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## RF Report

Proposed Wireless Facility  
85 Washington Road  
Pembroke, MA 02359



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September 11, 2020

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## 1. Overview

This RF Report has been prepared on behalf of Verizon Wireless in support of its proposal to the Town of Pembroke for the installation and operation of a wireless facility located at 85 Washington Road. The proposed facility consists of a 120' monopole tower within a fenced compound along with ground-based equipment cabinets and associated equipment mounted on the proposed tower.

This report concludes that the proposed site will fill in coverage gaps and provide additional capacity to northern Pembroke in order to improve deficient service areas along Route 53, Route 139, and the surrounding roads, neighborhoods, and business/retail establishments in the proximity of the proposed site.

Included in this report is: a brief summary of the site's objectives, maps showing Verizon Wireless' current network plan, and modeled Radio Frequency coverage of the subject site and the surrounding sites in Verizon Wireless' network.

## 2. Introduction

Verizon Wireless provides digital voice and data communications services using 3rd Generation (3G) CDMA/EVDO technology in the Cellular (800 MHz) and PCS (1900 MHz) frequency bands, and is in the midst of deploying advanced 4th Generation (4G) voice and data services over LTE technology in the 700 MHz, Cellular, PCS, and AWS (2100 MHz) frequency bands as allocated by the FCC. These networks are used by mobile devices for fast web browsing, media streaming, and other applications that require broadband connections. The mobile devices that benefit from these advanced networks are not limited to basic handheld phones, but also include devices such as smartphones, PDA's, tablets, and laptop air-cards. With the evolving rollout of 4G LTE services and devices, Verizon Wireless customers will have even faster connections to people, information, and entertainment.

As explained within this report, Verizon Wireless has identified the need to add a new facility to its existing network of sites in the area to improve coverage and capacity to a significant gap in service that exists in northern Pembroke, in order to support reliable communications and meet the growing demand in the area.

To maintain a reliable and robust communications system for the individuals, businesses, public safety workers and others who use its network, Verizon Wireless deploys a network of cell sites (also called wireless communications facilities) throughout the areas in which it is licensed to provide service. These cell sites consist of antennas mounted on structures, such as buildings and towers, supported by radio and power equipment. The receivers and transmitters at each of these sites process signals within a limited geographic area known as a "cell."

Mobile subscriber handsets and wireless devices operate by transmitting and receiving low power radio frequency signals to and from these cell sites. Handset signals that reach the cell site are transferred through land lines (or other means of backhaul transport) and routed to their destinations by sophisticated electronic equipment. In order for Verizon Wireless' network to function effectively, there must be adequate overlapping coverage between the "serving cell" and adjoining cells. This not only allows a user to access the network initially, but also allows for the transfer or "hand-off" of calls and data transmissions from one cell to another, and prevents unintended disconnections or "dropped calls."

Verizon Wireless' antennas also must be located high enough above ground level to allow transmission (a.k.a. propagation) of the radio frequency signals above trees, buildings, and other natural or man-made structures that may obstruct or diminish the signals. Areas without adequate radio frequency coverage have substandard service, characterized by dropped and blocked calls, slow data connections, or no wireless service at all, and are commonly referred to as coverage gaps.

The size of the area potentially served by each cell site depends on several factors including the number of antennas used, the height at which the antennas are deployed, the topography of the surrounding land, vegetative cover, and natural or man-made obstructions in the area. The actual service area at any given time also depends on the number of customers who are on the network in range of that cell site. As customers move throughout the service area, the transmission from the phone or other device is automatically transferred to the Verizon Wireless facility with the best reception, without interruption in service, provided that there is overlapping coverage between the cells.

Each cell site must be primarily designed to strike a balance between the overall geographic coverage area it will serve, and the site's capacity to support the usage within the coverage footprint. In rural areas, cell sites are generally designed to have broader coverage footprints because the potential traffic is sparser and distributed over a larger area. In more densely populated suburban and urban environments, the capacity to handle calls and data transmissions is of increasing concern, and cell sites must limit their coverage footprint to an area where the offered network traffic can be supported by the radio equipment and resources. Due to the aggressive historical and projected growth of mobile usage, particularly for mobile data (82% in 2017-2018 in the U.S.<sup>1</sup>), instances arise where the usage demand can no longer be supported by the site(s) serving an area, and new facilities must be integrated to provide capacity relief to the overloaded sites.

We have concluded that by installing the proposed wireless communication facility at 85 Washington Road at an antenna centerline height of 117' AGL (above ground level), Verizon Wireless will be able to provide improved coverage and capacity to residents, businesses, and traffic corridors within northern Pembroke that are currently located within a gap in service of Verizon Wireless' network.

