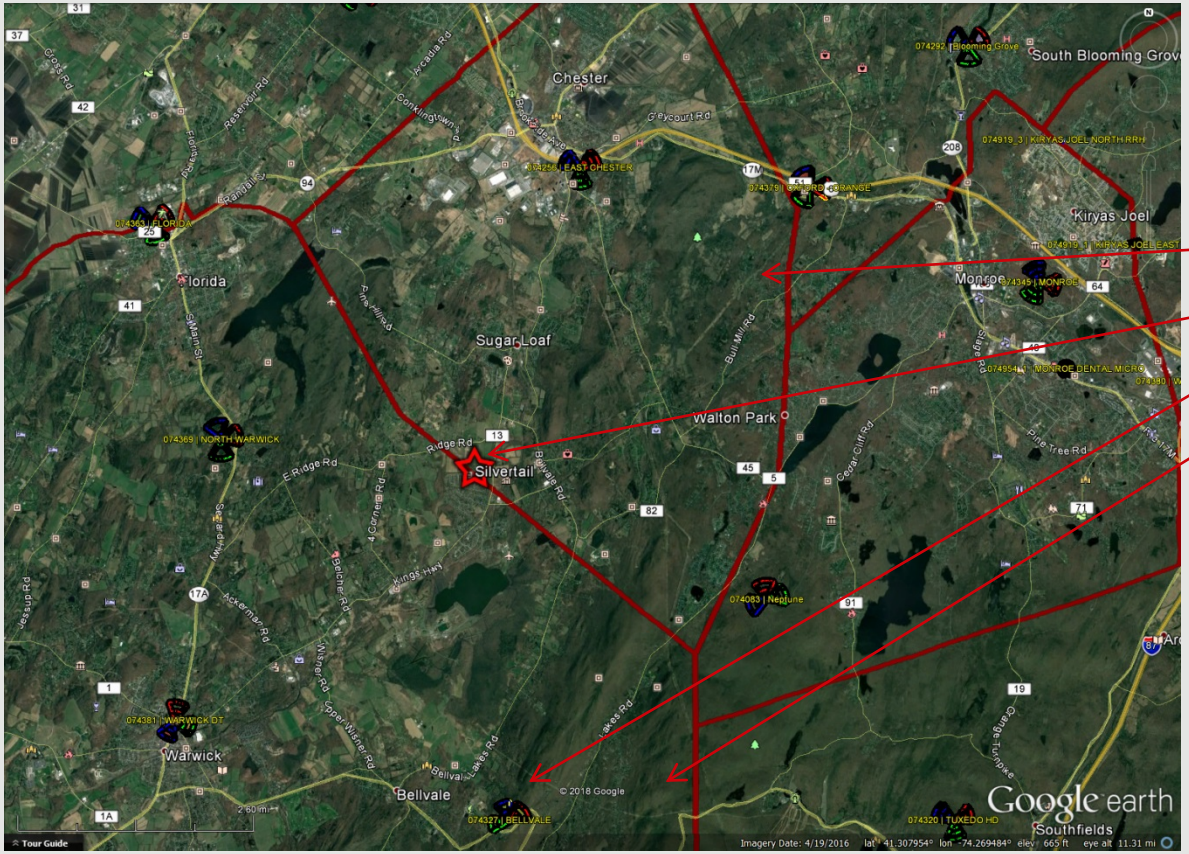
Verizon Wireless Communications Facility

Engineering Necessity Case – “Silvertail”



Prepared by: Michael R. Crosby

Project: The project is the installation and operation of a co-located wireless telecommunications site in the town of Chester (the “Project Facility”).

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Introduction

The purpose of this subsequent analysis is to summarize the technical radio frequency (RF) information to date and confirm that Verizon Wireless carefully considered and evaluated different alternative locations and structures in the surrounding area as potential alternatives before deciding on the site/structure ultimately proposed.

Coverage and/or capacity deficiencies are the two main drivers that prompt the need for a new wireless communications facility/site. All sites provide a mixture of both capacity and coverage for the benefit of the end user.

Coverage can be defined as the existence of signal of usable strength and quality in an area, including but not limited to in-vehicles or in-buildings.

The need for improved coverage is identified by RF Engineers that are responsible for developing and maintaining the network. RF Engineers utilize both theoretical and empirical data sets (propagation maps and real world coverage measurements). Historically, coverage improvements have been the primary justification of new sites.

Capacity can be defined as the amount of traffic (voice and data) a given site can process before significant performance degradation occurs.

