Broadcast Signal Lab

The State of Wireless Facilities On Lower Cape Cod

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Introduction

Wireless telecommunications antenna installations present a planning challenge to communities. Cape Cod is particularly sensitive to the proliferation of antennas and towers due to a number of factors:

The land consists of relatively low elevations, such that antenna structures can appear to dominate the surrounding terrain.
There is a high ratio of coastline to land area, creating many sweeping panoramic views.
Sight lines are often long and unobstructed by terrain allowing prominent structures to be visible over long distances.
Cape Cod's scenic nature is an asset to the region's quality of life and its economy.

Further, the sensitivity of the Lower Cape is amplified by several conditions:

The land of the Lower Cape is particularly narrow.
One major road, the Mid-Cape Highway (Route 6), links the communities.
A large portion of the Lower Cape is protected as designated National Seashore under the aegis of the National Park Service.

As a result of these conditions, municipalities of Lower Cape Cod may benefit from planning jointly to control future wireless installations. The federal Telecommunications Act of 1996 specifies that governmental entities must not prohibit the provision of wireless services nor unreasonably discriminate among providers of similar services. Numerous wireless installations have been proposed on the Lower Cape. Some are in service, some are in process, and some are defunct due to denial or withdrawal. It is clear that the wireless companies intend to provide additional coverage on the Lower Cape.
The Lower Cape Wireless Working Group (LCWWG), consisting of representatives from eight towns, the Cape Cod Commission, and the Cape Cod National Seashore, was formed to address wireless facility siting issues on the Lower Cape. The towns are Provincetown, Truro, Wellfleet, Eastham, Orleans, Brewster, Harwich, and Chatham. The Cape Cod Commission (CCC) is a county agency with regulatory responsibilities for the fifteen Cape towns[1]. The Cape Cod National Seashore (CCNS) is under the jurisdiction of the National Park Service, a federal agency. The LCWWG consisted of the following representatives:

Roland W. Breault, Jr.	- Town Administrator, Truro
Catherine Laurent	- Assistant Town Planner, Chatham
George Meservey	- Planning Director, Orleans
Judith Oset	- Director Regulatory Management, Provincetown
Rex Peterson	- Town Planner, Eastham
David Rego	- Planning Board, Wellfleet

[1] The CCNS has developed a classification scheme for describing sensitive areas, which is summarized in Appendix 3. The CCC developed a model bylaw that was used by many Cape Cod towns to guide their bylaw creation processes, as well as a set of Siting Criteria to aid in the evaluation of prospective sites.

Elizabeth Taylor	- Planning Board, Brewster
Robert Widegren	- Planning Board, Harwich
Maria Burks	- Superintendent, Cape Cod National Seashore
Sharon Rooney	- Sr. Regulatory Planner, Cape Cod Commission

The LCWWG takes a regional view of the potential impacts of wireless facilities in a manner that spans administrative boundaries while remaining sensitive to local preferences. The group's goal is to cooperatively direct the siting of wireless facilities on the Lower Cape while minimizing their scenic and environmental impacts.

To accomplish its goal, the Working Group determined that the present and future needs of the wireless industry should be identified. The Working Group could then use this information to coordinate an effective plan for controlling future wireless installations. With pooled funds, the CCC issued a request for proposals for a wireless telecommunications expert to assist in this process.

Broadcast Signal Lab, LLP was selected to provide the necessary services. See Appendix 6 for Request for Proposals and Broadcast Signal Lab (BSL) Proposal. BSL helped the Working Group develop a plan to identify the state of each major wireless company's network build-out on the Lower Cape. At the same time, the plan called for BSL to canvass stakeholders in the LCWWG for their particular issues and concerns about wireless facility placement.

The requirements of each carrier were mapped to identify areas where one or more carriers are expected to need additional facilities. These areas will be the focus of planning efforts by the LCWWG. The collaborative planning process will develop options for honoring the preferences of the communities, the CCC, and the CCNS while respecting the requirements of the Telecommunications Act.

This report presents our findings on the coverage and facilities needs of the wireless carriers. It identifies locations of greatest concern and recommends next-steps that the stakeholders might take to protect the Lower Cape from haphazard wireless facility development. See Appendix 7 for minutes of meetings held by the Wireless Working Group.

The facts that were accumulated for this report present somewhat of a "moving target" for the authors and the reader. Wireless facilities have been approved and denied by some Lower Cape localities during this process. Some facilities have been constructed and some legal actions have been concluded. Therefore, this analysis should be considered in terms of the general areas of interest and the general conclusions it offers. This document should not be considered a comprehensive inventory of wireless facilities on Lower Cape Cod.

Wireless Facility Development on the Lower Cape

Our efforts to obtain wireless facility information were focused on the six wireless carriers presently building facilities on the Cape:

Cellular
- Verizon Wireless, previously Bell Atlantic Mobile Systems
- Cellular One (a unit of Southwestern Bell Corp)

PCS (Personal Communications Services)
- Omnipoint
- Sprint Spectrum Wireless
- Telecorp (an affiliate of AT&T Wireless)

ESMR (Enhanced Specialized Mobile Radio)
- Nextel

Other types of services, such as paging, also qualify as personal wireless services. These services may require fewer facilities and fewer antennas per site by employing existing tall towers, however new two-way paging services may require a "cellular" approach with low-profile facilities on poles, rooftops, and smaller existing towers.

Each Personal Wireless Service company listed above participated in an information gathering session with a Broadcast Signal Lab representative. The table in Appendix 1 describes the current state of each wireless carrier's network on the Lower Cape. The table contains a column for each carrier. The rows designate specific wireless sites, or areas lacking coverage for one or more carriers. The rows start with Provincetown and subsequent rows mark locations proceeding south along Route 6 to the Dennis line. *Italics* indicate present lack of service.

In addition there is a plethora of other services utilizing the radio spectrum on the Lower Cape today, and plenty more new technologies are being developed. This report focuses on those facilities that are placing the most pressure on wireless facility development at this time. In addition to two-way paging mentioned above, we can expect other new technologies to be deployed in the coming years. Among them are wireless wide area networks (such as Metricom's Ricochet service with a "shoebox" technology mounted on lampposts), and new internet and video distribution systems employing MMDS (Multichannel Multipoint Distribution System) and LMDS (Local Multipoint Distribution System) bands.

Glossary of Common Wireless Communications Terms for Planners

A. ABOVE GROUND LEVEL (AGL) : A measurement of height from the natural grade of a site to a position above that grade level. Height above ground level is often reported for such things as: *structure height* (top of the structure without considering attachments to it), or *structure with appurtenances* (such as antennas, lightning rods or lights; also known as *overall height*), *antenna height* (top of the antenna), *antenna center* (vertical or electrical center of the antenna).

B. ACT: The Federal Telecommunications Act of 1996.

C. ANTENNA: A device by which electromagnetic waves are emitted or received

D. ANTENNA SUPPORT STRUCTURE: The structure upon which antennas are mounted, including the following four types of mounting configurations:

1. Roof-mount. A structure attached to a building roof to which antennas are mounted.
2. Side-mount. A structure attached to the side or other non-roof portion of a building to which antennas are mounted.
3. Ground-mount. A structure anchored into the ground to which antennas are mounted. Ground mounts include purpose-built structures such as poles, bases, posts, monopoles, and towers.
4. Structure-mount. A structure attached to a structure other than a building to which antennas are mounted.

In the absence of a separate structural component to hold an antenna, the antenna shall be considered to be its own ground, roof, side or structure mount.

A building is not an antenna support structure.

E. BAND: A segment of the radio frequency spectrum which is assigned a particular purpose or has a particular characteristic. Cellular telephones operate on the cellular band of frequencies. The cellular band of frequencies is divided in half, cellular bands “A” and “B” and licensed to two carriers in a geographical area.

F. CAMOUFLAGE: A wireless service facility or its components are CAMOUFLAGED when they are either A) disguised, painted or colored to blend in, or B) are hidden by a purpose-built decoy that is attached to a structure, or C) made to resemble an architectural feature of the building or structure on which it is placed. While some forms of camouflage literally conceal equipment, the meaning of the word CONCEAL is reserved here for another purpose. A false chimney added to a roof may CAMOUFLAGE a wireless antenna array inside it. Antennas mounted on the surface of a real chimney may be CAMOUFLAGED by painting them the same color as the chimney.

G. CARRIER: A company that provides wireless services for hire. A carrier may provide personal wireless services or other types of services. Synonymous with PROVIDER.

H. CHANNEL: A segment of the radio frequency spectrum in which a transmitter transmits a radio frequency signal. A band of radio frequencies may contain one or more channels.

I. CO-LOCATION: The practice of installing the antennas of more than one communications facility on one structure.

J. CONCEAL: A wireless service facility or components of it are CONCEALED when they are fully enclosed within parts of a building or other structure, which structure was built for another purpose, and those components are not visible from outside the structure. A church steeple may CONCEAL wireless antennas and cables by installing them inside the steeple. The CONCEALMENT may require making changes to the finish materials of the steeple such that the steeple still looks normal, but the materials are more transparent to radio transmissions.

K. EQUIPMENT SHELTER: An enclosed structure, cabinet, shed or box built to house radio frequency communications equipment and related gear such as batteries, generators and electrical equipment.

L. FACILITY SITE: A lot or parcel, or any part thereof, that is owned or leased by one or more wireless service providers and upon which one or more wireless service facility(s) are located.

M. MONOPOLE: A single, self-supporting vertical pole with no guy wires, usually constructed of metal, and hollow such that the antenna cables are concealed within the structure.

N. PERSONAL WIRELESS SERVICE CARRIER (PROVIDER): An entity licensed by the FCC to provide personal wireless services to individuals, businesses or institutions.

O. PERSONAL WIRELESS SERVICES: Services defined by the Telecommunications Act of 1996 that are granted certain legal protections in the local siting processes. These services include certain commercial mobile radio services, unlicensed wireless services, and common carrier wireless exchange services, as defined in the ACT. These services include, but are not limited to, cellular services, personal communication services (PCS), specialized mobile radio services and paging services.

P. RADIOFREQUENCY Energy (RFE): Electromagnetic energy in the frequency range from 3 kHz to 300 GHz.

Q. TOWER: An antenna support structure that is significantly taller than it is wide, that projects considerably above the ground or structure to which it is attached, and is built for the purpose of attaching antennas and related equipment. A TOWER may be mounted on the ground or be attached to a building or other structure. Local preference may define what distinguishes a mast from a tower.

A mast may be limited to, say, three inches across and/or twelve feet in height before it qualifies as a tower.

R. WIRELESS: An adjective referring to the use of electromagnetic energy to communicate between two or more points. In the context of planning and zoning matters, the term refers to the use of radio frequency electromagnetic energy.

S. WIRELESS COMMUNICATIONS FACILITY: A complete system operated by one entity on one communications service that is installed at one site. The system contains antennas, interconnecting cables, transmission and/or reception equipment, and related equipment for the purpose of supporting wireless communications.

T. WIRELESS SERVICE PROVIDER: An entity employing the radio frequency spectrum to provide wireless services to individuals, businesses or institutions. The entity may or may not hold an FCC license to operate.

Bylaw Comparison and Evaluation

Bylaw Comparison

In addition to meeting with representatives of each community of the Working Group, we reviewed their respective bylaws to enhance our understanding of community priorities. In appendix 2 we present a table comparing the main attributes of each town's wireless bylaw.

Towns followed one of two fundamental regulatory routes in developing their bylaws. Either they chose to regulate communications and/or communications structures as a broad class of use, or they chose to target Personal Wireless Communications specifically.

The federal Telecommunications Act of 1996 permits municipalities to regulate the placement of Personal Wireless Facilities as long as their actions do not have the effect of prohibiting wireless service or of unreasonably discriminating among carriers of equivalent services.[2] Some towns elected to specifically address the Act with bylaws specific to the Personal Wireless Services. Other towns saw it as an opportunity to manage the growth of all radio communications, and more importantly, all communications structures, whether or not they are for personal wireless services.

Unintended Consequences

The "law of unintended consequences" can apply in both cases.

Flaws in Regulations Covering All Communications Facilities

First, communities that have opted to regulate all, or nearly all, communications facilities may inadvertently over-regulate other types of services.

Eastham, for instance, exempts "business band" communications from its regulations[3]. It is not clear what services were intended to be exempt. Presumably, local companies using two-way radio or point-to-point radios on business or industrial frequencies are allowed to install what they require to accomplish their goals. However, other licensed or unlicensed services, such as scientific, broadcast, or common carrier (not personal wireless), are subject to the same rules as the Personal Wireless Services. In fact, Eastham's regulations, like many of the others of its kind, intermingles evaluation criteria and language that relate specifically to Personal Wireless Services, such as the terms "carrier" and "adjacent service areas," in regulations that intend to deal with communications in general. Therefore the Eastham regulations remain unclear on how to manage facilities that are not Personal Wireless Services.

[2] See Appendix 4 for details on the wording of the Act.

[3] Note that among the municipalities on the lower Cape, Eastham is alone in having a wireless regulation promulgated by its Planning Board. The other communities adopted wireless bylaws by way of public vote at Town Meetings.

Use of the broadcast spectrum is similarly unclear in many of the bylaws. For example, while Eastham allows a "home TV antenna," other communities allow TV antennas with no specification as to whether they are transmit or receive antennas. Arguably, in some communities a person technically is prohibited from installing an antenna just to receive AM, FM or short-wave broadcasts. By the same rule, if a TV station were licensed to *transmit* in the area, some bylaws inadvertently permit the TV broadcast station, but not an FM broadcast station, by permitting "TV antennas."

Another factor to consider in the bylaws is the definition of which types of emissions are to be regulated. Truro classifies all electromagnetic radiation into its definition of communication, with the exception of visible light. Though it may appear a mere technicality, this bylaw includes, for example, anything that emits radiant heat (infrared energy) or black light (ultraviolet). The Truro classification also includes *any* use of the radio spectrum that requires an antenna to transmit or receive a signal. Only amateur radio and TV antennas are exempted. Technically, a garage door opener or a cordless phone wall unit are attached to a structure and should be reviewed under this bylaw.

Wellfleet has similar rules, but even failed to exempt visible light. By this regulation, every outdoor light fixture must be approved by the permit authority.

The effectiveness of bylaws is diminished when they have broad or vague definitions. While common sense dictates that the bylaw should not apply to some ordinary electromagnetic emissions, citizens are put in an untenable position when adherence to the letter of the law would swamp the Town with trivial applications. Rather than encouraging citizens to selectively ignore certain uses that are regulated by a literal reading of the bylaw, the bylaw should be rewritten to more precisely describe what is and is not regulated.

We therefore recommend that those communities, which regulate communications in the generic sense, spend some time thinking about the panoply of radio communications services and tighten up their bylaws to make their intentions crystal clear. Does the community welcome CB radios or short wave enthusiasts who are not amateur operators? How does the community feel about AM or FM or TV broadcasting? Does the community intend more flexibility for radio stations than for Personal Wireless Services (as is the case in Provincetown)? Are the bylaws intended to limit height, antenna size, or other visibility factors, or is there a desire on the part of the community to limit development or certain kinds of enterprises by limiting their communications?

Flaws in Regulations Covering Personal Wireless Services

Secondly, rather than regulating communications, the remaining communities employ a class of bylaws that specifically addresses only Personal Wireless Services to the exclusion of any mention of others. This may inadvertently eliminate permission for other uses of the radio spectrum, or to the contrary, it may give other communications systems *carte blanche*, depending on how the bylaws are constructed. These towns

should also examine their intentions in light of the variety of other types of communications that presently exist.

All communities should take this opportunity to tune up local bylaws to prevent unintended consequences.

