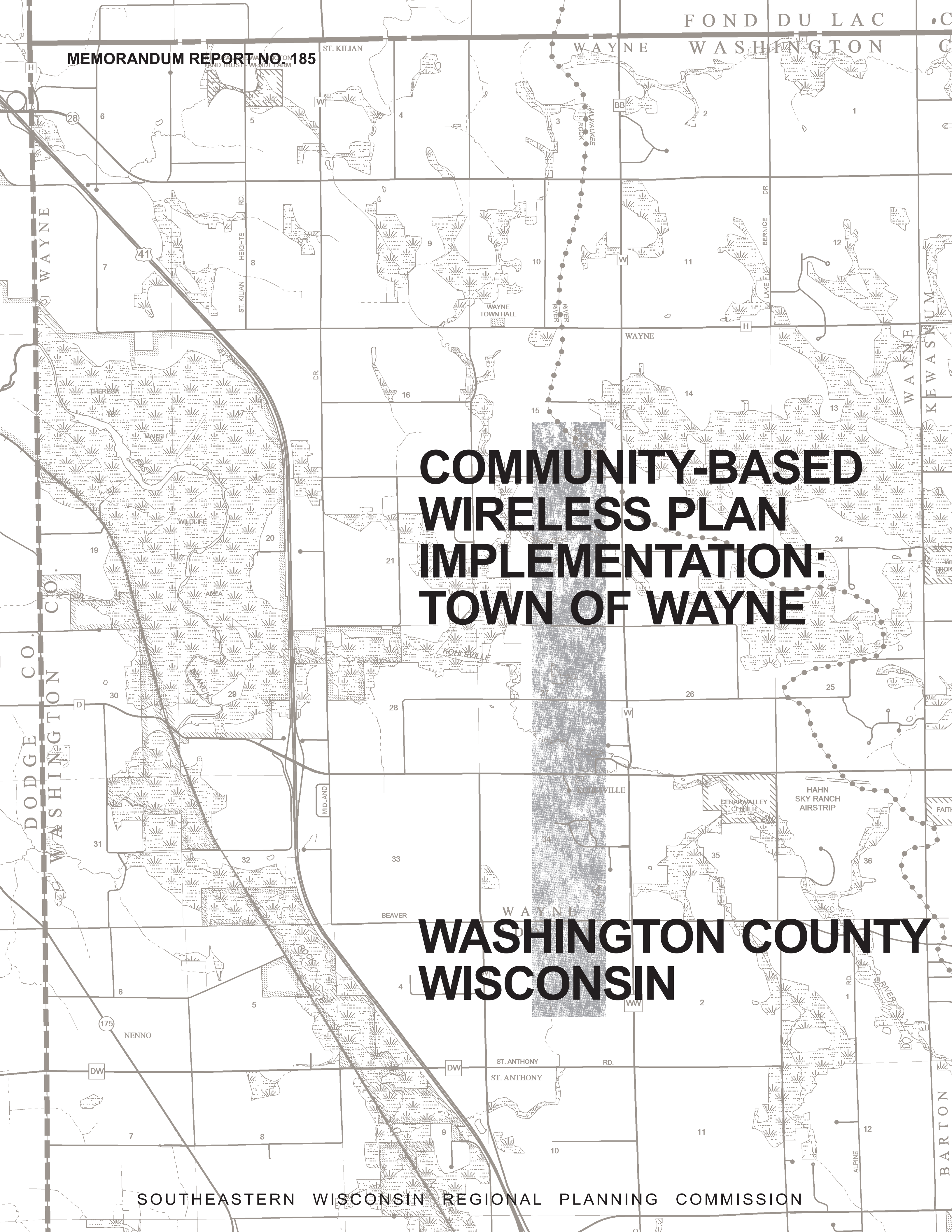
MEMORANDUM REPORT NO. 185



COMMUNITY-BASED WIRELESS PLAN IMPLEMENTATION: TOWN OF WAYNE

WASHINGTON COUNTY WISCONSIN

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SEWRPC Memorandum Report No. 185

COMMUNITY-BASED WIRELESS PLAN IMPLEMENTATION: TOWN OF WAYNE, WASHINGTON COUNTY

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January 2009

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Chapter I

INTRODUCTION

This report documents recent plan implementation activities relating to the community-based wireless plan element of the adopted regional broadband telecommunications plan for southeastern Wisconsin as set forth in SEWRPC Planning Report No. 53, *A Regional Broadband Telecommunications Plan for Southeastern Wisconsin*, October 2007. As envisioned in the adopted plan, community-based wireless plan implementation places primary emphasis on the 64 percent of the land area in Southeastern Wisconsin that is devoted to rural as opposed to urban land uses. The rural land use consists primarily of agricultural, agricultural related commercial, and very low density residential uses. These rural areas generally lack broadband telecommunications services of any kind. A major objective of the regional broadband telecommunications plan is to provide universal broadband telecommunications services to all geographic areas of the Region. Since the urban-suburban parts of the Region generally have some form of broadband telecommunications services (telephone-based DSL or cable), it was logical to focus plan implementation efforts first on those areas lacking any such services. It must be emphasized, however, that current broadband telecommunications performance, even in urban-suburban areas of Southeastern Wisconsin, do not fully meet the objectives and standards set forth in the adopted regional broadband telecommunications plan. These areas are also deficient in the broadband performance of communications services, particularly as compared to globally competitive regions in Europe and Asia. Nevertheless, it was considered best to try to first elevate the performance of the telecommunications infrastructure in the most under-served areas of the seven-county Region. The Town of Wayne in northwestern Washington County was selected as the pilot site for implementation of the community-based wireless element of the adopted regional plan. The reasons for this selection included:

1. The Town government was proactive with an early request for the preparation of a broadband wireless telecommunications system plan for the community;
2. The area met the rural population density standards of the U.S. Department of Agriculture which offered primary financial support for the development of the desired wireless communications technology[1]; and
3. It typified rural Southeastern Wisconsin, there being 50 other rural towns in the same population density category.

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[1] *In the interest of full disclosure, USDA financial support was made available to HeirComm, Inc. The principal consultant to SEWRPC for telecommunications planning is also a principal in HierComm, Inc.*

Following this introductory chapter, this report includes the following:

Chapter II	The Wayne Broadband Wireless Plan
Chapter III	The New Wireless Communications Technology
Chapter IV	The Wayne Trial Network
Chapter V	The Wayne Broadband Market and Business Model
Chapter VI	The Wayne Internet Service Provider
Chapter VII	Findings and Conclusions from the Wayne Experience

Chapter II

THE WAYNE BROADBAND WIRELESS PLAN

THE TOWN OF WAYNE

The civil Town of Wayne—consisting geographically of all of U.S. Public Land Survey Township 12 North, Range 18 East—is located in the northwestern corner of Washington County, Wisconsin. The Town has a land area of 35.8 square miles and a year 2000 resident population of 1,727 people located in 582 households. With a population density of 48.2 people per square mile, it is one of the lowest population density communities in the seven county planning region. Its primary economic activities are still agricultural, but the Town also serves as a "bedroom" community for the City of West Bend and other nearby urban centers. Based on its land use plan for 2020, prepared with the assistance of the Regional Planning Commission, the residents wish to preserve the existing rural nature of the community. It must be reemphasized that Wayne is typical of a class of 50 rural towns in the Southeastern Wisconsin Region that have population densities of 250 people or less per square mile. Although Wayne resides at the low end of the population density range of this class of communities, all of these communities are characterized by rural settings and a lack of broadband communications services.