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<sup>1</sup> "2019 Annual Survey Highlights", June 20, 2019, CTIA.  
<https://www.ctia.org/news/2019-annual-survey-highlights>

### 3. The Proposed Facility

Verizon Wireless' proposed facility would consist principally of the following elements:

- 1) A 120' monopole tower within a 50' x 50' fenced compound;
- 2) A 12' x 20' concrete pad within the compound mounted with telecommunications equipment cabinets, backup power generator, and telco/power/fiber connections;
- 3) Twelve (12) panel antennas (four per sector) mounted on the proposed monopole, at a centerline elevation of 117' AGL;
- 4) Remote Radio Heads (RRHs) with accessory junction boxes and surge suppressors, mounted alongside the antennas on the tower platform;
- 5) An ice bridge from the proposed equipment cabinets to the proposed tower to protect cabling between Verizon Wireless' equipment and the cable entry port located near the base of the tower.

## 4. Coverage and Capacity Objectives

As mentioned above, Verizon Wireless is in the process of rolling out its 4G LTE high-speed wireless broadband system in the 700 MHz, Cellular, PCS, and AWS frequency bands, in accordance with its licenses from the FCC. In order to expand and enhance their wireless services throughout New England, Verizon Wireless must fill in existing coverage gaps and address capacity, interference, and high-speed broadband issues. As part of this effort, Verizon Wireless has determined that significant gaps in service exist in and around sections of the Town of Pembroke, MA, as described further below.

Verizon Wireless currently operates wireless facilities similar to the proposed facility within Pembroke and the surrounding cities/towns. Due in large part to the distances between the existing sites, the intervening topography, and volume of user traffic in the area, these existing facilities do not provide sufficient coverage and capacity to portions of Town. Specifically, Verizon Wireless determined that portions of northern Pembroke are without reliable service in the following areas and town roads<sup>2</sup>, including but not limited to:

- Route 53 (Washington Street and Columbia Road);
  - Serves > 23,500 vehicles per day, as measured at Hanover town line (2019);
- Route 139 (Water Street);
- West Elm Street, Elm Street, and Broadway;
- The surrounding roads, neighborhoods, and business/retail establishments in the proximity of the proposed site and the above-mentioned roads.

The proposed site located at 85 Washington Road (“Pembroke 5”) is needed to fill in these targeted gaps in service, in order to improve network quality and reliability for Verizon Wireless subscribers traveling along these roads, as well as to the numerous residents, businesses, and visitors in this area.

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<sup>2</sup> Traffic counts are sourced from the MA Department of Transportation, Transportation Data Management System.

## 5. Site Search and Selection Process

To find a site that provides acceptable coverage, adequate capacity, and fills the gaps in service, computer modeling software is used to define a search area. The search ring identifies the area within which a site could be located (assuming sufficient height is considered) that would have a high probability of addressing the significant coverage gap and/or meeting the capacity objectives established by the Verizon Wireless RF (Radio Frequency) engineers.

Once a search ring is determined, Verizon Wireless' real estate specialists search within the proximity of the defined area for existing buildings, towers, and other structures of sufficient height that would meet the defined objectives. If none are found, then the focus shifts to "raw land" sites. A suitable site must satisfy the technical requirements identified by the RF engineers, must be available for lease, and must have access to a road and be otherwise suitable for constructing a cell site of the required size and height. Every effort is made to use existing structures before pursuing a "raw land" build to minimize the number of new towers throughout the cities and towns being served.

Since no suitable existing structures in the area have been identified, Verizon Wireless determined that the proposed wireless communications facility at 85 Washington Road is necessary to address the targeted coverage and capacity objectives with respect to its network requirements.

## 6. Pertinent Site Data

Table 1 below details the site-specific information for the existing (on-air), approved, planned, and proposed Verizon Wireless sites used to perform the coverage analysis and generate the coverage plots provided herein.