Future Need for Low Intensity Facilities

In addition to the unintended consequences resulting from the definitions contained in wireless bylaws, there is the matter of anticipating the future developments among the Personal Wireless Services, among others. We make a distinction, albeit somewhat arbitrary, between full-scale wireless facilities and low-intensity wireless facilities.

Full-scale facilities are those which typically have the following characteristics:

- They employ relatively high antennas to serve a radius of at least a mile,
- They employ sectorization
- The coverage area is broken into three or more pie-shaped segments.
  - Separate directional antennas serve each sector from the one site.
  - In some cases, considerable land and/or floor space is required to support the operation of the facility;
- Often, new utilities or infrastructure such as driveways, towers, power lines or fencing, must be installed to support the facility.

In contrast, our image of low-intensity facilities consists of:

- Antennas that are attached to existing structures, or
- Antennas that are attached to small poles or masts of little visual consequence,
  - Antennas are either disguised, totally hidden, or of low visual profile;
- Fewer antennas, sometimes, than in full-scale facilities;
- Coverage areas that would typically be a mile or less in radius;
- Signal power levels that are somewhat lower than those of full-scale facilities;
- Opportunistic use of existing infrastructure,
  - Basements, attics or small building-side concrete pads for equipment,
  - Existing electrical and telco lines employed or upgraded,

The above classifications do not precisely apply to every wireless facility. A facility may or may not have each of the characteristics corresponding to one of the two classes. Also, the characteristics of a facility may fall in both categories. However, the general concept of smaller and less equipment-intensive facilities is important in making planning distinctions.

Harwich Accommodates Low Intensity Facilities

The town of Harwich, for example, augments its wireless overlay districts with a general allowance for short, low-intensity facilities throughout the town.

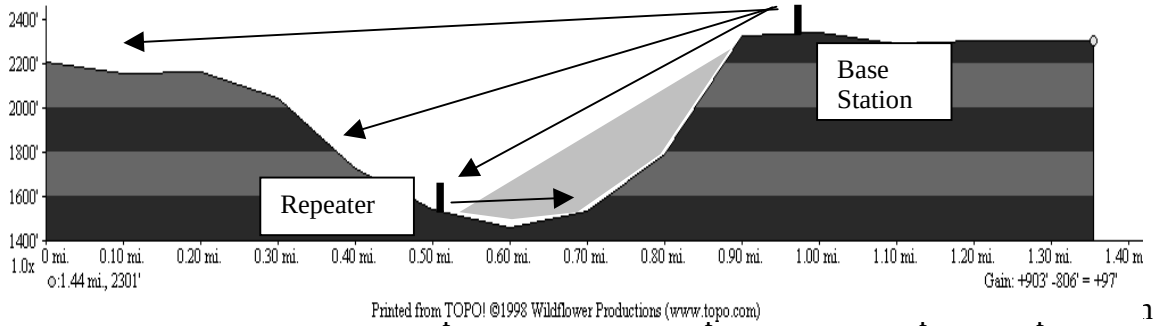
Unlike Harwich's two-prong regulation, some other communities simply limit wireless facilities to certain lots or districts, with no provision for low-intensity installations in other parts of town.

Provincetown Gives an Appearance of Accommodating Low Intensity Facilities

Provincetown's bylaw makes a small, but curious, allowance only for repeaters. The intent of the allowance seems to be to permit low power systems with low profile antennas in more locations than a standard wireless facility. On first impression, this appears reasonable, until one observes that the repeaters still have a large 200-foot setback from dwellings and a *minimum* height of 35 feet. Further, the selection of only repeaters for low-intensity installations is impractical.

Repeaters are a class of communications facility with a very specialized function. In a region where terrain causes abrupt loss of signal in the midst of otherwise reasonable coverage, a repeater can be employed. The repeater must have a link to the main base station providing service to the area and it must repeat these signals to the area where the abrupt loss of signal occurs. This condition occurs in rough terrain, such as mountains or canyons, where the signal loss is truly abrupt and there is a need to cost-effectively provide fill-in service to the weak area.

In the illustration below there is a wireless base station on the hill to the right. If the image were wider, the rest of the terrain to the left and right of the image would be at about the same elevation as that of the base station. The dip in the middle is a steep valley or canyon cutting through the area. Inside the valley the signal is blocked by terrain, as shown by the gray polygon and the signal arrows. Let us say there is a highway or a community in this void where the radio signals do not reach. Yet, on the high ground of the opposite side of the valley, the signal is still suitable because it is still close enough to the base station to receive a strong and direct signal.



a location where it can pick up the signal from the base station. It receives the signal on one antenna high above the ground, amplifies it, and repeats it on a second antenna closer to the ground. The repeater transmits the received signal on the same frequency it is received. Thus, the receive antenna and the transmit antenna must be separated from each other. Otherwise the repeater will not be able to "hear" the base station and will uselessly transmit to itself. To avoid this, two conditions are usually required: 1) the receive antenna must be quite high to intercept the base station signal instead of the repeated signal, and 2) the transmit antenna must be isolated by distance and/or by an obstacle from the receive antenna.

Consider how the nature of repeaters relates to their use in Provincetown: First, there must be a significant terrain blockage to make repeater use practical. Second, the receive antenna will have to be quite high and the transmit antenna quite low in order to isolate one from the other.

These conditions render the use of repeaters irrelevant to Provincetown. Therefore, in spite of the seemingly generous allowance for repeaters in the bylaw, to the exclusion of other low-intensity alternatives, wireless carriers are given no low-intensity alternatives for addressing signal strength issues in Provincetown.

Other Limitations to Low Intensity Facilities: Wellfleet

Other communities have permitted their bylaws to contain similar obstacles to low-intensity wireless facilities. Wellfleet precludes communications structures and buildings from its Central District and the Harbor Area of Critical Concern (HACC) and communications appurtenances from the HACC. Here are some possible unintended consequences that could result from this regulation:

- New installations for communications between town offices or for emergency services would not be permitted in sheds or additions in the Central District or Harbor Area.
- Scientific, environmental, or marine communications systems that might be reasonably operate in the Harbor Area are prohibited.
- Business communications that might reasonably be installed in a shed, on a pad, or in an addition are prohibited in the Central District, even if the antennas are properly concealed.
- Personal wireless communications sheds, pads, or additions to fill in coverage or to increase peak capacity at busy locations are prohibited in the Central District, even if the antennas are properly concealed.

Clarity of Definitions

Some bylaws lump any and all hardware related to wireless communications into the classification of a wireless facility. This is appropriate in regulating use by district. However, it can become unclear when making distinctions between allowed tower heights in districts versus allowed antenna heights on existing structures in the same districts.

Harwich, for example, limits the heights of facilities based upon districts. However, there may be circumstances in which an existing structure could appropriately host a facility above the district's allowed height.

In our experience, we have found that the term "facility" is often confused with the tower that sometimes supports part of a wireless facility. Bylaws should distinguish between communications facilities, communications buildings, and antenna support structures.

Facilities would include antennas, cables, transmitters, power supplies, and the like required to provide the communications for one company on one service or network.

Antenna support structures are structures such as towers, masts, poles, mounting brackets and the like that are specifically installed to support antennas. This definition leaves out other types of structure, such as steeples, buildings, smokestacks and such structures designed and installed for other purposes. These would simply be considered pre-existing structures.

Thus, a water tower is not an antenna support structure. However, a wireless tower designed to look like a lookout tower or a water tower, but built for the purpose of supporting wireless antennas, would be an antenna support structure.

Finally, a communications building would be a building built primarily for the purpose of housing communications equipment.

When possible, bylaws should be improved with these more clearly defined terms. Because there can be different siting criteria for antennas, antenna support structures and communications accessory buildings, the use of these separate terms in regulating wireless communications avoids ambiguity and unintended consequences.

Use of Conventional Technical Standards

In the drafting of bylaws, it is common for bylaw committees to state their preferences for technical compliance in non-technical terms. For instance, some bylaws call for towers to withstand certain wind speeds. The science of structural engineering and maximum wind speed prediction is not based on a single maximum wind speed, but a more complex assessment based on wind speed, elevation, and location. Hence a statement, such as that found in the Brewster bylaw, "…withstand a minimum wind loading of 150 MPH," is not in terms that a structural engineer would use.

It is more appropriate to refer to a specific hurricane category, as some of the bylaws do. However, the sciences of structural engineering and meteorology are constantly changing, and refinements to structural standards are regularly made. A specific standards organization might be mentioned, such as the Electronics Industry Association, or its applicable standard EIA/TIA 222. However, this standard, which has been in place for many years, is on its Revision G! As more detail is put into a bylaw, its probability of becoming outdated increases.

The best approach in requiring a facility to be safe and secure is to refer to "industry standards and construction codes applicable at the time of construction." We recommend that bylaws be worded to simply refer to applicable standards in disciplines where the bylaw drafters wish to explicitly call attention to them. Such disciplines include structural engineering, radio frequency safety, and safety of navigable airspace. Bylaws can require documentation from the appropriate engineers and/or evidence of approval by regulatory agencies such as the Federal Aviation Administration or the Massachusetts Department of Public Health.

Because system designs often change during the application process, is it appropriate to require an applicant to submit relevant documentation to the Code Enforcement Officer for final approval prior to issuance of a Building Permit.

Analysis of the State of Wireless Development On Lower Cape Cod

Analysis of the State of Wireless Development On Lower Cape Cod

- **Methodology**

In developing our analysis of the carriers' coverage, we studied the available information on both current and proposed antenna sites, their heights, and the coverage obtained from them. We utilized data supplied by the carriers, including propagation prediction models and some actual drive test data. We identified areas that we characterize as being of critical coverage concern. This classification describes areas where a majority of carriers have a service void and no clear alternatives. We also identified areas of some coverage concern, in which more than one carrier may require additional facilities in the future.

It must be emphasized that areas where service is marginal, but functional, for a carrier were ignored in this analysis. Similarly, areas where there may be pockets of no service, the size or locations of which are not material to the provision of wireless service, were excluded from our analysis. Thus, we boiled down the information to provide an indication of the key areas where wireless subscribers lack service and therefore where wireless carriers might demand access to their subscribers.

- **General Observations**

In general, the wireless carriers are steadily building along the Cape toward Provincetown. Some are actively pursuing sites further out on the Cape, while others are waiting for their corporate machinery to give them a green light in certain locales.

In our information gathering sessions, the general concerns of the carriers were focused on completing their first priority, the provision of relatively continuous service on the major traffic routes of the Lower Cape. When asked, they expressed interest in providing adequate service to the major centers of activity that are not on the main roads, such as beaches and parkland. However, even at sites where thousands of people may go on a summer day, the carriers present no coherent vision of what the carriers will need. We believe this is due to their immediate focus on the major thoroughfares. As this coverage is completed, and as the number of wireless phone users increases, we expect that there will be interest in providing facilities, possibly microcells, at major recreational areas that are not otherwise served. The ocean-side beaches of the National Seashore are shielded from wireless signals by steep bluffs and are likely locations where consumers may wish to receive wireless services.

<u>Areas of Critical Coverage Concern</u>

Some locations are problematic for all carriers. In any location where there is no provision of service, there may be a question about compliance with the Telecommunications Act. It is these areas about which are we are most concerned. In order to obtain coverage in a key area, a company may make an application for a facility that is undesirable for the town. However, if the town has created no mutually acceptable

alternatives for the applicant to pursue, the applicant may prevail in court with its undesirable proposal.

Areas of critical coverage concern are those in which most or all carriers indicate an inability to provide service:

Provincetown
Wellfleet, especially the town center and the north.
Harwich from Route 137 to Route 28 to Bank St

Areas of Some Concern

Some locations are problematic for only a few carriers, or are of marginal serviceability for a number of carriers. The Areas of Some Concern are:

Southern Truro, depending on how Wellfleet coverage is obtained.
Southern Eastham and north of the Orleans rotary.
Northern Orleans east of Town Cove (related to southern Eastham concern).

Areas in which to Expect Activity

The areas in which to expect activity are those where one or more carriers have substantial coverage requirements, but which are likely to be satisfied by facilities ushered through the regular design and application processes. These areas are:

Brewster Route 6A region.
Chatham water towers (two more carriers)

Review and Recommendations on Individual Cases

Area of Critical Concern #1: Provincetown

Review and Recommendations on Individual Cases

Area of Critical Concern #1: Provincetown

Interests of the Various Stakeholders

Provincetown's bylaw states that the intent of the bylaw is "to preserve and protect historic and scenic vistas as well as environmental, natural or man-made resources of the community…"(Article X, §10010) Clearly, this is one goal that all parties to the Lower Cape Wireless Working Group share.

The Cape Cod National Seashore has a mission to preserve its assets in the condition they were found at the time of the National Seashore's inception. The Seashore actively protects the scenic character of the areas for which it is responsible.

The Cape Cod Commission Development of Regional Impact (DRI) process emphasizes the utilization of existing structures as a key component of limiting the impact of new wireless facilities on the Cape.

Existing Structures

Provincetown hosts three water towers at two sites. Water towers are often regarded as excellent alternatives to the placement of new wireless towers in communities. Hence, we are perplexed by the fact that the Provincetown bylaw specifically excludes personal wireless services from the town water tanks. We asked two carriers' representatives to recall from memory some water tank installations in the region. Here is a list, not at all comprehensive, of some Massachusetts communities where wireless antennas are or will be mounted on water tanks:

Barnstable	Danvers	Rockport	Walpole
Bedford	Dennis	Sandwich	Wellesley Coll.
Beverly	Marion	Stoughton	Westford
Chatham	Marlborough	Sudbury	Yarmouth
Chelsea	Medfield	Tewksbury	
Cotuit	Raynham		

Narrow Mission of Water Authority Sometimes Given as Reason to Reject Antennas

In our experience working with communities, there are two reasons for avoiding water tower installations. One relates to the supremacy of the mission of public water supply infrastructure over other uses. The second relates to how water towers are sometimes close to residential areas.

On the first rationale, some believe that water towers exist solely for the public purpose of supplying water to a community. Other uses are seen as a nuisance to the primary mission of the water tower. Concerns are expressed about a range of issues relating to allowing alternative uses of water towers, including structural integrity, liability, water purity, and administrative burden.

These not-so-pretty water tank structures stand prominently on hilltops in our communities to provide a service to their residents. As evidenced by the above sampling of towns with water tower antenna installations, many communities have determined that the use of water towers for other purposes is beneficial to the community. They have successfully addressed their own concerns about the safety, legal, and administrative impacts of having wireless tenants on water towers. In short, they have found a way to safely maximize the potential of this community infrastructure to everyone's benefit.
Water lines coexist under our streets along with sewer, gas, and sometimes electric and telephone lines. The fact that our streets are shared by a variety of utilities illustrates the wisdom of employing public infrastructure for more than one purpose.

Fewer antenna towers are necessary when water towers are put to use, and communities benefit from the revenue provided by the carriers' rental fees. The Town of Medfield, for example, is using the income from its water tower tenants to pay for a large tract of open space that was recently purchased.

We note in Provincetown that radio station WOMR has antennas prominently mounted on top of one of the water towers, and the bylaw specifically exempts emergency dispatch, broadcast radio, amateur, and citizens' band radio antennas from the town's wireless regulation.

We can only conclude that
1) The Town of Provincetown is indeed willing to re-use its water towers for other purposes, and
2) The Town of Provincetown has other reasons for regulating personal wireless facilities more tightly than other forms of radio communications.

