber-to-the-premises (FTTP) equipment requirements, performance data and cost data were all obtained from Alcatel specifications and pricing schedules as confirmed by cost data publicly available from either corporate financial reporting or the FCC.

A summary of the characteristics of the alternative broadband wireless and wireline communications plans in terms of plan objectives and standards are set forth in Table 20. The plan characteristics shown in the table will be used to evaluate alternate plans and select a final plan in the next chapter.

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Chapter VIII

ALTERNATIVE PLAN COMPARISON AND EVALUATION AND SELECTION OF A RECOMMENDED PLAN

INTRODUCTION

The previous chapter of this report described a set of alternative wireless or wireline broadband telecommunications plans that alone, or in combination, were candidates for a recommended comprehensive, regional telecommunications plan for Southeastern Wisconsin. This chapter presents the findings of a comparative evaluation of these alternative plans; and based upon these findings sets forth a recommended plan. The plan selection process looks back to Chapter III of this report which defines the objectives, principles and standards that are intended to serve as the basis for the comparative evaluation of the various alternative and adjunct plans considered, and for selecting one of these alternative plans, or combination of these plans, as the preferred plan for future broadband telecommunications within the Region.

METHOD OF EVALUATION

In the preparation of long range public works facilities plans, the Commission usually uses the benefit-cost analysis method for the comparative evaluation of alternative plans. Although this method may be theoretically applicable to the shorter range alternative telecommunication system plans presented in this report, the method loses much of its effectiveness in such application because of the following limitations:

1. It is impractical to assign a monetary value to the many intangible benefits and costs attendant to telecommunication system development within the Region, and it is extremely difficult to assign monetary values to even the direct benefits and costs associated with such development.

2. Because of the relatively greater uncertainty associated with implementation of a regional telecommunications plan, there can be no assurance that the potential benefits will ever be realized, even though some of the costs associated with the development of a given system may, nevertheless, be incurred.

It was determined that the alternative telecommunication system plans considered would be compared by scaling each plan against each development objective set forth in Chapter III of this report, utilizing the standards supporting each objective and the results evaluated by the Regional Telecommunications Advisory Committee. In addition, the comparative evaluation was supplemented by the application of a method which seeks to assign a value to each alternative plan.

The method chosen, overcomes, to a considerable extent, the difficulties inherent in the application of benefit-cost analysis to telecommunication system planning. The method is an adaptation of the rank-based expected value method used for corporate and military decision making.[1] This method avoids the difficulties associated with the assignment of monetary values to potential benefits and costs associated with the alternative plans by limiting the plan evaluation problem to one of rank ordering each alternative under each of the stated development objectives. It is usually easier to rank order the perceived effectiveness of a given plan in achieving a given development objective than it is to attempt to assign monetary values to the benefits accruing to the attainment of the objective.

The difficult problems associated with uncertainty of plan implementation are also ranked in the chosen method of plan evaluation through the medium of probability estimation. Some alternative plans, while theoretically highly desirable, may have a low probability of implementation; and, in the application of the method, such plans are assigned a lower value for probability of implementation. Other plans, while theoretically less desirable on the basis of the ability to attain stated objectives, may have higher actual value because of a greater likelihood of implementation.

In plan evaluation, then, the application of the rank-based expected value method involves the following sequence of activities.

1. All specific development objectives, n in number, are ranked in order of importance to the agreed upon development objectives and assigned "weight" of n, n minus 1, n minus 2, and so on to n minus one (n-1) in descending rank order.

2. The alternative plans, m in number, are ranked under each of the specific development objectives and assigned a "score" of m, m minus 1, m minus 2, and so on to m minus one (m-1) in descending rank order.

3. A probability, p, of plan implementation is assigned to each of the plans being ranked.

4. The value, V, of each alternative plan is then determined by summing the products of n times m times p for each of the specific development objectives, or:
   $V = p \sum (n_1m_1+n_2m_2+\ldots+n_nm_n)$

In Chapter III of this report, specific telecommunication system development objectives were expanded into sets of supporting standards which could be used to evaluate the ability of an alternative plan to achieve a given specific development objective. Any ranking of an alternative plan for a given specific development objective must, therefore, be consistent with the ability of the plan to achieve the supporting standards set forth for that objective. To achieve this consistency, it is necessary to compute a value for each of the alternative plans according to the supporting standards set forth for each development objective before arriving at an overall value for each plan in relation to the development objectives. This subsidiary evaluation utilizes a series of matrices in which the development standards replace the development objectives in the matrix table, and in which it is usually not necessary to assign a probability estimate for the standard evaluation.

[1] *C. H. Igor Ansoff,* Corporate Strategy, *McGraw-Hill, New York, N.Y., 1965; K. J. Schlager, "The Community-The Rank-Based Expected Value Method of Plan Evaluation,"* Highway Research Board, *1968; Z. Hu, et al., "Fuzzy Expected Value model for Transmission Planning with Hybrid Intelligent Algorithm,"* Computers and Advanced Technology in Education Conference, *October 8-10, 2007, Beijing, China; Yian-Kui Liu and Baoding Liu,* Information Sciences, *Volume 155, Issues 1-2, 1 October 2003, Pages 89-102.*

Ranking the Objectives/Standards

From the eight sets of objectives and standards presented in Chapter III, six were selected to serve as a basis for the comparative evaluation of the alternative plans.

1. Performance
2. Universal geographic coverage
3. Infrastructure cost
4. Redundancy
5. Public safety
6. Most demanding application – video and multimedia

The other two objectives: antenna base site minimization, and antenna aesthetics and safety were not used in the evaluation since these apply only to wireless telecommunications systems, and so can not serve as a basis for comparing wireline and wireless systems.

The above objectives were also ranked in a perceived order of priority—or importance—beginning with the highest in priority listed first. Performance was ranked first since it represents the very definition of broadband telecommunications. Performance is also strongly related to the economic development goal of the telecommunications planning program. Universal geographic coverage was ranked second since such coverage is not likely to occur within Southeastern Wisconsin through the operation of market forces alone and without strong governmental incentives and encouragement. Infrastructure cost also rank high since this cost is an important determinant of the economic viability of an alternative plan. Redundancy is an important feature of any telecommunication system because of the need for system reliability in a wide range of public and private applications. Public safety was designated an objective in its own right because maintenance of public safety and effective response to natural and man-made disasters represent two of the most important uses of modern telecommunications. Finally, the ability to meet the most demanding use of the telecommunications bandwidth—video telecommunications—was considered important to certain business and governmental functions as well as to the entertainment function of telecommunications systems.

EVALUATION BASED UPON STANDARDS

Prior to the application of the rank-based expected value method (RBEV) to aid in the selection of a regional comprehensive broadband telecommunications plan, each of the four alternative and two adjunct plans were evaluated and ranked on the basis of the ability to meet the supporting standards under each of the six objectives. Such an evaluation and ranking then provided the basis for final plan selection.

Performance Objective

The performance objective, as defined in Chapter III, embraces not only throughput—transmission rate—but also network reliability and quality of voice communications. Ranking the alternate plans for this objective can be readily accomplished based upon the nature of the four alternate plan technologies. An all fiber network, as represented by the FTTP plan, would clearly be first in rank in this respect. If the active (AON) rather than the passive (PON) optical network had been the selected technology, there would be little or no limit on ultimate network performance. PON technology does have some limitations based on network topology, but even with these restrictions, the FTTP has the highest ultimate performance potential. While the electronic equipment for wireline network may be expected to continue to evolve and improve, the fiber infrastructure will impose little or no performance limitations for many years to come.

The remaining plan alternatives, FTTN wireline and the two broadband wireless plans all promise to achieve 4G performance levels. The wireless plans, however, while competing favorably on throughput performance short-term and long-term, will probably never achieve the "five nines—99.999 percent—reliability of wireline networks.

Based upon the foregoing considerations, the four alternative plans were ranked for performance as follows:

1. Fiber-to-the Premises (FTTP) Wireline Plan
2. Fiber-to-the Node (FTTN) Wireline Plan

3. Regional Wireless Plan

4. Community-Based Wireless Plan

Universal Geographic Coverage Objective

The universal geographic coverage objective, ranked second in importance among the six plan objectives, is one well suited to plan comparison and evaluation. Only the two wireless alternative plans make such widespread geographic coverage a feasible object-tive. The Fiber-to-the-Node (FTTN) and Fiber-to-the-Premises (FTTP) wireless alternative plans would serve about 36 percent of the total area of the Region and, therefore, cannot achieve high rank for geographic coverage. Those alternative plans may, however, be expected to serve about 92 percent of the anticipated year 2035 resident population of the Region; about 93 percent of the land anticipated to be devoted to commercial use within the Region; and about 90 percent of the land anticipated to be devoted to industrial use within the Region in that year. The community-based wireless plan has the potential for full geographic coverage of the Region, but such full coverage would depend on the deployment of broadband wireless networks in each of the Region's 147 cities, villages and towns, or in a somewhat smaller number of cooperative municipal service areas. Such a universal adoption and deployment of broadband wireless networks is considered highly unlikely. Even if each municipality were to desire the installation of a community-based wireless network, there is no assurance, especially in low density rural areas, that private, or public, capital funds would be available to support the needed infrastructure deployment. This potential lack of capital funding should not, however, be interpreted as indicating that there would be little demand for high-speed broadband telecommunications services in low density rural areas of the Region: experience has indicated the opposite to be true. Only the regional wireless plan alternative has both the economic rationale and governmental support structure required for the attainment in a timely fashion of region-wide geographic coverage. The economic rationale is provided by a joint public safety-commercial antenna site infrastructure. The governmental support, however, would have to come from the counties. While the regional wireless plan is truly region-wide in scope, the required joint public safety-commercial antenna site network could be accomplished on a county-by-county basis.

Based upon the foregoing considerations, the four alternative plans were ranked for geographic coverage as follows:

1. Regional Wireless Plan

2. Community-Based Wireless Plan

3. Fiber-to-the-Node (FTTN) Wireline Plan

4. Fiber-to-the Premises (FTTP) Wireline Plan

Infrastructure Cost Objective

Two methods were used to determine the infrastructure costs of the alternative plans. The first set of infrastructure costs was limited to the actual capital costs of the infrastructure equipment with no provision for operating costs. The second method included the capital costs of the first method plus the present value of that portion of the operating costs representing capital substitution costs, i.e. the incrementally higher Internet access costs resulting from the purchase of Internet access locally at each antenna site rather than regionally based on a optic fiber cable backhaul network allowing for lower Internet access costs.

Based on the first method, the following infrastructure costs were estimated:

1. Community-based Wireless Plan – $20.3 million

2. Regional Wireless Plan – $6.4 million

3. Fiber-to-the-Node Wireline Plan – $77.7 million

4. Fiber-to-the Premises Wireline Plan – $246.0 million

Ranking of the alternative plans on the infrastructure cost minimization objective was also accomplished on the basis of the infrastructure costs plus the present value of any higher operating costs resulting from the avoidance of increased fiber infrastructure costs that would result in lower operating rates. The basic direct Internet access rate for the 141 base station sites of the Regional Wireless Plan and the 54 backhaul stations of the Community Wireless Plan is $70 per megabit per second per month. If additional fiber optic infrastructure were installed allowing for high volume Internet connections in the 5 gigabit per second range at only three connections, the Internet access rate would drop to $45 per megabit per second per month. The $25 per month difference in the two rates was then capitalized based on the present value of the payments over a ten year period at 5 percent interest rate. The modified infrastructure costs using the second method change only for the two wireless plans. The wireline plans are assumed to have no substituted capital costs in their operating costs. Under the second method, the modified infrastructure costs were estimated as follows:

1. Community-based Wireless Plan – $38.6 million
2. Regional Wireless Plan – $39.1 million

3. Fiber-to-the-Node Wireline Plan – $77.7 million
4. Fiber-to-the-Premises Wireline Plan – $246.0 million

The above infrastructure cost estimates assume that the full cost of the regional wireless plan will be borne by the private service provider. In the actual implementation, the public safety wireless communications network will utilize the same base station infrastructure and share the deployment costs. The effect of such cost sharing considerations will be considered later in the final plan selection.

All cost estimates here are based on the detailed cost breakdowns developed in Chapter VII which included wireless infrastructure costs in Table 18 and wireless operating costs in Table 19 Wireline cost estimation methodology is covered in the text for each plan alternative.

Redundancy Objective

The inclusion of redundancy as a separate objective was based, at least in part, on the almost universal failure of telecommunication networks, both public and private, in recent national natural and terrorist-inspired post disaster environments. Wireline and wireless networks failed to a large extent to operate after both the September 11, 2001, terrorist attack on the World Trade Center in New York and the Gulf hurricane of 2005 that destroyed much of the New Orleans area. Wireline as well as wireless telecommunications networks are critically dependent on major infrastructure elements such as central offices and antenna base sites. A variety of disaster-induced events such as explosion, grid power loss, or flooding as well as terrorist inspired sabotage, can severely damage telecommunication infrastructure. Emergency-related network traffic congestion can also disable a network even when the infrastructure remains intact. Network redundancy can also play an important role in normal network operation where high network reliability is required to maintain government, commercial and social communications—especially public health and safety related communications. Wireless networks in particular have experienced reliabilities far below the 99.9 percent standard due to a lack of network redundancy.

As already noted under the performance objective, wireline networks have demonstrated very high reliability in network operations. Such wireline networks, however, do not have known elements of network redundancy. Both the FTTN and FTTP networks are critically dependent on the operation of central offices. A disruption of a single central office operation may disconnect the entire service area of that office. In like manner, loss of a single antenna base station site can disrupt wireless communications over a wide service area. Protection against such communication disruptions requires redundancy in the network. Redundancy was defined in Chapter III as the "average number of alternative transmission paths between users in a network". Accordingly, network redundancy is created by providing alternative transmission paths through the networks. Traditional cellular wireless networks do not typically provide redundancy in the form of alternative transmission paths through the networks. Users communicate through the antenna base stations assigned for a particular time and location. Operational failure of the base station concerned will terminate all communications in the station service area. Established alternative paths are generally not available.