Site Name	Address	City/Town	Location		Structure Type	Antenna Height (ft AGL)	Status
			Latitude	Longitude			
Duxbury	Moduc Street	Duxbury	42.0472	-70.7186	Lattice	155	On-Air
Duxbury 2	454 Franklin Street	Duxbury	42.0692	-70.7320	Monopole	160	On-Air
Hanover	263 Winter Street	Hanover	42.0986	-70.8703	Monopole	131	On-Air
Hanover East	596 Washington Street	Hanover	42.1224	-70.8270	Lattice	135	On-Air
Hanson	Industrial Blvd.	Hanson	42.0482	-70.8997	Lattice	147	On-Air
Hanson 3	111 Liberty Street	Hanover	42.0779	-70.8722	Monopole	146	Approved
Kingston 2	Independence Ind. Park	Kingston	42.0152	-70.7409	Monopole	109	On-Air
Kingston 5	254 Pembroke Street	Kingston	42.0125	-70.7813	Watertank	103	On-Air
Marshfield	Pleasant Street	Marshfield	42.1337	-70.7324	Guyed	230	On-Air
Marshfield 2	130 Enterprise Drive	Marshfield	42.1024	-70.7490	Lattice	155	On-Air
Marshfield 3	117 Grove Street	Marshfield	42.1111	-70.7042	Guyed	170	On-Air
Marshfield 5	0 Snow Road	Marshfield	42.0890	-70.7085	Monopole	120	Planned
Marshfield 6	Lone Street	Marshfield	42.1051	-70.7604	Lattice	100	On-Air
Norwell	18 South Street	Norwell	42.1526	-70.8426	Lattice	130	On-Air
Norwell 2	Forest Street	Norwell	42.1571	-70.8040	Monopole	105	On-Air
Norwell South	Pine Street	Norwell	42.1297	-70.8036	Stealth Pole	100	On-Air
Pembroke	171 Mattakeesett Street	Pembroke	42.0638	-70.8245	Monopole	125	On-Air
Pembroke 2	School Street	Pembroke	42.0415	-70.8383	Monopole	98	On-Air
Pembroke North	360 Washington Street	Pembroke	42.0882	-70.7905	Stealth Pole	127	On-Air
Pembroke South	Valley Street	Pembroke	42.0398	-70.7678	Monopole	127	On-Air
Rodland	55 Accord Park Drive	Rodland	42.1652	-70.8888	Lattice	140	On-Air
Rodland 2	855 Market Street	Rodland	42.1181	-70.8898	Lattice	180	On-Air
Rodland 3	Maple Street	Rodland	42.1253	-70.9211	Smokestack	82	On-Air
Rodland 4	West Pleasant Street	Rodland	42.1492	-70.9160	Lattice	105	On-Air
Situate South	280 Dirftway	Situate	42.1797	-70.7423	Monopole	170	On-Air
Whitman	7 Marble Street	Whitman	42.0806	-70.9329	Smokestack	95	On-Air
Pembroke 5	85 Washington Road	Pembroke	42.1033	-70.8042	Monopole	117	Proposed

**Table 1: Verizon Wireless Site Information Used in Coverage Analysis<sup>3</sup>**

<sup>3</sup> Some sites listed in this table are outside the plot view but are included for completeness of information.



## 7. Coverage Analysis and Propagation Plots

The signal propagation plots provided in this report were produced using deciBel Planner™, a Windows-based RF propagation computer modeling program and network planning tool. The software considers the topographical features of an area, land cover, antenna models, antenna heights, RF transmitting power and receiver thresholds to model coverage and other related RF parameters used in site design and network expansion.

The coverage plots included as attachments show coverage based on RSRP signal strengths of -95 dBm and above. All other areas (depicted in white) fall within coverage areas characterized by poor service quality, low data throughput, and the substantial likelihood of unreliable service.

Attachments A - E are discussed below:

**Attachment A** titled “*Pembroke 5 – Existing/Approved 700 MHz & 2100 MHz LTE Coverage (Macro-Sites)*” shows the coverage provided to areas of Pembroke from the “On-Air” and “Approved” macro-sites listed in Table 1. “On-Air” sites are existing Verizon Wireless facilities and “Approved” sites are defined as those that are in the final stages of permitting or construction and are expected to be turned on-air soon. The green and yellow shaded areas represent the minimum desired level of coverage for most of this area for the 700 MHz and 2100 MHz network layers, respectively. Because of the superior propagation characteristics of 700 MHz relative to 2100 MHz, the 2100 MHz coverage areas (yellow) are generally contained within the 700 MHz coverage areas (green). As such, the deficient areas of 700 MHz coverage are defined by the unshaded areas, whereas the deficient areas of 2100 MHz coverage consist of both the green and white areas. As shown in this plot and described in the Coverage and Capacity Objectives section of this report, portions of northern Pembroke are in areas of deficient coverage. These coverage gaps, particularly at 2100 MHz, include Route 53, Route 139, and the surrounding roads, neighborhoods, and business/retail establishments.