<u>Signal Level or Visibility Sometimes Given as Reasons to Reject Antennas at Certain Locations</u>

The second reason why communities shy away from water tower re-use is based on a perception that antennas should be as far away from population as possible. This distance criterion can be based on a belief that the addition of antennas on a particular water tower would be visually obtrusive. The distance criterion can also be based on a belief that radio frequency communications signal strengths are safety risks, even if compliant with federal standards.
If there were a place in a community where a new wireless tower would be less visible than antennas on a water tower, it would be sensible to state a *preference* for distantly located radio towers over a water tank installation. This approach can be successful in communities with large tracts of rolling wooded landscape where an isolated new tower may be nearly invisible to a community. Such is not the case in Provincetown. Any location in Provincetown where a prominent new structure would be located will have a significant visual impact on the town and/or the Seashore.
The other reason for encouraging antenna placements to be away from population is the perception that this will reduce the signal strength of the wireless communications in populated areas. This perception is based on the mistaken belief that the closer one is to an antenna site, the higher the signal strength one obtains.

Several factors are involved in determining the signal strength from a wireless base station at a particular location on the ground. Of course, the height of the antenna above

ground is a factor. Also a factor is whether the elevation of the ground at the base of the antenna structure is higher than much of the surrounding terrain. That is, water towers and radio towers are frequently placed on hilltops, thereby increasing their effective height above the surrounding land

However, of even more significance to the matter of evaluating wireless signal strength coming from a facility is the antenna signal pattern. As a lighthouse lens focuses light, so an antenna focuses radio waves horizontally. The ideal result of a particular combination of antenna height and antenna pattern is a signal coverage that remains fairly constant as one approaches the base of the source.

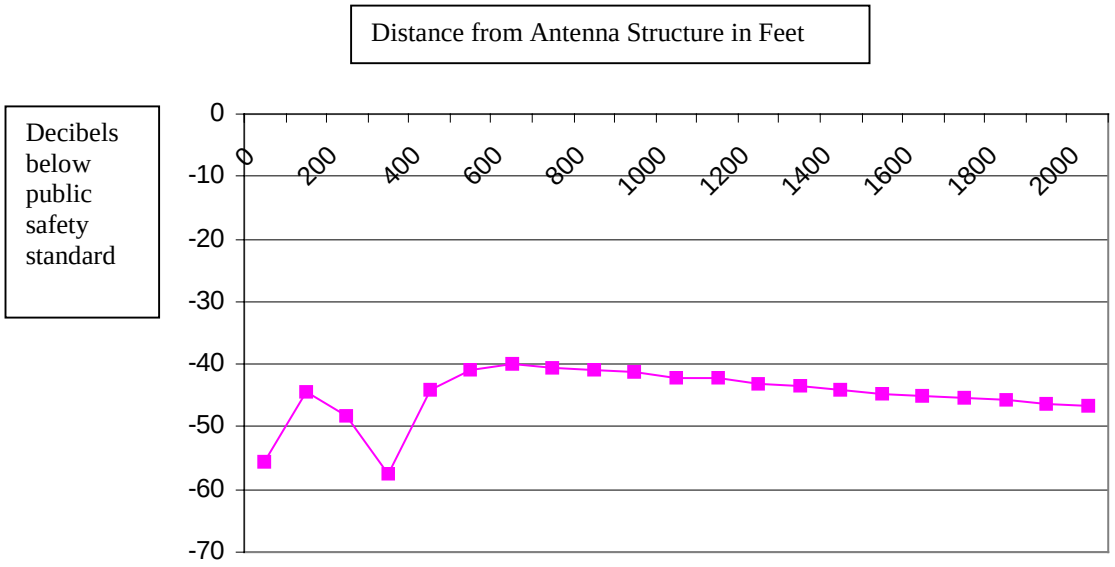
In our experience, this focusing effect of the antennas yields remarkably even signal coverage over unobstructed terrain. For example, we performed a survey of the antennas on the eight-story Carney Hospital in Boston that demonstrates this fact. Signal levels were very low, and varied in a narrow range as we moved our instruments from the base of the building to a distance of about ¼ mile (~1300 feet).

This characteristic of antennas is employed to increase the efficiency of wireless communications. By providing a more even distribution of signal energy, the cost of transmitting signals is minimized. Energy is not wasted on the nearby terrain to which the antenna is relatively close. Less powerful transmitters are employed, reducing both the capital outlay for the equipment and the recurring operating expense of the electricity. Another benefit of an efficient antenna design is that signal strengths reaching the public remain quite low, even at locations close to the base of a wireless facility.

The graph below is a simplified representation of the effect an antenna's vertical pattern has on the received signal level on the ground. For the purposes of illustration we have graphed the signal level that would be received from an active urban cell site with as many as thirty telephone conversations being carried through the antenna. We have assumed the antenna is one hundred feet above ground and that the ground is perfectly flat and has no obstructions. The horizontal scale runs from the antenna on the left to 2000 feet on the right. The vertical scale indicates the number of decibels below the public safety standard that the signal would be. Note how at the 600-foot mark the received signal is the strongest, and is four orders of magnitude lower than the safety limit (~-40 dB). Closer to the antenna tower, the signal level is comparable to the levels found at much greater distances. Farther from the tower, the signal level gradually tapers off.

It is reassuring to note that the vertical scale of decibels has a special characteristic that is often misunderstood. The –40 decibel line on the graph represents a power density level that is *ten thousand times weaker* than the safety standard at 0 decibels. Put another way, it would take ten thousand cellular companies with identical antennas on top of this one hundred foot pole to create a signal level that approaches the safety limit. Presently there are only six companies active on the Cape.

Model of Coverage from a Common Cellular Base Station Antenna
--Assumes open and perfectly level ground
--Assumes antenna is 100 feet above ground
--Assumes 30 simultaneous conversations continuously for >½ hour



The graph illustrates how one's proximity to an antenna site is not the only determinant of the signal strength received. Other wireless signals employing a different antenna, or placed at a different antenna height, or operating on a different frequency will exhibit a similar characteristic shape. However, the location of the actual minor deviations of the signal strength curve will vary depending on the specific case. In general, the signal strength at the base of a wireless facility is usually quite a bit less than that which is found hundreds of feet away

In light of this characteristic of antennas, the application of an arbitrary setback to all facilities is an ineffective way to regulate facilities. Factors other than antenna location have a significant effect upon the strength of the radio signals received from a wireless facility. The surrounding terrain, vegetation, and structures cause variations in the signal coverage. Therefore, if one does not take into account antenna design, antenna height, plus the surrounding physical conditions, one cannot predict how a particular setback will affect a facility's coverage. The Provincetown 500-foot setback therefore provides no meaningful limitation to received signal level.

Because of this lack of a singular relationship between signal strength and one's proximity to an antenna structure, it is advisable to permit the use of an existing water tower in lieu of requiring a new tower that is merely hundreds of feet away. A prominent new structure would produce essentially the same signal strengths in the community as a water tower installation while creating a new eyesore for the community.

Permissible Locations for Wireless Facilities

Provincetown's bylaw places highest priority on wireless sites that would be on National Seashore land. (§10080 M.3) Provincetown's unique topological character makes it impossible for the Seashore to permit a wireless tower on its own local land without compromising the mission of the Seashore. There is no development on local Seashore land with which new wireless towers would be compatible. In addition, the airport is inherently incompatible with a wireless tower of sufficient height to provide wireless service to Provincetown.

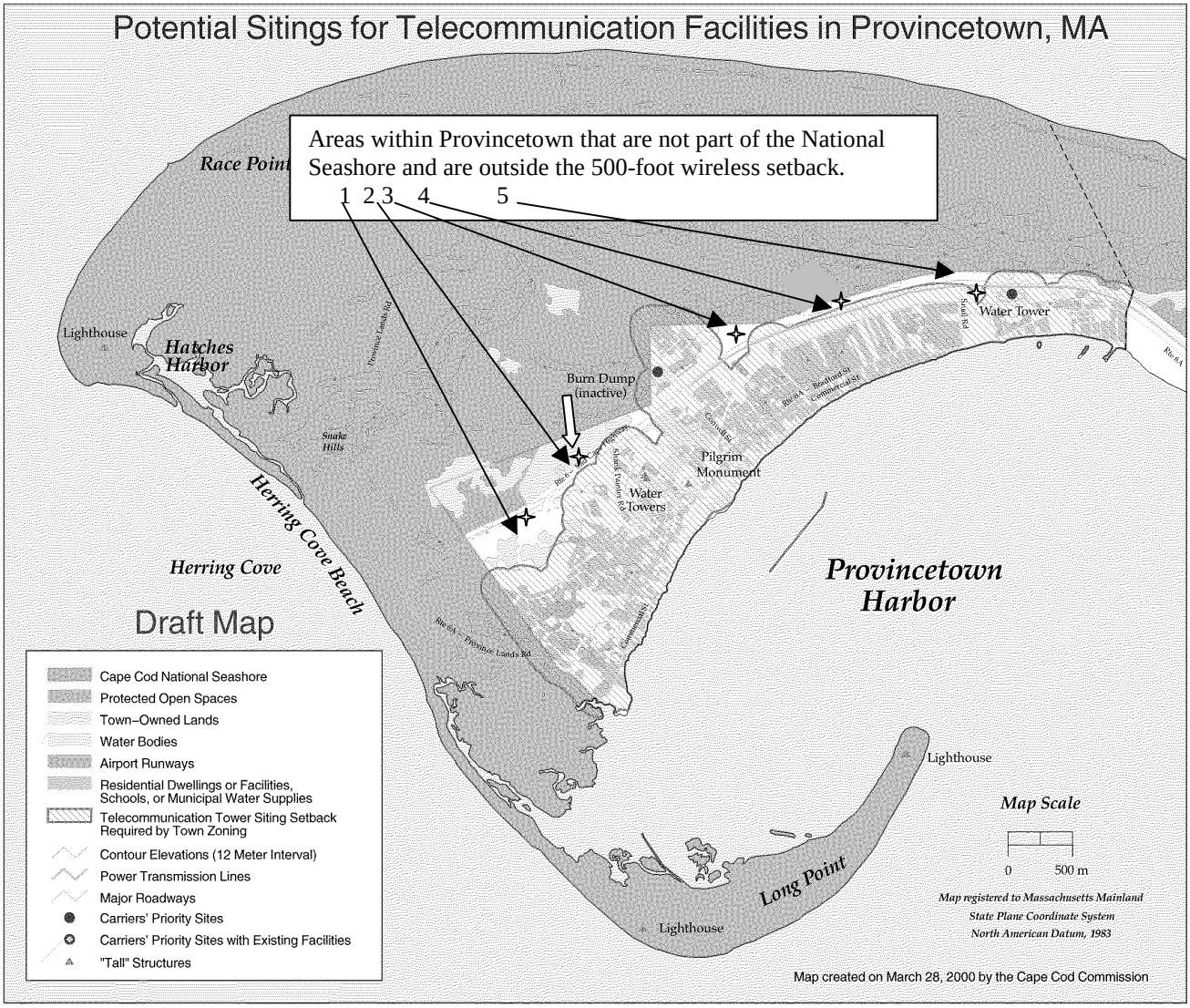
The GIS department of the CCC prepared a map that estimates the actual locations within Provincetown where wireless towers could be sited to meet the 500-foot setback requirement. A low resolution, black and white version is included below for illustration purposes.

The dark gray area covering most of the map indicates the National Seashore land. The diagonal crosshatch area over most of the area of the community of Provincetown roughly indicates a wireless exclusion zone. This crosshatch zone, which is bounded by a heavy line, indicates the 500-foot wireless facility setback from residential structures and certain other structures. Because the map utilizes the boundaries of lots containing residential or other excluded structures, rather than utilizing actual physical structures, it may slightly overestimate the land restricted from wireless development by the 500-foot setback.

Arrows on the map indicate five general areas that will be discussed below. Starbursts on the map indicate locations from which terrain profiles were modeled.

The five general areas marked on the map above are referred to as "Permissible Areas." Below, each Permissible Area is described and terrain profile maps are presented to illustrate potential visibility and signal obstructions. The left ends of the profiles are marked with a vertical line representing an 80-foot tower for illustration purposes.

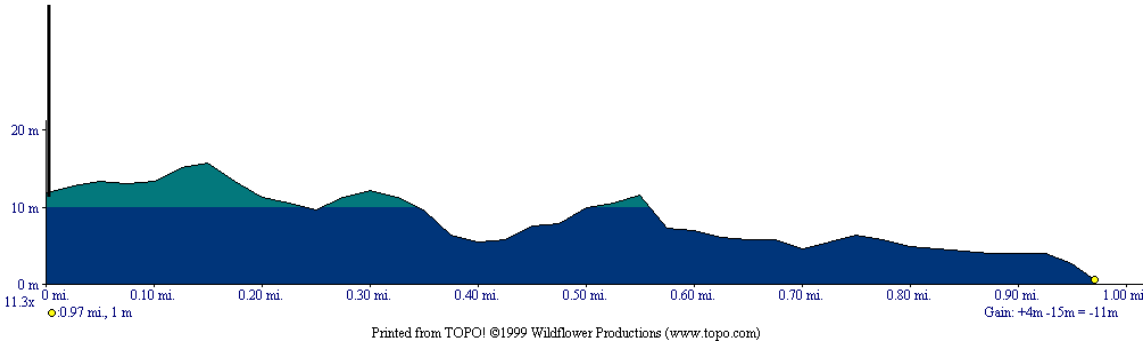
To eliminate tower beacons, the heights of towers in Provincetown may be limited to about 95 feet above sea level (western portions of Route 6) to about 160 feet above sea level (near Mt Gilboa), depending on location. FAA criteria define the limit of unmarked tower heights based on the distance from the airport and the elevation of the ground on which the tower would be mounted. We selected an 80-foot tower height for our profiles to illustrate the impact of relatively short towers.



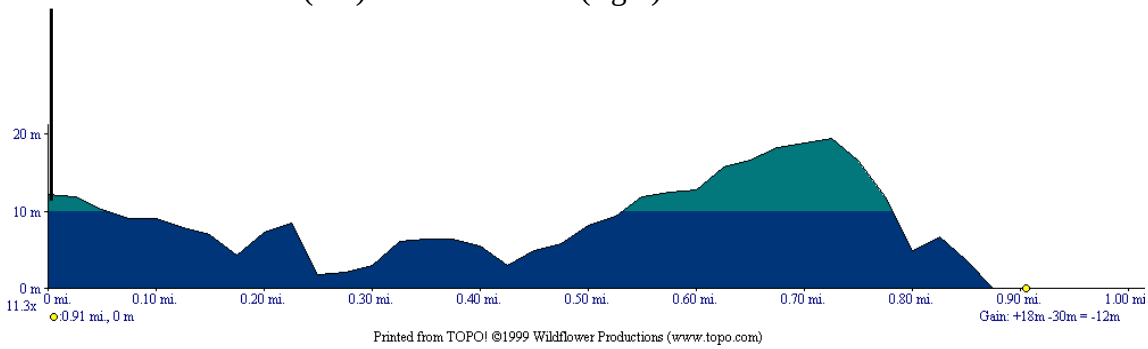
Permissible Area #1
High ground beside Route 6 near Shank Painter Pond

Permissible Area #1 encompasses the Shank Painter Pond and wetlands. A sliver of land on either side of Route 6 in this area appears to be out of wetlands and therefore available for closer consideration. Some land in this area was recently purchased by the town as open space. We modeled the terrain profile from this area in the directions of Herring Cove Beach and Provincetown center. These profiles are shown below.