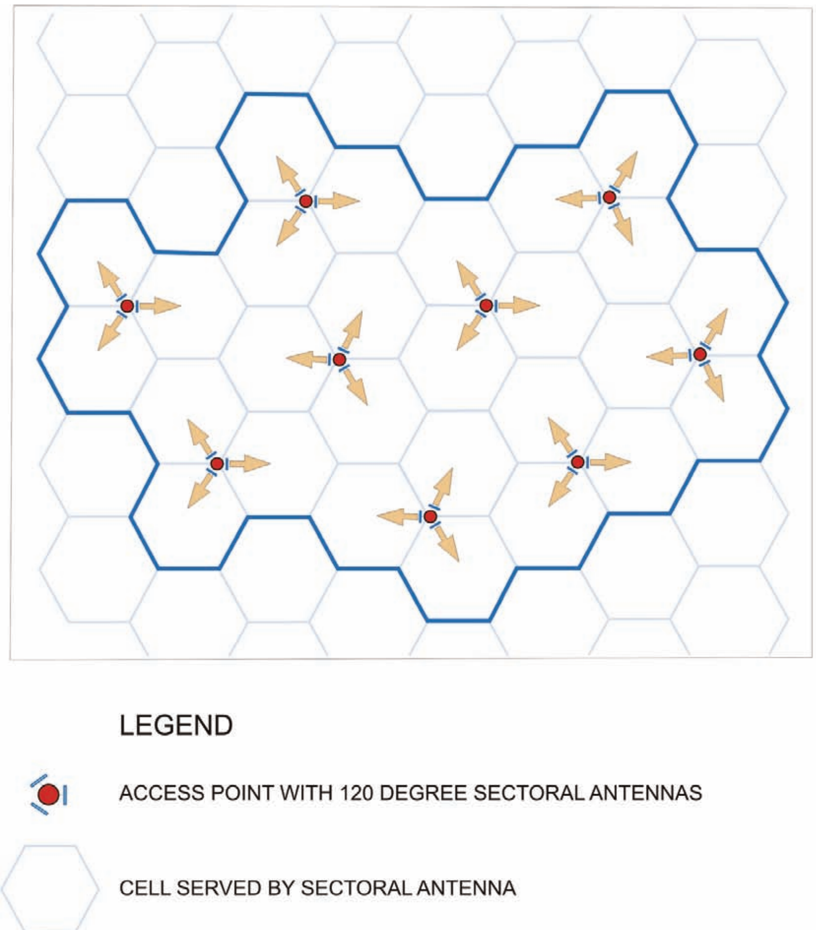
THE WAYNE BROADBAND WIRELESS PLAN

A sectoral cellular wireless network plan was prepared for the Towns of Wayne and neighboring Addison in northern Washington County and published as SEWRPC Memorandum Report No. 166. The sectoral cellular network architecture, shown in Figure 1, provides for three different 120 degree sectors at each access point – each sector with its own directional antenna. This network has the advantage of utilizing high gain antennas at both the access point and at the user, providing longer range and higher transmission rate performance. Its directionality also results in less interference from other networks such as omnidirectional mesh networks. Network layout plans were formulated with the aid of radio propagation modeling for Wayne and Addison individually and also as a joint network. Although the joint network provided for lower costs with a smaller number of access points, each Town preferred to have its own network. Since Wayne was designated as the initial town for community-based wireless plan implementation, only its network plan implementation will be described here. It is noteworthy, however, that the adjoining Town of Addison as of the date of this publication—January 2009—has informally indicated to Commission staff that it desired to be next in line for the planned wireless network deployment.

A map of the initial Wayne network plan prepared for Memorandum Report No. 166 is shown in Map 1. This plan calls for four access points located in the northeast, southeast, northwest, and southwest quadrants of the Town as indicated. Although field tests confirmed that these access points provided adequate coverage to all areas of the Town, a fifth access point was later added in the center of the Town as shown in Map 2 to allow for

Figure 1

CONCEPTUAL SECTORAL CELLULAR NETWORK



Source: SEWRPC.

the use of lower cost subscriber equipment for a larger majority of Town users. Users at extended ranges from access points require home or business communications equipment of higher cost than other users. The fifth access point reduced the cost of subscriber equipment for the future service users.

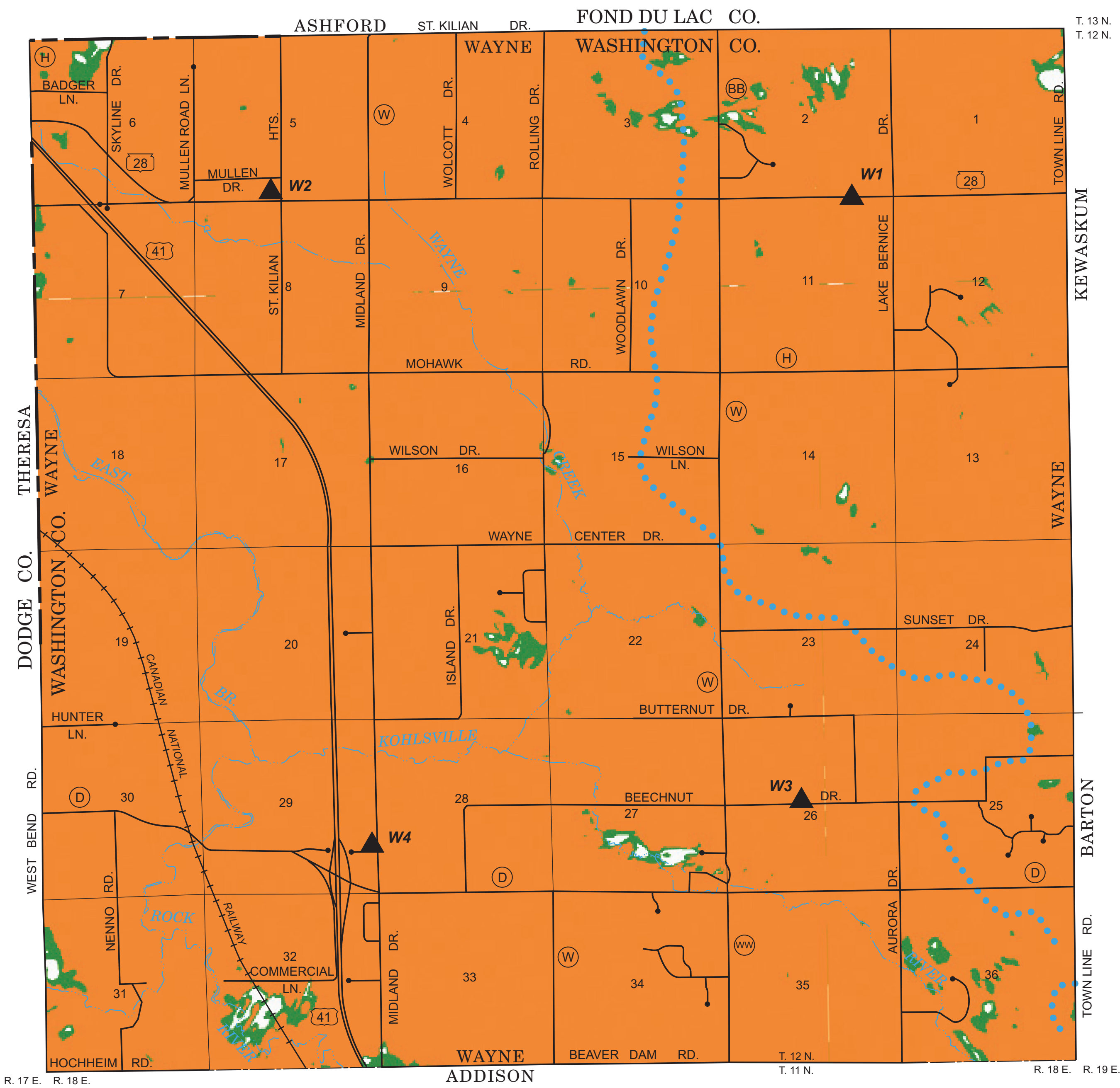
An important feature of the SEWRPC wireless communications planning process is field testing. The mathematical foundation of radio propagation modeling is well established. For this reason, model-based plans provide a sound basis for wireless communications network design. The more questionable part of radio propagation modeling relates to the database used to describe the terrain of the network geographic area. While terrain databases based on topographic maps are quite accurate, they do not provide for the effects of natural obstacles, or clutter, such as forest cover, or artificial obstacles—such as tall buildings—to radio propagation. Existing databases depend upon satellite photography which has both resolution and accuracy limitations. For this reason, field testing in a given geographic area is necessary to confirm radio attenuation profiles in different classes of clutter. Field tests of the Wayne network plan were carried out in September and October of 2006. A mobile truck-based access point with a 20 foot antenna mast was stationed at each access point. Geographic coverage and performance measurements were then made utilizing a second motorized vehicle equipped with user transceiver equipment and a laptop computer supported with loaded field survey software which traveled the coverage area recording geographic location by Global Positioning System technology and signal and noise levels along with channel performance data from the transceiver outputs. This field testing permitted the subsequent mapping of signal-to-noise (SNR) ratio data as a function of geographic location. The field testing covered all of the roads and streets on which homes, farms, or other businesses front as well as prospective development of this kind as shown in Map 3. It may be noted, using the color code legend provided, that all areas of the Town were characterized by green or yellow dots – each dot indicting a field SNR measurement. The high level of network plan performance is more clearly indicated in Map 4 where a red dot indicates a signal-to-noise ratio above the required threshold of 10 decibel (dB) (10 to 1 signal to noise ratio). The dark blue spots indicating sub-threshold performance are widely dispersed, and are correctible with network adjustments.