**Attachment B** titled “*Pembroke 5 - 700 MHz & 2100 MHz LTE Coverage with Proposed Site (Macro-Sites)*” shows the composite coverage with the proposed “Pembroke 5” facility. As shown by the additional areas of coverage, the proposed facility will provide coverage to:

- ~ 0.3 mi (700 MHz) and 0.6 mi (2100 MHz) along Route 53 (Washington St. / Columbia Rd.);
- ~ 0.2 mi (700 MHz) and 0.4 mi (2100 MHz) along Route 139;
- ~ 0.9 mi (700 MHz) along West Elm Street;
- ~ 1.3 mi (700 MHz) along Broadway;
- ~ 0.8 mi (700 MHz) and 0.3 mi (2100 MHz) along Elm Street;
- ~ 2,000 (700 MHz) and ~ 700 (2100 MHz) additional residents<sup>4</sup>;
- ~ 800 (700 MHz) and ~ 650 (2100 MHz) additional employees<sup>5</sup>;
- ~ 1,000 (700 MHz) and ~ 250 (2100 MHz) additional structures<sup>6</sup>;

<sup>4</sup> Residential population counts referenced here and elsewhere in this report are based upon the 2010 U.S. Census data.

<sup>5</sup> Employee population counts referenced in this report are based upon the 2017 U.S. Census Bureau LEHD database.

<sup>6</sup> Structure counts referenced here in this report are based upon “roofprint” data sourced from MassGIS (Bureau of Geographic Information). The dataset contains two-dimensional roof outlines for all buildings larger than 150 ft<sup>2</sup> and may not necessarily include only dwellings. For additional information, refer to <https://docs.digital.mass.gov/dataset/massgis-data-building-structures-2-d>

**Attachment C** titled “*Pembroke 5 – Existing/Approved 700 MHz LTE Sector Footprints (Macro-Sites)*” depicts the areas primarily served by the sectors (a.k.a. signal “footprints”) of the surrounding Verizon Wireless macro sites in the area, which are shown by the unique color for each particular sector of interest. For clarity, all other sectors of less interest with respect to the proposed site are shown in grey. As demand for wireless voice and data services continues to grow, Verizon Wireless manages the footprint of each sector so that it can support the demand within the area it is primarily serving. In addition to improving coverage to the area, the proposed site will also serve existing and anticipated demand in the vicinity and thereby offload some of the burden experienced by the surrounding sites. In that way, those sites will be able to more adequately serve the demand for service in the areas nearer to those surrounding sites. Please note that the outer parts of each sector footprint may include areas that presently have signal strength below the targeted value required for reliable service to Verizon Wireless’ customers. The fact that low-level signal may reach these areas does not mean that these areas experience adequate coverage. These unreliable areas of low signal level can impose a significant capacity burden on the sites primarily serving the area.

**Attachment D** titled “*Pembroke 5 - 700 MHz LTE Sector Footprints with Proposed Site (Macro-Sites)*” shows the composite coverage with the overall footprint of the proposed facility in green. As shown in this map, the proposed “Pembroke 5” facility is an effective solution to provide capacity relief to the area, particularly to the “Marshfield 6” gamma sector (blue), the “Pembroke North” alpha sector (red), the “Pembroke” alpha sector (yellow), and the “Hanover East” alpha sector (orange). The proposed facility is centrally located in a busy area of deficient coverage making it particularly suited to distribute the traffic load across multiple sectors and provide a dominant server to this pocket of heavy usage. Table 2 below details the capacity relief based on the sector footprints shown in Attachments C and D.

Sector	Current			With "Pembroke 5"			Offload Summary		
	Residential Pops	Employee Pops	Structures	Residential Pops	Employee Pops	Structures	Total Residential Pops Offloaded	Total Employee Pops Offloaded	Structures Offloaded
Marshfield 6 Gamma	1834	1904	944	947	1253	446	887 ( 48.4%)	651 ( 34.2%)	498 ( 52.8%)
Pembroke North Alpha	775	657	456	427	322	261	348 ( 44.9%)	335 ( 51%)	195 ( 42.8%)
Pembroke Alpha	1437	459	606	851	139	363	586 ( 40.8%)	320 ( 69.7%)	243 ( 40.1%)
Hanover East Alpha	692	581	337	372	195	145	320 ( 46.2%)	386 ( 66.4%)	192 ( 57%)

**Table 2: Capacity Offload Summary**

**Attachment E** titled “*Pembroke 5 – Area Topography Map*” details the topographical features around the proposed “Pembroke 5” site. These terrain features play a key role in dictating both the unique coverage areas served from a given location, and the coverage gaps within the network. This map is included to provide a visual representation of the terrain variations that must be considered when determining the appropriate location and design of a proposed wireless facility. The blue and green shades correspond to lower elevations, whereas the orange, red, and grey shades indicate higher elevations.