Profile A: From Route 6 (left) to Herring Cove Beach (right)



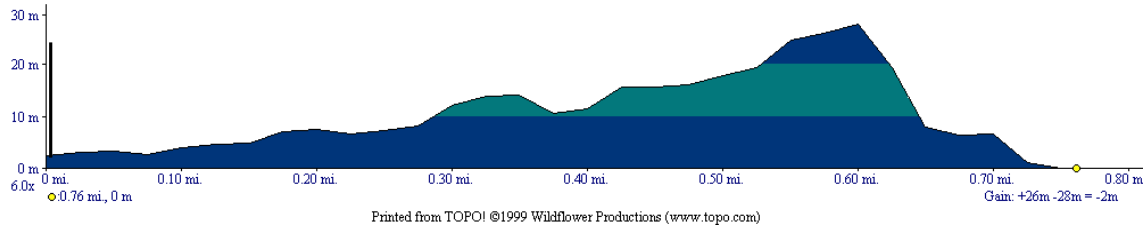
Profile B: From Route 6 (left) to Town Wharf (right)



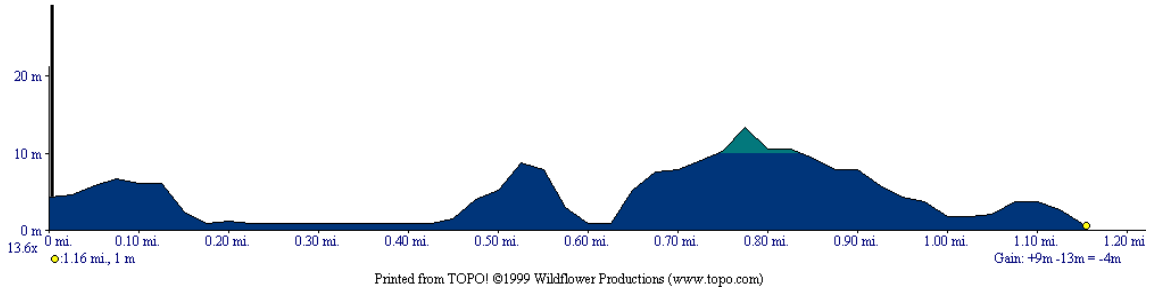
The terrain profiles above indicate that a tower along Route 6 near Shank Painter Pond will need to be fairly tall to overcome the terrain that could block signals from reaching the center of town. At the same time, the tower will likely be very visible in the Herring Cove Beach area and on its approaches.

Permissible Area #2
Town Land North of Route 6, including site of burn dump.

Profile C: Town Land (left) to Town Wharf (right)
(Vertical scale differs from other plots)



Profile D: Town Land (left) to Herring Cove Area (right)



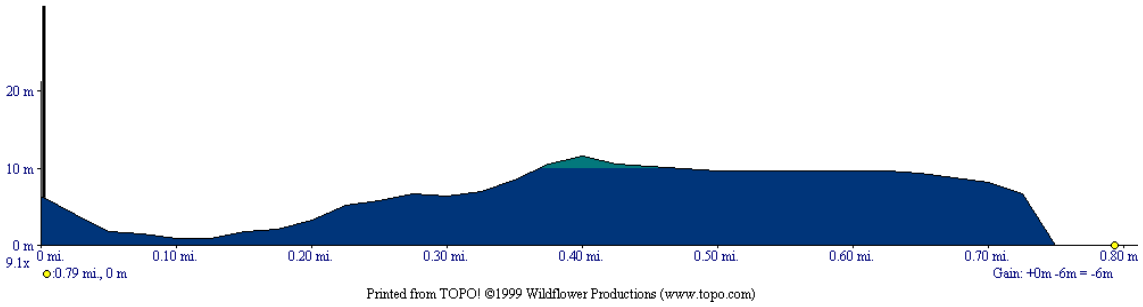
This site on Town Land north of Route 6, above Shank Painter Pond and Road poses difficulties with visibility similar to those of the previous location. To make matters worse, the ground elevation is lower, which could require a taller tower to achieve the same coverage within the town center. (However, for comparison, tower height is represented as 80 ft above ground on all terrain profiles)

There appears to be an additional wedge of land, on the south side of Route 6 and due north of the water towers, that meets the wireless facility setback requirement. This is in the vicinity of Jerome Smith Rd and Alden St. Ironically, it is about as close to the dual water towers as the water towers are to the Pilgrim Monument. If a site were available in this area, the community would gain another tall structure that could be as prominent as the Monument and the water towers.

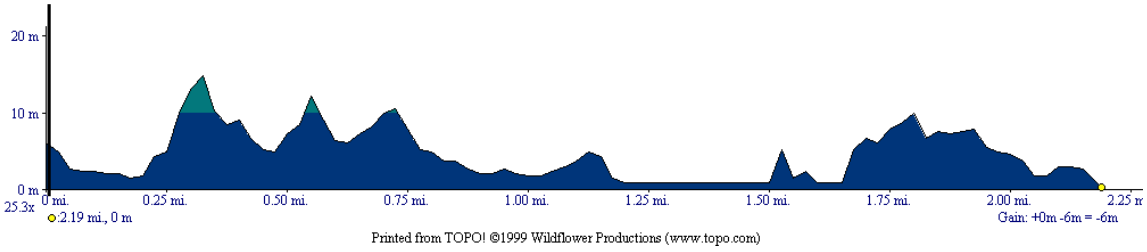
Permissible Area # 3
East of Neighborhood that Is East of the Burn Dump

The next area is on the opposite side of the neighborhood east of the burn dump. Area #3 is largely wetland. The terrain profiles below were taken from a point in the area where the National Seashore boundary begins to depart from running parallel to Route 6, roughly across from Howland Rd. This site is shown on the map below. Its viability as a developable location has not been determined.

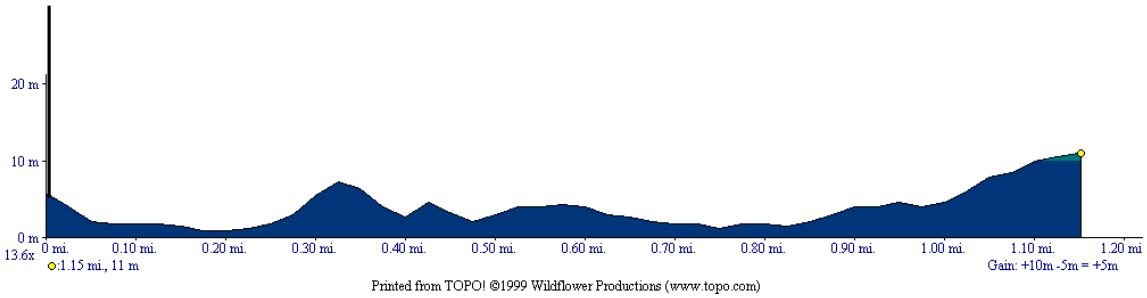
Profile E: From Area #3 (left) to Town Wharf (right)



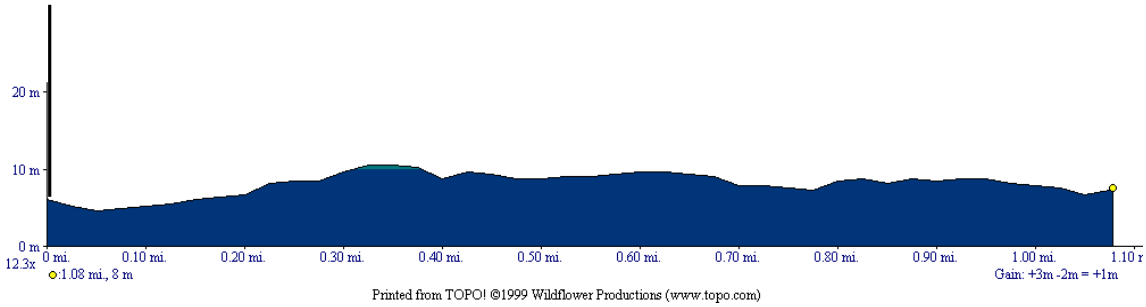
Profile F: From Area #3 (left) to Herring Cove Beach Area (right)



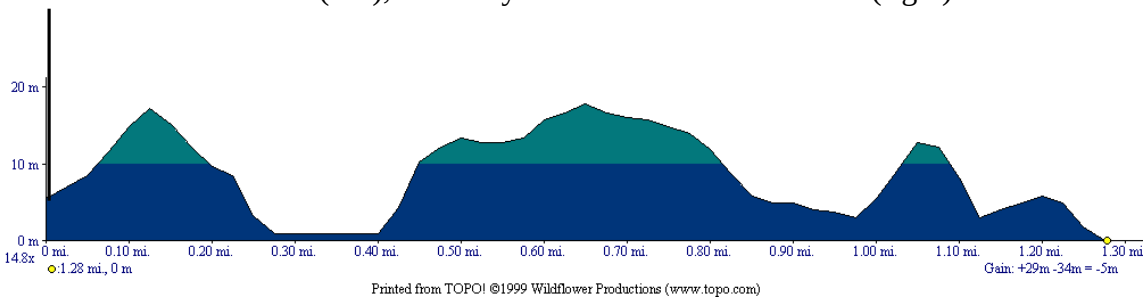
Profile G: From Area #3 (left), along the bore of Route 6, westerly to the high ground near Shank Painter Pond (right).

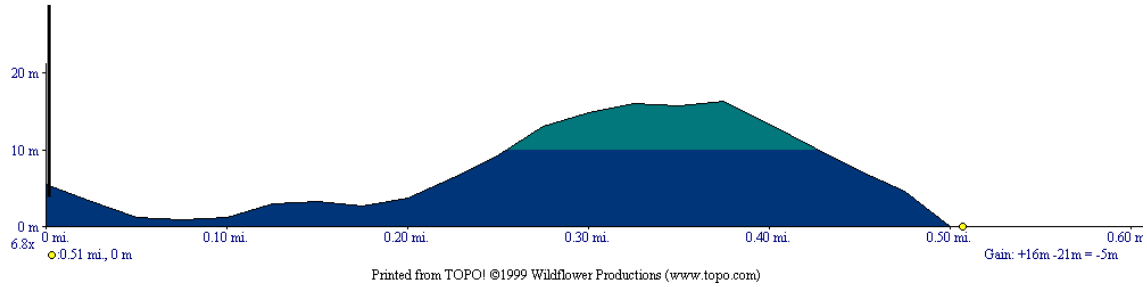


Profile H: From Area #3 (left) along the bore of Route 6 easterly to Snail Rd (right)



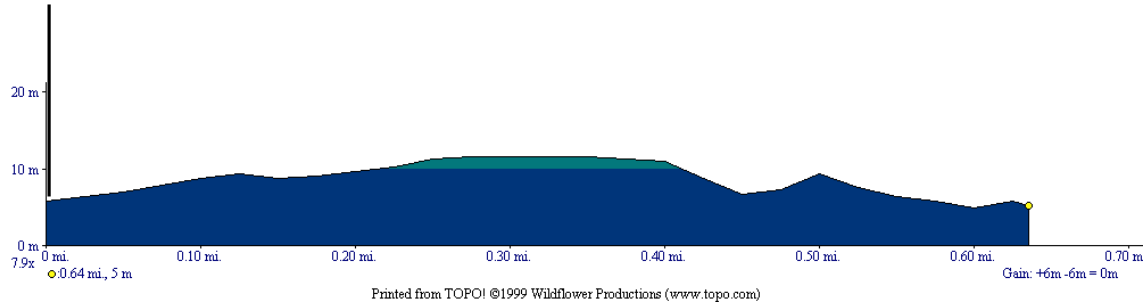
Profile I: From Area #3 (left), northerly into the National Seashore (right)





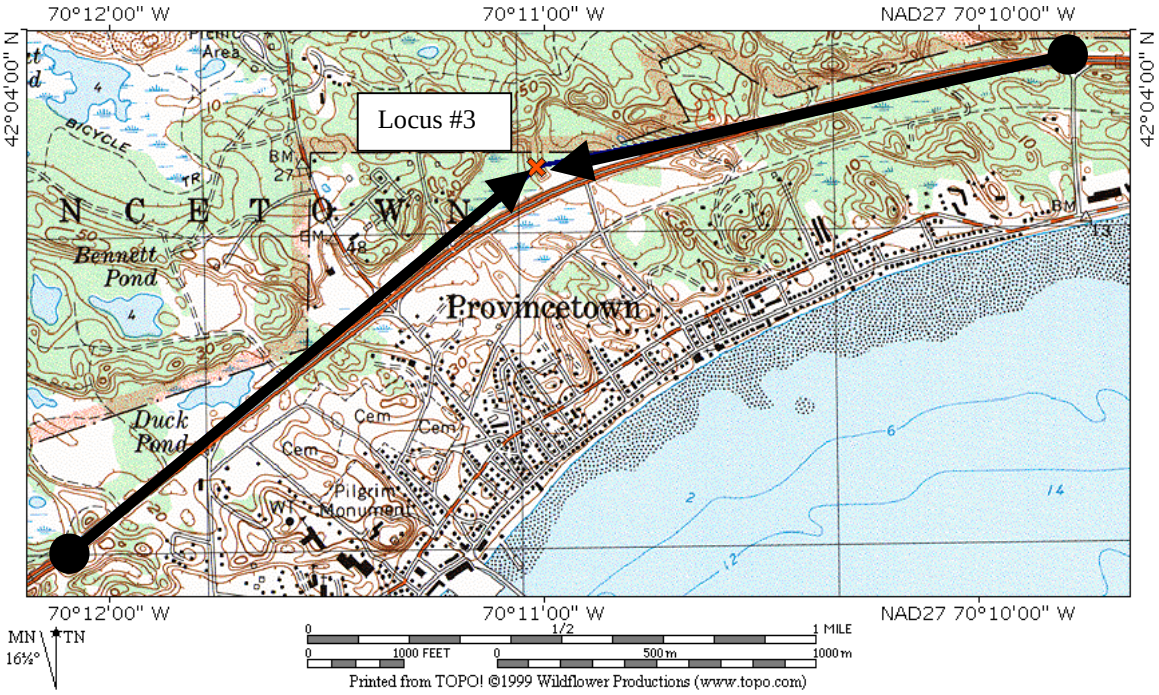
Profile J: From Area #3 (left) southerly to nearest point on the Harbor shore.

Profile K: From Area #3 (left) to picnic area and trails off Race Point Road



Intervening terrain may obscure a tower at Area #3 partly or fully from the more populated parts of town and the shoreline—advantageous to the community, disadvantageous to successful signal reception in town.

The terrain of the National Seashore may be sufficiently rugged near Area #3 to limit the visual impact in the high dunes of the Seashore, except from the tops of dunes, if accessible. Other parts of the National Seashore, such as in the direction of Race Point Road will be more negatively affected.



Potential Boresight View of Area #3

Meanwhile, a tall structure at this area would be quite visible for at least a mile in either direction along Route 6. Because it is tangent to the bend in the highway, it presents a potential "boresight view" to those approaching the tower from either direction along Route 6. Such a view occurs when vehicle occupants have a direct line of sight to a structure as they look forward from their vehicles down the bore of the highway. (see above map) More detailed analysis would be necessary to determine the exact visual impact of a structure at the site as well as the site's actual development potential.

Permissible Area #4
Northern edge of Route 6 along National Seashore boundary

This area consists of a narrow strip of land on the northerly side of Route 6, which runs from approximately Snail Road to Howland Road. This strip of land poses several obstacles to successful wireless implementation. First, as a narrow strip of land it may be particularly difficult to find a location with appropriate space to support a wireless facility. Second, the land is apparently under the jurisdiction of the Massachusetts Highway department, which may be particularly difficult to obtain rights from. Third, a wireless facility in this area would directly abut particularly sensitive National Seashore land. Fourth, much of the land along the highway is very low in elevation, which suggests that much of it is likely to be protected wetland and that a taller structure would be necessary to obtain coverage comparable to that available from sites n higher ground. Fifth, the site presents the same issues as Area #3 above with respect to visual impacts of a boresight view from both directions.