The Backhaul Network

All commercial broadband wireless communication networks require a gateway connection to an Internet-linked fiber network. Each access point transmits its area traffic to the gateway for connection to the Internet. The most suitable gateway location for the Wayne network was a 420 feet antenna tower located at 4650 Highway 33 West in the Town of West Bend. The tower is owned by Charter Communications and managed by KGI Wireless.

Map 1

INITIAL WAYNE NETWORK PLAN



LEGEND

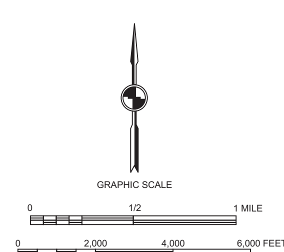
ACCESS POINT LOCATIONS

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

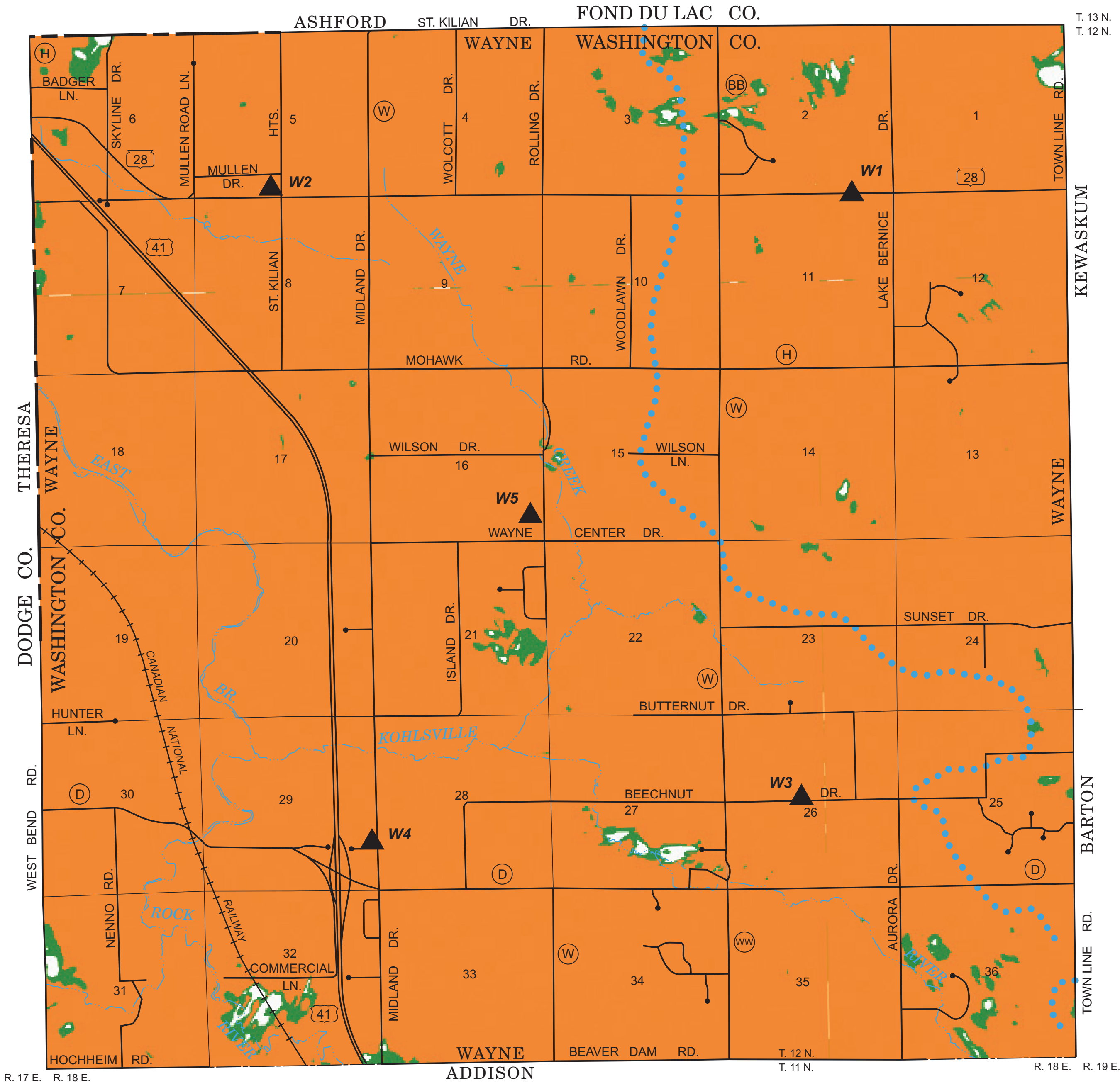
AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Map 2

FINAL WAYNE NETWORK PLAN



LEGEND

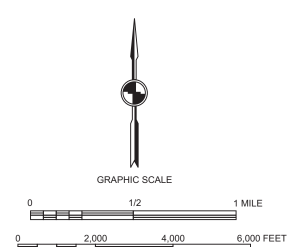
ACCESS POINT LOCATIONS

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

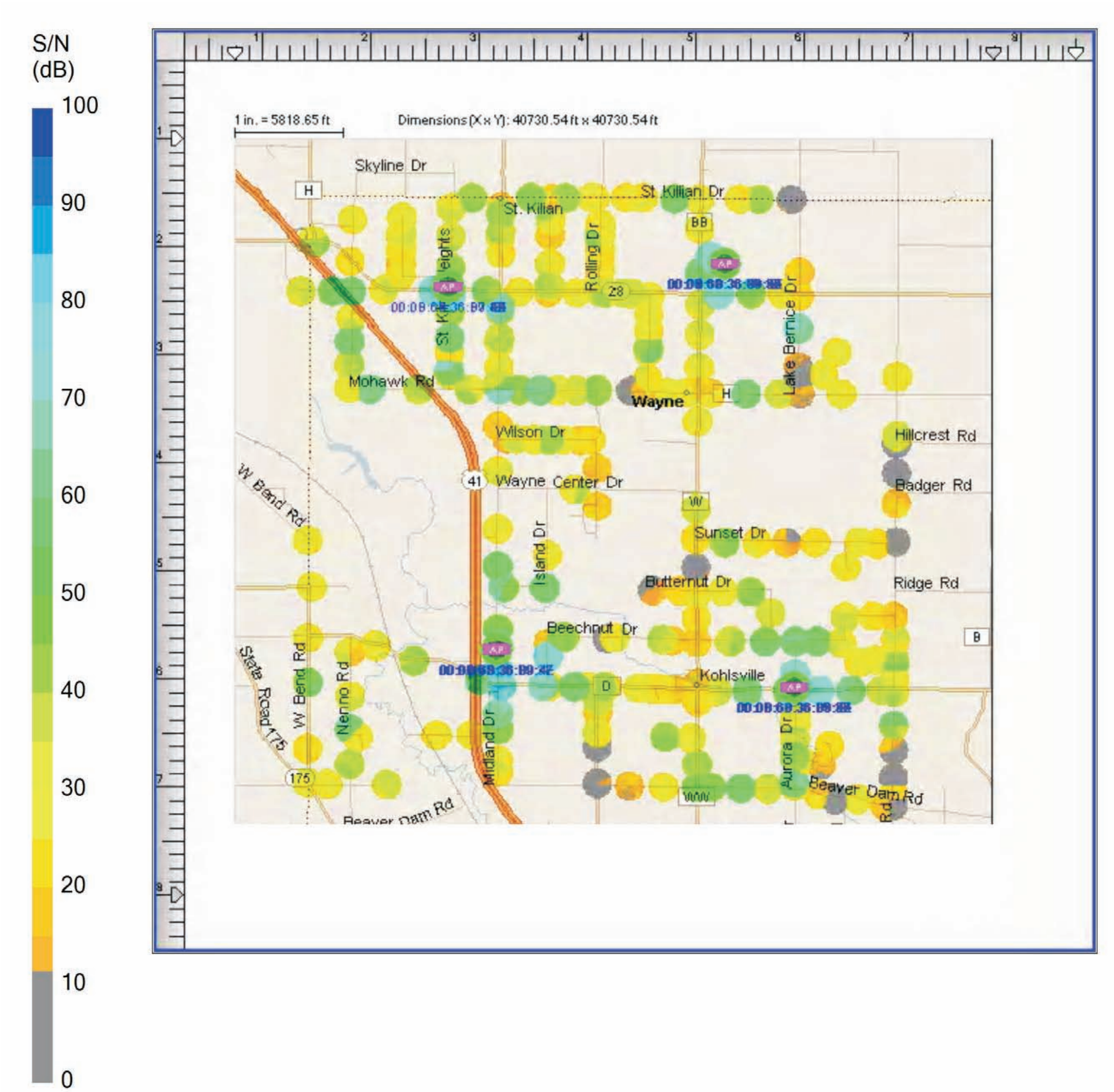
AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Map 3