The most redundant communications network topology is the mesh network design. In a mesh network, users with omnidirectional antennas may connect with alternative access points. Once connected, alternative transmission paths through the network provide strong redundancy as long as sufficient access points are available for such redundant transmission paths. Power outages and other emergency situations, however, can still drastically reduce the number of such alternative transmission paths. Comprehensive wireless network redundancy requires alternative transmission paths that are independent of the basic infrastructure. Such redundant independence is possible only in ad hoc, peer-to-peer mesh networks that employ the users themselves as backup transmission point nodes. Such an ad hoc mesh network differs from current mesh networks in two primary ways: (1) the ad hoc, peer-to-peer network serves only as an emergency supplement to the basic cellular network; and (2) the mesh network nodes are end users, serving as nodes not separate network elements. Both the community-based and regional wireless plans are envisioned as incorporating this backup ad hoc, peer-to-peer network feature to provide high levels of redundant network operation.

Redundant features of the FTTN and FTTP wireline networks, if any, are unknown at the present time. The basic structure of these networks does not lend itself to redundant transmission paths. Both are critically dependent on central offices for basic operation. Alternate paths to remote nodes from the host, or from another central office, are not known to be provided. Disabling a node in an FTTN network will terminate communications in its square mile service area. Failure of a splitter node in a FTTP network will terminate communications in its service area. In the absence of additional information, redundancy in the FTTN and FTTP wireline networks must be assumed to be low or nonexistent. The redundancy of an FTTP network must be rated better than an FTTN network only because a fiber splitter is a passive component, while a FTTN node operates with active electronic equipment. Based on the forgoing considerations, network redundancy for the alternative plans was ranked as follows:

1. Regional wireless plan
2. Community-based wireless plan
3. Fiber-to-the-premises (FTTP) wireline plan
4. Fiber-to-the-node (FTTN) wireline plan

Public Safety Objective

The public safety objective relates to the response of the telecommunications system in supporting public safety objectives both in normal operations and in public safety emergencies. Because the Regional Wireless Plan would be jointly designed with the public safety communications network, it would directly support public safety communications in the Region. Community-based wireless networks may also choose to integrate network access points, or antenna base stations, into a shared public-commercial framework in which infrastructure development costs are shared. Such cost sharing directly enhances public safety by leveraging the public safety communications investment for enhanced public safety communications performance.

Wireline networks, since they do not support mobile, or nomadic users, are less directly involved with public safety communications. Wireline networks, however, are routinely used for public safety communications between fixed locations, and can serve the public safety objective by granting priority to public safety traffic particularly in times of public emergency. The FTTN broadband wireline network would be particularly useful to public safety because of its wider availability throughout the Region. Based on the foregoing considerations, the alternative plans were ranked as follows:

1. Regional wireless plan
2. Community-based wireless plan
3. Fiber-to-the-node (FTTN) wireline plan
4. Fiber-to-the premises (FTTP) wireline plan

Most Demanding Application Objective

Video, in both its broadcast and videoconferencing forms, is the most demanding broadband communications application. Bandwidth requirements for video can range from 256 kilobits per second to 200 megabits per second depending on application and desired quality. Broadcast television, even in its least demanding form, requires at least five megabits per second. The FTTN and FTTP plans, as presently being deployed by telephone carriers, such as AT&T and Verizon, are primarily aimed at the broadcast television market. As presently constituted, they are asymmetric and so do not support high quality videoconferencing. Videoconferencing, however, has not yet developed as a major application, and so generates minor traffic in comparison to broadcast television. For this reason, the plans were ranked primarily on their downstream throughput performance as follows:

1. Fiber-to-the premises (FTTP) wireline plan
2. Fiber-to-the-node (FTTN) wireline plan

Table 21

COMMUNITY-BASED WIRELESS PLAN RANKINGS AND RELATED SCORES

Item	Performance	Universal Geographic Coverage	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Rank	4	2	1	2	2	3
Score	1	3	4	3	3	2
Weight	6	5	4	3	2	1
Value	6	15	16	9	6	2

Note: Summation of the above value provides a total valuation score of 54.

Source: SEWRPC.

Table 22

REGIONAL WIRELESS PLAN RANKINGS AND RELATED SCORES

Item	Performance	Universal Geographic Coverage	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Rank	2	3	3	3	3	2
Score	3	2	2	2	2	3
Weight	6	5	4	3	2	1
Value	18	10	8	6	4	3

Note: Summation of the above value provides a total valuation score of 65.

Source: SEWRPC.

3. Community-based wireless plan

4. Regional wireless plan

Rank-Based Expected Value Plan Evaluation

Plan evaluation using the rank-based expected value method involves the combination of rank value calculations and an estimate of the probability of implementation. Beginning with the community-based wireless plan, each plan was scored based on these rank valuations and implementation probability estimates.

Community-Based Wireless Plan

The community-based wireless plan received rankings and related scores as shown in Table 21.

Estimating the probability of implementation of this plan is a difficult task since the implementation depends on deployment in each of the 147 cities, villages and towns within the Region, or on a somewhat smaller number of cooperative municipal service areas. Counties are excluded since they are better served by the Regional Wireless Plan. Regional communities have already begun to consider the process of deploying community wireless networks, but the probability of all of the communities in the Region adopting community wireless plans within the plan implementation period is judged to be about 60 percent, for a probability estimate of 0.6. Combining the probability with the rank valuation score of 54 produces a total plan evaluation value for the Community-Based Wireless Plan of 32.4.

Regional Wireless Plan

Following the same scoring procedure, the rankings and related scores for the Regional Wireless Plan are shown in Table 22.

Initially, the probability of implementation of a regional wireless plan was judged to be rather low because there is no regional governmental authority to carry out such a plan. Recent experience with a potential demonstration project in Kenosha County, however, indicates a higher probability of implementation on a county-by-county basis. A successful implementation of the plan in a single county such as Kenosha could ignite sufficient interest for other counties to follow suit for an

Table 23

FIBER-TO-THE-NODE (FTTN) WIRELINE PLAN RANKINGS AND RELATED SCORES

Item	Performance	Universal Geographic Coverage	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Rank	2	3	3	3	3	2
Score	3	2	2	2	2	3
Weight	6	5	4	3	2	1
Value	18	10	8	6	4	3

Note: Summation of the above value provides a total valuation score of 49.

Source: SEWRPC.

Table 24

FIBER-TO-THE-PREMISES (FTTP) WIRELINE PLAN RANKINGS AND RELATED SCORES

Item	Performance	Universal Geographic Coverage	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Rank	1	4	4	3	4	1
Score	4	1	1	2	1	4
Weight	6	5	4	3	2	1
Value	24	5	4	6	2	4

Note: Summation of the above value provides a total valuation score of 45.

Source: SEWRPC.

eventual regionwide deployment. Such a possibility raises the probability of implementation to 60 percent (0.6) for a plan evaluation value of 39.0.

The Kenosha County joint public safety/WiFiA wireless communications demonstration project is currently at the contract closure stage and is scheduled to begin in September, 2007. The project activities will include a detailed 4.9 GHz (public safety) and 5.8 GHz (commercial WiFiA) plan followed by a field demonstration of long-range, high-performance at 4.9 GHz communications with law enforcement vehicles. The project will also include a demonstration of peer-to-peer backup communications for public safety that would provide for network continuity when infrastructure is damaged in major public emergencies. If the field demonstration project is successful, Kenosha County intends to implement an early broadband public safety communications safety deployment that is county-wide in coverage.

Fiber-to-the-Node (FTTN) Wireline Plan

The FTTN Wireline plan rankings and related scores are shown in Table 23.

The probability of FTTN plan implementation is quite high since AT&T is already implementing an FTTN network in the Region. The primary obstacle to assigning a probability implementation of 100 percent is that AT&T is not the ILEC in all of the FTTN proposed service areas within the Region. AT&T has also clearly stated that it will not provide universal geographic coverage, but coverage only in those areas promising an adequate economic return. These limitations lower the implementation value to 0.8, the highest of any of the plan alternatives. Such a probability produces an FTTN plan evaluation value of 39.2.

Fiber-to-the-Premises (FTTP) Wireline Plan

The FTTP Wireline Plan rankings and related scores are shown in Table 24.

With the major regional ILEC, AT&T deploying a lower cost alternative wireline technology (FTTN), the probability of implementation of an FTTP network must be considered extremely low. AT&T must recover its return on the FTTN investment, and the FTTN nodal infrastructure still leaves the major costs of an FTTP to be covered in a network expansion. These costs relate to the fiber installation expenses from the nodes to each of the user premises. A probability of implementation of 0.3 seems appropriate. Such a probability produces an FTTP plan evaluation value of 13.5.

Rank-Based Expected Valuation (RBEV) Summary

The RBEV summary of the four alternative plans in priority order is listed below:

1. Regional Wireline Plan – V=39.0

2. FTTN Wireline Plan – V=39.2

3. Community-Based Wireless Plan – V=31.2

4. FTTP Wireline Plan – V=12.6

The above RBEV evaluation produces essentially the same values for the FTTN wireline plan and the Regional Wireless Plan. Each contributes a different set of attributes to regional telecommunications capabilities. The Regional Wireless Plan provides universal geographic coverage throughout the Region and significantly enhances the state of public safety communications in the seven county area. The FTTN plan provides the beginnings of an areawide fiber network in urbanized areas and provides competition in cable television service. A major cost factor not considered in the evaluation is the sharing of the cost of infrastructure deployment between county governments and private providers that would be possible under implementation of the Regional Wireless Plan. Such cost sharing would reverse the above plan rankings and designate the Regional Wireless Plan as the preferred broadband telecommunications plan for the Region. In actual practice, both plans satisfying complementary needs may be expected to proceed toward plan implementation.

None of the above primary plans provide for the mobile (cell phone) users. The fiber link plans, both FTTN and FTTP, do not provide for either the nomadic (laptop computer) or the mobile user. The community and regional wireless networks offer broadband communication services to the nomadic user. Since mobile communications will play a dominant role in future broadband communications, each of the above primary plans must be supplemented with an adjunct broadband mobile wireless network.

WiMAX versus WiFi for a Regional Mobile Broadband Wireless Network

The two alternative broadband wireless networks described in Chapter VII utilized either WiMAX or WiFi technologies. Adjunct Plan A was an independent plan based on WiMAX (IEEE Standard 802.16e) and deployed 743 base stations throughout the Region. Adjunct Plan B was a true adjunct plan in that its implementation depended on the pre-existence of one of the two alternative wireless plans—regional or community-based—for its implementation. Following the same approach used for the primary alternative plan evaluation, these two adjunct plans will be rank-evaluated for each of the Chapter III objective standards.

Performance Objective

Early released versions of WiMAX mobile wireless technology do not provide for the throughput data rates of 20 megabits per second as specified in the Chapter III performance standard. Later versions will probably improve in performance but at an unknown rate. The WiMAX plan illustrated in Map 36 in Chapter VII, depicts 20 megabits per second performance in most areas throughout the Region. Such performance was achieved through the deployment of a very large number of antenna base stations (743).

The WiFi and WiFiA based mobile wireless plan, as illustrated in Maps 37 and 38 in Chapter VII, achieves the specified throughput performance using the community-based wireless network but not with the regional wireless network. Some new features will be added to the regional wireless plan to upgrade throughput performance to standard level, but these features are still untested and so can not be relied upon at this time. Given the uncertainty in this aspect of the regional wireless plan, the WiMAX plan must be ranked higher.

1. WiMAX Mobile Wireless Plan A

2. WiFi Mobile Wireless Plan B

Universal Geographic Coverage Objective

Because it employs licensed radio frequency bands, the WiMAX adjunct mobile wireless plan A must be deployed by a major wireless carrier that owns spectrum in these licensed bands. The high cost of region-wide WiMAX deployment combined with the low economic return expected in lower density rural areas makes it highly unlikely that any private wireless carrier would provide region-wide mobile wireless WiMAX coverage. WiFi Plan B, in contrast, operates off a primary wireless infrastructure, either the regional and the community-based, and so has a reasonably high probability of region-wide implementation. Given this situation, the WiFi mobile wireless plan outranks its alternative adjunct WiMAX plan.

1. WiFi Mobile Wireless Plan B

2. WiMAX Mobile Wireless Plan A

Infrastructure Cost Objective

With an estimated infrastructure cost of $38.0 million, the mobile wireless WIMAX plan far exceeds in cost any added features needed to extend the range or performance of the Regional Wireless Plan for mobile users as called for in Adjunct Mobile Wireless Plan B. With the Community Based Wireless Plan, there is little or no added infrastructure costs to support mobile wireless users. The Regional Wireless Plan will require some infrastructure augmentation, but at no where near the level of the WiMAX alternative. In either event, the WiFi adjunct plan provides a lower cost alternative than WiMAX based Plan A.

1. WiFi Mobile Wireless Plan B

2. WiMAX Mobile Wireless Plan A

Redundancy Objective

Both the regional and community-based primary wireless plans will be augmented by design features that allow for alternate transmission paths through the network. Based on such design features, WiFi adjunct plan B will have built-in redundancy not known to be featured in WiMAX. For this reason, the WiFi-based mobile wireless plan must be ranked above the WiMAX alternative for network redundancy.

1. WiFi Mobile Wireless Plan B

2. WiMAX Mobile Wireless Plan A

Public Safety Objective

A major feature of the Regional Wireless Plan is its joint public safety-commercial capabilities. As an adjunct to the Regional Wireless Plan, the WiFi Mobile Wireless Plan B would incorporate a capability for communication with hand-held devices, including cell phones. WiMAX mobile wireless networks could also operate in the 4.9 GHz public safety frequency band, but this additional capability is not likely to be incorporated in a region-wide WiMAX network by a private wireless service provider. As an adjunct to a community-based WiFi network, Plan B also requires a 4.9 GHz upgrade. On balance, however, the WiFi mobile wireless Plan B better serves this objective.

1. WiFi Mobile Wireless Plan B

2. WiMAX Mobile Wireless plan A

Most Demanding Application Objective

With equivalent bandwidth capability, both the WiFi and the WiMAX can serve the demands of video and multimedia communications. The improved quality of service (QoS) features of WiMAX would appear to favor WiMAX for this objective.