Permissible Area #5
Near Mt Gilboa

This area appears to penetrate the southerly side of Route 6 with a wedge of territory between Snail Rd and Mt Gilboa. An antenna structure at this location would be similar in elevation and height to the Mt Gilboa water tower. It therefore would be as visible as the water tower. With the water tower only about 500 feet away, it would offer the same wireless coverage that would be obtained from a facility mounted on the water tower.

Some wireless carriers have indicated that they would obtain satisfactory coverage in much of Provincetown from the Mt Gilboa location, in the expectation that the more distant and terrain-shadowed portions of the community might receive serendipitous service from sites across the open water of the bay. (This level of service is likely to suffice for a limited period of time.)

The arc of beach along the harbor provides an open path for signals to pass from the Mt Gilboa area to the center of the town. This is potentially better penetration than would be available from a tower placed in terrain-obstructed areas north of the town center (areas #1-3).

Other carriers indicate a preference for a site more centrally located than Mt Gilboa, to obtain coverage that maximizes the use of the facility and reduces the need for future facilities in Provincetown. Optimal coverage for these carriers would be obtained from the tops of the dual water towers (or possibly at low elevations on the monument) rather than at locations along Route 6.

Conclusions on Provincetown Options

At the sites Provincetown has set aside for wireless communications, as described above, a structure capable of supporting multiple wireless carriers would be highly visible to both the community and the Seashore. Such structures would fail to, in the words of the Provincetown bylaw,

"preserve and protect the historic and scenic vistas…" §10010
"preserve the character and appearance of Provincetown…" §10020 A
"protect the scenic…resources…"§10020 B
"minimize the total number and height of towers throughout Provincetown…"§10020 F
"minimize and mitigate the adverse visual effect of the towers and facilities…"§10020 I

Permit the Use of Water Tanks

We strongly recommend that the community abolish its exclusion of the town's prominent structures (three water towers and a monument, as well as other less lofty locations). Such a decision will encourage the carriers to reuse existing structures and would be the best policy for ensuring that the character of the community is protected in a safe and harmonious manner.

Consider the Monument as Well

While the monument may seem too sacred a facility to employ for wireless communications, its location is nearly ideal for providing in-town coverage. If the monument were made available for wireless facilities, and a highly qualified architect were employed to develop a proper design, the community could benefit from sharing this prominent monolith. Antennas do not have to be visible, and the carriers indicate that they don't need to be anywhere near the top of the structure. The lease revenue would very nicely support the stewardship of the monument.

Best Tower Locations

Among the currently available locations for new tower structures, all locations pose significant visual impact. The area near Mt Gilboa may be the least detrimental, visually, for the construction of a major wireless tower. The visual field in this area is already affected by the water tower with the radio station antenna on it. The site is also quite distant from the high traffic areas of the National Seashore, reducing its potential visual impact to visitors and its potential effectiveness as well.

The region north of the dual water towers and the monument, but south of Route 6 offers the best coverage for the carriers, given a tower of sufficient height. The addition of a tower in this location may be less offensive than one along the dunes and Route 6 because it is in proximity to the existing visual projections of the water towers and the monument. However, such a structure would be a prominent addition to the community. And the water towers may obstruct signals in key directions.

It is important to emphasize that the terrain profiles shown above are based on hypothetical locations and employed a relatively low tower height of 80 feet. Even under these circumstances it appears that the visual impact of a wireless tower will be significant.

Wireless Services Are Potentially Excluded from Provincetown

More analysis is required to determine if any of the permissible sites are feasible. There are numerous restrictions, such as a minimum setback from property lines measured by the sum of the height of the structure plus 50 feet. Any site that clears the size limitations would have developable space free of wetland. Such restrictions significantly reduce the number of lots on which a wireless structure may be located.

Finally, the development potential of any particular site first relies upon the availability and willingness of landowners with developable land to engage in leases. In a sensitive region, such as Provincetown, this can further limit the options available to carriers.

The Town Should Take Immediate Action

With recent developments in federal court (e.g. Omnipoint vs Town of Lincoln, Massachusetts) it is especially important that the Town of Provincetown move quickly to enable wireless companies to employ existing structures such as the water tanks. Otherwise, the town may find itself in the position of permitting an unsightly new tower on the order of the court.

Review and Recommendations on Individual Cases

Area of Critical Concern #2: Wellfleet

Area of Critical Concern #2: Wellfleet

Wellfleet presently hosts several wireless facilities at several locations.

Current Sites

Two companies occupy the DEM fire tower along Route 6. This pre-existing structure is relatively short, requiring additional facilities in Wellfleet for these carriers.

Another company occupies a pole at the power substation on Gross Hill Road. This facility is apparently grandfathered, having been installed prior to the current wireless bylaw taking effect. It, too, is relatively short, requiring additional facilities in the community to provide a reasonable amount of service. A recent application to expand the Gross Hill Facility and add at least two more carriers was approved by the Cape Cod Commission. It was subsequently denied by the Town of Wellfleet for non-compliance with setback requirements. The two carriers involved in the application will require facilities in the community.

The Congregational Church in the center of town will host at least two carriers. It, too, is relatively low in elevation, requiring additional facilities in Wellfleet to provide these carriers reasonable coverage.

Bylaw

Wellfleet's bylaw is similar to others in the region, such as Truro's. It encourages use of existing structures and the sharing of structures, states a preference for new structures to be placed on public land, and calls for more, shorter structures rather than fewer taller ones. The bylaw requires a setback from property lines consisting of the sum of the overall structure height plus ten feet. The Wellfleet Harbor Area of Critical Environmental Concern, comprised mostly of water, wetland and shoreline, is specifically excluded from communications facility development. The Town's Central District is excluded from communications structures and buildings, but permits communications appurtenances. The Bylaw gives the Planning Board the authority to waive requirements of the Bylaw if it is in the public interest to do so.

Since the implementation of the Bylaw, only existing structures have been granted permits for wireless facilities. All carriers actively developing facilities in the region have expressed a need to install new facilities in the Wellfleet area.

Existing and Prospective Locations

The Nauset facility in northern Eastham will provide carriers with coverage that penetrates into southern Wellfleet. The extent of this penetration will depend on each carrier's antenna height on the Nauset tower, as well as the particular technology employed by the carrier.

The DEM fire tower site will provide Sprint and Telecorp with a reasonable overlap with the Nauset tower site. The height of the fire tower limits the coverage available from the site. To complete service along Route 6 to northern Wellfleet, Sprint and Telecorp will require additional facilities in Wellfleet. A relatively high facility at a site such as the Gross Hill Road substation might provide the coverage necessary to complete a reasonable amount of coverage in Wellfleet and extend service to the Truro line. Depending on what Sprint and Telecorp obtain for a second facility in Wellfleet, there is a possibility either company could require a third facility to provide service more fully into the town center and points west.

The outlook for the other carriers appears more challenging. They are not occupants on the DEM fire tower, and will therefore require facilities in the lower third of the town. At least one company is considering a church steeple on Route 6. Steeples are not particularly high, and are often limited in their capacity to hold antennas. Therefore the steeples would likely be insufficient for meeting the needs of the carriers in the southern two-thirds of Wellfleet.

The Headquarters of the National Seashore has a water tower nearby. This structure is approximately 120 feet high and rests on relatively high ground. The water tower is approximately two miles north of the Nauset tower site and 0.6 miles east of Route 6. Its location is not ideal because it is somewhat close to the Nauset site while being somewhat distant from Route 6. However, coverage from this site appears to be capable of reaching past South Wellfleet, which is about two miles northwest of the water tower.

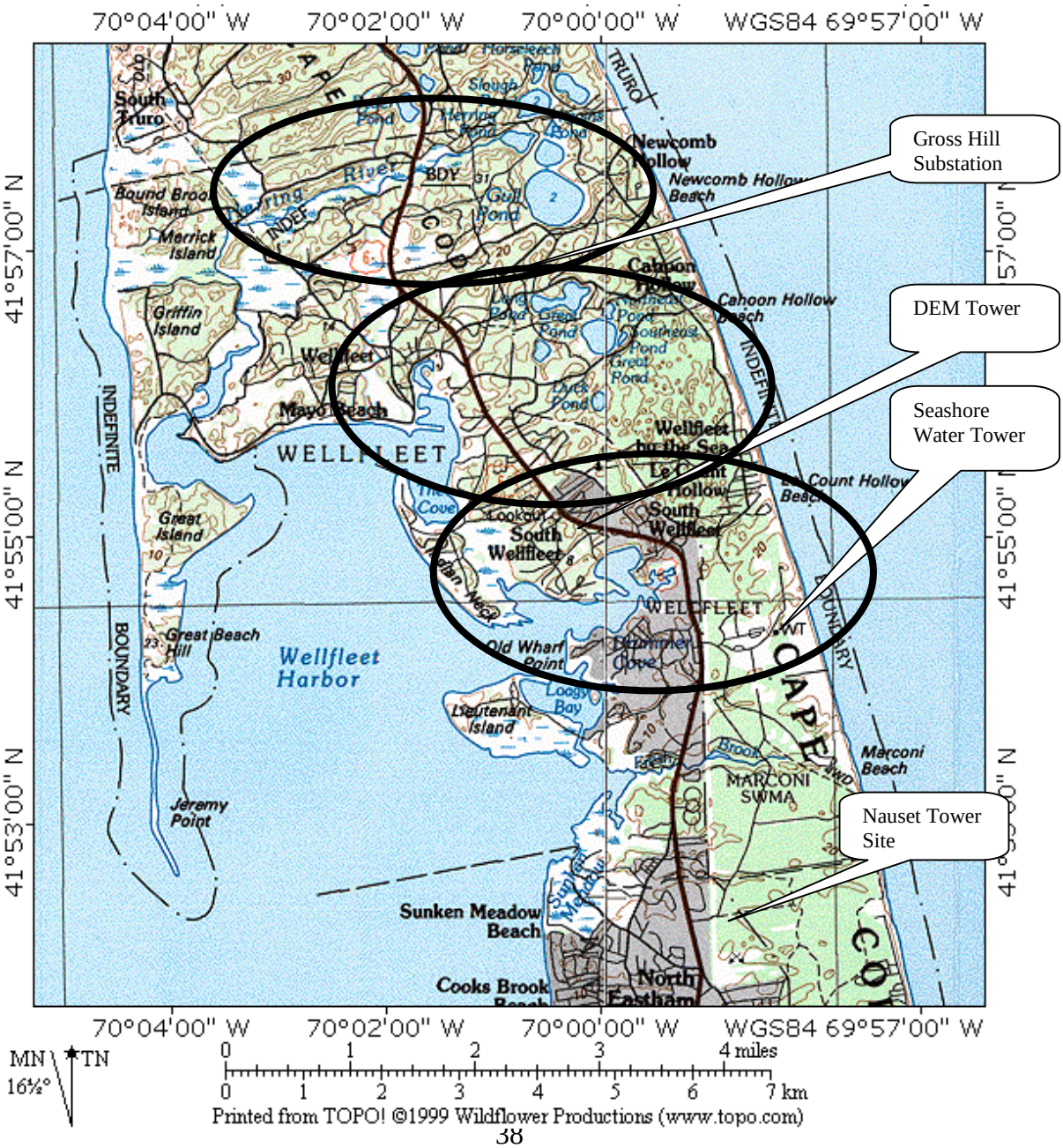
The National Seashore water tank site could play an important role in providing wireless carriers enough alternatives to piece together adequate service in Wellfleet.

To round out the carriers' coverage in the northern reaches of the town, and in the town center, some additional creativity may be necessary. First, a site similar to the Gross Hill Road site should be selected for providing primary coverage in the northern third of the community. It should be set back from the highway, and ideally be of limited visibility to local residences as well. There may be locations along the utility right of way, or on either side of it that would be acceptable to the community, the Commission and the Seashore. Such a structure would have to be fairly tall to accommodate multiple carriers and provide coverage sufficient to reach both Truro and southern Wellfleet.

An alternative approach would address Wellfleet's preference for more towers rather than higher ones. The preference could be met by identifying acceptable locations along the utility right of way between southern Wellfleet and the Truro line. Carriers would be encouraged to split their coverage between two facilities employing shorter structures. Such locations could be on either the town side or the seashore side of the right of way, depending on facility impacts and space availability. This strategy would result in one or more shorter structures as near the Truro boundary as possible, to provide optimum linkage with the proposed landfill site facilities in Truro. An intermediate site would be required further south, depending on each carrier's next facility location (DEM tower, water tower, churches, or Nauset tower).

The map below illustrates three hypothetical zones in which carriers might locate low-elevation facilities to provide adequate coverage in Wellfleet. This is a schematic representation of areas each facility would need to serve to be successful. It is intended to illustrate a manner in which Wellfleet could be divided into three service regions that would join with Truro and Eastham facilities. Individual carriers will have different requirements depending on their present coverage and what new facilities they eventually obtain.

Hypothetical Layout of Three Wellfleet Service Areas
Served by Shorter Towers



Summary of Conclusions about Wellfleet

Wellfleet has a bylaw that gives its Planning Board some discretion in allowing wireless facilities to be placed in a manner that is in the Town's best interest. To date, several carriers have been granted permission to install facilities on existing structures, and have done so. All carriers presently lack reasonably complete coverage in the Town.

We recommend that additional scrutiny be given to the remote areas along the electrical transmission line right of way, on both the town's side and the Seashore's side, to find locations that would be acceptable for new wireless antenna structures. To address the bylaw criterion of more towers at shorter heights, the carriers should be expected to plan three facilities each in the town. Carriers should take advantage of the National Seashore's water tower, in spite of it being somewhat close to the Nauset site, in order to push coverage deeper into the town reduce the need for new towers.

Review and Recommendations on Individual Cases

Area of Critical Concern #3: Harwich

Area of Critical Concern #3: Harwich

Bylaws

The Town of Harwich has a wireless bylaw with multiple levels of wireless accommodation. First, the Town has identified essentially two overlay districts. One is along Route 6 that already is host to two wireless towers. The other is a composite of irregularly shaped areas within the area defined by Route 39, Chatham Rd, and the Chatham town line. In these two overlay districts structures may be built by special permit and may be as high as 150 feet, in the case of a four-or-more-carrier structure.

Existing towers of any sort and at any location in Harwich may accommodate additional antennas with only site plan review, as long as the additions do not increase the structure height more than the applicable height limit, up to a maximum increase of 20 feet.

Facilities installed on new structures or on existing buildings must obtain special permits and may be installed in any district in the town. The height of antennas on new structures or on existing buildings must be no more than 45 feet above ground. The Town is exempt from the special permit requirements of this paragraph.

The bylaw demonstrates that Harwich has clearly made an effort to make room for wireless communications facilities.