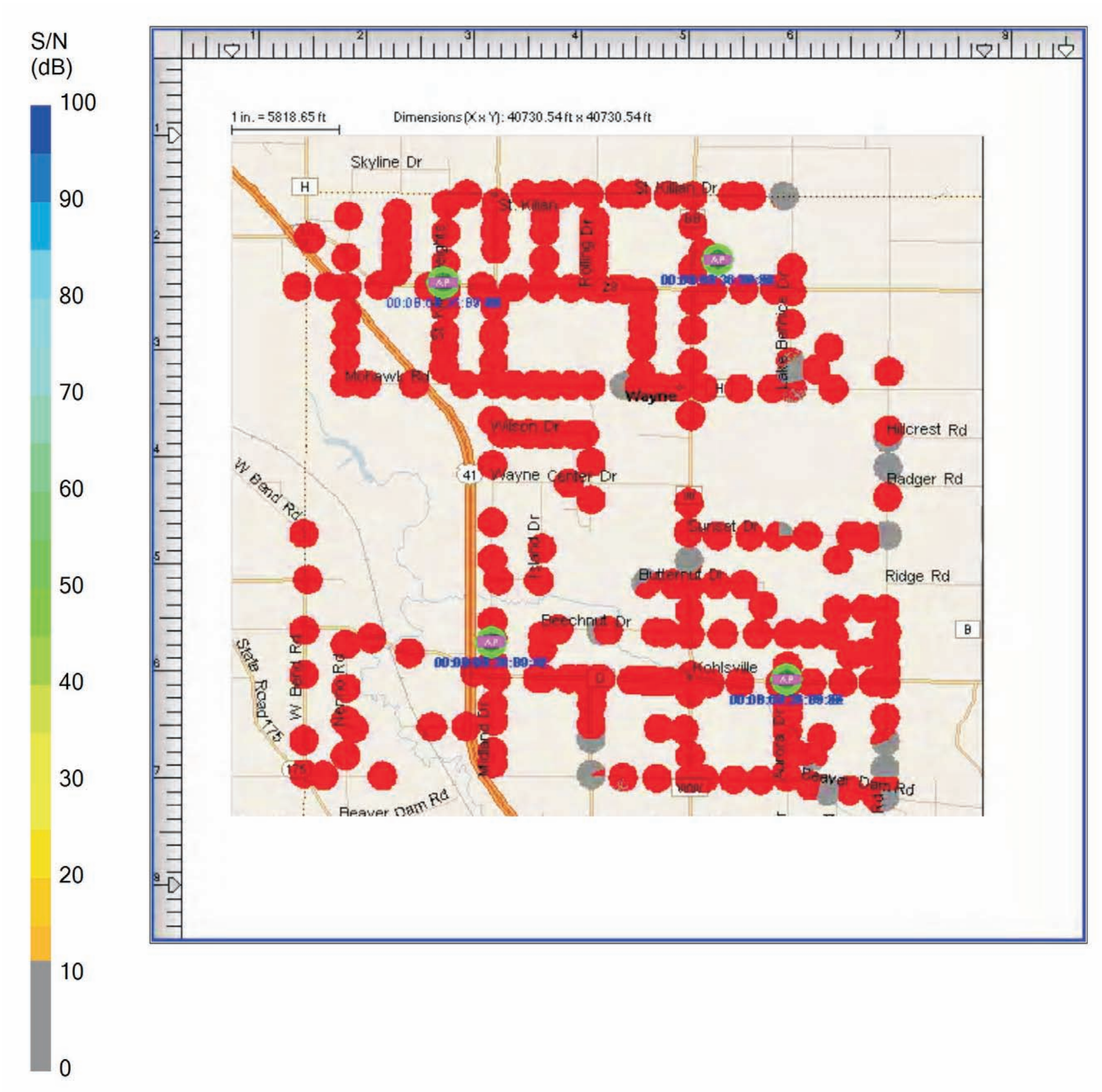
SIGNAL TO NOISE RATIO SURVEY MAP



Source: SEWRPC.

Map 4

THRESHOLD-LEVEL SIGNAL-TO-NOISE RATIO



Source: SEWRPC.

Fiber channel bandwidth may be purchased on a monthly basis for data rates varying from 5 megabits per second to 100 megabits per second. For the trial network installed in 2007, a 20 megabits per second channel was contracted. The backhaul links for each of the five access points are shown in Map 5. Backhaul ranges were all less than 10 miles, well within standard backhaul ranges which often exceed 20 miles.

In preparing the community-based wireless plan set forth in SEWRPC Planning Report No. 53, two options were considered for backhaul in community networks;

1. Individual backhaul connections to the closest or most cost effective Internet gateway; and
2. An integrated combination wireless/fiber regional backhaul network

An integrated, county-wide, backhaul network was recommended as the best long-term solution for uniform quality of service at the lowest cost. Although deployment of an integrated, county-wide, backhaul network was not possible at the time, a beginning was made in Washington County with a backhaul link deployment plan as shown in Map 6. This wireless backhaul network will link access networks in Wayne, Addison and other towns in Washington County to a location in the Town of Germantown where Time Warner-Telecom (a separate company from Time Warner Cable) has a fiber network for Internet gateway connections. Extension into towns in middle and southern Washington County would have eventually necessitated such a backhaul network extension in any case. In the meantime, the Germantown backhaul extension provided a competitive alternative that will assist in reducing monthly Internet connection costs.

This new backhaul link operating in the 5.8 gigahertz (GHz) frequency band also introduced a new approach to backhaul link infrastructure also being evaluated in the access network in Wayne – the use of wooden poles—similar to electric power line poles—for access point tower structures. These wooden poles have a number of advantages over alternative tower structures including:

1. Community Acceptance

   The wooden poles have the advantage of wider community acceptance as compared to their metal counterparts. The poles stand about 50 feet tall as access points, and about 100 feet for backhaul links. Their shorter stature combined with their ability to blend into the landscape make them more acceptable to community residents. Town conditional use permits were readily provided for the five access points required within the normal 30-day cycle. Obtaining such permits for the erection of a higher metal tower can be a multi-year process and involve public opposition and significant legal costs. Also, all but one of access point locations could be located on a public right-of-way providing significant savings in on-going tower rental costs.

2. Network Design Flexibility

   The use of wooden poles also provides significant flexibility in network design. While co-location on existing high elevation metal towers represents a feasible alternative, it may be expected to be more costly on an on-going basis, and could prevent providing universal geographic coverage. Metal tower locations may also be expected to be more or less fixed in number within a defined coverage area. If existing towers do not allow for adequate coverage of an entire community, it may be difficult, as well as costly, to provide the additional towers needed for universal geographic coverage. This problem has sometimes prevented existing wireless service carriers from providing the full coverage that most communities desire.