1. WiMAX Mobile Wireless Plan A

2. WiFi Mobile Wireless Plan B

RANK-BASED EXPECTED VALUE ADJUNCT PLAN EVALUATION

Based on the above rankings, Tables 25 and 26 summarize the valuation scores for the WiMAX and WiFi mobile wireless plans.

WiMAX Mobile Wireless Plan A

The probability of implementation of a broadband mobile wireless plan must be considered rather low because of the cost and the low financial return in rural areas of the Region. There is also some basis for questioning the need for 4G-level throughput in many areas of the Region. These uncertainties result in a implementation probability of only 0.3 which results in a plan evaluation value of only 8.4.

WiFi Mobile Wireless Plan B

The probability of implementation of this WiFi mobile wireless plan is quite high since it operates off the infrastructure of either the regional or community-based wireless plan. Given the region-wide deployment of either of these fixed user plans, the addition of a mobile wireless capability is judged to be highly likely, so that it should be assigned the same probability of implementation as those two plans which is 60 percent or 0.6. Such a probability value results in a total plan evaluation value of 21.0.

Table 25

WiMAX MOBILE WIRELESS PLAN A RANKINGS AND RELATED SCORES

Item	Performance	Universal Geographic Coverage	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Rank	1	2	2	2	2	1
Score	2	1	1	1	1	2
Weight	6	5	4	3	2	1
Value	12	5	4	3	2	2

Note: Summation of the above value provides a total valuation score of 28.

Source: SEWRPC.

Table 26

WiFi MOBILE WIRELESS PLAN B RANKINGS AND RELATED SCORES

Item	Performance	Universal Geographic Coverage	Infrastructure Cost	Redundancy	Public Safety	Most Demanding Application
Rank	2	1	1	1	1	2
Score	1	2	2	2	2	1
Weight	6	5	4	3	2	1
Value	6	10	8	6	4	1

Note: Summation of the above value provides a total valuation score of 35.

Source: SEWRPC.

It is clear from the above that the WiFi mobile wireless plan is the best plan as indicated by the ranked based expected value score and probably the only broadband wireless plan able to economically achieve 4G standards in the entire Region.

Regional Comprehensive Broadband Telecommunications Plan Selection

Based on the Rank-Based Expected Value scoring, the leading contender for adoption as the regional telecommunications plan would be the Regional Wireless Plan supplemented by the WiFi Mobile Wireless Adjunct Plan. Together, these two complementary plans would meet the objectives and standards established in Chapter III for a comprehensive, regional broadband telecommunications system to serve the Region in the coming decade. Other considerations, however, require the provision of flexibility in the structure of the plan. This flexibility is required for the following reasons:

1. Existing and Expected Broadband Wireline Network Deployments – AT&T has already begun the deployment of a Fiber-to-the-Node Broadband Wireline Network in Southeastern Wisconsin. Time Warner and Charter Communications also have the potential of upgrading their cable network in a modified FTTN configuration to satisfy fourth generation broadband requirements. Since these new or modified networks are at least in partial compliance with current 4G objectives and standards, flexibility must be provided within the recommended plan to accommodate the continued deployment of these wireline networks.

2. Existing and Expected Community-Based Broadband Wireless Network Deployments – Strong interest in community-based broadband wireless networks currently is evident within the Region. Initial deployment of some of these networks is already underway. Since those networks would operate in a different frequency band than that which would be

used for the regional wireless plan—2.4 GHz for the Community-based systems and 5.8 GHz for the regional plan—they are operationally compatible and could serve together in the Region.

3. Broadband Communications Competition – In the current regulatory environment, consumer protection and technology innovation are both fostered by competition. It is Federal communications policy as set forth by the Congress and the Federal Communications Commission to encourage such competition. For these reasons, the recommended regional broadband telecommunications plans must provide for a level of diversity that recognizes current trends and the desire for a competitive telecommunications environment.

With the Rank-based Expected Value evaluation results as a foundation, but upon consideration of the foregoing trends and the desire for broadband competition in the Region, the following composite regional comprehensive broadband telecommunications plan is recommended for adoption within Southeastern Wisconsin:

1. Regional Wireless Plan for region-wide broadband coverage to serve fixed and later nomadic users; and

2. WiFi-based Mobile Wireless Plan B for region-wide broadband coverage of mobile users.

The above primary plan components would be supplemented by:

1. Fiber-to-the Node Wireline Plan

   – to provide television and related broadband services within the urbanized areas of the Region.

2. Community-Based Wireless Plans

   – for communities selecting local networks to compete with and complement the regional wireless networks.

   – to further support the WiFi-based Mobile Wireless Plan B.

Public Sector Broadband Wireless Networks

All of the above alternative broadband communications plans relate to commercial networks generally owned and operated by private service providers. These plans and the final selected composite plan are intended as an advisory plan to the private sector. A separate class of telecommunications networks relate to functions performed by the public sector. These public enterprise telecommunications networks were described in SEWRPC Memorandum Report No. 164, *Potential Public Enterprise Telecommunications Networks for Southeastern Wisconsin*, September, 2005.

One of the particularly important classes of potential public enterprise telecommunications networks described in the aforereferenced report are public safety emergency response networks which support law enforcement, firefighting, pre-hospital emergency medical service (EMS), and public works personnel with their communications needs. This class of network was described in the aforereferenced report with emphasis on high speed data, video, and multimedia applications in the new FCC (2002) frequency spectrum of the 4.9 GHz band. This band is dedicated solely to public safety applications and has sufficient bandwidth—50 MHz—to support high speed fourth generation (4G) communications performance. Experimental deployment of 4.9 GHz is expected in the next few years. Initial applications will emphasize data and video transfer, but extension to voice communication is expected to rapidly follow.

There is a strong synergy between the needs of public safety communications and the recommended regional telecommunications plan. Based upon interoperability needs, there is broad agreement that public safety communications should be regional in nature. The perpetuation of various community-based communications networks is not in the interest of effective operations particularly in times of major, disaster-level emergencies.

The wireless element of the recommended regional telecommunications plan could not only support commercial broadband wireless communications, but also region-wide, interoperable public safety broadband telecommunications. The estimated infrastructure cost of the recommended plan of $6.4 million made no allowance for base station site cost sharing between the public and commercial wireless networks. The close proximity of the public safety band—4.9 GHz—and the commercial WiFiA band—5.8 GHz—makes such base station cost sharing feasible and useful. Such cost sharing would further reduce the regional wireless plan infrastructure cost, and would allow for ready accomplishment of region-wide geographic coverage, an important objective of the regional telecommunications planning effort. Thus the recommended regional telecommunications plan has a unique advantage in being able to support both commercial and public sector broadband telecommunications in the Region.

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Chapter IX

PLAN IMPLEMENTATION

The recommended regional telecommunications plan described in Chapter VIII of this report provides a design for the attainment of the specific regional telecommunications objectives set forth in Chapter III of this report. In a practical sense, this recommended plan is not complete until the actions required to implement it, that is to convert the plan into action policies and programs that result in actual network deployments, are specified. This Chapter is, therefore, presented as a guide for use in the implementation of the recommended plan. This Chapter sets forth a recommended procedure for plan implementation, outlining the actions which must be taken by the various public and private agencies concerned if the recommended plan is to be fully carried out. Those public and private agencies which have plan adoption and plan implementation functions applicable to implementation of the recommended plan are identified; the necessary formal plan adoption or endorsement actions are specified; and specific implementation actions are recommended for each of the public and private agencies concerned.

Plan implementation as presented here extends beyond the physical and technical development of the telecommunication networks to the business and operational models required to effectively fund, market and operate the networks concerned. The business model addresses the economics of a telecommunication system in terms of the user charge rates required for economically viable operation, as well as the marketing activities needed to establish and operate the facilities and services envisioned in the plan. The operational model is concerned with network management and an associated network monitoring system necessary to supervise network operation. The plan implementation recommendations are based upon and related to the existing public and private agency programs functioning within the Region. Given the predominance of the private sector in telecommunication network development, a well-defined procedure for plan implementation becomes an important element of the plan itself.

The currently prevailing telecommunication systems development process within the United States, as established by Federal law, places the responsibility for system development generally within the private sector, that process being, however, regulated by Federal and State laws and regulations. Public Telecommunications service planning efforts such as that conducted by the Southeastern Wisconsin Regional Planning Commission are intended not to replace, but rather to supplement this competitive, market oriented process in the public interest. The adopted regional plan and its recommended implementation efforts are not intended in any way to impede the implementation of alternative plans prepared and put forth by private providers, or by communities or municipalities within the Region, that would move the existing level of service toward the attainment agreed upon objectives and standards. It is, however, hoped that the adopted plan would serve as a point of departure for further telecommunication planning by private providers and public agencies.

Because of the complex combination of public and private interests involved in the provision of telecommunication facilities and services within the Region, and because of the ever present possibility of unforeseen changes in economic conditions, in State and Federal legislation, in case law decisions, in governmental organization, and in public and private fiscal policies, it is not possible to declare, once and for all time, exactly how a process as complex as regional telecommunication plan implementation should be pursued. In the continuing planning process it will, therefore, be necessary to not only update periodically the recommended plan, and the data and forecasts on which the plan is based, but also the recommendations for implementation.

PLAN ADOPTION OR ENDORSEMENT

Public plan implementation measure must grow out of adopted plans. Because of the completely advisory role of the Commission, implementation of the recommended regional telecommunications plan will be entirely dependent upon action by the county and municipal units of government which constitute the Region, and by the private telecommunication facilities and service providers operating within the Region. If plan implementation is to proceed in an effective, coordinated way, adoption or endorsement of the plan by various potential implementing agencies is highly desirable.

Commission Plan Adoption and Certification

The Regional Planning Commission is empowered by State law to prepare and adopt a master plan for the physical development of the Region. It has no statutory plan implementation powers. Its powers are limited to, among others, publicizing plans; issuing reports; and providing—on request—planning assistance to county, municipal and special purpose units of government within the Region. For the recommended regional telecommunication plan to have official status, it must be adopted by the Regional Planning Commission itself, and such adoption constitutes the first action to be taken toward plan implementation. In accordance with the *Wisconsin Statutes*, the Commission—following such adoption—transmits certified copies of the resolution adopting the plan and the plan itself to the legislative bodies of the counties, local municipalities and special purpose units and agencies of government concerned. Such transmittal may also be made to concerned Federal and State agencies, including, in this case, the Wisconsin Public Service Commission.

County and Municipal Plan Endorsement

Endorsement, or formal acknowledgement of the transmitted resolution and plan by the county and municipal units and agencies of government, and by the State agencies concerned is desirable, and may in some cases be necessary, to assure a common understanding between the several levels of government concerned and to enable their staffs to program necessary implementation work. The plan endorsement actions should extend to special purpose agencies such as the Regional Telecommunications Commission, a cooperative agency serving a number of local municipalities within the greater Milwaukee area. It is important in this respect to understand that endorsement of the recommended telecommunications plan by any unit or agencies of government pertains only to the statutory statutes and functions of the adopting agency, and such endorsement itself cannot in any way preempt action by another unit or agency of government within its jurisdiction.

Private Service Provider Endorsement

Private wireless or wireline service providers do not typically have an explicit endorsement process for Commission-developed infrastructure plans. Instead, they may implicitly endorse the plan by their organizational decisions that deploy telecommunications networks consistent with the approved regional plan. Wireline service providers such as AT&T will deploy broadband networks such as their new FTTN network only in so far as they are consistent with independently developed corporate plans.

The role of private service providers in the newly planned wireless networks is significantly different. In the regional wireless plan, the county is the key governmental agency. Endorsement of the plan by a county will set the stage for plan implementation involving private service providers as described in the section below. Adoption of a community-based wireless plan by a local unit of government will, in a similar manner, open the way for private service providers to participate in plan implementation.

Plan endorsement by private service providers then takes two possible forms:

1. Explicit endorsement and implementation of the plan by a private service provider; or

2. Responding to requests for proposals by local government agencies for services consistent with the plan.

PLAN IMPLEMENTATION

Plan implementation as presented here will take notice of multiple broadband telecommunications networks either being deployed, or expected to be deployed, in the coming years:

1. The Regional Broadband Wireless Network
   - in the 4.9 GHz public safety frequency band
   - in the 5.8 GHz unlicensed commercial frequency band
   - implemented on a county-by-county basis
2. Community-Based Wireless Networks
   - in the 2.4 GHz unlicensed WiFi frequency band
   - implemented on a community-by-community basis
3. Fiber-to-the-Node (FTTN) Wireline Network
   - implemented in the Region by AT&T and perhaps other wireline carriers

The implementation procedures for the above three network plans differ considerably, but the implementation features of each will be described here. While the regional wireless plan is the primary plan for providing universal geographic coverage in the Region, the other two plan initiatives are proceeding forward and must be recognized as key elements in the regional comprehensive broadband telecommunications system.

County Level Public/Private Communications Network Plan Implementation – Regional Wireless Plan

The new 4.9 GHz public safety broadband communications network is an integral part of the regional wireless plan. A major advantage of the regional wireless plan is its public safety network component and the prospect of infrastructure cost sharing with a compatible commercial 5.8 GHz WiFiA broadband wireless network. Public safety communications can also be compatible with community-based wireless networks operating in a different frequency band. If the public safety and the commercial networks are to be jointly developed, however, a decision must be made early in the planning process to assure coordination of the planning and deployment of the two networks.

Since there is no regional government structure in Southeastern Wisconsin for telecommunication system plan implementation, such implementation must take place on a county-by-county basis. The seven county governments are, therefore, the key to regional wireless plan implementation. Plan implementation by individual counties, or groups of counties, would consist of the following sequence of steps:

1. Following endorsement of the recommended regional plan, an interested county government, or group of county governments, approve initiation of a 4.9 GHz/5.8 GHz wireless plan implementation project. That initiation approval would include a request to the Regional Planning Commission, or to a consultant, to prepare a more detailed, second level system plan, for the area designated in the request;

2. Review and approval of the preliminary second level system plan by the county or counties concerned. The preliminary system plan should provide for a joint 4.9/5.8 GHz public safety/commercial network that defines the system infrastructure, its estimated performance, and its capital and operating costs;

3. Conduct of field tests to verify or modify the preliminary second level plan as may be

found necessary. A randomized test location selection will provide for the necessary plan test at a reasonable cost. For public safety communications, testing with mobile vehicles as well as fixed locations will be required.