## 8. Certification of Non-Interference

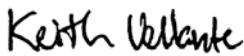
Verizon Wireless certifies that the proposed facility will not cause interference to any lawfully operating emergency communication system, television, telephone or radio, in the surrounding area. The FCC has licensed Verizon Wireless to transmit and receive in the Upper C-Block of the 700 MHz band, B Block of the Cellular (850 MHz) band, the C3, E, and F Blocks of the PCS (1900 MHz) band, and the A and B Blocks of the AWS (2100 MHz) band of the RF spectrum. As a condition of the FCC licenses, Verizon Wireless is prohibited from interfering with other licensed devices that are being operated in a lawful manner. Furthermore, no emergency communication system, television, telephone, or radio is licensed to operate on these frequencies, and therefore interference is highly unlikely.

## 9. Summary

In undertaking its build-out of 4G LTE service in Plymouth County, Verizon Wireless has determined that an additional facility is needed to provide reliable service and additional capacity throughout areas of northern Pembroke, MA. Verizon Wireless determined that the proposed wireless communications facility at 85 Washington Road in Pembroke at an antenna centerline height of 117 feet (AGL) will provide additional coverage and capacity needed in the targeted coverage areas including key roadways such as Route 53, Route 139, and the surrounding roads, neighborhoods, and business/retail establishments in the proximity of the proposed site. Without the installation of the proposed site, Verizon Wireless will be unable to improve and expand their existing 4G LTE wireless communication services in this area of Pembroke; therefore, Verizon Wireless respectfully requests that the Town of Pembroke act favorably upon the proposed facility.

## 10. Statement of Certification

I certify to the best of my knowledge that the statements in this report are true and accurate.



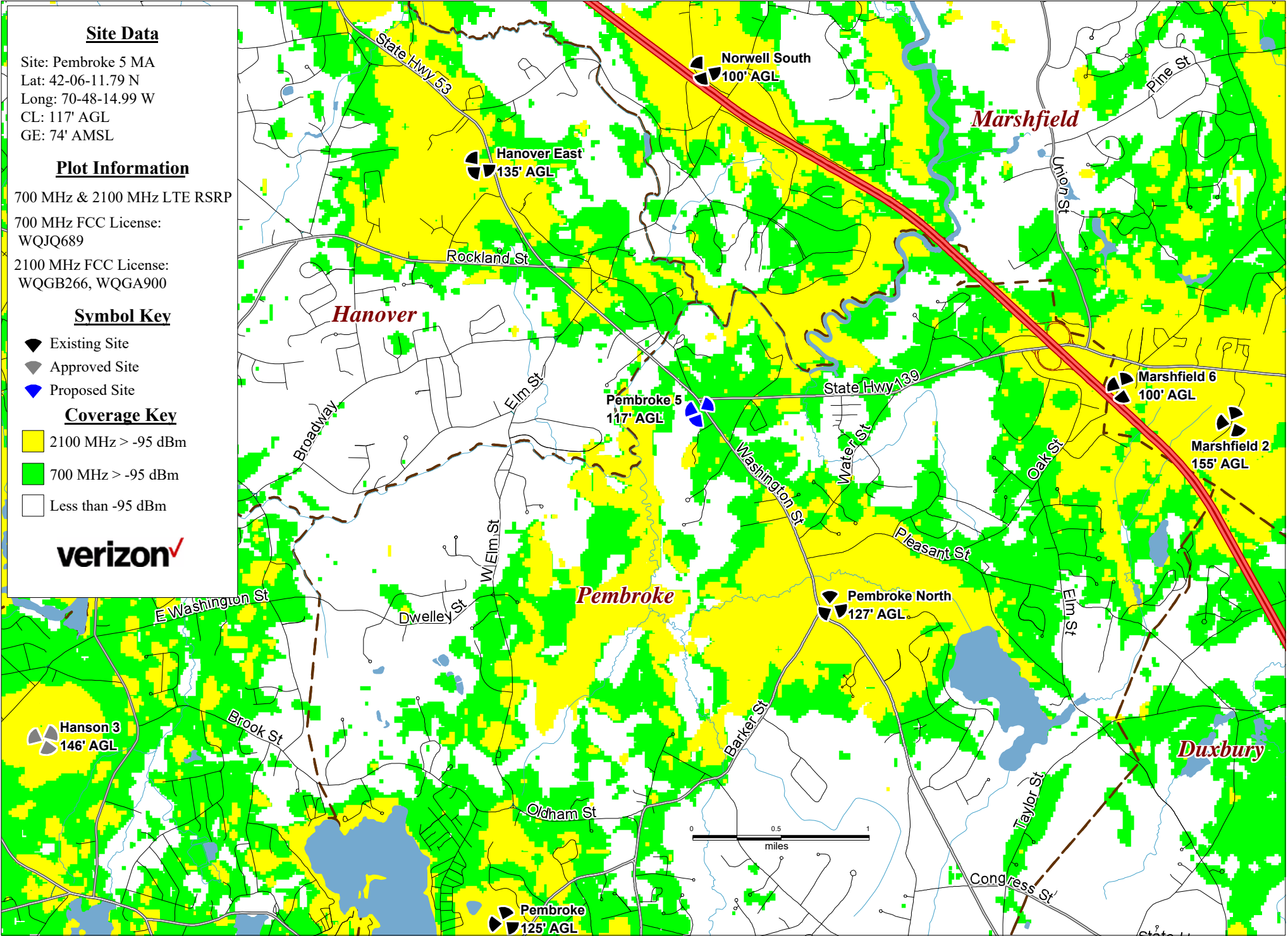
Keith Vellante  
RF Engineer  
C Squared Systems, LLC