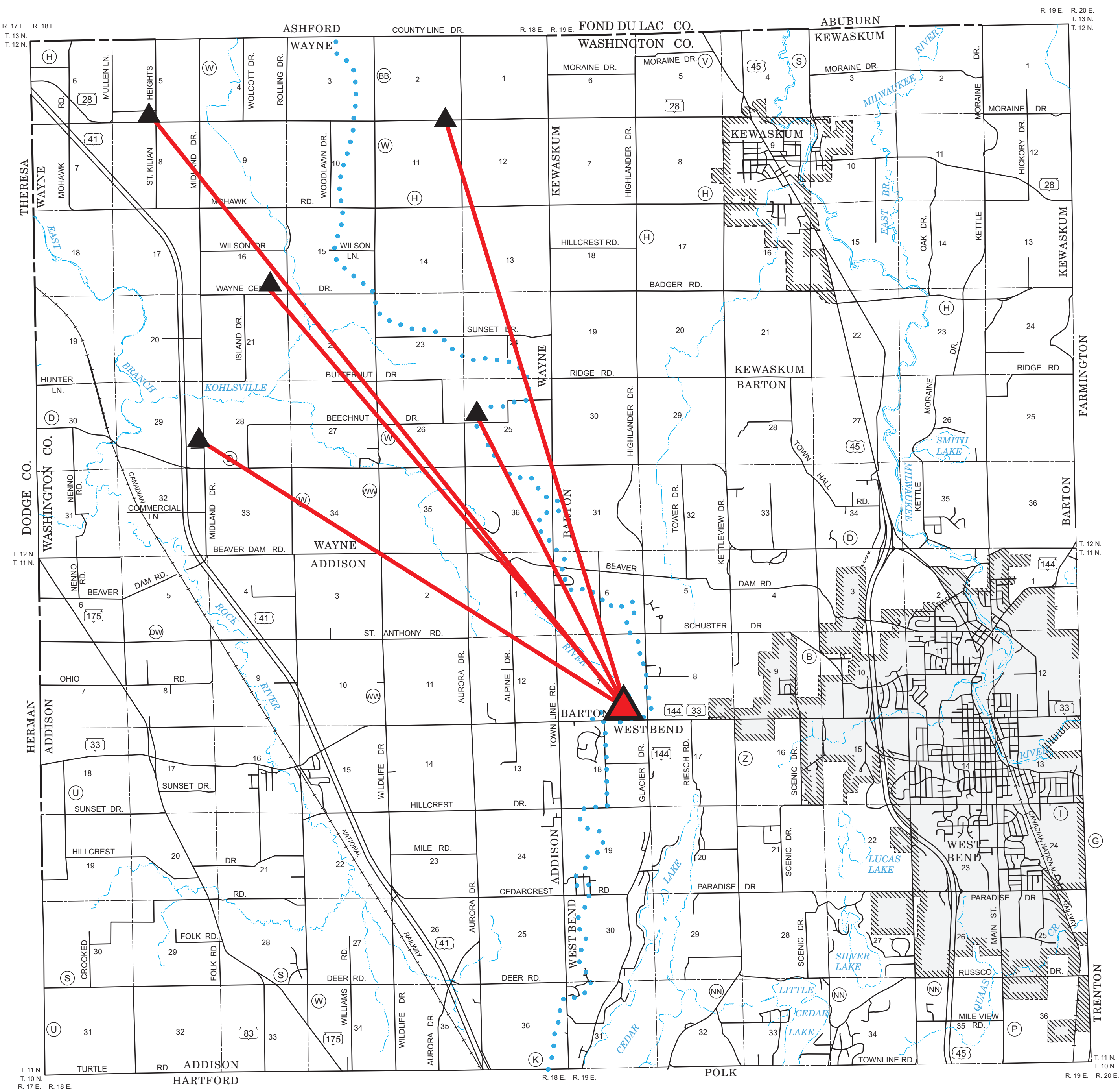
3. Cost

   The initial cost for installation of a wooden pole averages about $2,000 and requires little engineering and rarely any on-going costs. Metal towers require costly high tower engineering load and installation studies. After installation, metal towers will typically require an antenna rental cost that approaches $600 per month or more.

With field tested confirmation of the modeled network plan, and a backhaul network plan in place, plan implementation moved on to a trial network with a single access point and multiple users for an operational test of the system. At this point in the description it is important to understand the new communications technology that made such an operational test possible.

Map 5

WAYNE BACKHAUL NETWORK



LEGEND

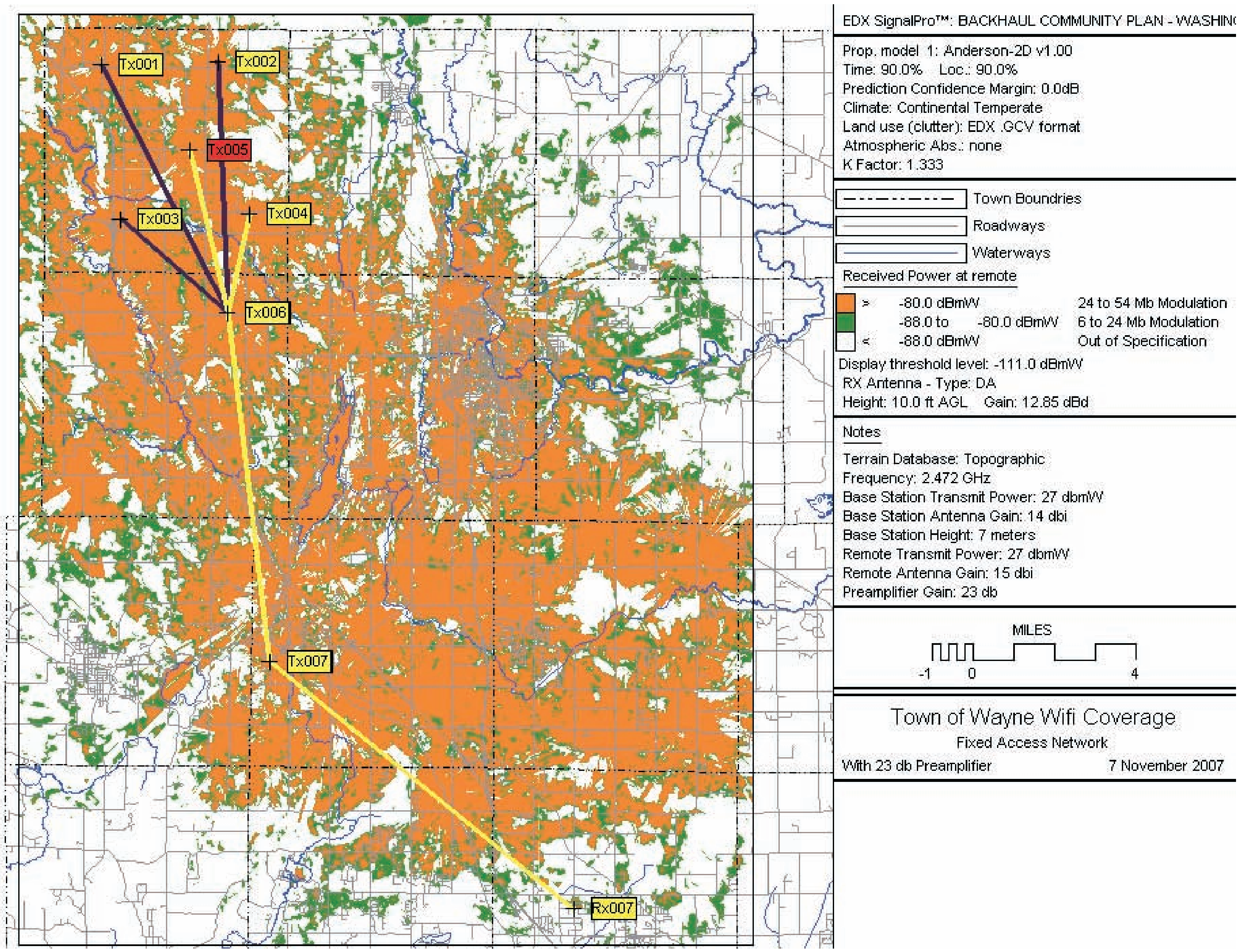
▲ BACKHAUL BASE STATION

● ACCESS POINT LOCATION

Source: SEWRPC.

Map 6

WASHINGTON COUNTY BACKHAUL LINK



Source: SEWRPC.

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Chapter III

THE NEW WIRELESS COMMUNICATIONS TECHNOLOGY

THE WIRELESS TECHNOLOGY CHALLENGE

From the beginning, it was clear that wireless communications technology offered the only feasible broadband alternative for the Town of Wayne. Neither telephone-based Digital Subscriber Line (DSL) nor hybrid co-axial cable networks could justify the deployment of wireline broadband into a town with only about 17 households per square mile. The question remained, however, whether any wireless technology was sufficiently cost effective to provide a viable business model for such an area. The most popular current wireless technologies deployed in some municipalities in the United States, the static mesh network, would require at a specified density of 25 access points per square mile, 900 for the entire Town. Such a 900 access point deployment would exceed the number of households in the service area. An alternative sectoral cellular network topology as shown in Figure 1 that allowed for the use of high gain antennas reduced the number of access points to 22 – still too costly in terms of the projected return on investment for a service provider.

These shortcomings in current wireless technologies, both WiFi and WiMAX, called for a technical augmentation of both access point range and channel throughput to permit the economical provision of broadband telecommunications service in the Town of Wayne. Fortunately, the availability of a Small Business Innovation Research (SBIR) research and development grant from the U.S. Department of Agriculture (USDA) was coincident in time with the plan implementation effort in Wayne. The objective of this grant program, called Broadband Telecommunications for Rural America, was to demonstrate the technical and economic feasibility of broadband telecommunications in low density, rural areas of the U.S. The grant was awarded to HierComm, Inc. a Waukesha County engineering company that cooperated with SEWRPC on the Wayne network deployment.