4. Review and approval of the revised second level system plan by the county or counties concerned; and approval of a budget for partial or full-scale deployment of the proposed broadband public safety network;

5. Issuance of a request for proposals to deploy the proposed infrastructure required for the 4.9 GHz public safety network in accordance with the approved plan; and selection of an infrastructure development vendor. Network infrastructure deployment must be supported by an equipment operation and maintenance training program for county law enforcement, fire, EMS and public works staff.

6. From this point in the implementation process, the commercial WiFiA network will follow a different path than the public safety network. In the public safety network, the county government is the owner and operator of the network. In a commercial network, the government typically plays a facilitator role. The next step in implementing the commercial element of the network would be the issuance of a request for proposals to deploy the required infrastructure in accordance with the approved plan.

   The deployment of this 5.8 GHz infrastructure would use common base stations with the public safety network, but would be an independent endeavor from the public safety wireless deployment. Substantial gains in efficiency may be expected from coordinating the two deployments.

   A firm commitment for county-wide deployment by the commercial service infrastructure contractor will be an important aspect of the regional wireless plan implementation. Restricting deployment to only areas with higher population densities would defeat a major objective of the plan.

   A major problem encountered by many communities interested in deploying broadband wireless networks has been finding a financially viable and stable means for operation and maintenance of the desired wireless networks. For a county-wide commercial component of a regional wireless network, this problem may be aggravated by the size and deployment cost of the network. For this reason, alternative means of financing and maintaining a commercial county-wide wireless network must be evaluated. One alternative, if no acceptable private infrastructure contractors can be found, involves the establishment of a special nonprofit economic development corporation to finance, deploy and maintain the wireless network infrastructure. The details related to the establishment of such a corporation are beyond the scope of this report. Detailed procedures for the launch of such an initiative are available based on similar organizations in other parts of the United States.

7. Issuance of a request for proposals to operate the system and selection of an Internet Service Provider (ISP) to operate the network.

   The proposals concerned should typically represent a simple procedure, since there are a significant number of internet service providers operating in the Region. If a separate organizational entity is available to deploy and maintain the commercial wireless network, a number of independent service providers should be well qualified to operate in a broadband wireless environment. A decision will be required by the county or counties concerned relating to whether one or multiple ISPs will be allowed to operate on the county network.

8. System operation

   There are at least two separate functions involved in system operation.

   a. Network management monitoring and maintenance (M^3); and

   b. Internet service provider operation (ISP)

   The network M^3 function involves maintaining the integrity of the network by monitoring network traffic and performing actions as required to detect and repair equipment failures and supply sufficient capacity to insure a specified quality of service. ISP operation includes providing web, e-mail and other services along with marketing, sales, help desk and back office functions for customer billing and collections.

Wireless Communications Systems Business Model

The ultimate economic viability of any business depends on the validity of its business model. The wireless communications service business is no exception. The business environment for municipal and rural broadband wireless networks is currently clouded by the difficult startup experiences of municipal WiFi mesh networks. These networks have been plagued by sub-standard performance, unreliability, and subsequent loss of subscriber interest. The performance issue is a critical competitive factor.

Market surveys indicate that wireless network performance must exceed current DSL and cable broadband services in order to attract user interest. Municipal wireless mesh networks now operating in many cities throughout the United States are generally struggling financially with high infrastructure costs and too few users. Unless new wireless services are able to offer superior performance, market interest lags. Municipal wireless mesh networks now are limited to throughput of from 1 to 2 megabits per second, with inconsistent network reliability. The sectoral cellular wireless networks that are integral to both the regional wireless and the community-based wireless networks offer significantly lower infrastructure costs and throughput performance in the 15 to 20 megabits per second range. WiFi mesh network deployment costs range from $100,000 to $250,000 per square mile, with full coverage closer to the latter figure[1]. By contrast, the infrastructure costs for community-based wireless networks employing the sectoral cellular network topology are currently costing about $2,500 per square mile in rural areas such as the Town of Wayne[2] and about $14,000 per square mile in urban areas such as the City of Waukesha[3]. These infrastructure costs cover all of the access point equipment, the network monitoring system, the Internet gateway connection and initial engineering support, but does not include the server computer equipment of the Internet Service Provider (ISP) which is not part of the network itself. Since there may be multiple ISPs on a given wireless network, these costs are not really part of the network infrastructure. These low infrastructure costs in conjunction with the enhanced throughput performance provide the foundation for a sound business model.

Community Level Network Plan Implementation

Plan implementation by individual municipalities or groups of municipalities would consist of the following sequence of steps:

1. Following adoption or endorsement of the recommended regional plan, the interested municipality, or group of municipalities, would request the Commission, or a consultant, to prepare a second level, more detailed plan for the area designated in the request;

2. Review and approval of the preliminary system plan by the municipalities comprising each service area concerned;

3. Conduct of field tests to verify or modify the preliminary plan as may be found necessary, a randomized test location selection will provide the necessary plan at a reasonable cost;

1 *Daggett, B. V. "Dollars and Sense on Muni Wireless"*, Government Finance Review, *February, 2007.*

2 *Broadband Wireless Field Test Report, Town of Wayne, Washington County, Wisconsin, SEWRPC, October 16, 2006.*

3 *Broadband WiFi Wireless Telecommunications Planning Proposal, City of Waukesha, Wisconsin, SEWRPC, October, 2006.*

4. Review and approval of the revised second level system plan by the municipalities concerned, and approval of a budget for partial, or full scale deployment of the proposed system;

5. Issuance of a request for proposals to deploy the proposed infrastructure in accordance with the approved plan; and selection of an infrastructure development vendor. Network infrastructure deployment must be supported by an equipment operation and maintenance training program for designated municipal staff;

6. Issuance of a request for proposals to operate the system, and selection of an Internet service provider to operate the system; and

7. System operation.

Plan preparation using radio propagation modeling and design optimization model tools would take place as previously described in Chapter VII, and would be initiated by the Commission or a consultant upon request of the community. Each community level wireless plan would then be presented to the appropriate local governing body and advisory committees to that body for review and approval. Upon approval, the community would submit a letter requesting the Commission or a consultant to move to step 3—field study verification of the community wireless plan.

Field study plan verification involves an extensive series of radio frequency signal intensity measurements using temporarily located access point equipment, equivalent to that planned for use in the network infrastructure. A truck-mounted antenna mast is employed for a series of temporary access point locations. For each temporary access point location, a signal-level coverage map is prepared based on a large number of radio frequency signal level measurements collected in a moving vehicle equipped with a WiFi-enabled laptop computer with a professional site survey software package. A variety of network performance measures will be recorded including signal level, noise level, throughput (packet speed), and packet retry and loss rates. In small networks with a few access points as in rural areas, all of the access points can be covered and performance verified. In larger networks, a randomly selected set of access points can be used to statistically verify network coverage and performance. The field survey will identify weak coverage or performance areas which may require additional or relocated access points to achieve network coverage and performance objectives.

Following the completion of the field survey studies, the adjusted plan is resubmitted to the community for final review and approval. Upon approval, the plan implementation process would move to the final five stages which involve various aspects of vendor selection and system startup. The manner in which these final stages are approached depends on the general business model selected. If private service providers are asked and respond to a formal request for proposal, then steps 5 through 8 would be accomplished as a continuous final single stage process. If an alternative government ownership model is chosen, then infrastructure deployment and ISP (Internet Service Provider) selection would be executed as a two-stage process.

Whether the private or public version of a business model is selected, this business model plan must detail the marketing, training, financial and general business aspects of the proposed network operation in order to generate confidence in the economic viability of the new venture in a competitive environment.

Operational management of the new wireless system would be based on a network management system that employs real-time network monitoring to measure network performance in order to provide information for rapid trouble-shooting of network outages, and early identification and correction of network bottlenecks or areas of weak signal coverage.

The end result of the community-based WiFi network plan implementation process would be an operating broadband wireless network system that achieves the agreed upon performance objectives and is able to grow and adapt to an expanding network clientele. A wireless communications network system can be well managed only through constant observation of its dynamic nature as it grows its user base and adapts to changing traffic patterns.

Private Service Provider Plan Implementation

In addition to implementation of the primary regional wireless plan and the supporting community-based wireless plan, other wireline and wireless service providers will be deploying advanced networks designed to enhance the broadband telecommunications capabilities of Southeastern Wisconsin.

In the wireline arena, AT&T is rapidly deploying its U-Verse Network (Project Lightspeed) in selected communities within the Region. A list of the communities within the Region with AT&T agreements governing the deployment could be obtained by inquiries to communities. Even such a list, however, would not necessarily accurately define the geographic coverage of the FTTN network since AT&T is under no obligation to serve all geographic areas of a given community. U-Verse is a downstream-oriented communications technology. The emphasis is on television service, particularly high definition and interactive video which requires significant downstream bandwidth capacity. Internet upstream data throughput is limited to 1 megabit per second, while downstream throughput is limited to 7 megabits per second. These parameters, originally covered extensively in Chapter VII, are repeated here only to provide a better understanding of the nature of the U-Verse market and its impact on overall regional plan implementation.

Given the performance parameters of U-Verse, there is no inherent conflict envisioned between the parallel deployment of AT&T's U-Verse network and the regional and community-based wireless networks. U-Verse's primary objective is to compete with the cable companies in providing a combination of television, telephone, and Internet data services. The primary objective of the regional wireless network is to provide fourth generation (4G) symmetric broadband Internet data services throughout the entire Southeastern Wisconsin Region. Voice communications services through the Internet (VoIP) will also be available if the demand emerges. A major subsidiary objective of the regional wireless network is a robust telecommunications network for public safety, a network capable of functioning in a major public emergency. Since the commercial element (5.8 GHz) of the regional wireless network will share a common base station layout, these same robust features could also be built into the regional 5.8 GHz network.

The implementation of community-based wireless networks has similar objectives as the regional plan, albeit at a more local level. The objectives of these community networks may vary greatly depending on the location and characteristics of the community. Rural townships within the Region such as Wayne in Washington County generally have no broadband services at all. For these communities, a community-based wireless network is practically the only opportunity to cross over the digital divide and achieve 4G-level broadband performance.

Suburban communities within the Region, such as Hartland, Thiensville or the North Shore suburbs, are in a different competitive situation. Broadband communications in the form of cable, telephone DSL or the new AT&T U-Verse networks are, or generally will be, available to all residents and businesses. Except for the new U-Verse network, broadband services from these providers is generally in the 1.5 to 2.5 megabits per second range. Upstream data rates are in the under 500 kilobits per seconds range (0.5 megabits per second). U-Verse, aside from television services, offers upgrades to 7 megabits per second downstream, and 1 megabit per second upstream. The driving force in these communities for advanced broadband communications will be from individuals and organizations whose needs are better satisfied by high speed symmetrical data and video transmission. An example of such an application is video conferencing. High quality video conferencing requires significant data transmission rates not satisfied by current cable, DSL or U-Verse offerings. Business conferencing and medical monitoring in home healthcare, are two examples of potential videoconferencing applications. Such applications along with data intensive small business firms may be expected to comprise the primary justification for the provision of 4G broadband and community based wireless in the coming years.

Cellular Wireless Service Providers

A major class of regional private service providers are the cellular wireless companies: AT&T, Verizon Wireless, Sprint/Nextel, U.S. Cellular and T-Mobile. All five service providers have extensive wireless networks in the Region. Only one of these five, Sprint/Nextel, has committed publicly to a 4G-level technology, WiMAX, for planned deployment in the United States, although not yet in the seven-county region. Some other service providers and communications equipment manufacturers are supporting another evolving technology called Long-Term Evolution (LTE). LTE represents an attempt by the manufacturers and wireless service providers to regain the initiative for proprietary wireless communications technologies. Having lost the performance initiative to IEEE Standard Technologies such as WiFi and WiMAX, LTE tries to find a future broadband role for the current proprietary

GSM/UMTS and CDMA technologies. LTE Standards are scheduled to be finalized by the end of 2007. First commercial applications are scheduled to take place in late 2009 or early 2010. Throughput performance exceeding 100 megabits per second is promised. The infrastructure costs of LTE proprietary technologies may be expected to exceed significantly those of IEEE standards. Whether such higher cost technologies can compete with technologies based upon IEEE Standards is still to be demonstrated.

The future of WiMAX as a broadband mobile wireless technology is still uncertain. Originally conceived as an IEEE standards replacement technology for WiFi, WiMAX has currently emphasized use by the private wireless service providers. All of the early releases of WiMAX (802.16e) are in the licensed frequency bands such as 2.5 GHz and 3.5 GHz. These bands are available only to major wireless service providers. At the same time, the early releases of WiMAX seem compromised in throughput performance. Early range targets of 30 to 40 miles have been replaced with 0.5 to 1.0 mile maxima. At these ranges, the WiMAX mobile wireless plan is not competitive and the only alternative for mobile broadband wireless in the Region, at least in the near future, is advanced Mobile WiFi.

SUMMARY

Plan implementation strategies and procedures are outlined in this chapter for both private service providers and public agencies. Public agencies must first approve the plan in a formal plan endorsement process. The regional wireless plan would require endorsement by each of the seven counties prior to implementation in the respective county areas. Community-based wireless plans would require endorsement by the individual local units of government.

Recommended plan implementation strategies and procedures are detailed in this chapter for the regional wireless plan and the Community-based wireless plan. Potential plan implementation strategies and procedures for private service providers in the Region are reviewed and explained.

Regional Wireless Plan implementation at the county level first requires approval of a project that will initiate a planning, field testing and eventual deployment of a broadband public safety network within the county. The initial phases of the project involve network plan preparation and field testing to verify the plan. After the verified plan is approved, the county must provide budget authorization for the deployment of the 4.9 GHz public safety communications portion of the county-based regional wireless plan. Deployment of the public safety network can then move forward in a county-wide application.