When traffic volume exceeds the capacity limits of a site serving a given area, network reliability and user experience degrades. Ultimately this prevents customers from making/receiving calls, applications cease functioning, internet connections time out and data speeds fail. This critical condition is more important than just a simple nuisance for some users. Degradation of network reliability and user experience can affect emergency responders and to persons in a real emergency situation can literally mean life or death.

Project Need Overview

The project area located within the south western portion of Chester is currently served by one site. This site is overloaded requiring capacity relief. Additionally the project area is relatively distant from this existing serving site. This distance combined with area terrain and foliage prevent effective propagation of Verizon's RF signals into this area compounding the capacity issue with areas of variable coverage creating significant gaps in coverage.

The primary serving site is **Bellvale,** located in the neighboring town of Warwick, which is approximately four miles south (of the project location) situated on a mountain top tower located off Pysners Park Rd (near the Appalachian Trail and Rt. 17A). While this site provides weak/variable coverage (on low band 700MHz) in portions of the project area, it does so from such a great distance that the site is not capable of efficiently or effectively providing adequate coverage or capacity. Available (high band AWS/PCS) carriers at existing sites including Bellvale are not capable of effectively serving/offloading this area due to inherent propagation losses due to excessive distance and challenging terrain negatively impacting high band coverage and capacity offload capabilities.

There are other Verizon sites in this general area but due to distance and terrain they also do not provide any significant overlapping coverage in the area in question that could allow for increased capacity and improved coverage from other sources.

The primary objectives for this project are to increase capacity and improve coverage in the south western portion of Chester including but not limited to portions of Sugarloaf, Kings Highway, Bellvale Rd, Ridge Rd, Lake Station Rd, as well as the surrounding residential areas (including portions of Warwick near the project location). In order to offload capacity from Bellvale a new dominant server must be created. This new dominant coverage will effectively offload the existing overloaded site/cell as well as provide improved coverage where significant gaps exist today.

Following the search for co-locatable structures to resolve the aforementioned challenges and finding only one tall, properly situated co-locatable structure, Verizon proposes the current application to attach it's antennas to the existing 95' tall Silvertail water tank. Verizon's antennas will utilize 100' for the ACL (Antenna Center Line) with a top of antenna height of 104'. This solution will provide the necessary coverage and capacity improvements needed.

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Wireless LTE (Voice and Data) Growth

Each year Verizon experiences substantial increases in data volume including VoLTE (Voice over LTE) that its customers utilize. Data traffic grew 65% between Q3 2016 and Q3 2017 (Ericsson Mobility Report, November 2017)

Machine to Machine communications will also increase the data burden on wireless networks. During the next five years increasingly more services that improve our safety and make our lives easier will become available via the wireless infrastructure, such as:

- Autonomous vehicular communications including automatic 911 notification when airbag deploys.
- Medical monitors that alert caretakers of patient related issues.
- Home alarms that notify people when their child arrives home from school.
- Smart street lights that notify the city when they are not working.
- City garbage cans that let people know when they need to be emptied.
- Tracking watches that can aid in finding lost Alzheimer patients, children, etc.

Explanation of Wireless Capacity

Capacity in this analysis is evaluated with up to three metrics further explained below. These metrics assist in determining actual usage for a given site as well as are used to project when a site is expected to run out of capacity (i.e. reach a point of exhaustion where it can no longer process the volume of voice and data requested by local wireless devices, thus no longer providing adequate service).

- Forward Data Volume ("**FDV**"), is a measurement of usage (data throughput) on a particular site over a given period of time.
- Average Schedule Eligible User ("**ASEU**"), is a measurement of the loading of the control channels and systems of a given site.
- Average Active Connections ("**AvgAC**") is a measurement of the number of devices actively connected to a site in any given time slot.

Verizon Wireless uses proprietary algorithms developed by a task force of engineers and computer programmers to monitor each site in the network and accurately project and identify when sites will approach their capacity limits. Using a rolling two-year window for projected exhaustion dates allows enough time, in most cases, to develop and activate a new site. It is critical that these capacity approaching sectors are identified early and the process gets started and completed in time for new solutions (sites) to be on air before network issues impact the customers.