Locations where Wireless Coverage Is Lacking

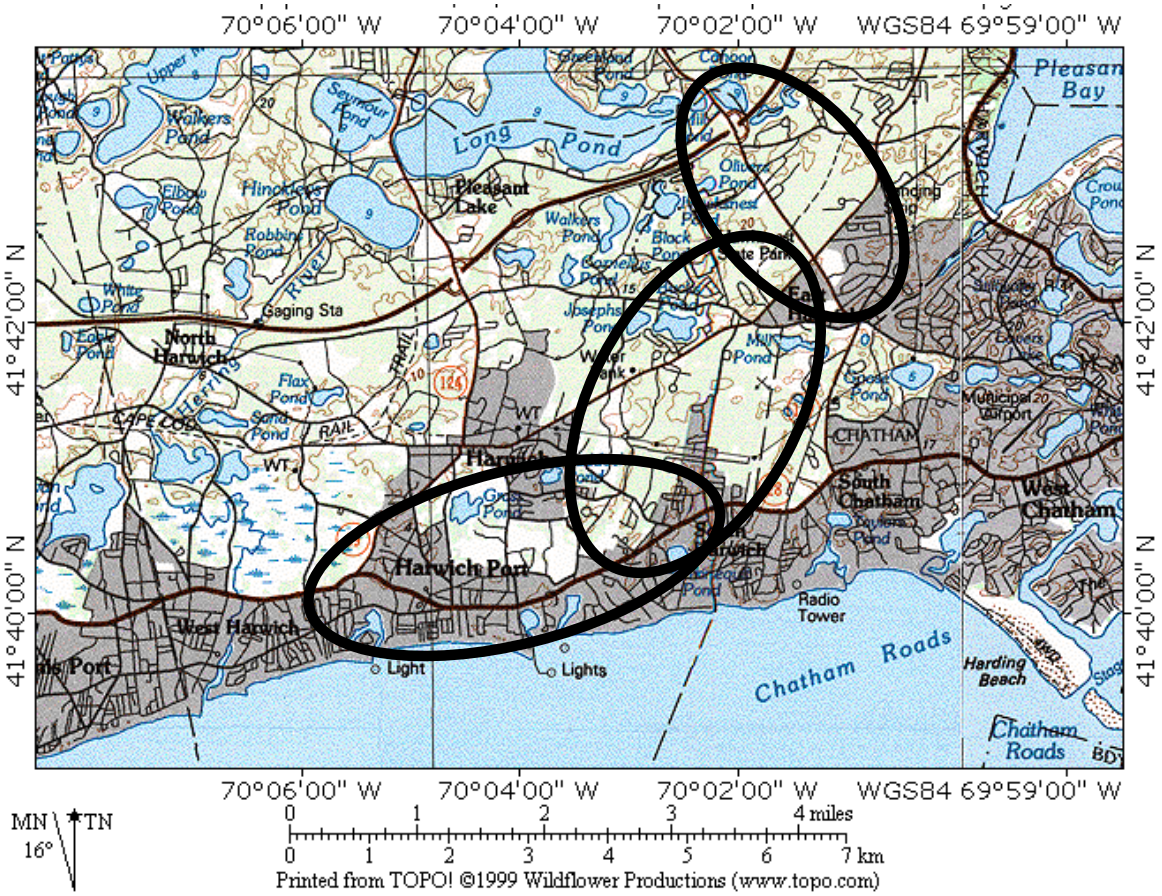
The table in the appendix shows where various carriers have coverage within the borders of Harwich. In summary, there are significant coverage problems near the Route 6 and 137 interchange, along route 137 toward Chatham, along Route 39 west of Route 137, and along Route 28 including the Harwichport area.

The map below illustrates general areas where carriers share coverage voids. They are denoted by the ellipses drawn on the map. Each carrier has slightly different needs, depending on their existing facility locations and antenna heights. Therefore, the ellipses are only a rough guide to the general areas of difficulty in Harwich.

There are multiple carriers on the towers along Route 6 at Queen Anne Rd. The next major site along Route 6 is at the WFCC tower on Freeman's Way. About halfway between these two sites is the interchange of Routes 6 and 137, which appears to be a problem for all carriers in obtaining continuous coverage along Route 6.

Heading south on Route 137 from the Route 6 interchange, each carrier maintains some voids in coverage, depending on the locations and heights of their facilities at the two Route 6 locations and their Chatham facilities. These voids tend to arc down Routes 39 and 28 into the Harwichport area.

Harwich: Simplified Interpretation of Coverage Voids Common to Most Carriers



Water Towers Can Be Good Locations for Wireless Facilities

There are two water towers along Route 39 that would be logical existing structures on which to mount antennas. The westerly water tower, near Bank Rd., is relatively close to the Queen Anne Rd facilities and might be somewhat inefficient to utilize now. The easterly water tower is well situated to cover the area between Route 6 and the Chatham line. It is likely that facilities at this site will not adequately address the coverage void that some companies experience at the Route 137 interchange. Similarly, service in the area of Harwichport and Route 28 would remain incomplete.

If the carriers were encouraged to employ the water towers, remaining signal problems could be addressed with the installation of a limited number of the 45-foot or lower elevation facilities in critical areas such as at Routes 6 and 137 or in Harwichport. However, it is our understanding that the water towers are not being made available.

Water towers have proven to be effective locations for wireless facilities. We asked two carriers' representatives to list from memory some water tower installations that they recalled. Here is list, not at all comprehensive, of some Massachusetts communities where wireless antennas are or will be mounted on water towers:

Barnstable	Dennis	Stoughton
Bedford	Marion	Sudbury
Beverly	Marlborough	Tewksbury
Chatham	Medfield	Walpole
Chelsea	Raynham	Wellesley Coll.
Cotuit	Rockport	Westford
Danvers	Sandwich	Yarmouth

Narrow Mission of Water Authority Sometimes Given as Reason to Reject Antennas

In our experience working with communities, there are two reasons for avoiding water tower installations. One relates to the supremacy of the mission of public water supply infrastructure over other uses. The second relates to how water towers are sometimes close to residential areas.

On the first rationale, some believe that water towers exist solely for the public purpose of supplying water to a community. Other uses are seen as a nuisance to the primary mission of the water tower. Concerns are expressed about a range of issues relating to allowing alternative uses of water towers, including structural integrity, liability, water purity, and administrative burden.

These not-so-pretty structures stand prominently in our communities to provide a service to its residents. As evidenced by the above sampling of towns with water tower antenna installations, many communities have determined that the use of water towers for other purposes is beneficial to the community. They have successfully addressed their own concerns about the safety, legal, and administrative impacts of having wireless tenants on water towers. In short, they have found a way to safely maximize the potential of this community infrastructure to everyone's benefit.

Water lines coexist under our streets along with sewer, gas, and sometimes electric and telephone lines. The fact that our streets are shared by a variety of utilities illustrates the wisdom of employing public infrastructure for more than one purpose.

Fewer antenna towers are necessary when water towers are put to use, and communities benefit from the revenue provided by the carriers' rental fees. The Town of Medfield, for example, is using the income from its water tower tenants to pay for a large tract of open space that was recently purchased.

Signal Level or Visibility Sometimes Given as Reasons to Reject Antennas at Certain Locations

The second reason why communities shy away from water tower re-use is based on a perception that antennas should be as far away from population as possible. We have not heard any suggestion that this is an issue in Harwch and will not belabor the point here. It is discussed in detail in the section on Provincetown. Wireless facilities can be well camouflaged on water towers and can be installed to be fully compliant with all safety requirements.

We therefore recommend that the people of Harwich make its water towers available to current and future wireless carriers. The three water towers in Harwich are strategically placed along the spine of the community in a manner that would provide significant coverage for carriers and reduce the need to have tall new structures dotted about the community. More importantly, it would potentially eliminate the need to add wireless overlay districts in the presently underserved areas.

Easterly Wireless Overlay District

The middle ellipse shown on the above map encompasses the wireless overlay district near the Chatham town line. According to the bylaws, this district is an acceptable location for multi-carrier towers up to 150 feet in height. Assuming there are available lots with sufficient space to meet the setback requirements, this district appears to be well situated to help carriers address their needs in the area.

Harwichport and Coastal Areas

Whether or not wireless facilities are installed on or near the town water towers or in the current eastern overlay district, service in the vicinity of Harwichport will remain incomplete. Considering the size of the present void for most carriers, each carrier is likely to need several of the 45-foot facilities to serve that area adequately. With six current carriers, that amounts to a fairly large number of taller-than-usual poles along Route 28.

Use of the town water towers could significantly reduce the need for 45-foot installations in the Harwichport area. Not only will the act of making the water towers available reduce the total number of new installations in the town, but it will also make it more economically feasible for the carriers to make up the difference with smaller facilities, reducing the chances that a carrier will challenge the town in court.

Route 137 to the Route 6 Interchange

The Route 137 interchange with Route 6 will remain a difficult location for most of the carriers. Some carriers have marginal coverage on Route 137 while others have lapses in coverage. There will likely be an attempt by some carriers to locate a facility relatively near Route 6 to provide signal continuity to the highway traffic while improving the reliability of service both north and south of that area of Route 6.

Summary of Conclusions about Harwich

Harwich has a bylaw that provides several options to carriers. However, after both wireless overlay districts are employed, there will remain a large swath of town without adequate coverage. The Bylaw permits up to 45-foot high facilities outside the overlay districts. The swath of unserved area must be reduced before the implementation of numerous 45-foot facilities becomes practical.

We recommend that an additional overlay district be identified to serve the Harwichport area, or that the water towers be made available for wireless antennas. The water towers are not ideally located to serve Harwichport, but should do adequately, possibly with in-fill from small facilities in key locations.

In addition to Harwichport, Route 137 will be a problem for some carriers, especially at Route 6. Authorization for greater antenna height should be permitted for this area, although not necessarily the full 150 feet. The actual height required will depend on the carriers' success at obtaining coverage in the easterly overlay district and therefore how close to Route 6 they need to be.

The Harwich bylaw and its Table of Use Regulations leave some ambiguity about what types of facilities are allowed in various locations. We recommend that the bylaw be revised with separate definitions and criteria for towers (antenna support structures) and antennas. However, in spite of recent ZBA action at a Harwichport church, the use of a steeple appears to us as a use of an existing tower anticipated in 2.1.1 of the bylaws. One difficulty we see in this rule is that according to the Table of Use Regulations antennas might be limited to a 45-foot height in certain districts even when the steeple (or other existing tower structure) might be higher than that.

Similarly, to make the water towers available, the districts in which they are located may prevent their use for wireless communications. This data was not available to us at the time of completion of this report.

Areas of Some Concern
And
Areas to Expect Activity

Areas of Some Concern

Truro

The Truro facility slated for the landfill location is not ideally situated. While it is located in a fairly well obscured location, its visual impact remains to be demonstrated.

The Truro landfill facility is on lower ground, forcing a greater overall structure height (190 feet) to overcome nearby terrain. It is somewhat distant from Wellfleet and the existing Truro tower at the public safety building. As a result, at least one carrier reports avoiding the landfill facility in order to establish at least two facilities to serve the same corridor more completely. Other carriers express concern that the landfill facility may not prove to be sufficient over the long term.

The strategy we described in the Wellfleet area could be extended to Truro to make a balance between the quantity of towers, their heights, and their visibility. This region is largely National Seashore land. There may be land in this region that may be reasonably compatible with wireless facilities where less-intrusive facilities could be placed. We recommend that Broadcast Signal lab facilitate a dialog between the National Seashore and the wireless companies to determine whether there are any potential sites worthy of presenting to the Working Group for its consideration.

Eastham/Orleans Line

Near the Eastham-Orleans boundary the signals for most carriers will be insufficient, even after completion of the Nauset facility. One carrier is operating on the Eastham town offices site. The structure is visible from the National Seashore visitor area. The location of the tower at the town offices is desirable to other carriers. If there are other sites in the area which would be less obtrusive to the Seashore and to passersby on Route 6, they should be identified and made available to the carriers as soon as possible.

- **Areas to Expect Activity**

Route 6A, Brewster

The central and western portions of Route 6A in Brewster are underserved by some of the carriers. Brewster's overlay district limits towers, not wireless facilities. Some carriers expressed intentions to propose water tank or power stanchion installations in that part of town. Because Brewster's bylaw is perhaps the most flexible of those we have reviewed, some of the newer carriers might be satisfied with these options.

However, it would be advisable to determine whether there is a location in the Route 6A and Setucket Road corridor where a tower overlay district could be established. The district could be very small containing at least one feasible site. A height restriction

could be applied, say 150 feet, possibly less, depending on terrain. Community leadership, including the Planning Board, local stakeholders, and the Old King's Highway Historic District Commission, may be able to develop an acceptable location for such a district such that the northwestern portion of the community would be served in a manner that minimizes visual impact. Of course, any proposed new district should have the support of the community and the wireless carriers before implementation.

In other parts of town, water towers should be made available through an RFP process. Existing towers that are not in the overlay district should be granted some flexibility to increase height to maximize reuse of existing structures.

Chatham

Chatham has aggregated all wireless service in town to its water towers. Two additional carriers intend to join the others already there. This site appears to provide adequate service to the entire community, with the possible exception of some fringe coverage at the town borders. This coverage would be made up by new facilities that would predominantly serve Harwich and Orleans. There may be capacity problems sometime in the future, which could be accommodated by microcell installations in areas where people congregate. There appears to be no urgency to further wireless site development in Chatham at this time.

Looking into the Crystal Ball

Looking into the Crystal Ball

When Will They Be Done?

When the areas described above are provided with wireless service for all the carriers, the Lower Cape will be substantially built-out. Once facilities are in place, the carriers will look at several factors when considering future needs.

First, after facilities are installed and in use, the carriers can measure their customers' perception of service through such things as dropped call statistics and coverage complaints. In some cases, a fill-in facility may be required. We identified the southern Eastham area as one such potential area.

Second, the goals and strategy of the carriers will continue to evolve. Wireless communications have evolved from business phones with higher-powered automobile installations, to a consumer service with low power hand held phones. The new phase in evolution is coming in the form of wireless messaging and low bandwidth internet access. This will be followed by higher bandwidth wireless Internet access and data transmission. Ultimately, we can expect the wireless companies to compete with the local wireline company for home and business dial tone and data service. At that point, customers and providers will expect service to be as accessible and reliable as our local phone service is today.

Therefore, we can expect wireless companies to continue to build facilities to reach home and office flawlessly. The old adage that "they don't need 100% perfect service" may be true when we try to stop a 150-foot tower from being built in the wrong place. However, it will become a less effective argument when the services evolve to provide perfect home-quality service from rooftops and poles.

The wireless carriers will continue to build after this multi-year flurry of rapid construction. Consider the continuing development of Cellular One and Verizon, two companies that have been around for a long time. They continue to improve their networks, enhance their coverage, reduce their cell sizes, and add new services.

When Can We Expect Towers to Be Obsolete?

Many hope that the towers will become obsolete as new technologies advance. It may be true that there will be less demand for *new* towers in the near future. However, the prospect of dismantling large numbers of existing towers seems very far off.

If local regulations encourage wireless companies to develop facilities that are smaller, lower, more numerous, and closer to home, office and play, then there may be

opportunities to reduce the height of some towers. It may be somewhat difficult, especially with co-located carriers stacked on full towers, to have all the events coincide that would prompt all the carriers to reduce height and lop off a portion of a tower.

Will Satellite Service Overtake the Terrestrial Technologies?

People sometimes wonder whether satellite service will make the terrestrial wireless telephone service obsolete. We don't see that happening. Terrestrial wireless networks use comparatively small cell sizes and reuse their calling channels repeatedly throughout their networks. Terrestrial wireless is a very spectrum-efficient service. Presently, satellite services by necessity have larger "cell" sizes and must therefore consume greater radio spectrum to carry the same number of simultaneous conversations. Satellite services also suffer from obstruction losses (buildings, bridges, etc) that terrestrial services can resolve with additional cell installations. (Some satellite services propose terrestrial "gap-fillers" to address this—it sounds like terrestrial wireless!) We expect that satellite services will evolve to serve functions complementary to that of terrestrial wireless services.