September 11, 2020

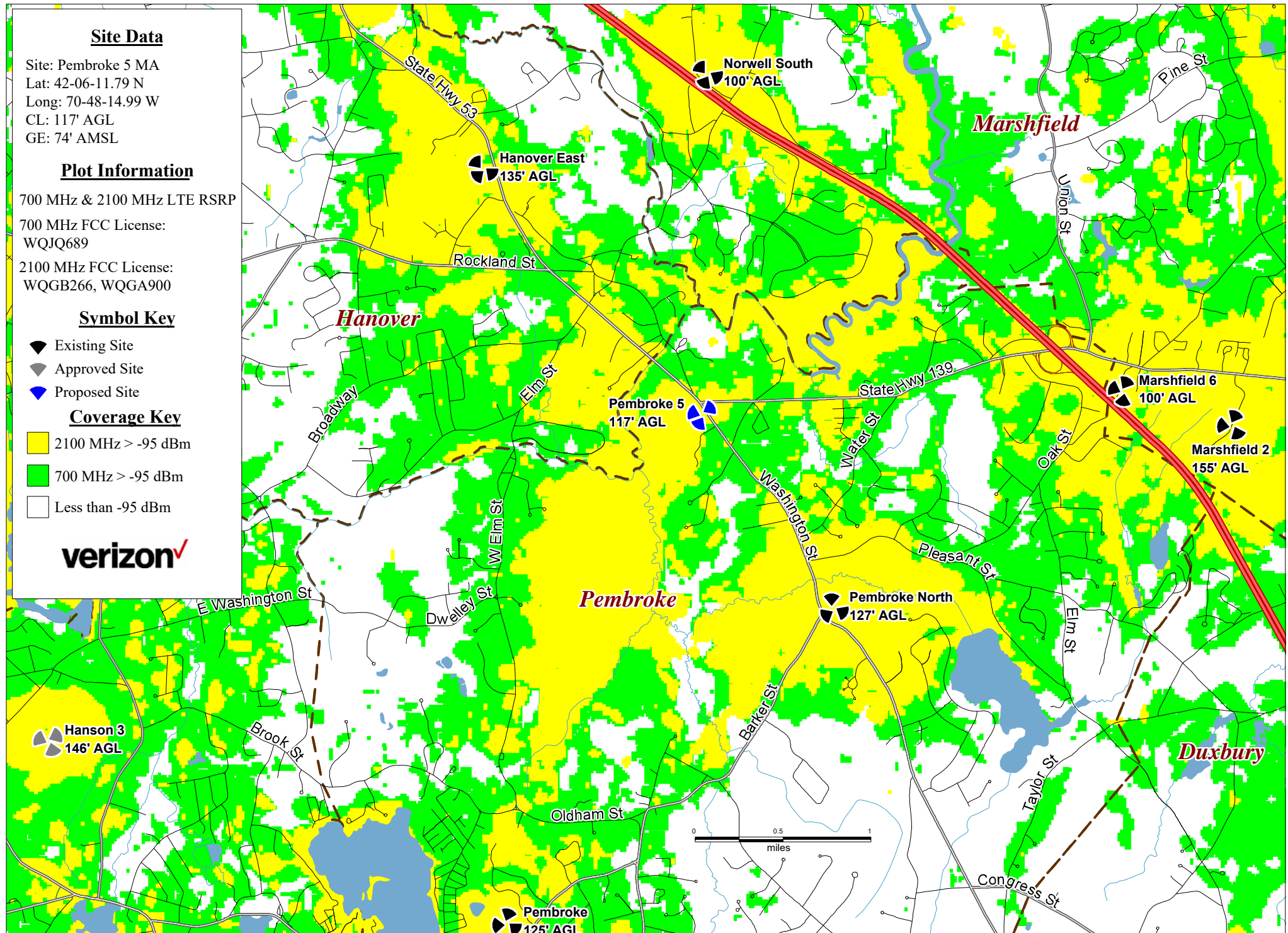
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## 11. Attachments