Implementing the commercial wireless portion of the Regional Wireless Plan follows a similar path to the public safety network in the early planning and testing phases, but the path of implementation changes in final system deployment. It must be reemphasized here that a central strength of the Regional Wireless Plan is this public-private partnership. This partnership not only supports a major advancement in public safety communications, but it also improves the business model for service to low population density geographic areas throughout the Region that otherwise would go unserved. In light of the recent adverse publicity relating to the viability of WiFi business model, this cost sharing partnership feature is a strong reason for the universal endorsement of the regional wireless plan. Universal geographic coverage has been ranked as second only to performance as a primary objective of this regional telecommunication planning process. A serious effort to accomplish this objective requires implementation of the regional wireless plan.

Implementation of community-based wireless plans face more complex issues. Deployment in rural towns will differ greatly from deployment in urban and suburban areas of the Region. Rural towns currently have little or no broadband telecommunications services and may be expected to be eager to cooperate with any broadband service that can close the digital divide. Urban and suburban areas already have competing cable and telephone line-based broadband communications services. Implementation in such areas will require a more competitive business model with emphasis on service differentiation. Successful community-based wireless networks will require marketing emphasis on performance features that distinguish them from cable or DSL broadband services. Successful community-based wireless networks will also require the selection of a financially-sound and technically capable service provider. Recent experience indicates a shortage of such organizations, and it may be necessary to divide the responsibility between two organizations – one to finance, deploy and maintain the network infrastructure, and a second, the Internet Service Provider, to operate the system as a business.

Finally, private service providers such as AT&T and the wireless service providers have their own implementation plans. To the extent that these plans improve broadband telecommunications in the Region, they are supportive of regional telecommunications plan objectives. Unfortunately, none of these private plans, wireline or wireless, announced to date, meets all of the objectives set forth in Chapter III of this report. AT&T's U-Verse network complies with downstream throughput objectives, but only for television services, not for general Internet usage. Its upstream throughput performance and geographic coverage are far below established 4G standards.

Neither the wireline cable service provider nor the cellular wireless carriers have released any 4G level plans as of this writing.

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Chapter X

SUMMARY

This planning report documents the findings and recommendations of the planning process conducted by the Southeastern Wisconsin Regional Planning Commission to develop a comprehensive telecommunications system plan for the seven-county Southeastern Wisconsin Region. The planning process concerned was initiated in August 2004. The wireless telecommunications element of the planning process was completed in May 2006, and the findings and recommendations are set forth in SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin*. The plan presented in this report integrates wireless and wireline communications technologies into a comprehensive regional plan for a telecommunications network. The findings and recommendations are presented in the nine chapters which together with this summary comprise the report.

The planning program was directed by a Telecommunications Planning Advisory Committee. This Committee was created by the Commission to assist in the preparation of a regional telecommunications plan for the seven-county Southeastern Wisconsin Region. The Committee was comprised of 21 members chosen by the Commission on the basis of their knowledge and experience in telecommunications and in comprehensive planning. The membership of the Committee is listed on the inside front cover of this report. The Committee met 21 times during the course of the planning effort, to review, revise as found to be necessary, and approve the draft chapters of this report. Minutes of the Committee deliberations are on file in the Commission offices.

Chapter I presents background information about the Regional Planning Commission, the regional planning concept in Southeastern Wisconsin, and about the seven-county planning Region; including basic information on the size, resident population, employment, real property valuation, and governmental structure of the Region. The Chapter also contains a brief description of the work programs undertaken by the Commission from its creation in 1960 through 2004. Importantly, the Chapter describes the importance of telecommunications to the continued sound social and economic development of the Region, and the need for regional telecommunications planning. The Chapter notes that the regional telecommunications planning effort was being conducted in accordance with a Prospectus adopted by the Commission in December 2003. This Prospectus envisioned the regional telecommunications plan to be comprised of two principal elements: a broadband wireless communications plan, and a comprehensive telecommunications network plan that considered both wireless and wireline technologies.

Chapter II sets forth the basic principles and concepts underlying the regional telecommunications planning process; describes that process; and, importantly, describes the technologies involved, including wireless and wireline networks.

Chapter III sets forth a set of eight objectives that should be met by the regional telecommunications system, together with their supporting principles and standards. These objectives relate to system performance, as measured by data transmission rate, availability, quality of voice transmission, error rate, and packet loss; universality of service; redundancy; antenna site number optimization; application to be served; cost minimization; antenna site aesthetics and safety; and use in public safety emergencies. The objectives and supporting quantitative standards were intended to be used in plan design and evaluation of alternative plans and the selection of a recommended plan.

Chapter IV presents inventory findings relating to pertinent background conditions within the Region including information on the demographic and economic base, land use pattern, and supporting transportation facilities and services.

Chapter V presents the geographic coverage areas and broadband communications service offerings of wireline and wireless service providers in the Region. The dominant broadband service providers are the incumbent telephone service providers, AT&T, Century Tel and Verizon North, along with the cable companies, Time Warner Cable and Charter Communications. The inventories conducted under the planning program indicate that none of these service providers currently provide the fourth generation (4G) level of performance called for in the objectives and standards specified in Chapter III of this report. None of the existing wireline or wireless services also offer the universal regional geographic coverage recommended in the Commission's fourth generation (4G) standards. AT&T's current deployment of Project Lightspeed will offer download throughput speeds at 4G standards, but upload transmissions of 1 megabit per second will be below 4G specifications. This new fiber-to-the-node network deployment also will not provide universal geographic coverage within the Region.

Chapter VI documents the current performance of existing broadband wireline and wireless communications technologies based on data collected at the national, state and regional levels. Telephone line-based DSL and hybrid fiber-coax cable broadband services are emphasized since these technologies and companies control about 98 percent of the broadband services communications services market. Throughput performance for both DSL and cable services is in the 1 to 3 megabits per second range, below the specified 4G standards. Upload speeds are well below 500 kilobits per second for both DSL and cable as well as for most broadband wireless services. In addition to national and state-level aggregate performance information, performance ratings are also graphically presented for both major and smaller wireline and wireless carriers.

Chapter VII describes the alternative broadband wireless and wireline communications technologies and regional plans for Southeastern Wisconsin. Technology reviews emphasize broadband wireline fiber optic technologies since wireless technologies were extensively covered in SEWRPC Planning Report No. 51. Particular interest was directed to Fiber-to-the-Node (FTTN) and Fiber-to the-Premises (FTTP) technologies. FTTN technology involves the deployment of fiber optic links to remote locations that then connect with subscribes through existing copper wiring. Each node is able to serve users within a radius of 3,000 feet with high speed video and data services. Download throughput, however, is emphasized, with rates up to 25 megabits per second. Upstream transmission in contrast is limited to 1 megabit per second. Fiber-to-the-Premises technology represents the greatest throughput potential even though the particular passive form now being deployed has serious limitations compared to the active form which is significantly more expensive both initially and in operating costs.

One new wireless technology, mobile WiMAX, which was not considered in SEWRPC Planning Report No. 51, is considered in this report. Mobile WiMAX – as defined by IEEE Standard 802.16e – is the mobile cellular version of WiMAX in which the user employs a WiMAX cellphone. The technology, unlike fixed WiMAX and WiFi, is restricted to large service providers who have purchased licensed spectrum from the Federal FCC. It is a technology with great potential to comply with the plan objectives set forth herein, but in its initially released form it requires an excessively large number of base stations and is not cost effective for universal geographic coverage in the Region.

The majority of Chapter VII is devoted to descriptions of four alternative primary, and two alternative adjunct, regional broadband communications plans. These alternative primary plans included: 1. A Community-Based Wireless Plan; 2. Regional Wireless Plan; 3. Fiber-to-the-Node Wireline Plan; and 4. Fiber-to-the Premises Wireline Plan.

The two alternative adjunct plans provided for mobile cellphone wireless communications in support of the primary plans that emphasized fixed users. The two adjunct plans included: 1. Mobile WiMAX-Based Wireless Plan, and 2. Mobile WiFi-based Wireless Plan.

All of the primary and adjunct plans were presented in terms of their technical characteristics, geographic coverage, cost and other features to provide the basis for quantitative evaluation and plan selection in Chapter VIII. The only alternative plan which meets the objective of full regional geographic coverage is the regional wireless plan. Geographic coverage of the other plans depends upon the individual decisions of either private service providers or local government officials. The regional wireless plan also provides the lowest infrastructure cost even without considering the cost sharing benefits of common base station sites with public safety communications networks. The regional wireless plan includes explicit provisions for public safety communications in the 4.9 GHz band which may be expected to become the preferred system in broadband wireless public safety communications.

All of the four primary alternative plans, two wireline and two wireless, comply with the basic throughput standard of 20 megabits per second, but the fiber-to-the-premises (FTTP) offers potentially higher performance in future years extending up into the gigabits per second range. The Fiber-to-the Node Plan alternative currently being deployed by AT&T in the Region in Project Lightspeed has more limited throughput performance growth potential based on the bandwidth limitations of the final copper link connection. New developments in wireless communications such as multiple input - multiple output (MIMO) are standardized in the IEEE standard 802.11n which deals with advanced multiple antenna WiFi. Table 20 in Chapter VII provides an abbreviated but comprehensive summary of the four alternative primary and two alternative adjunct plans considered.

The adjunct plans relate to mobile wireless communications. Mobile cellular networks in the United States have developed as semi-independent entities serving mobile users primarily in voice communications. Data services were initiated in second generation (2G) networks and enhanced for faster data transmission recently in 3G networks. The primary focus of this planning effort was higher throughput networks providing the same performance as fixed user networks. Such improved performance is important since mobile wireless networks have become the primary means of communication for a growing part of the regional population. Many users, particularly younger users, communicate exclusively by mobile and have no fixed service in their place of residence.

The first released versions of WiMAX have limited range as mobile networks and are costlier than their WiFi counterparts which can operate as auxiliary networks to the regional wireless and community-based wireless networks. The lower costs of WiFi equipment and its ability to operate jointly with fixed wireless networks contributed to its choice for the broadband mobile wireless plan.

Chapter VIII documents the plan evaluation and selection process involved in selecting a final regional comprehensive broadband telecommunications plan. The rank-based expected value method is presented as the basis for plan evaluation and selection. The method involves a priority ranking first of the applicable objectives and standards followed by a ranking of each plan under each standard. These dual rankings are then used to determine the value of each plan. The plan value combined with the probability of plan implementation determine the expected values of the various plans. The plan with the highest expected value is then selected as the preferred plan. The primary alternative plans received rank-based expected values as follows:

1. Regional Wireless Plan – V = 39.0
2. FTTN Wireline Plan – V= 39.2
3. Community-Based Wireless Plan – V = 31.2
4. FTTP Wireline Plan – V = 12.6

The rank-based expected value method produces a virtual tie between the Regional Wireless Plan and the FTTN Wireline Plan, but the Regional Wireless Plan was selected as the preferred plan based on public-private cost sharing of the regional wireless plan and its commitment to provide universal geographic coverage in the Region.

The adjunct mobile wireless plans received expected value scores of:

1. WiMAX Mobile Wireless Plan – V = 8.1
2. WiFi Mobile Wireless Plan – V = 21.6

Based on the evaluation scores, the regional wireless plan and the WiFi mobile wireless plan were selected as the recommended regional comprehensive broadband telecommunications plan for Southeastern Wisconsin.

Chapter IX sets forth an approach to the implementation of the regional wireless plan and its associated WiFi mobile wireless plan together with provision for other broadband wireline and wireless networks already being deployed in the Region. Telecommunications plans involving public agencies, particularly those including public safety communications networks, require a formal adoption process. Deployment of the regional wireless plan will require regional plan endorsement and subsequent implementation at the County-level of government. Community-based wireless plans are adopted and implemented by municipal units of government.

A central feature of the selected regional wireless plan is the potential for cooperative effort by the public and private sectors in which the infrastructure costs are shared between the public safety and commercial networks. The public safety telecommunications networks are envisioned to be implemented at the county or multi-county level, providing an opportunity for cooperation between the counties and private sector providers.

Community-based wireless networks are implemented on a community-by-community basis with significant differences depending on the location and nature of the community. Low density rural communities such as towns are generally easier to serve than urbanized communities due to their pressing need for broadband communications services. Urbanized communities usually have broadband communications in the form of hybrid fiber-coax cable and telephone-network based DSL. Such communities must be persuaded of the advantages of new higher speed networks in comparison with existing broadband networks.

The only declared 4G-level private service provider initiative in Southeastern Wisconsin is AT&T’s Project Lightspeed also called U-Verse. Its primary target however, is the television entertainment market rather than regional economic development as evidenced by the majority of bandwidth being devoted to broadcast television. Neither downstream (7 megabits per second) nor upstream (1 megabit per second) data rates comply with the 4G objectives and standards established in Chapter III of this planning document.

Neither of the regional two cable service companies nor the five mobile wireless cellular service providers have announced any fourth generation broadband communications initiatives at the time this planning report was completed.

Appendix A

ENVIRONMENTAL IMPACT ASSESSMENT OF THE REGIONAL BROADBAND WIRELESS SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN

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Introduction

It has been the long-standing policy of the Southeastern Wisconsin Regional Planning Commission to perform an environmental assessment of its recommended plans, and to include the findings of such assessments in the planning reports which set forth the Commission recommended plans. Accordingly, this Appendix sets forth the findings of an environmental assessment of the Commission's recommended wireless telecommunications plan for Southeastern Wisconsin.

The environmental assessment focuses on the potential effects on human health of radio frequency transmissions, considering to the extent possible given the current state of the art of both the thermal and athermal effect of such transmissions. The assessment does not concern itself with the potential impacts of the location of transmitting and receiving structures on surrounding land uses and on property values. Such impacts are highly site specific and can only be properly considered in the preliminary engineering stage of plan implementation when specific station locations together with their surrounding environments have been identified.

Background Information

Wireless communications systems are usually based on transfers of radio frequency electromagnetic energy between users with antenna base stations or network access points as intermediaries. Some wireless networks such as amateur radio and citizen band radio also allow for direct communications between users without the need for base station or access point intermediaries. The radio frequency signals used in these wireless networks are typically of low power, with transmitting powers ranging from about 100 milliwatts to as high as 1,000 watts. To put these power levels in perspective, most commercial AM radio broadcasting stations transmit at power levels of 50,000 watts. The Voice of America broadcasts at power levels of 500 kilowatts, with directional power levels as high as 100 megawatts. The typical cellular wireless network base station transmits at about 150 watts, far below the levels of radio and television broadcasting stations, and also far below the levels of shortwave radio broadcasting stations and many amateur radio stations.