The demise of the Iridium satellite telephone system is a revealing example of the risks of providing satellite telephone services. A multi-billion dollar consortium of companies launched dozens of satellites to provide this international telephone service. The system failed to be competitive with terrestrial services and was shut down in March of this year. It seems one of the problems with the technology was that it was stuck in an early design that was far less efficient than current terrestrial wireless technology. It is impossible to retrofit dozens of satellites to keep them competitive. In comparison, the two analog cellular companies have been able to "go digital" by adding new hardware to their base stations, allowing them to keep up with the newcomers in the PCS business.

What About those Cable-mounted Wireless Transmitters?

We spoke with industry experts, some of whom would benefit from the deployment of those "wireless-over-cable" devices, about the state of the art for pole and cable mounted systems. Unfortunately, the consensus is that these devices are very limited in their application.

First, they have only been deployed for services that communicate with CDMA technology. On the Cape, only Sprint has a CDMA system (Verizon's system, a hybrid of analog and CDMA, would not be compatible with the technology). The telephones and base stations of the other carriers' systems will not work with this technology.

Second, the cable-mounted transceivers have to use cable bandwidth to carry telephone calls back to the telephone network. This requires a cooperative cable company and

available bandwidth. With the recent development of broadband internet service over cable, cable companies would have little incentive in leasing part of their bandwidth to wireless companies.

Separate cable or fiber systems could conceivably be installed on local utility poles just for these units, but the complexity of obtaining cable rights of way, and the cost of installing the equivalent of a second cable system in each town, conspire to doom the concept economically. This is especially true when the system is only compatible with two carriers' technologies.

The wireless-over-cable concept is not an all-encompassing solution to the dilemma of wireless facility placement.

Will there Be More Wireless Services in the Future?

There is additional spectrum in the PCS band that is licensed by other services. These companies were not available for participation in our review, and are not currently deploying their networks. Either they will attempt to build their own networks, or they will sell out to an existing company some time in the future. In either case, additional antennas and facilities will be required to implement technologies on these presently un-used channels.

New technologies are being developed that will qualify as "Personal Wireless Services" protected by the Telecommunications Act. They will provide higher bandwidth services to home and commercial users, as well as new specialized services to mobile customers. Their network topologies and system design constraints may be different from those of the current players. In plainer English, the cell sizes and antenna heights of the new technologies could be very different, making it difficult to make any predictions of their needs.

Summary of Future Developments

In the near future, the currently active wireless companies will attempt to build additional facilities to provide nearly full coverage where it is needed. They will follow with a continuing program of deployment to augment coverage in marginal areas and handle peak capacity demand in congested areas.

While the proliferation of low-power handheld phones has driven companies to have more base station sites, we do not foresee any *technological* developments that will continue to reduce the size and height requirements of the present wireless companies. Therefore, it is the growing *economic demand* rather than technological innovations, that will continue to shrink cell sizes and antenna heights. (Of course, we may be allowing

ourselves to be blind to the possibility of extremely low-power phones worn as jewelry or implants that would require a high concentration of small-scale wireless facilities!)

New technologies will be developed that will provide new services on new spectrum. These will require new wireless facilities, some of which may be able to share tower space with current carriers. Some new services may require a large number of installations, more closely related to the antenna-every-quarter-mile concept. Towns should review their bylaws now to determine whether they readily accommodate numerous low-intensity transceiver installations on poles, buildings, and the like. A network requiring one or two dozen small boxes around town should be controlled differently than networks that require antenna towers every couple of miles.

Summary of Recommendations

Summary of Recommendations

Areas of Critical Coverage Concern

We have identified three areas of critical coverage concern where a lack of action on the part of a community could result in court-mandated solutions to the coverage issues. Provincetown is at great risk of being charged with prohibiting the provision of service. Wellfleet has accommodated some antennas, but is also on the verge of being non-compliant. Two Wellfleet permit denials were challenged. One was settled, and the other may be settled. In Provincetown, the bylaw establishes limits that may be nearly impossible to meet. Meanwhile, Harwich has some clear coverage problems for all carriers, but provides more options in its bylaws, such that it will take some time to determine whether carriers are technically prohibited from providing service.

Areas of Some Coverage Concern

We have noted areas of some concern where there are weaknesses in coverage that most carriers will try to resolve in the not-too-distant future. One such area is in southern Truro where there may be a significant void in coverage for several carriers, depending on how Wellfleet's coverage issues are resolved. The other area is in the region of the Eastham-Orleans town line. The primary issue will be continuous coverage, and eventually capacity, on this narrow stretch of the Cape. The residential area of northeastern Orleans may require attention when the carriers seek to penetrate residential areas more thoroughly.

Areas in which to Expect Activity

Areas in which to expect activity include those above, plus Chatham and in the western area of Brewster's Route 6A. These are locations where the siting options are limited, where some carriers have managed to provide service, and where other carriers are actively looking to develop facilities. It appears that there are options that are likely to address some carriers' immediate needs.

Both towns should consider adjusting their bylaws to anticipate demand in marginal areas. It is recommended that Brewster adjust its bylaws to open existing towers to minor height increases and to create at least one opportunity for a structure in the Route 6A/Setucket Rd area.

Bylaw Flexibility

We recommend that communities review their bylaws for flexibility. Those communities that allow low-intensity alternatives in their bylaws have anticipated the next phase in wireless deployment. Such alternatives involve wireless facilities on buildings, utility

poles, or very short monopoles. These alternatives must be generally applicable to all districts in the community, enabling the carriers to creatively camouflage antennas on or within existing structures. By their low-intensity nature, these facilities are intended to serve small, targeted areas and therefore require the flexibility of being close to their objectives.

It is easier for a community to succeed at resisting the development of new towers when it has an effective process for permitting low-intensity facilities. However, communities such as Provincetown and Wellfleet bear the risk of court-ordered tower development because their bylaws obstruct the development of effective low-intensity facilities as well as full-scale facilities. Recent court action on low intensity steeple installations in Wellfleet underscores this observation.

Some communities treat all wireless facilities as if they were on towers. Those communities that limit all facilities to specific locations or overlays can expect future challenges from carriers. We recommend that bylaws make a distinction between facilities on towers or other tall structures, and facilities that are of such low intensity as to be easily camouflaged.

Facilities on towers are obvious candidates for co-location of additional facilities. In contrast, facilities on smaller existing structures and buildings are not necessarily compatible with the co-location concept. We found, for instance, a community in the metropolitan Boston area that prioritized co-location above all other criteria. Under its co-location rules, what began as an unobtrusive false chimney on a four-story building was destined to become a lone roof festooned with false chimneys of co-locating carriers. By employing nearby buildings instead of co-locating on one building as required, the antennas of additional carriers would be more readily hidden from view. This is one example of how bylaws should manage separate large, tall facilities in a different manner than small, low-intensity installations.

Facilities on towers are also candidates for strict placement and setback criteria. Towers can be limited to carefully-selected districts or sites. Non-tower installations are opportunistic in nature. They result from the marriage of an existing structure situated in just the right place with a wireless company's need to serve that place. Thus, non-tower facilities rely upon community flexibility to be unobtrusive as possible.

Similarly, some communities have height criteria that either set fixed limits or take into account average heights of structures or trees. Relying simply upon averages may be self-defeating because a low intensity installation on the highest rooftop in an area might be the best choice visually as well as in terms of coverage. Similarly, a strict height limit, such as five feet above a rooftop, may eliminate more benign-looking solutions in some circumstances.

For the reasons outlined above, wireless bylaws should set general parameters for low-intensity wireless installations while giving Planning Boards case-by-case discretion in approving requests for low-intensity wireless installations on existing structures.

Terminology

To eliminate ambiguity, towns should separate the concept of a wireless facility from the concept of a tower in their bylaws. Each has unique characteristics that require separate regulatory criteria.

Appendix 1
Table of Wireless Facilities

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Provincetown	*High location near town center desired*	*High location near town center desired*	*Proposing 120-ft monopole near town center*	*Not presently developing sites north of Eastham. (Could begin in 1-2 years)*	*In litigation over eastern water tank. Site expected to be sufficient for near future.*	*Either east water tank, or high location near town center would be sufficient.*
	These facilities are on the same general frequencies and appear to link well with coverage from the Truro facility. Due to the PCS use of different technologies the PCS carriers may generally require a site more to the east of town center.				*Coverage from east water tank may be spotty west of town center. Potential for future need of rooftop or steeple type of installation to complete coverage when customer base is large enough to warrant it.*	
Truro Public Safety Building Tower	Present occupant	Present occupant	*Prospective occupant*	*Potential site, but no interest expressed at this time*	*Prospective occupant at 170 ft*	*Prospective occupant*
	Coverage expected to merge well to the north with coverage from suitably high facility near center of Provincetown.				*Coverage expected to merge somewhat unevenly to the north with coverage from Provincetown east water tank. Overlap to alternative site in center of Provincetown could be more unreliable.*	

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Truro Landfill site	*Prospective occupant.*	*Lead carrier in town RFP.*	Says not interested in this site	*Potential site, but no interest expressed at this time*	P*rospective occupant at 175 ft*	*Prospective occupant.*
	Site appears somewhat inefficient due to its proximity to Public Safety site. Ideal locus appears to be near to or south of Wellfleet line, if elevation could be obtained.		*Expressed intention to avoid inefficiency of landfill site by locating on suitably high structure in northern Wellfleet.*		*Due to low ground elevation at landfill, coverage to south appears to diminish quickly just north of Wellfleet line.*	
Comm Electric Pole 20						*Proposes at 85 ft on utility pole to fill in between coverage from DEM and landfill site*
Wellfleet Gross Hill Road	Present low-elevation facility (80 ft) was to increase height and share with subsequently-denied Nextel proposal at site.		*Proposed facility passed by CCC, denied by Town, due to setback encroachment.*		*Had expressed interest in subsequently-denied Nextel proposal, if Nextel's proposed height were increased.*	*Proposed facility was to share with subsequently-denied Nextel proposal.*
Wellfleet Congregational Church		Low intensity, low elevation installation in steeple. Limited coverage in town center area.		Low intensity, low elevation installation in steeple. Limited coverage in Town center area.		

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Wellfleet DEM fire tower					Present occupant at 75 ft	Present occupant at 72 ft. Telecorp indicates that there are no plans in year 2000 to develop sites north of this one.
		Indicates that it is pursuing a 50-ft facility about ¾ mile north of DEM tower, possibly at a church.			*Relatively low height prevents solid coverage in town center and Lecount Hollow. Second site near Truro line is necessary.*	
Eastham "Nauset tower"	*Prospective occupants*					
	150 ft	170 ft	180 ft			160 ft
	Coverage to north generally past DEM tower but not to Wellfleet center.			*Coverage to north would be comparable to Sprint and Telecorp*	*Coverage to north should overlap well with DEM tower coverage*	
	End of coverage to south varies between town offices and Orleans line, depending on carrier's technology and antenna height.					

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Eastham Town Offices Monopole				Sole carrier on tower.	*Indicates it is waiting for funding to actively seek a site between Orleans and Nauset sites.*	*Indicates interest in future RFP at site and 112 ft antenna height.*
Southern Eastham to Orleans rotary, and east of Town Cove in Orleans	*This area is generally problematic for the carriers. Some are more successful than others are at providing service in the area just north of the rotary. Some will not know how well they serve this area until new facilities in Orleans are complete.* *The residential area to the east of Town Cove is somewhat isolated from each company's network. Because it is residential, it is not likely to require high-capacity facilities in the near term. However, the bylaws prohibit wireless installations in this zone, compounding the difficulty providing service to this area if it turns out that one or more carriers cannot provide adequate signal from nearby facilities.*					
	New facility to the south may provide adequate signal penetration into this region. Combined with Nauset facility, this may be sufficient for Route 6 service. Coverage east or west of Route 6 north of the Eastham line may remain spotty. Coverage east of Town Cove may be spotty, especially in northern Orleans.	*Signal penetration into Route 6 area will be nearly identical to Bell Atlantic due to use of similar sites to north and south.*	*Signal penetration into Route 6 area will be nearly identical to Bell Atlantic due to use of similar sites to north and south.*	Overlap with facilities to the south should be adequate.	*Indicates it is waiting for funding to actively seek a site between Orleans and Nauset sites.*	Over-water signal from Chatham water tank said to fill residential area in Orleans fairly well

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Orleans in the area of Routes 6 and 6A intersection	*Replacement tower on electric utility property*	*Negotiating to be on Cape Cod Concrete site tower*	*Replacement tower on electric utility easement*		On Cape Cod Concrete site tower	On Cape Cod Concrete site tower
	Coverage in the Orleans-Brewster line area of Route 6 is or will be generally solid for all carriers.					
Brewster Route 6 area		Replacement tower (WFCC) on Freeman's Way is host to these carriers. Coverage from this site extends southwest on Route 6 past Route 137 providing marginal to fair overlap with Queen Anne Rd facilities				
Brewster/ Harwich interchange Route 6 and 137 and surrounding area	*This area is central to a large area of diminished coverage bounded by coverage from Orleans, Chatham, Harwich (Queen Anne Rd) and Brewster Police sites*	*Because these companies are at the WFCC site and Bell Atlantic is not, their voids of coverage south of Route 6 and west of 137 are smaller than that of Bell Atlantic's, but still significant.*			*Marginal coverage along route 137 from Route 6 to Route 28. Southwest of this part of 137 and continuing to Bank St in Harwich, there is a void in service.*	*A relatively small void in coverage appears between Route 6 and Chatham line along the vicinity of Route 137. Additional coverage voids along Route 28 in Harwich.*
	Indicates interest in Harwich's most easterly water tank site.	*Harwich's most easterly water tank site could satisfy much of these shortcomings. However in some cases the water tank is too far north to complete coverage along Route 28.*				

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Harwichport	*As described above, this area is lacking good service from all carriers. Many are looking at steeple or similar installations. The steeples in the area lack key features for successful deployment of all carriers' antennas: The churches are few and far between. Their steeples are not as high as more traditional New England steeples, limiting the coverage and the room for co-location.* *A combination of facilities at or near Town water tank site(s) and low elevation fill-in facilities along Route 28 may be necessary for carriers to provide service.*					
Chatham	General coverage of Chatham from town water tower	*Church turned down offer. Cell One now considering water tower options.*	General coverage of Chatham from town water tower	*General coverage of Chatham planned from town water tower (if not already accomplished)*	General coverage of Chatham from town water tower	General coverage of Chatham from town water tower
Area near junction of Harwich, Dennis, and Brewster boundaries	Two towers at Queen Anne Rd along Route 6 serve all carriers. Easterly coverage from this site is generally east of the interchange of Routes 6 and 124, the intersection of Route 28 and 124. Westerly coverage extends past the Dennis border, which is the limit of this review. Southerly coverage fails to reach Route 28 in some locations. Northerly coverage extends to Brewster line at Route 124. Each company's coverage differs somewhat, due to their differing systems and differing antenna heights.					