Attachment A:  
Pembroke 5 - Existing/Approved 700 MHz & 2100 MHz LTE Coverage (Macro-Sites)

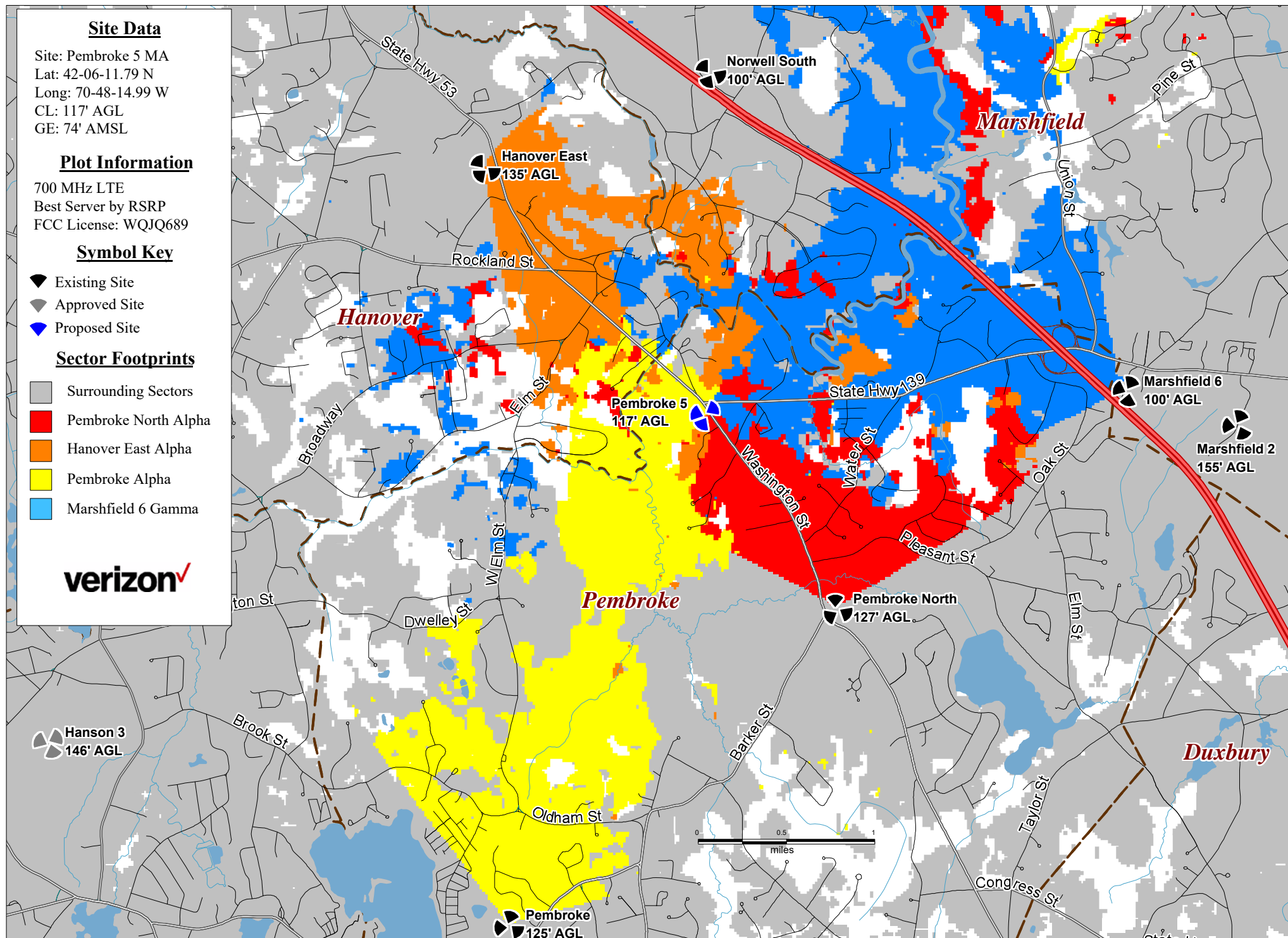


**Attachment B:**  
**Pembroke 5 - 700 MHz & 2100 MHz LTE Coverage with Proposed Site (Macro-Sites)**

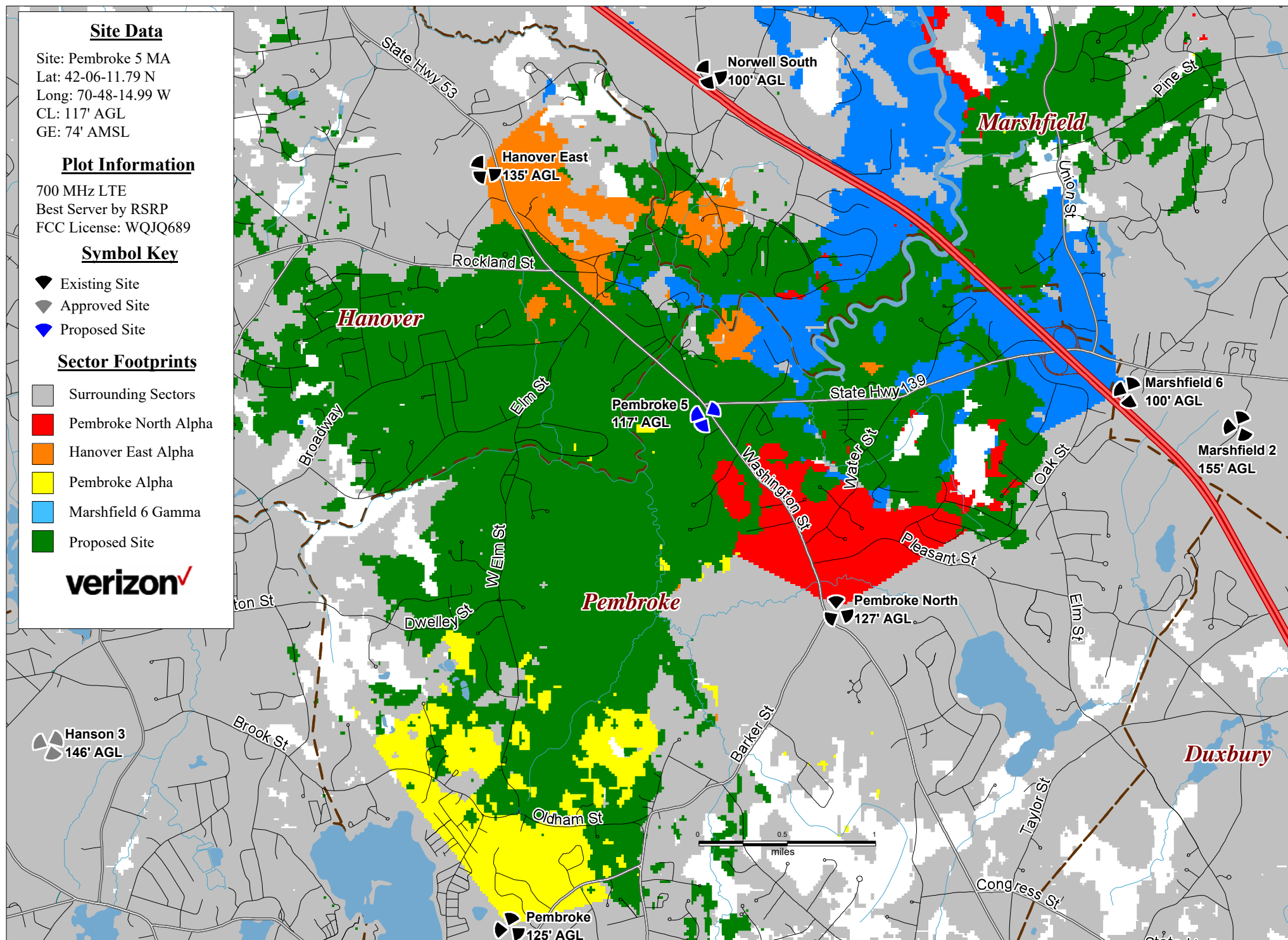




**Attachment C:**  
**Pembroke 5 - Existing/Approved 700 MHz LTE Sector Footprints (Macro-Sites)**



**Attachment D:**  
**Pembroke 5 - 700 MHz LTE Sector Footprints with Proposed Site (Macro-Sites)**





**Attachment E:**  
**Pembroke 5 - Area Topography Map**