Whatever the power level, the function of wireless radiowave communications is to convey information, not to transfer power or energy. Whether the media is voice, data, or video, radio frequency signal performance is based on the transfer rate of information and not the watts of power. To transfer information, however, an adequate level of radio frequency power is required, the power required depending on the frequency of the signal transmitted, the distance, the nature of the propagation path traversed, and the sensitivity of the receiver processing these signals. Although the primary function in telecommunications is information transfer, various levels of radio frequency power may have secondary effects. These secondary effects may affect the health of persons in the path of radio frequency radiation. The purpose of this assessment is to evaluate the potential health effects of radio frequency radiation created by wireless telecommunications networks particularly those existing and proposed networks comprising a part of the broadband wireless telecommunications system plan for Southeastern Wisconsin.

The two types of radio frequency health effects to be examined are thermal effects and athermal effects. The thermal effects of radio frequency energy on the human body are fairly well understood, and maximum permissible exposure limits as a function of frequency are specified by the Federal Communications Commission (FCC). Wireless telecommunications networks are prohibited by law from violating these exposure limits in their network operations. Athermal effects, in contrast, are not well understood, and are currently very controversial with conflicting results from controlled laboratory and epidemiological studies.

The findings of this assessment of potential environmental impacts indicate that the FCC maximum permissible exposure limits for radio frequency thermal exposure are not being violated by cellular/PCS or other wireless systems currently deployed within the Region. The Commission planned broadband WiFi/WiMAX based systems with their very low transmitting power are even farther below these thermal exposure limits, and pose no thermal health hazards for citizens of Southeastern Wisconsin.

Athermal effects present a more ambiguous picture with conflicting results in different controlled studies. A recent major study sponsored by the European Union (EU 2004), which aggregated the results of many RF-EMF (radio frequency electromagnetic fields) studies, did indicate that there were valid concerns about athermal effects on human DNA strands and various body tissues at lower than published FCC thermal effect exposure levels. These studies, all based on *in vitro* laboratory investigations, however, were not directly related to human health effects; and, therefore, were not considered conclusive with respect to use in establishing new maximum permissible exposure (MPE) limits for athermal radio frequency radiation.

Given the uncertainty of radio frequency radiation athermal health effects, prudence would require that a low power telecommunications approach be used in the preparation of Commission broadband wireless communications plans. Radio frequency radiation effects, whether thermal or athermal, are a function of radio frequency power density. Low power telecommunications facilities may be defined as facilities with transmitting powers limited to a maximum power of 5 watts. Use of such relatively low power requires significantly increased receiver sensitivities to compensate for reduced transmitting power. Such enhanced receiver sensitivities, are well within the current state of telecommunications technologies. Use of low power transmitters not only reduces the risks of radio frequency exposure, but also provides an improved radio frequency environment. Radio frequency interference (RFI) has become one of the major obstacles to wireless telecommunications, and universal adaptation of low power standards would do much to alleviate this obstacle. Environmentally, low power transmission also allows for the use of solar panels on access points, taking wireless off the electric power grid for more reliable and environmentally-friendly telecommunications.

Radio Frequency Radiation

Radio frequency (RF) radiation, for the purposes of this study is defined as radiation in the spectral range of 50 MHz to 18 GHz. Such a frequency range encompasses all known current commercial and public wireless communications networks. Most existing and planned commercial and public wireless networks are, and may be expected to remain in the 800 MHz to 6 GHz range. The only major exceptions are satellite broadband transmissions which operate in the 12 to 18 GHz band. Some public safety telecommunications networks still operate in the 50 or 150 MHz bands.

Radio frequency radiation is classified as a non-ionizing form of radiation in contrast with x-rays, gamma rays, and even some ultra-violet fields which are designated as ionizing radiation. Ionizing radiators have enough energy to dislodge electrons from their atoms. When this happens, positive and negative ions are formed with well-documented potential damage to human health. At sufficiently high power densities, however, radio frequency radiation can pose health hazards. Experience since the early days of radio has shown that radio frequency energy can cause injury by heating body tissue. Radio frequency burns can be extremely painful, but even lower level tissue heating can be damaging to internal body organs. Radio frequency induced heating of the eye can result in cataracts or even cause blindness. These heat-related hazards of radio frequency radiation are called thermal effects.

Extensive research has also been conducted on changes in physiological function in the presence of radio frequency energy that is too low to cause heating. These athermal effects are more subtle than thermal heating and involve changes in function at the cellular level that may produce breakages in DNA strands. The conflicting results of laboratory studies relating to this concern make it difficult to establish exposure guidelines. The alternative approach is to adopt a policy requiring low power telecommunications.

Thermal Effects of Radio Frequency Energy

Body tissues exposed to very high levels of radio frequency energy may suffer serious heat damage.[1] These effects depend upon the frequency of the energy, and the power density of the radio frequency field striking the body, together with other factors such as the polarization of the radio wave.

Radio frequency energy is absorbed more efficiently at frequencies near the body's natural frequency which is about 35 MHz for a grounded person, and 70 MHz for a person insulated from ground. Various parts of the body have different resonant frequencies such as the adult head of about 400 MHz and the infant head of about 700 MHz. As the frequency moves away from body resonance, less radio frequency heating is experienced. The specific absorption rate, (SAR) defines the rate at which radio frequency energy is absorbed in tissue.

[1] *Hare E.* Radio Frequency Exposure and You, *American Radio Relay League, 2003-Chapter 3.*

Based on power density levels specified by the IEEE/FCC in the latest releases, there is no evidence to support a conclusion that existing or planned wireless base stations, or access points, exceed the thermal radio frequency exposure limits. On October 3, 2005, the Standards board of the IEEE Standards Association approved a new "Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz"[2,3] The maximum permissible exposure standard for the frequency range of interest is between 2 watts per square meter and 10 watts per square meter in the band from 400 to 2000 MHz, and 10 watts per square meter for frequencies above 2000 MHz.

Three particular frequencies of interest related to existing cellular/PCS or planned WiFi/WiMAX networks are:

Cellular – 800 to 900 MHz
PCS – 1900 MHz
WiFi/WiMAX – 2.4 to 5.8 GHz

The maximum permissible exposure (MPE) for these three frequency bands are:

800-900 MHz: 4.0 to 4.5 W/m^2
1900 MHz: 9.5 W/m^2
2.4 to 5.8 GHz: 10.0 W/m^2

The above MPEs are all for so-called "uncontrolled environments" in which the people involved are unaware of radio frequency radiation. Such limits generally are about 20 percent of the limits for controlled environments where technical personnel are aware of radio frequency radiation.

[2] *Lin, James,* A New Standards for Safety Levels with Respect to Human Exposure to Radio Frequency Radiation *IEEE Antennas and Propagation Magazine, 48, 1, February 2006.*

[3] *IEEE International Committee on Electromagnetic Safety (SCC39), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE Std C95.1TM-2005 (Revision of IEEE Std C95.1-1991).*

The formula for radio frequency power flux density in free space is:

$$S = p_t/4\pi r^2$$

Where
S – power flux density – watts per square meter
p_t – transmit power – kilowatts
r – distance – kilometers

Using logarithmic ratios and practical units:

$$S = -41 + P_t - 20 \log d$$

Where
S – power flux density in dBW – decibels relative to watt per square meter
P_t –power dBKW decibels relative to 1 kilowatt
d – distance – kilometers

The above formula represents radio propagation in free space. In terrestrial application, the presence of natural foliage and structural interferences will attenuate the radio signal below free space levels. Therefore, free space presents a worst case scenario.

Based on the above formula, a typical 100 watt cellular transmitter in the 800 MHz frequency band produces a power density of 0.00079 watts per square meter at 100 meters from the site and 0.079 watts per square meter at 10 meters from the site. The largest regional cellular transmitter radiating at 1,000 watts would result in 0.0079 watts per square meter at 100 meters, and 0.79 watts per square meter at 10 meters from the site. A low power—4 watt—WiFi transmitter creates power densities of only 0.0003 watts per square meter at 100 meters from an access point and 0.003 watts per square meter at 10 meters from the access point.

From the above, it is apparent that none of the three classes of wireless radio frequency radiation violate the latest IEEE/FCC MPE limits. These limits are based upon thermal effects testing involving heating tissue with radiation of 2 watts per kilogram of body weight. Although none of the above examples violate the latest IEEE/FCC MPE restrictions; the 1,000 watt transmitter at 800 MHz does approach the limit—0.79 watts per square meter versus 4.00 watts per square meter—and the question of cumulative effects arises. The averaging time used to determine the above MPE standards is 30 minutes; the radio frequency temperature effects on human tissue and organs having been studied during 30 minute periods. Varying levels of radio frequency radiation were evaluated, and the level of radio frequency radiation that produced sustained temperature rise in human tissue was established. MPE limits were then set at 2 percent of these thresholds, providing a safety factor of 50 to one for uncontrolled environments. The MPE for controlled environments was set five times higher at 10 percent of the sustained temperature threshold.

The official IEEE/FCC position on cumulative effects is that such effects do not exist below the MPE limits. Restated, if the radio frequency radiation level is below the MPE limit for the frequency of interest, the exposure time whether continuous or intermittent is irrelevant. The rationale for this stated position is clear. If the radio frequency radiation level does not produce sustained heating of human tissue, then exposure time does not matter.

In summary, investigation of the potential thermal effects of radio frequency radiation on human health from wireless communications systems in Southeastern Wisconsin indicates that all current and planned systems should be operating within the latest IEEE/FCC standards. Since the investigation was based entirely on theoretical radio propagation in free space, it is important to confirm this analysis with propagation modeling and some field measurements.

Radio Propagation Modeling

Radio propagation modeling estimates radio frequency radiation levels in a given terrestrial environment. Such radiation levels will be lower in value than those estimated by the free space propagation power density formulas because of signal attenuation from buildings and terrestrial vegetation. To determine the effects of terrestrial attenuation on radio frequency radiation exposure, a series of radio propagation modeling plots were prepared for both cellular (800-900 MegaHertz) and WiFi/WiMAX (2400 MHz) frequency bands. Because available modeling software produced results only in terms of field strength, it was first necessary to convert the IEEE/FCC standard into field strengths limits. To utilize the standard FCC formula for field strength conversion set forth in FCC DET Bulletin 65, Edition 97-01, it is necessary to convert from watts per square meter to milliwatt per square centimeter.

By dimensional analysis:

10 watts per square meter = one milliwatt per square centimeter

The conversion formula in FCC Bulletin 65 states:

$E^2 = 3770S$

where E = electric field strength in volts per meter

and S = power density of one milliwatt per square centimeter

Solving

E = 61.4 volts per meter

$E = 61.4 \times 10^6$ microvolts per meter

$= 20 \log_{10} 61.4 \times 10^6$

= 155.8 decibels microvolts per meter (dB µV/m)

The lower two watts per square meter standard for the 800 MHz band is[4]

E = 27.4 volts per meter

= 148.7 dB µV/m

Observing the two radio propagation plots shown on Maps A-1 and A-2, the highest field strength category for a 100 watt, 891 MHz site is represented by the yellow colored area, representing a field strength of only one volt per meter, well below the 27.4 volts per meter standard. The highest field strength level predominant near the base station is indicated by the brown colored area which represents about 0.1 volt per meter–again well below the MPE standard.

In Map A-2, for a 4 watt WiFi access point, the highest field strength level is indicated by the purple colored area representing 75 dB µV/m which is three orders of magnitude below a field strength of about 0.001 to 0.002 volt per meter.

From the above field strength plots shown in Maps A-1 and A-2, it is clear that both the existing cellular/PCS base stations should operate well within the IEEE/FCC MPE standards. Future WiFi/WiMAX networks may be expected to be at least three orders of magnitude below these same standards.

[4] *Barclay, Les,* Propagation of Radio Waves, *The Institution of Electrical Engineers, United Kingdom, 2003.*

The field strength plots shown on Maps A-1 and A-2 are based upon one transceiver-antenna unit mounted on a station structure. For multiple unit installations the radiation output will be a multiple of the transceiver-antenna units. The maximum number of co-located antennas in the Region was five. Even the power radiated by this collection of antennas would still be a very small percentage of the standard for the worst case in the 800 MHz band.

Field Testing
Thermal radiation effects based on free space formulas and radio propagation modeling were supplemented by field measurements taken with a Spectran HF spectrum analyzer instrument manufactured by Aaronica AG of Germany. Measurements were made of both a 55 watt, 1,932 MHz base station (Sprint) and a 4 watt, 2.4 GHz access point. The following power density and field strength levels were recorded.

1. 1,932 MHz base station at a distance of 300 feet from the base of the antenna tower
   S = 120.14 microwatts per square meter
   E = 0.213 volt per meter

2. 2.4 GHz access point at a distance of 300 feet from the base of the utility pole.
   S = 51.4 microwatts per square meter
   E =0.139 volts per meter

A comparison of the RF radiation standards compliance for thermal effect is summarized in Table A-1. It is apparent from the table that whether radio propagation formulas or field measurements are applied that both cellular/PCS and WiFi/ WiMAX networks are well below FCC/IEEE exposure standards.

Athermal Effects
Athermal effects of radio frequency radiation are caused by low-level energy fields insufficient to cause either ionization or heating effects. Research investigations in this area relating to possible health effects of radio frequency radiation exposure has been of two types: epidemiological research and laboratory research. Epidemiologists observe health patterns of large groups of people using statistical methods. These studies look for associations between environmental factors and an observed pattern of illness. Some epidemiological studies have shown an exposure to radio frequency radiation to be associated with malignancies such as leukemia and brain cancer. A large number of equally well designed and performed studies have shown no such association.

Laboratory studies of radio frequency radiation have a similar history. Some studies have indicated the ability of low levels of radio frequency radiation to alter the human body's circular rhythms and weaken the immune system. Attempts to replicate these studies have also had mixed results.