The basic technical challenge for rural broadband wireless communication is to extend the range of each access point in the network so as to require fewer access points to cover a designated geographic area. Such a reduction in access point density would lower the initial investment and improve the economic return. The range of any wireless access point (antenna base station) is a function primarily of the radio signal level. Transmissions radiated from any radio antenna into free space will decrease in signal level proportional to the square of the distance as the distance increases from the access point. In real world operation, radio waves are also attenuated by natural clutter—such as trees—and man-made clutter such as buildings. Such attenuation diminishes radio wave signal levels and the range of an access point in a network. Signal levels and access point range can be improved through either higher transmit powers or more sensitive receiver equipment.

Since good broadband telecommunications service involves both throughput and geographic coverage, it is important to understand Shannon's Law which expresses the relationship between the capacity of a communications channel in terms of the bandwidth of the channel, and the logarithm of the signal to noise ratio of the channel. The law may be expressed as:

Channel Capacity = Bandwidth + logarithm to the base two (1+ Signal-to-Noise Ratio)
Where Channel Capacity is expressed in bits per second; bandwidth
in Hertz, and both signal and noise in milliwatts.

Since the bandwidth for a specified frequency channel is fixed by the Federal Communications Commission (FCC), the only parameter available for improving channel capacity is the signal to noise ratio (SNR). The SNR may be improved by either increasing the signal or reducing the noise. The signal may be increased by higher transmitted power, but such increase is severely limited by the FCC to avoid signal interferences. The signal level may also be elevated using high gain antennas and amplifiers at the receiver end of the channel. There are no FCC restrictions on receiver gain or sensitivity. Given the legal restrictions, the only path open for signal level augmentation in unlicensed frequency bands is signal amplification in the channel receiver. Such augmentation may be achieved in "front end" radio frequency (RF) components of the system, namely antennas and signal preamplifiers. Net gain increases in these two types of components will improve the SNR and consequently the channel capacity. It will also allow the same channel capacity to be achieved at longer ranges thereby decreasing the required access point density and system investment.

The USDA-sponsored research and development grant focused on developing antenna and amplifier components that would provide the higher gains necessary to achieve the ranges and capacity necessary to provide for cost effective broadband wireless networks in low population density areas. This engineering effort at the component level was matched with equivalent progress at the system level dealing with network architectures and protocols that further enhance the cost effectiveness of the system. The basic sectoral cellular network architecture shown in Figure 1 initially contributed to network cost effectiveness by allowing both infrastructure access points and subscribers to use high gain directional antennas for longer range and enhanced data transmission rates. A second innovation related to the alternative peer-to-peer communications capability which provided for communication through other network users in lieu of direct communication with an access point. Such indirect communication not only provided a backup in public safety networks in the event of power outages or other major emergencies, it also provided an economic approach for coverage of remote users in "hidden" terrain locations, that is, in terrain which cannot be reached by the signals involved due to clutter or other reasons. It is not possible with any wireless network to economically avoid "dead spots" of poor or no coverage using the base station infrastructure alone. The alternate peer-to-peer path allows for ready coverage of areas not normally economic to reach.

The peer-to-peer supplemental network architecture is relatively easy to implement since it involves only software changes to the router unit of the user's transceiver/router module. Peer-to-peer software would also be loaded in the router unit at all access points. A negative aspect of using the peer-to-peer approach for "signal hopping" to remote users is the increase in the latency (transmission) time of communicated information. While such time delays are not important in Internet messaging or web data transfers, they can degrade the quality of voice communications if the network usage is expanded to provide VoIP telephone services.

Other network innovations related to improving the throughput performance for a given signal-to-noise ratio. Such improvements, however, would also improve the range and geographic coverage of the technology since smaller signal-to-noise ratios would be required for any defined range extending the coverage for a specified level of performance. Taken altogether, the improvements developed in extended range and geographic coverage were found to be sufficiently encouraging to permit the plan implementation effort to move on to the next phase, the deployment of a trial network.

Chapter IV

The Wayne Trial Network

INTRODUCTION

The new, longer range wireless communications technology developed for the implementation of the regional community-based wireless plan required testing on a small scale with actual users prior to an investment in a full-scale deployment. While useful in confirming the radio propagation-based modeling plan, even field testing did not completely evaluate the effectiveness of the technology in an operating environment.

To evaluate the technology in actual system operation, a single access point was installed in the southeast quadrant of the Town of Wayne in September 2007 to provide Internet services to three pilot subscribers. This access point, shown on both Maps 1 and 2, is located on Beechnut Drive east of County Trunk Highway W. The access point antenna/transceiver/router equipment was mounted on a WE Energies electric power pole at a height of 22 feet as illustrated in Figure 2. As previously described, each access point has a three-sector configuration with three antennas, each covering a 120 degree sector.

The three initial pilot users were located north, southeast and east-southeast of the access points at distances up to 2 miles. The southeast subscriber represented the greatest challenge with the longest range and significant forested interference. The other two users were essentially line of sight with only minor attenuations due to trees or buildings. All three users experienced symmetric data rate throughput in the 10 to 15 megabits per second range. One of the three users, a small business user, was able to make use of these higher data rates particularly for large file transfers. A user family with young children also challenged the network with large movie downloads. Two of the three users had previous experience with wireless communications service providers employing the Motorola Canopy System. Canopy typically operates in the 900 MHz frequency band where bandwidth is more limited and data rates much slower, in the range of 2 megabits per second. All three users commented on the increased speed of the new broadband network.

Network reliability exceeded the highest expectations. During the six month trial period from September 2007 through February 2008, there was only one extended network outage. It occurred in January 2008 and was the result of moisture entering the transceiver/router enclosure and disrupting the power-over-ethernet power supply. The enclosure was quickly replaced, and no further outages took place during the trial period.

One of the important tools used in the trial period was the Air Magnet network monitoring system. This system employs sensors that measure network traffic and, in conjunction with a software package, deliver a wide range of operational data to a server located at a central control center. With network monitoring, it is possible to identify a fault location from central control and rapidly respond to network outages. It is also possible to collect data on network performance and identify potential bottlenecks in the system. Centralized network monitoring is the key to effective and efficient network management.

Figure 2

ORIGINAL SOUTHEAST ACCESS POINT EQUIPMENT

Source: SEWRPC.

The success of the Wayne trial network was later confirmed by the fact that all three of the trial users provided enthusiastic support at Town Board meetings related to obtaining conditional use permits for sites involved in the full-scale deployment.

Chapter V

THE WAYNE BROADBAND MARKET AND BUSINESS MODEL

INTRODUCTION

A major concern in the Town of Wayne broadband wireless network deployment was the viability of this market for broadband communications services. Whether a town of only 830 households scattered over 36 square miles could economically support such a network was an unanswered question. Ultimately, the viability of any broadband service would depend on the "take rate," defined as the percentage of the households in an area that subscribe to the service. To answer this important question, the Town conducted a mail survey to estimate the expected take rate for the proposed broadband wireless services.

The survey was sent out to all 830 resident households within the Town, and returned by 221 households representing 27 percent of Town households. Regarding the take rate, 100 of the respondents (45 percent) expressed a willingness to sign up immediately. Another 45 respondents (20 percent) offered to sign up during the first 12 months. The overall estimated take rate of the respondent households then totaled 145 out of 221, or 66 percent.

Preliminary breakeven analysis indicated that the Town of Wayne by itself, with about 548 potential user households at a 66 percent take rate, might not provide for a sustainable broadband wireless business operation. The addition of the adjoining Town of Addison, however, with 1,328 resident households might make the provision of service economically viable. Assuming the same 66 percent take rate as in Wayne, the estimated customer base would be expanded by 877 households to a total of 1,425 households. Based on estimated fixed expenses of $12,500 per month, variable costs per user of $5 per month, and a service fee of $40 per month for each user, a breakeven take rate of about 358 households can be calculated. These fixed expenses, however, cover only required operating expenses such as the Internet fiber gateway connection, a customer service person, a network technician, and some sales/marketing and administrative expenses. This level of fixed expenses does not cover the general and administrative expenses that support a full-scale business enterprise. Covering such an expanded level of expense would raise monthly fixed expenses to about $30,000 per month. Such an expense level would increase the breakeven customer base to about 858. Since competition exists from satellite and other fixed essential wireless service providers, a 100 percent market share is not achievable. Assuming a 40 percent market share, the Wayne-Addison market would provide a potential user base of 570, above the operating breakeven of 358, but far below the enterprise level of 858. Such other enterprise expenses must be supported elsewhere until the customer base is expanded sufficiently throughout rural Washington County and surrounding Dodge, Fond du Lac and Ozaukee Counties.