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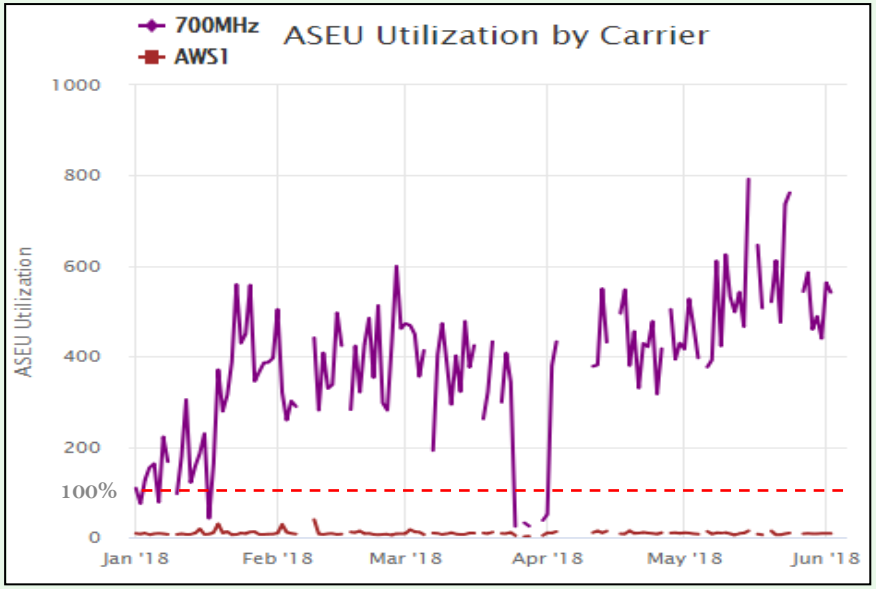
Capacity Utilization ASEU (Bellvale Gamma)



Summary: This graph shows ASEU (**A**verage **S**chedule **E**ligible **U**ser). ASEU is a measurement of the loading of the control channels and systems of a given site. The ASEU load is heavily impacted by distant users or those in poor RF conditions.

The purple line represents the daily max busy hour 700MHz utilization on the **Gamma** sector of the **Bellvale** site. The dark red line represents the daily max busy hour 2100MHz (AWS) utilization on the **Gamma** sector of the **Bellvale** site. The red dashed line is the limit where the sector reaches exhaustion and service starts to significantly degrade. The point in time where we see the purple or dark red lines reach or exceed the red dashed line is when service quickly degrades as usage continues to increase.

Displaying the ASEU separately by carrier reveals the inability of high band (AWS) to resolve the capacity issues described in this case. Adding another high band (PCS) carrier (capacity relief for AWS) does not solve the fundamental and underlying problem impacting 700MHz capacity for this site. Network densification is required.

Detail: The existing **Bellvale Gamma** sector cannot support the data traffic throughout the extents of the excessively large area it covers. **Bellvale Gamma** is already overloaded, as shown by the purple actual use line exceeding the red dashed exhaustion threshold line. The **Bellvale Gamma** site is too far away to effectively serve this portion of the town of Chester.

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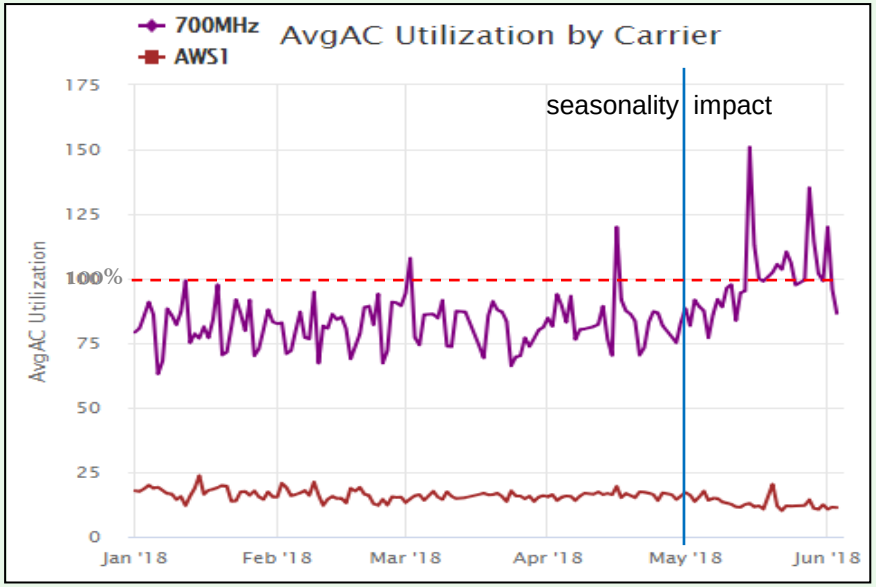
Capacity Utilization AvgAC (Bellvale Gamma)