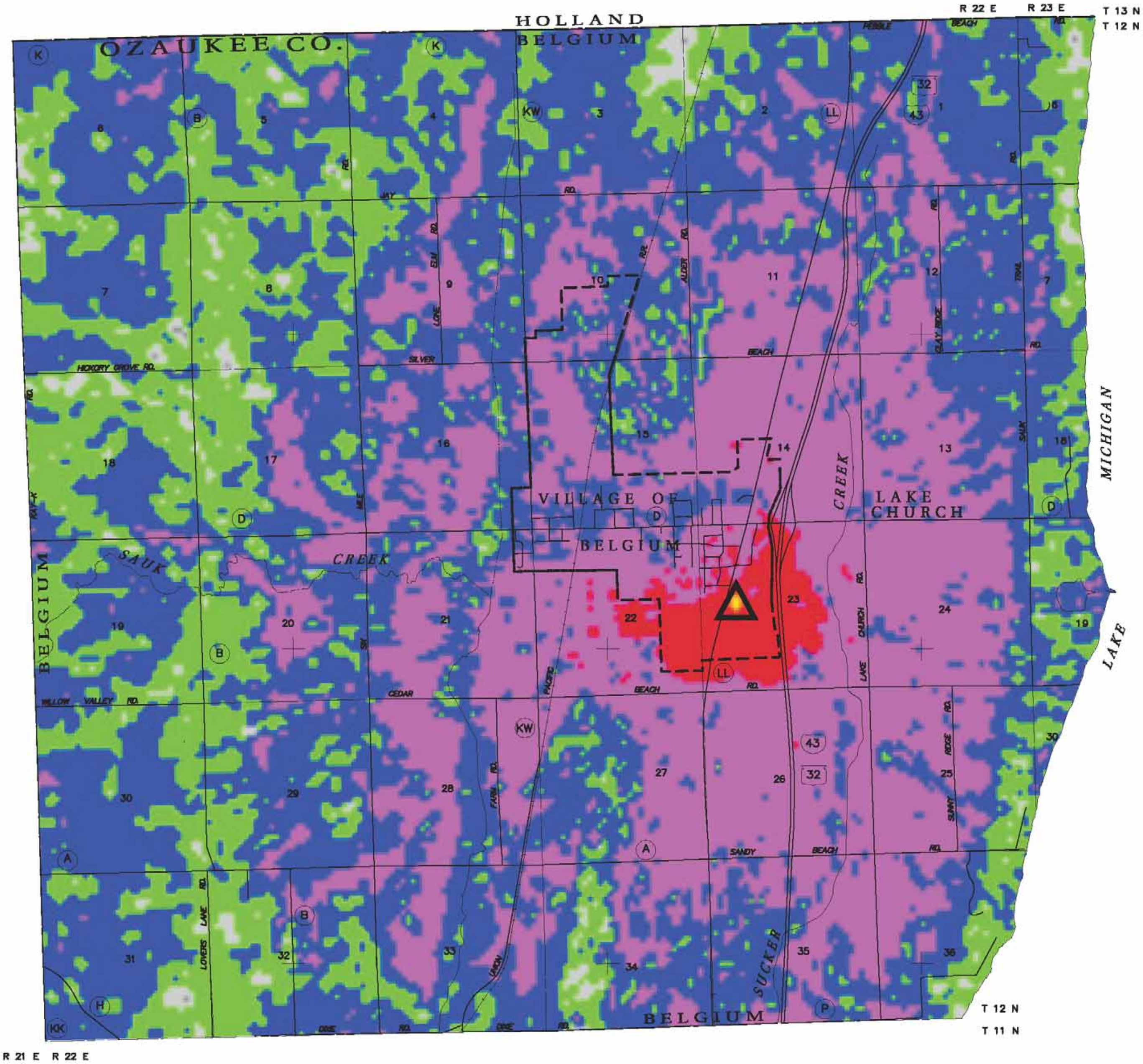
The overall conclusion at this time regarding athermal effects of radio frequency radiation must be that adverse health effects have not been demonstrated sufficiently to establish maximum permissible exposure (MPE) limits lower than those specified for thermal affects. One factor, however, is certain lower power communication is beneficial for all effects of radio frequency radiation. For this reason, the Commission's planning efforts have continually emphasized low power transmission supported by high sensitivity reception as the key to minimizing the environmental impact of wireless communications.

Other Environmental Impacts
This review of the environmental effects of radio frequency radiation has concentrated exclusively on human health impacts. There are however, two other environmental consequences of radio frequency radiation that should be noted.

A major consequence of the growth of cellular wireless communications and the proliferation of cell phone users and WiFi "hot spot" locations has been radio frequency interference. The 2.4 GHz unlicensed frequency band used in WiFi networks is also used by microwave ovens and many cordless phones. WiFi systems operate in unlicensed bands which are open to all users, so that interference becomes a major issue. Private cellular networks typically employ licensed frequency bands that are exclusive for the licensed operator. These systems, because they operate at higher transmit power levels, can also be a source of interference to other frequency bands based on the harmonic signals they generate. Harmonics are integer multiples of the base frequency that are generated and transmitted along with the base frequency. For example, an 800 MHz transmitter could generate harmonics at 1600 MHz and 2400 MHz. The second harmonic at 2400

Map A-1

FIELD STRENGTH OF SIGNAL AT REMOTE ANTENNA USING EXISTING FREQUENCY OF 891 Mhz AND 100 WATTS OF POWER IN THE VILLAGE OF BELGIUM AND THE TOWN OF BELGIUM



LEGEND

EXISTING ANTENNA

GREATER THAN 120 dBuV/m

105 dBuV/m TO 120 dBuV/m

90 dBuV/m TO 105 dBuV/m

75 dBuV/m TO 90 dBuV/m

60 dBuV/m TO 75 dBuV/m

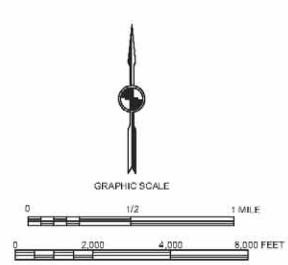
45 dBuV/m TO 60 dBuV/m

30 dBuV/m TO 45 dBuV/m

15 dBuV/m TO 30 dBuV/m

0 dBuV/m TO 15 dBuV/m

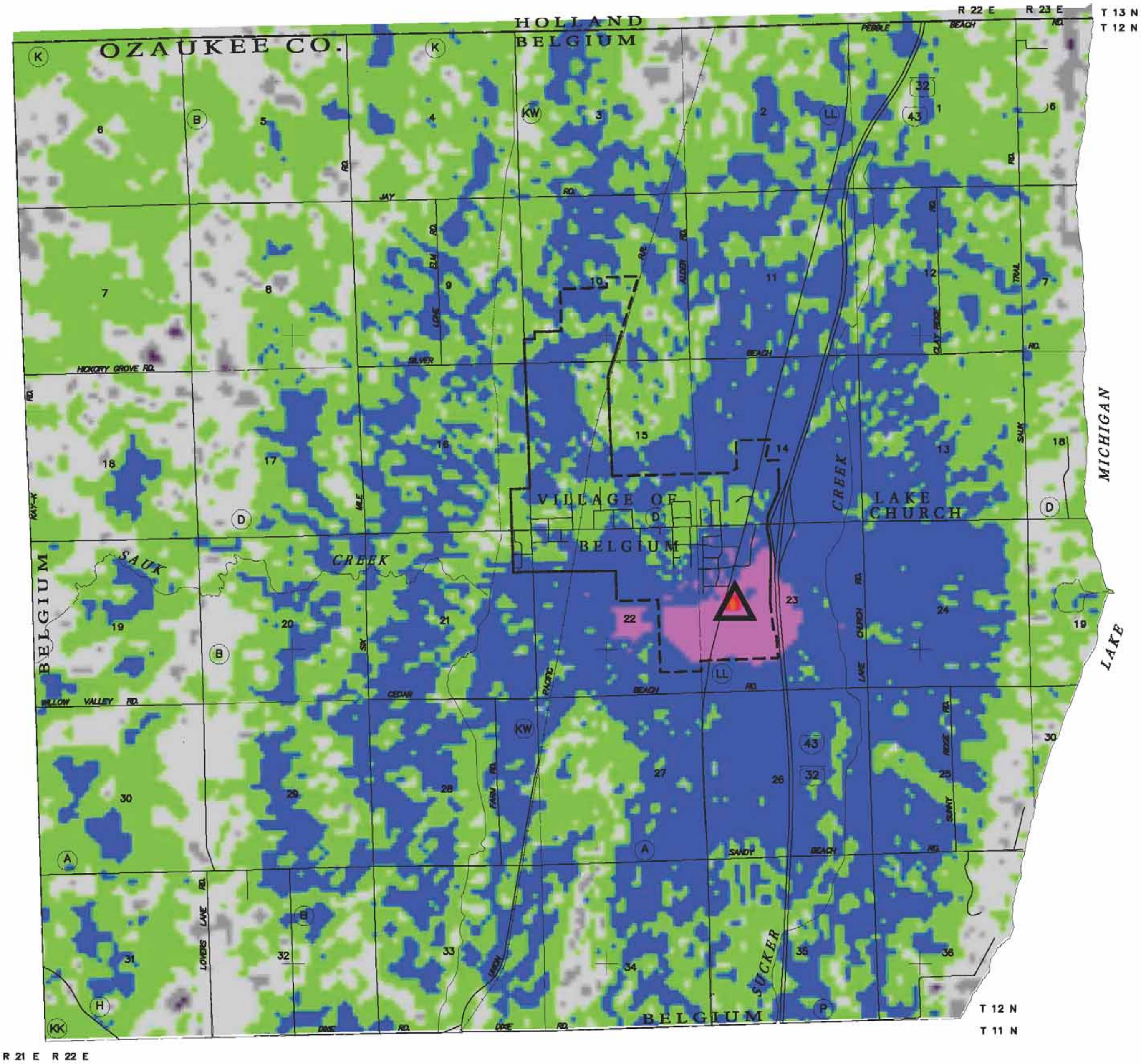
LESS THAN 0 dBuV/m



Source: SEWRPC.

Map A-2

FIELD STRENGTH OF SIGNAL AT REMOTE ANTENNA USING PROPOSED FREQUENCY OF 2400 Mhz AND 4 WATTS OF POWER IN THE VILLAGE OF BELGIUM AND THE TOWN OF BELGIUM



LEGEND

EXISTING ANTENNA

GREATER THAN 120 dBuV/m

105 dBuV/m TO 120 dBuV/m

90 dBuV/m TO 105 dBuV/m

75 dBuV/m TO 90 dBuV/m

60 dBuV/m TO 75 dBuV/m

45 dBuV/m TO 60 dBuV/m

30 dBuV/m TO 45 dBuV/m

15 dBuV/m TO 30 dBuV/m

0 dBuV/m TO 15 dBuV/m

LESS THAN 0 dBuV/m

Source: SEWRPC.

Table A-1

COMPARISON OF RADIATION EXPOSURE LIMITS, COMPUTED VALUES AND MEASURED VALUES: SEPTEMBER 2006

Type	Frequency (Megahertz)	Standard		Computed		Measured	
		Power Density (watts per meter^2)	Field Strength (volts per meter)	Power Density (watts per meter^2)	Field Strength (volts per meter)	Power Density (watts per meter^2)	Field Strength (volts per meter)
Cellular/PCS	1,932	9.5	59.8	0.00079	0.54	0.000120	0.213
WiFi/WiMAX	2,400	10.0	61.4	0.00030	0.34	0.000051	0.139

Note: Radio propagation computations and field measurements are based on radiation levels 100 meters from the antenna location.

Source: SEWRPC.

MHz could interfere with WiFi communications. Responsible communications practices recommend the conservation of transmit power in the interest of other users. The golden rule of wireless communications is to utilize only the transmit power necessary to reliably serve the network. Excess transmit power contributes to the electronic pollution of the airwaves. Radio interference is currently the limiting factor in most wireless communications systems. The low power wireless systems advocated in this plan serve to free up the airwaves for higher communication performance.

Another environmental benefit of low power communications relates to its potential use of renewable power sources. Solar panels and their associated photovoltaic cells and rechargeable batteries are particularly attractive low power sources for network access points. Small solar power units have been developed that are capable of operating in overcast weather for very extended periods. Use of solar power also provides for a lower cost, more reliable and robust network.

Summary

A combined theoretical and experimental investtigation of the environmental impact of radio frequency (RF) radiation generated by existing and planned wireless communications systems in Southeastern Wisconsin confirms that all are in compliance with maximum permissible exposure (MPE) limit standards published by the Federal Communications Commission. These standards are based on the thermal effects of radio frequency on the human body. Some epidemiological and laboratory investigations of athermal effects of radio frequency radiation have indicated possible adverse effects on human health, but the results of these studies have not been sufficiently confirmed to allow for standards lower than those already established for thermal effects. In the absence of conclusive recommendations on athermal effects, the Commission staff recommends the deployment of low power wireless communications systems that will not only tend to minimize radio frequency radiation effects on human health, but also reduce electronic pollution of the airwaves and allow for low power renewable energy sources such as solar cells.

Appendix B

GLOSSARY

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GLOSSARY

Term	Definition
1G	First generation wireless technology: Analog technology, introduced circa 1983.
2G	Second generation wireless technology: Digital technology, introduced circa 1992.
2.5G	Second and a half generation wireless – 2G digital technology plus added feature of GPRS (General Packet Radio Service).
3G	Third generation wireless technology: Broadband, high speed, digital technology, currently being introduced.
4G	Fourth generation wireless technology: Advanced broadband, high speed, digital technology, anticipated to be introduced circa 2007.
Access Network	A network that connects users to a core network such as the Internet.
ADSL	A symmetrical Digital Subscriber Line
Advanced Broadband	The FCC defines advanced broadband as service providing data transmission at a rate of at least 200 kilobits per second in both directions.
AMPS	Advanced Mobile Phone Service. Another word for the North American analog cellular phone system.
Antenna Site	A geographic location used for an antenna structure.
Antenna Structure	The tower, mast or other support on which antenna are mounted together with the radiation system and attendant appurtenances.
Antenna	A device for transmitting, receiving or transmitting and receiving radio frequency signals.
AT&T	American Telephone & Telegraph Company: Prior to 1984, AT&T was the major telephone service provider and equipment manufacturer in the U.S. Broken up by court decree in 1984, the Company became a long distance service provider and eventually spun off its manufacturing arm in a series of divestitures. Both the wireline and wireless components of the company have been acquired by the old SBC (Southwestern Bell) which has renamed itself the "New AT&T".
ATM	Asynchronous Transfer Mode: ATM service was developed to allow one communication medium (high speed packet data) to provide for voice, data and video service. During the 1990s, ATM became a standard for high-speed digital backbone networks. ATM networks are widely used by large telecommunications service providers to interconnect their network parts (e.g., DSLAMs and Routers). ATM aggregators operate networks that consolidate data traffic from multiple feeders (such as DSL lines and ISP links) to transport different types of media (voice, data and video).