Such an expansion is already in the plans of the Internet Service provider (ISP) as described in the chapter that follows. The Town of Addison network is in the final planning stages, with the access point locations designated and the Town Board indicating potentially favorable action on the conditional use permit approvals. The following other Washington County rural towns are potential locations for short term network expansion:

	Civil Division	Resident Households
1.	Kewaskum (town not village)	425
2.	Barton	1,005
3.	West Bend (town not city)	2,124
4.	Hartford (town not city)	1,490
5.	Polk	1,537
6.	Jackson (town not village)	1,452
7.	Erin	1,492
8.	Richfield	4,254
	Total	13,779

Such an expansion would increase the potential market from 2,158 households to over 13,700. At this level, it would be possible to support the management, marketing, and comprehensive technical support of a profitable business enterprise.

A second wave of expansion into the rural areas of northeastern Washington County and northern Ozaukee county would also be logical. Such additional expansion would add seven more towns to the market with at least 10,000 more potential household users. A wireless telecommunications utility of this scope would fully validate the community-based wireless plan presented in SEWRPC Planning Report No. 53.

Moreover, a major expansion of the service to include voice communications is possible for the Wayne Internet Service Provider. The cost of basic telephone service from Verizon North, the current incumbent service provider, ranges from $40 to $50 per month. Expansion of the ISP offerings to include Voice over the Internet Protocol (VoIP) service could be a profitable addition for the Wayne ISP and could greatly improve the economics of the network deployment.

Chapter VI

THE WAYNE INTERNET SERVICE PROVIDER

INTRODUCTION

Having tested wireless network operation on a pilot scale and established the existence of a potentially profitable market, full-scale deployment and operation of a broadband wireless service in Washington County requires an Internet Service Provider (ISP). Because there are numerous ISP's operating in Southeastern Wisconsin and at least three operating in the Wayne area (NConnect, Netwurx and Bertram), the first approach to finding an ISP to serve the Town involved the preparation of a Request for Proposal (RFP) document that could be sent out to wireless service providers that might have an interest in providing the desired service. An RFP document was prepared by Commission staff and approved by the Town of Wayne Board. It was issued in late November 2007 and sent to five local ISPs—the three listed above and Comstar, LLC of Waukesha and Techware of Germantown. A final reply date of January 11, 2008, was listed. The deadline date passed, and no proposals were received. To understand the reasons for this lack of response, some background information on the wireless Internet service provider business is required.

Internet service providers came of age with the beginning of the commercial Internet in the 1980s. Telephone subscribers having desktop computers with an attached modem could be connected to the Internet through an ISP with the required server computers and a high speed direct Internet connection. Many ISPs were able to build up substantial customer bases of dialup customers with relatively small investments in computer equipment.

High speed broadband telecommunications services were not available on a wide-scale until the late 1990s. The advent of high speed Internet greatly changed the nature of the Internet services market. While traditional telephone and cable service providers competed previously with smaller ISPs in the dialup market, they had no particular advantage offering this service. The high speed services offered later by the major service providers, however, slowly eroded the dialup market so as to place in jeopardy the continued existence of the smaller dialup ISPs. Since all of the broadband wireline channels were controlled by telephone or cable service providers, many of the smaller ISPs moved into broadband wireless technology. Entry into this market however, required an investment much larger than the previous dialup market. In addition to an expanded set of server computers for network monitoring and other functions, an investment in the base station infrastructure was required. Prior dialup services utilized the established telephone network infrastructure with only the normal line charges. With broadband wireless, each ISP found it necessary to initially construct its own infrastructure and to expand that infrastructure as new service areas were added. Building such a wireless network with its sizable financial commitments involved the selection of an equipment manufacturer. Most ISPs selected one of the major wireless communications equipment manufacturers, such as Motorola, to protect the security of their investment.

Four of the five ISPs receiving the Wayne RFP employed the Motorola Canopy System in their networks. The fifth ISP, Comstar, currently provides only dialup services and would be new to wireless communications services. Having committed to a major equipment vendor, existing wireless ISPs were reluctant to commit to a new technology even if that technology provided greater geographic coverage and much faster throughput performance. Comstar was not constrained by previous equipment commitments, but still deferred because of the required infrastructure investment.

Having failed to secure a vendor through the normal RFP process, implementation of the plan would require either:

1. A change to existing wireless technology, such as Motorola Canopy, to interest ISPs committed to that technology; or
2. Creation of a new ISP willing to endure the risks as well as reap the rewards of the new technology.

The first alternative was deemed infeasible since it would not be capable of achieving either the geographic coverage or the performance objectives of the community-based wireless plan. Compliance with the standards of this plan requires a new technology. Although challenging, the second alternative seemed to be the only choice.

A new Internet Service Provider, HierComm Networks, LLC, was incorporated in July 2008 with the initial mission of establishing the broadband wireless network in the Town of Wayne. As previously indicated in Chapter V, the new company would plan to expand throughout Washington County in order to develop a viable full-scale business enterprise. The new company was aware of the challenges inherent in providing rural broadband wireless communication services, but was committed to meeting those challenges.[1]

Under HierComm Network's direction, the Wayne Trial Network was reconstituted with some improvements in the technology that provided significantly higher throughput performance. It also instituted a deployment policy featuring wooden poles sixty feet in height in place of either higher metal towers or leasing space on electric power poles. These wooden pole structures offered lower costs and flexibility for placement that allowed for full geographic coverage in rural areas. The poles were to be placed, as necessary, on public-rights-of-way, or on easements obtained from private property owners. The cost of obtaining and installing the poles was estimated to approximate $2,000 per pole. An example access point for the southeast quadrant is shown on Figure 3.

At the time of publication of this report, HierComm Networks was initiating its first wireless broadband Internet service. An initial sign up backlog of about 40 household subscribers are scheduled to have equipment installed for immediate provision of data communications services. This first group of users are all located in the southeast quadrant of the Town. The additional four access points required to serve the remaining areas of the Town are scheduled for installation in January of 2009. All areas of the Town then will have coverage, with some prospect for spillover into surrounding towns. Based on strong expressions of interest in the remaining rural areas of Washington County, the new ISP is optimistic about its prospects for its success as a business.

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[1] *In the interest of full disclosure, the principal consultant to SEWRPC for telecommunications planning is also a principal in HierComm Networks, LLC.*

Figure 3

FINAL SOUTHEAST ACCESS POINT EQUIPMENT

Source: SEWRPC.

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Chapter VII

FINDINGS AND CONCLUSIONS FROM THE WAYNE EXPERIENCE

INTRODUCTION

Findings and conclusions from the Town of Wayne experience as a prototype for implementation of the community-based wireless plan are best considered in the following categories:

1. The Technology
    - How well did the proposed technology meet the needs of the rural and urban areas of the Region?
2. The Business Model
    - Does the plan provide a foundation for a profitable and sustainable business for a private service provider?
    - What are the critical characteristics of the business model?
3. Lessons for Regional Telecommunications Planning
    - Given the Town of Wayne experience, what changes if any should be made to the telecommunications planning process?

THE TECHNOLOGY

The amplified wireless network technology described in SEWRPC Planning Report No. 53 for the community-based wireless plan represented a significant improvement over the legacy fixed wireless currently in use in the Region. This improvement was manifested in three ways:

1. Access Point Density Reduction
The longer range capabilities of the amplified network technology reduced the number of access points needed by a factor of five vastly improving the economics of a service provider's investment.
2. Performance Improvement
The downstream and upstream performance of the system was also upgraded by a factor of five, from peaks of 2 to 3 megabits per second to 10 to15 megabits per second during the trial network period. The new technology was also symmetric, with equal upstream and downstream rates while the original technology had much slower upstream throughput rates. The data rate performance of the system further improved after the trial network period with both downstream and upstream rates exceeding 20 megabits per second. It is

important, however, to distinguish between data rates that are technically achievable versus those that are economically desirable. Bandwidth charged at the Internet gateway (in this area by Charter Communications) rises with increased throughput capability. The ISP operator, for business reasons, may choose lower throughput rates to minimize his monthly Internet connection cost to the level where he still has a competitive advantage. Throughput rates exceeding this performance level with the higher attendant gateway connection costs are not financially advisable.