Locus	**Bell Atlantic Mobile**	**Cellular One**	**Nextel**	**Omnipoint**	**Sprint**	**Telecorp**
Brewster Route 6A	On Police tower.	*Interested in a site in the general area of the Police tower*	*Interested in a site west of the police tower, closer to the Dennis line, possibly an electric tower; also interested in a separate installation at the water tower at Route 137 and Underpass Rd.*	On Police tower. *Omnipoint will have similar needs in the remainder of the area. Nothing specific stated at this time.*	*Interested in Route 137 water tank at Underpass Rd.*	On Police Tower

Appendix 2

Table of Key Points of Bylaws of LCWWG Towns

Key Points of Bylaws of LCWWG Towns

Key Points of Bylaws of LCWWG Towns

Town	What the bylaw controls	Zone or District	Height Limit	Permit	Setback	Priorities
Brewster	**Communications Towers**	All	35 ft	By right	"Tower shall fall within confines of the site" (not explicitly the tower height)	
		Overlay: 67 specific parcels of land near Rt 6	Greater than 35 ft, but no upper limit specified	Special Permit by Planning Board		
Chatham	**Public Utility Building and Facilities** (note, definition is for "Public, Private Utility" but use descriptions refer to "Public Utility" uses. We assume these are equivalent terms)	R60, R40, R20, R20A, SB, GB, I, M	35 ft maximum (no explicit provision for reuse of existing structures over 35 foot height)	Special Permit by Zoning Board	Same as the standard setback for the district	Town interprets bylaw to permit attachment of antennas to existing structures on municipal land without special permit
		Municipal Conservancy (M/C)	Not allowed			
Eastham (Planning Board *Regulation* instead of bylaw)	**Communication Structures** (excludes amateur radio, TV receive, and business radio antennas from regulation)	Shall be located on public land owned by Town of Eastham	20-ft maximum increase to existing facility. No height limit specified for new facilities.	"Site Plan Special Permit" by Planning Board	Height of structure from property line as well as from dwelling, business or institutional use or public recreational area (presumably on same parcel as tower)	Carrier use of multiple sites on existing structures preferred over single high facility. Multiple carriers preferred on shared structure over the use of separate structures for each carrier.

Key Points of Bylaws of LCWWG Towns

Town	What the bylaw controls	Zone or District	Height Limit	Permit	Setback	Priorities
Harwich	**Personal Wireless Service Facilities**	All	Atttach at any height to tower of any type existing at bylaw inception (including water towers), if tower height not increased (not clear whether a steeple qualifies as a tower, but we recommend any existing structure be considered a tower if it is greater than 45 ft in height and is not a building)	No Special Permit required; only site plan approval	Fall zone based on the height of the facility or mount, unless it is an existing structure, or unless Board finds cause to reduce it up to 50%. Normal setback provisions for each district also apply.	Occupy existing structures first if installation preserves structure's character. New structures to be camouflaged as much as possible.
			Attach at any height to existing power and telephone utility structures, which may be increased up to 20 ft, but may be no higher than 150 ft above ground.	Only site plan approval, no SP, required. Restrictions on impact to scenic and historic areas.		
		Overlay District consisting of two regions in town	New towers in Overlay Districts have height limits based on number of carriers: 4: 150 ft 3: 135 ft 2: 120 ft 1: 105 ft	Special Permit by Planning Board (town land exempted from SP requirement)		
		All	If not in the exceptions above, PWS facilities are limited to 45 ft in all districts, regardless of what they are mounted upon.			
	Note: The Harwich wireless bylaw text is interpreted above. The Table of Use Regulations may contradict the text. The Table makes no distinction between use of existing structures and new towers. It indicates all zones require a special permit for facilities up to 45 feet. It indicates no facilities may be installed 45 to 150 feet (on existing structures or new) in RH1, RH2, RH3, CV, MRL, MRL1, but 45-150 foot facilities may be installed in all other zones.					

Key Points of Bylaws of LCWWG Towns

Town	What the bylaw controls	Zone or District	Height Limit	Permit	Setback	Priorities
Orleans	**Communications Structures** except those for amateur or government use or for TV antennas.	Commercial	Towers limited to 150 ft.	Special Permit by Zoning Board	Engineered fall zone plus 50 ft from property line. Structure height plus 100 ft from residential district.	Pre-existing structures preferred, if preserving structure's character or minimizing visibility. New structures or appurtenances preferred on public land. Co-location encouraged on communication structures.
			Monopoles limited to 150 ft	Allowed with Site Plan Review		
			Communications Appurtenances limited to structure height plus ten feet	Allowed with Site Plan Review		
		General Business	Monopoles limited to 75 ft	Special Permit by Zoning Board		
			Communications Appurtenances limited to structure height plus ten feet	Allowed with Site Plan Review		
		RB, LB, VC	Communications Appurtenances limited to structure height plus ten feet.	Special Permit by Zoning Board		
		All of the above	Heights exceeding above limits	Special Permit by Zoning Board		

Key Points of Bylaws of LCWWG Towns

Town	What the bylaw controls	Zone or District	Height Limit	Permit	Setback	Priorities
Province-town	**Telecommu-nications facilities** (defined to be the same as Personal Wireless Communications facilities—all other types of radio communications are not addressed in this bylaw, except the specific exemption of emergency dispatch, CB, AM, FM, and amateur antennas and the exclusion of satellite teleports.	**All districts**, however most available land is eliminated with large setback. No facilities permitted in wetlands.	**150 ft** maximum	Special Permit by Planning Board	Height of tower plus 50 feet, as long as the structure is more than 500 ft from dwellings, schools, municipal water supply tanks, child care facilities, and housing for the infirm or elderly	**Shared use** of structures, clustering of structures, use of **public lands**, and use of " very low power repeaters" are encouraged. First priority given to the use of National Seashore land, as long as distance to dwellings is 1500 ft or more. 2nd, 3rd, and 4th priority to land more than 500 ft from dwellings at, respectively, the National Seashore, the Burn Dump, and town or private land.
		Wireless repeaters allowed in all districts	*Minimum height* 35 ft above ground, unless demonstrated that being lower is the only way to provide adequate coverage	Site plan review only. No Special Permit required	200 feet from dwellings, unless demonstrated that being closer is the only way to provide adequate coverage	

Key Points of Bylaws of LCWWG Towns

Town	What the bylaw controls	Zone or District	Height Limit	Permit	Setback	Priorities
Truro	**Communications Structures**, Building and Appurtenance	**Route 6 General Business**, with a strong preference for public land	**150 ft** maximum	Special Permit	Structure height plus ten feet	Preference for use of pre-existing structures followed by a new structure to be on public land. Single tower for all carriers, to the extent lawful and feasible.
Wellfleet	**Communications Structures,** Buildings, and Appurtenances. Only amateur radio and home TV antennas are exempt.	**All districts, except the CD district**. The Harbor Area of Critical Environmen-tal Concern is also excluded	**No height limit** specified. Existing structure heights shall not be increased by the addition of appurtenances.	Special Permit by Planning Board	Structure height plus ten feet	Preference for use of pre-existing structures followed by new structure on public land. Multiple shorter towers preferred to achieve carrier's coverage objectives. Structures to be shared at by multiple carriers at any particular site rather than multiple structures.

Key Points of Bylaws of LCWWG Towns

Appendix 3
Cape Cod Commission Classification
Of
Sensitive Areas

Cape Cod National Seashore Classification of Sensitive Areas

The Cape Cod National Seashore maintains a general classification scheme to aid in evaluating the sensitivity of an area to the development of new wireless facilities.

Preferred Siting Areas with Fewest Restrictions

These are developed areas where buildings, signs, significant utility infrastructure, paved areas, or other man-made elements dominate the character of the vicinity. Facilities sited here can be quite visible, but should be consistent with existing patterns of development. Height should generally match that of nearby vegetation, but exceptions could be made if existing development provides sufficient context for higher structures, and if views from key viewpoints (see below) remain unaffected.

Sensitive Siting Areas with Greater Design Restrictions.

These are partially developed areas where modern infrastructure is visible within a more natural context. Facilities sited here must blend with existing development so that they do not appreciably stand out, or change the overall feel of the locale. (Height should be no more than ten feet above existing vegetation and development, depending on how siting and design mitigate its visibility or appearance.)

Very Sensitive Siting Areas with Severe Design Restrictions

These areas contain historically significant structures and groupings of structures, cultural landscapes and significant views, as well as views from these locales. This category also includes archaeologically sensitive areas, wetlands, and important natural habitat areas. Some areas will have no appropriate sites at all. When facilities are sited here they must not be visible, or must be made to match existing elements in an appropriate way. Facilities sited elsewhere must not be visible from these areas in any way that changes the significant character or feel of the area.

Vista Points

These are locations from which larger views can be seen that are important to the viewer experience. Facilities that can be seen from these areas must be sized and sited so that they do not materially affect the important qualities for which the view is deemed significant.

Key Landmarks

These are highly visible and familiar eye catchers whose character and identity mark and define the important qualities of the landmark and its surroundings. Facilities sited on or near these cannot change the defining characteristics of the site from important viewpoints.

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Appendix 4

Laws Protecting
Wireless Communications Antenna Installations

Laws Protecting
Wireless Communications Antenna Installations

In addition to the Telecommunications Act of 1996, which includes protection of Personal Wireless Facilities, other laws protect Amateur radio operators ("Ham Radio"), and television viewers. This Appendix excerpts rules related to these antenna-siting issues.

While the focus of this report is on controlling the proliferation of personal wireless communications facilities, wireless communications occur in many forms. Communities should ensure that their regulations anticipate all forms of wireless communications. The three categories below enjoy various forms of legal protection.

Personal Wireless Services and the Telecommunications Act of 1996

Section 704 of the Telecommunications Act of 1996 sets specific requirements for the regulation of personal wireless services.

•Communities must not prohibit the provision of personal wireless services.[4]
•Communities are still entitled to regulate personal wireless services on zoning matters
•Communities must not unreasonably discriminate among providers of equivalent personal wireless services
•Communities may not regulate personal wireless services on basis of environmental impact of radio emissions
•Community decisions must be timely and written

•Zoning Is Not Preempted
–"Except as provided in this paragraph, nothing in this Act shall limit or affect the authority of a State or local government or instrumentality threreof over decisions regarding the placement, construction, and modification of personal wireless service facilities."

•Prohibition Prohibited
–"The regulation of the placement, construction, and modification of personal wireless facilities by any State or local government or instrumentality thereof shall not prohibit or have the effect of prohibiting the provision of personal wireless services"

[4] Personal Wireless Services are certain communications services specified in Section 332 of the Act that provide connection to the public switched telephone network. Anything with an area code and phone number is part of the public switched telephone network. Thus, for example, a pager that can be reached by dialing an access number is providing personal wireless service, just as a cell-phone that can make and receive calls is also provides personal wireless service.

•Discrimination Prohibited
–"The regulation of the placement, construction, and modification of personal wireless facilities by any State or local government or instrumentality thereof
shall not unreasonably discriminate among providers of functionally equivalent services"

•Timely Decisions and Written Record Required
–"A State or local government or instrumentality thereof shall act on any request for authorization to place, construct, of modify personal wireless service facilities within a reasonable period of time after the request is duly filed with such government or instrumentality, taking into account the nature and scope of such request."

–"Any decision… shall be in writing and supported by substantial evidence contained in a written record."

•Compliant Radio Emissions May Not Affect Decision
–"No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions."

Amateur Radio Antennas

From Massachusetts General Law 40A, Section 3:

> No zoning ordinance or by-law shall prohibit the construction or use of an antenna structure by a federally licensed amateur radio operator. Zoning ordinances and by-laws may reasonably regulate the location and height of such antenna structures for the purposes of health, safety, or aesthetics; provided, however, that such ordinances and by-laws reasonably allow for sufficient height of such antenna structures so as to effectively accommodate amateur radio communications by federally licensed amateur radio operators and constitute the minimum practicable regulation necessary to accomplish the legitimate purposes of the city or town enacting such ordinance or by-law.

From Title 47, Code of Federal Regulations 97.15:

> Sec. 97.**15** Station antenna structures.
> (b) Except as otherwise provided herein, a station antenna structure may be erected at heights and dimensions sufficient to accommodate amateur service communications. (State and local regulation of a station antenna structure must not preclude amateur service communications. Rather, it must reasonably accommodate such communications and must constitute the minimum practicable regulation to accomplish the state or local authority's legitimate purpose. See PRB-1, 101 FCC 2d 952 (1985) for details.)

FCC PRB-1 101 FCC 2nd 952 (1985) states, in part:

> 25. Because amateur station communications are only as effective as the antennas employed, antenna height restrictions directly affect the effectiveness of amateur communications. Some amateur antenna configurations require more substantial installations than others if they are to provide the amateur operator with the communications that he/she desires to engage in. For example, an antenna array for International amateur communications will differ from an antenna used to contact other amateur operators at shorter distances. We will not, however, specify any particular height limitation below which a local government may not regulate, nor will we suggest the precise language that must be contained in local ordinances, such as mechanisms for special exceptions, variances, or conditional use permits. Nevertheless, local regulations which involve placement, screening, or height of antennas based on health, safety, or aesthetic considerations must be crafted to accommodate reasonably amateur communications, and to represent the minimum practicable regulation to accomplish the local authority's legitimate purpose.

Home TV Reception

FCC regulations protect the reception of TV signals, including

Broadcast TV
Satellite TV
Multipoint TV Distribution systems.

Title 47 Code of Federal Regulations, Part 1, Subpart S—
Preemption of Restrictions That ``Impair'' a Viewer's Ability To Receive Television Broadcast Signals, Direct Broadcast Satellite Services or Multichannel Multipoint Distribution Services

> Sec. 1.4000 Restrictions impairing reception of television broadcast signals, direct broadcast satellite services or multichannel multipoint distribution services. Source: 61 FR 46562, Sept. 4, 1996, unless otherwise noted.
>
> (a)(1) **Any restriction**, [*emphasis added*] including but not limited to any state or local law or regulation, including zoning, land-use, or building regulations, or any private covenant, contract provision, lease provision, homeowners' association rule or similar restriction, on property within the exclusive use or control of the antenna user where the user has a direct or indirect ownership or leasehold interest in the property **that impairs the installation, maintenance, or use of:**
> (i) An antenna that is designed to receive **direct broadcast satellite service**, including direct-to-home satellite services, that is one meter or less in diameter or is located in Alaska;
> (ii) An antenna that is designed to receive video programming services via **multipoint distribution services**, including multichannel multipoint distribution services, instructional television fixed services, and local

multipoint distribution services, and that is one meter or less in diameter or diagonal measurement;
(iii) An antenna that is designed to receive **television broadcast signals**; or
(iv) A mast supporting an antenna described in paragraphs (a)(1)(i), (a)(1)(ii) or (a)(1)(iii) of this section;
is prohibited to the extent it so impairs, subject to paragraph (b) of this section.

(2) For purposes of this section, a law, regulation or restriction impairs installation, maintenance or use of an antenna if it:
(i) Unreasonably delays or prevents installation, maintenance or use,
(ii) Unreasonably increases the cost of installation, maintenance or use, or
(iii) Precludes reception of an acceptable quality signal.
(3) Any fee or cost imposed on a viewer by a rule, law, regulation or restriction must be reasonable …[*edited for brevity*]
(b) Any restriction otherwise prohibited by paragraph (a) of this section is permitted if:
(1) It is necessary to accomplish a clearly defined, legitimate safety objective that is either stated in the text, preamble or legislative history of the restriction or described as applying to that restriction in a document that is readily available to antenna users, and would be applied to the extent practicable in a non-discriminatory manner to other appurtenances, devices, or fixtures that are comparable in size and weight and pose a similar or greater safety risk as these antennas and to which local regulation would normally apply; or
(2) It is necessary to preserve a prehistoric or historic district, site, building, structure or object included in, or eligible for inclusion on, the National Register of Historic Places, as set forth in the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470, and imposes no greater restrictions on antennas covered by this rule than are imposed on the installation, maintenance or use of other modern appurtenances, devices or fixtures that are comparable in size, weight, and appearance to these antennas; and
(3) It is no more burdensome to affected antenna users than is necessary to achieve the objectives described in paragraph (b)(1) or (b) (2) of this section.

[*end of excerpt*]

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Appendix 5

Memoranda of Agreement with Participating Towns

Appendix 6

Request for Proposals and Broadcast Signal Lab Proposal

Appendix 7

Lower Cape Wireless Working Group
Meeting Minutes

Appendix 8

Comments on Final Draft Report