Term	Definition
AON	Active Optical Network
Base Station	A fixed station used for communicating with mobile stations most commonly handsets. Fixed stations usually consist of an antenna site, antenna structure, antennae and supporting electronic and electric power facilities.
Backhaul Network	A wireless or wireline communications network that transports access points to gateways for Internet interconnection.
Bluetooth	A standard for short range wireless personal area networks (IEEE 802.15.1). Operates in the 2.45 GHz unlicensed frequency band.
B-ONT	Business Optical Network Terminal
Broadband	In general, any telecommunications connection to a user providing transmission at a rate of at least of 256 kilobits per second or more is considered broadband Internet. The official International Telecommunications Union Standardization Section (ITU-T recommendation I.113 has defined broadband as a transmission capacity that is faster than ISDN, at 1.5 to 2 megabits per second. It should be noted, however, that there is no international uniformity with respect to the definition of the term "Broadband," for example, the United States FCC definition of broadband is 200 kilobits per second in one direction, while the country of South Korea defines as broadband a telecommunication connection providing a transmission rate of over 50 megabits per second."
CDMA	Code Division Multiple Access.
CLEC	Competitive Local Exchange Carriers: The term was coined by the Telecommunications Act of 1996 and refers to an organization that competes with the incumbent, i.e., a former monopoly local phone company.
CO	Central Office: The CO is the location which houses switches and routers to serve local telephone subscribers.
Core Network	A combination of high-capacity switches and transmission facilities which form the backbone of a carrier network. End users gain access to the core of the network from access networks.
dBi	Decibals isotropic. A unit of gain applied to antennas, both directional and omnidirectional.
dBmW	Decibel Milliwatts
DMT	Discrete multi-tone
DNS	Domain Name Service.
DSL	Digital Subscriber Line: A generic name for a family of technologies (also called xDSL) being provided by local telephone companies for high speed data services.

Term	Definition
DSLAMS	Digital Subscriber Line Access Multiplexers in DSL networks.
DSSS	Direct Sequence Spread Spectrum. RF modulation technique that uses algorithms to code transmissions in sequential channels and then decodes them in the receiving end.
DWDM	Dense Wave-Length Division Multiplexing: A version of fiberoptic communication that combines many optical channels on a single fiber to increase the data transmission capacity of the fiber. Dense wave division multiplexing provides a significant increase to wave division multiplexing (WDM) that combines up to four different optical channels (different wavelengths) on a single fiber. As of 2001, DWDM systems provided for 8 to 80 different wavelengths with the capability of transferring over 1 trillion bits of data per second (Tbps).
EHF	Extremely High Frequency: The band of microwave frequencies between the limits of 30 GHz and 300 GHz (wavelengths between 1 cm and 1 mm).
Ethernet	An access control method based on IEEE standard 802.3.
EV-DO	Evolutionary Data Optimized – a cellular wireless technology.
FAA	Federal Aviation Administration
FCC	Federal Communications Commission: The federal organization set up by the Communication Act of 1934 to regulate all interstate (but not intrastate) communications in the U.S.
FHSS	Frequency Hopping Spread Spectrum. A technique used in spread spectrum radio transmission systems, such as Wireless LANs and some PCS cellular systems. FHSS involves hopping rapidly from one frequency at another to avoid jamming or eavesdropping.
FSO	Free Space Optical: FSO refers to wireless telecommunications transmission in the infrared frequency bands in the 800-1600 nanometer wavelength range.
FTTC	Fiber-to-the-Curb: A hybrid transmission system which involves fiber optic links to the curb and either twisted pair or coaxial cable to the premises.
FTTH	Fiber-to-the-Home: A transmission system in which optical fiber is carried all the way to the customer's premises.
FTTN	Fiber-to-the-Node: A hybrid transmission system involving optical fiber from the carrier network to a neighborhood node. The connection from the neighborhood node to individual homes may be wireless or involve legacy twisted pair or coaxial cable.
FTTP	Fiber-to-the-premises: another name for fiber-to-the-home.
FTTU	Fiber-to-the-user

Term	Definition
Gateway Base Station	Base station with an Internet connection.
GEO	Geosynchrous Satellite
GHz	Gigahertz: A unit of frequency denoting one billion Hertz (Hz) or one billion cycles per second.
GIS	Geographic Information System: Computer applications involving the storage and manipulation of maps and related data in electronic format.
GSM	Global System for Mobile Communications. The standard digital cellular phone service found in Europe, Japan, Australia and elsewhere – a total of 85 countries.
GPRS	General Packet Radio Service
Hertz	Cycles per second named after German physicist, Heinrich Hertz.
HFC	Hybrid Coax-Fiber Optic Cable: An advanced CATV (cable television) transmission system that uses fiber optic cable for the head end and feeder distribution system and coaxial cable for the customer's end connection. HFC are the 2nd generation of CATV systems. They offer high-speed backbone data interconnection lines (the fiber portion) to interconnect end user video and data equipment. Many cable system operators anticipating deregulation and in preparation for competition began to upgrade their systems to HFC systems in the early 1990s. As of late 2000, over 35 percent of the total cable lines in the United States had been converted to HFC technology.
H-ONT	Home Optical Network Terminal
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
HTTP	Hyper Text Transfer Protocol – text or graphic.
HTTPS	The secure version of HTTP.
iDEN	Integrated Dispatches Enhanced Network
IEEE	Institute of Electrical and Electronic Engineers: Founded in 1884 as the AIEE (American Institute of Electrical Engineers), it later merged (circa 1960s) with the Institute of Radio Engineers (IRE) to become the world's largest technical professional society renamed the IEEE. It sponsors technical symposia, conferences and local meetings and publishes technical papers. In telecommunications, it is best known for the publication of standards such as the 802 series for local area networks.

Term	Definition
ILEC	Incumbent Local Exchange Carrier: A telephone carrier (service provider) that was operating a local telephone system prior to the divestiture of the AT&T Bell system. Also specifically defined in the Telecommunications Act of 1996 as a carrier providing local exchange service to a specific area as of the date of the enactment of the Act.
IP	Internet Protocol: The IP is a protocol describing software used on the Internet that routes outgoing messages, recognizes incoming messages, and keeps track of addresses for different nodes.
ISAM	Intelligent Services Access Manager
ISO/FCAPS	International Standards Organization/Fault Configuration Accounting Performance Security: ISO is a voluntary organization chartered by the United Nations in 1947 that develops and publishes international standards in many technical areas. FCAPS is a standard for the management of telecommunications networks. The standard embraces performance management which is the function of the proposed network monitoring system in Southeastern Wisconsin.
ISP	Internet Service Provider: A company that provides an end user with data communications service that allows them to connect to the Internet. An ISP purchases a high-speed link to the Internet and divides up the data transmission to allow many more users to connect to the Internet.
ITS	Intelligent Transportation System: A technology that employs computers, sensors and communications networks to improve the operation of transportation systems.
ITU	International Telecommunications Union: An organization based in Geneva, Switzerland, the most important telecom standards setting body in the world.
IXC	Interexchange Carriers
LAN	Local Area Network: A LAN is a communications network connecting computers, work stations, printers, file servers and other devices inside a building or campus.
LATA	Local Access Transport Area: An area served by a local telephone company in which it may offer both local and toll services.
LEO	Low Earth Orbit
LTE	Long-Term Evolution
MAC-Media	Media Access Control. Protocol for network access at layer 2 of OSI.
MC-CDMA	Advanced 4^{th} generation version of CDMA
Mesh Network	A network in which each is connected to multiple neighbor nodes.
MHz	Megahertz: A unit of frequency denoting one million Hertz (Hz) or one million cycles per second.

Term	Definition
MIB	Management Information Base: A database of network management information used by CMIP (common management information protocol) and SNMP (simple network management protocol).
MIMO	Multiple Input - Multiple Output: Involves the employment of phased array antennas for increased range of data transfer rates.
MMDS	Microwave Multipoint Distribution System: A method of distributing television signals through microwave from a single transmission point to multiple receiving points.
MOS	Mean Opinion Score
MPLS	Multiple Protocol Label Switching: MPLS is a widely supported method of speeding up IP-based communications over ATM or Ethernet networks.
MSC	Mobile Switching Center
Network Architecture	The philosophy and organizational concept for enabling communications between multiple locations and multiple organizational units. Network architecture is a structural statement of the terminal devices, switching elements and the protocols and procedures to be used for the establishment effective telecommunications.
OC	Optical Carrier: OC is a term used to designate transmission rates in fiber transmission systems using the SONET protocol.
OFDM	Orthogonal Frequency Division Multiplexing. A modulation technique for wireless communications.
OFDMA	Advanced version of OFDM using more frequency bands.
OSI	Open System Interconnection: A reference model developed by the ISO that defines the seven layers used in communication network protocols.
OSP	Optical Splitter
PCS	Personal Communication System: A low-powered, high frequency alternative to traditional wireless cellular communications systems.
P-OLT	Packet Optical Line Terminal
PON	Passive Optical Network
POP	Point of Presence: A physical location that allows an interexchange carrier (IXC) to connect to a local exchange company (LEC) within a LATA. The point of presence (POP) equipment is usually located in a building that houses switching and/or transmission equipment for the LEC.
POTS	Plain Old Telephone Service: The basic service supplying standard telephone single line telephones and access to the public switched network.

Term	Definition
PSC-WI	Public Service Commission of Wisconsin: The agency that regulates public utilities in Wisconsin.
PSTN	Public-Switched Telephone Network: The local, long distance, and international phone system.
QoS	Quality of Service: A measure of the quality of telephone service provided to a subscriber. It embraces a wide range of specific definitions depending on the type of service provided.
RBEV	Rank-based expected value method-a technique for evaluating alternative plans or other.
RF	Radio Frequency: Electromagnetic waves operating between 10 kHz and 30 GHz in either cables or free space.
RTM	Regional Traffic Matrix: A data matrix that defines the origins and destinations of voice, data, or multimedia communications in a geographic region.
SCADA	Supervisory Control and Data Acquisition Systems used by electric power, gas, water, wastewater and other utilities to monitor and manage the operation of geographically dispersed facilities.
Sectoral Cellular Network	A cellular network with 3 or 4 sectors at each access point.
SHF	Super High Frequency: The frequencies ranging from 3 GHz to 30 GHz (wave-lengths between 10 cm and 1 cm).
SNMP	Simple Network Management Protocol: A standard communication protocol that is used to setup, test, and manage network equipment. By conforming to this protocol, equipment assemblies that are produced by different manufacturers can be managed by a single program. SNMP protocol can operate via Internet protocol.
SNR	Signal to Noise Ratio.
SONET/SDH	Synchronous Optical Network/Synchronous Digital Hierarchy: The current leading optical transmission protocols used in North America (SONET) and internationally (SDH).
T/DS	Transmission-Digital Signal: The T and DS define levels of digital transmission speed capabilities of digital lines and trunks. The T-1 line has a signaling speed of 1,544,000 bits per second.
TCP/IP	Transmission Control Protocol/Internet Protocol: TCP/IP is standard set (suite) of protocols that define the transmission of Internet messages. The Transmission Control Protocol (TCP) portion ensures message delivery between two points and the Internet Protocol (IP) defines the routing of physical packets of data.

Term	Definition
TCP/IQ	A website that collects and publishes data on broadband network performance.
TDMA	Time Division Multiple Access. One of several technologies used to separate multiple conversation transmissions over a finite frequency allocation of through-the-air bandwidth.
TIA	Telecommunications Industry Association: An association of telecommunications equipment manufacturers.
UHF	Ultra High Frequency. The frequency range from 300 MHz to 3000 MHz (3GHz).
UMTS	Universal Mobile Telecommunications System. Advanced version of GSM.
UNE	Unbundled Network Element: Network elements owned by ILECs that must be available to CLECs in accordance with the Telecommunications Act of 1996.
VA	Vulnerability Assessment: Methods used to determine the security of a network.
VDSL	Very High bit rate digital subscriber line.
VHF	Very High Frequency: The band of frequencies between the limits of 30 MHz and 300 MHz (wavelengths between 10 meters and 1 meter).
VoIP	Voice Over Internet Protocol: A process of sending voice telephone signals over the Internet. If the telephone signal is in analog form (voice or fax), the signal is first converted to a digital form. Packet routing information is then added to the digital voice signal so it can be routed through the Internet.
V-OLT	Video Optical Line Terminal in FTTN networks.
WAM	Web-based Access Manager
WAVE	Wireless Access In Vehicular Environments.
WCDMA	Wideband CDMA.
WiFi	Wireless Fidelity: A popular term for wireless local area networks operating under IEEE Standard 802.11b or 802.11g in the 2.4 GHz range.
WiFiA	A term for the higher frequency version of WiFi operating in the 5 GHz frequency band (IEEE standard 802.11a).
WiFi5	A higher frequency version of WiFi defined under IEEE Standard 802.11a operating in the 5 GHz frequency band.
WiMAX	(Worldwide Interoperability Microwave Access) Wireless Technology serving Metropolitan Area Networks under IEEE Standard 802.16.
WiMAXA	A term for the version of WiMAX operating in the 5 GHz frequency band.

Term	Definition
WLANS	Wireless Local Area Network. A LAN without wires.
WNMS	Wireless Network Monitoring System.
ZigBee	A standard for short range wireless sensor networks (IEEE 802.15.4). Operates in the 2.40 GHz band. Emphasizes small size, low power and low cost.