3. Geographic Coverage
   The longer range capability of the technology along with the use of shorter wooden poles for access point structures in place of much taller metal towers allowed for full geographic coverage of all areas of the Town. Existing wireless service providers are limited to the metal towers currently in place since local government approvals of new towers is a costly and lengthy process. Shorter wooden poles also do not seem to have such strong citizen resistance.

All of the above advantages of the new wireless technology were experienced in Wayne, a low population density rural town. The role of this same technology in urban areas has not yet been established. Urban areas are characterized by strong saturation of broadband telecommunications markets by major telephone and cable wireline service providers. These service providers, although dominant in market share at the 97 percent level, still only provide throughput rates that peak at 5 megabit per second downstream and less than one megabits per second upstream. The wireless communications technology deployed in Wayne could logically compete well with the existing providers, but a major user education seems necessary for both local government officials and ordinary citizens. The United States, as personified by its metropolitan areas, is behind in the deployment of broadband telecommunications to the detriment of regional and local economies. In the absence of a major educational initiative on the importance of broadband telecommunications in a global economy, the commercial applications of regional broadband telecommunications plan implementation in Southeastern Wisconsin should focus on the rural areas of the Region. In these areas, the need for broadband telecommunications is well understood, so that the issues are primarily technical and economic rather than political in nature.

Overall, the technical performance of the new wireless technology and its Wayne embodiment must be considered a success. With the significant 5 to 1 reduction in access point density and the achievement of symmetric 20 megabits per second data rates, all of the original plan objectives and standards were achieved. More important perhaps than the data rate itself was the perception in the community that the service provider was committed to serve the whole town and not just profitable portions of it. And that the services provided were on the frontier of wireless communications technology. It was this perception that stimulated the town board to be proactive in supporting the successful deployment of the new technology.

THE BUSINESS MODEL

Advances in wireless communications technology have significantly improved the economics of rural broadband wireless communications networks. Despite such advances, however, developing and implementing a viable business model for a rural broadband business remains a challenge. Communications networks by their very nature are very capital intensive. Extensive infrastructure investment is required prior to the generation of any revenue. Such infrastructure investment continues as the network grows and new users are connected. The Wayne example supports the view that the time to breakeven operation for Internet Service Providers (ISP) utilizing technology may be measured in years rather than months. This breakeven time period can be shortened, of course, if larger sums of capital are available. The smaller wireless service provider will typically grow in spurts with major infrastructure investments, separated in time by “catch-up” periods needed to replenish the capital base.

Moving beyond the breakeven analysis detailed in Chapter V, the following business lessons learned in the Wayne deployment are worth consideration:

1. Voice Services
   Significant improvement in service provider profitability is possible through early introduction of voice communications (VoIP) services. Wholesale VoIP services are available on both a national or global scale at

rates as low as $7 per month per subscriber. Assuming only a small increase in monthly fixed costs from an initial $12,500 per month to $14,500 per month, a monthly service charge of an additional $30 per month would lower the breakeven from 358 to 250 users. Voice telephone services also open the way to other revenue sources, such as call waiting and caller ID, that are usually offered at additional charge.

2. <u>Community Support</u>
   Major advantages to the service provider result from cooperation with the local unit of government, in most instances the Town Board. The incumbent responsibility usually required of the service provider is full geographic coverage of the whole community area. Most ISPs are unable to provide full geographic coverage because of the restricted range and coverage of existing metal towers or other elevated structures. The ability to locate new mounting structures, such as wooden poles, provides the flexibility necessary to guarantee full coverage of most rural areas. Some of the other advantages of community cooperation can include timely approval of use permits on public right-of-way plus the favorable publicity resulting from having local government subscribers, including schools and public works departments.

3. <u>Customer Support</u>
   One of the most difficult and underestimated functions involved in wireless network operation is customer support. While most of the fixed and variable costs of wireless ISP operations are quite predictable, customer service expenses are almost always underestimated. A complicating factor in responding to subscriber service requests is that most service complaints are not the result of the wireless infrastructure and related services. First and foremost, since most service problems manifest themselves at the user's desktop computer, the computer and its supporting software is typically the number one suspect. Such a service situation places a high premium on high quality call desk personnel who are able to screen calls and avoid an unmanageable number of false alarms in maintenance service operations.

4. <u>Competent Management</u>
   Since rural and urban broadband wireless communications services are typically low profit margin enterprises, a high level of management competence is necessary for sustained profitability. While technical competence in network operations is an obvious requirement for business survival, management's ability to control expenses is often the difference between success and failure.

   HierCom Networks, LLC is a startup company launching its new network in Washington County in difficult economic times. In addition to the usual problems of any startup company, the company will be significantly limited by the unavailability of bank loans or other debt sources that typically finance communications network expansions. The year 2009 at this juncture promises to be a difficult one for expanding wireless communications service providers not from any lack of new user demand but because of the difficulty of financing network expansion in very tight credit markets.

   Credit availability aside, skilled management will be necessary to survive the startup phase and build toward a growing but stable company in the months ahead.

LESSONS FOR REGIONAL TELECOMMUNICATIONS PLANNING

The Wayne experience in the implementation of the community-based wireless plan has some important lessons for regional telecommunications planning:

1. <u>Areal Planning Unit</u>
   The Town of Wayne was selected for the pilot implementation area of the regional community-based wireless plan for reasons related to its low population density and the proactive stance of its Town Board of Supervisors. In most ways, it was a fortunate choice based on the enthusiastic response of both governmental officials and most of the citizenry to the proposed broadband wireless network. As an economically viable market for a new and independent wireless service provider, however, it was too small a market for business sustainability. A better choice from this viewpoint would have been a county such as Washington County, or a consortium of towns large enough to achieve a threshold of business profitability

for the wireless service provider. The technical demonstration of the technology might still occur at the town level, but the business model planning will have to be done at a more sustainable economic level.

2. Planning
   In traditional regional planning involving physical infrastructure, there is usually a well-defined demarcation between the planning and the subsequent engineering functions. The closest parallel is regional transportation planning where the planning function ends with the basic definition of the transportation network and the identification of the capacities required down to the arterial street and highway level. The engineering function begins with the basic network definition and develops all of the geometric and structural dimensions and traffic control movements of specific facilities proposed for construction. In telecommunications planning, the regional planning function should also end with the basic definition of the telecommunications network. Differences lie in the rapidly changing nature of telecommunications technology. The feasibility of a particular telecommunications network design critically depends on the state of technology of the various components of a telecommunications network. In the Wayne network design and deployment, deficiencies were found in the current wireless communications technology that would prevent achievement of the objectives and standards of the regional community-based wireless plan. Based on the requirements of the U.S. Department of Agriculture research and development grant which called for technological innovation to overcome technical constraints preventing universal rural broadband communications, a major effort was devoted to targeted technological innovation. The major constraint was the high density cost of access point base stations required to service a town the size of Wayne. Unless the range of these base stations could be greatly extended, the standards of the regional community-based wireless plan would not be economically achievable. Innovation primarily took the form of developing amplified signal levels at both the access point and the user end of the wireless communications channel. High gain antennas and high gain amplifiers at both ends increased the signal-to-noise ratio (SNR) the critical parameter in channel throughput. Higher SNRs allowed for longer propagation distances for the same level of throughput performance. The end result was a lower access point density and a more cost effective communications system. Future telecommunications planning efforts must be cognizant of the state of communications technology and its future direction. Otherwise, the plan becomes obsolete before it can be implemented. In fact, effective telecommunications planning must look beyond the current state of technology and build into the plan a natural evolution to higher performance 5, 10, and 15 years down the line. Contrary to the popular view, such extensions and augmentations of the future network are possible and should be incorporated into the planning program.

3. Network Architectural Design
   Although telecommunications planning is multi-faceted and provides a wide variety of information useful to telecommunications service providers, the primary output of the planning process is the communications network design. For this reason, much of the value of the planning effort is incorporated in this network design. In telecommunications networks, such value can be considerably enhanced by more imaginative network architectures. The tendency, particularly in wireless network architecture, is to fixate on one network architecture such as the cellular network architecture used in all mobile wireless networks. Needed is a more expansive design viewpoint that allows for a mixed architecture that adapts to the rural or urban terrain and its associated market. Because of the wide variation in both terrain and rural/urbanized land use, the most appropriate wireless network architecture will vary throughout the region. In recognition of this situation, multiple network designs should be prepared for future telecommunications planning. These design examples should attempt to illustrate the wide variety of feasible network structures that can adapt to the local environment.