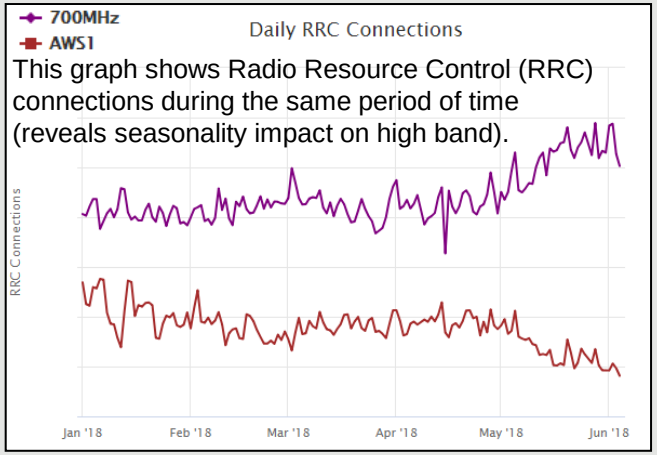


Summary: This graph shows ASEU (**A**verage **A**ctive **C**onnections). AvgAC Utilization by carrier is a measurement of max active connection capacity per sector in any given time slot. When this limit is reached, no additional devices will be able to connect to the site, resulting in connection failures and dropped calls.

The purple line represents the daily max busy hour 700MHz utilization on the **Gamma** sector of the **Bellvale** site. The dark red line represents the daily max busy hour 2100MHz (AWS) utilization on the **Gamma** sector of the **Bellvale** site.The red dashed line is the limit where the sector reaches exhaustion and service starts to significantly degrade. The point in time where we see the purple or dark red lines reach or exceed the red dashed line is when service quickly degrades as usage continues to increase.

This graph reveals a recent decline in AWS utilization while 700 is increasing at the time of increased springtime foliage which further complicates capacity offload capability for high band carriers.

Detail: The existing **Bellvale Gamma** sector cannot support the number of users in the excessively large area it covers and has already reached overloaded conditions recently, as shown by the daily max busy hour use line peaking above the red dashed exhaustion threshold line.



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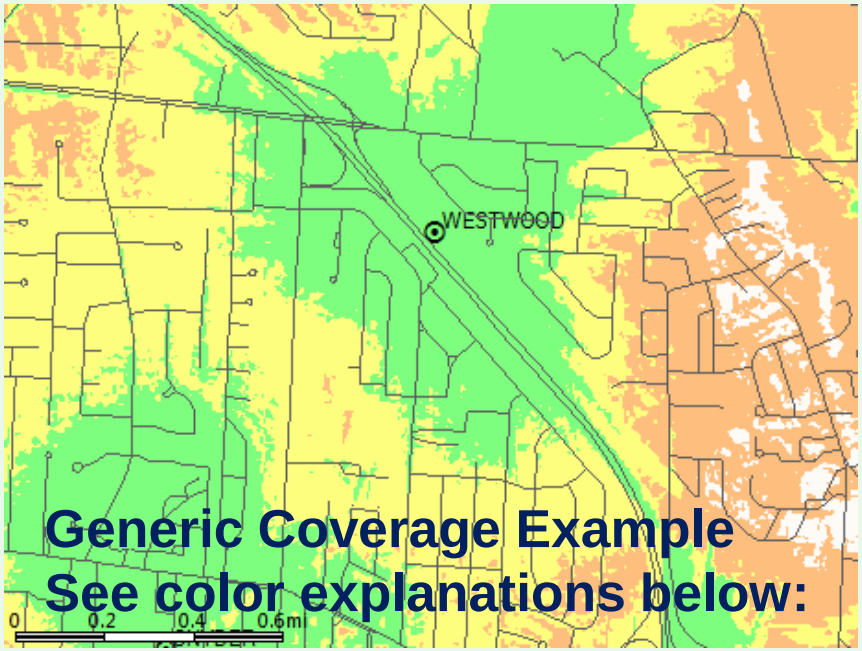
Explanation of Wireless Coverage



Coverage is best shown via coverage maps. RF engineers use computer simulation tools that take into account terrain, vegetation, building types, and site specifics to model the RF environment. This model is used to simulate the real world network and assist engineers to evaluate the impact of a proposed site (along with industry experience and other tools).

Most Verizon Wireless sites provide 3G CDMA at 850 MHz and 4G LTE at 700 MHz. As capacity requirements increase, higher frequency PCS (1900 MHz) and AWS (2100 MHz) carriers are added. In some mountaintop situations the high band AWS and PCS carriers are not effective due to excessive distance from the user population.

Coverage provided by a given site is affected by the frequencies used. Lower frequencies propagate further distances, and are less attenuated by clutter than higher frequencies. To provide similar coverage levels at higher frequencies, a denser network of sites is required (network densification).

Note the affect of clutter on the predicted coverage footprint above
Green = -85dBm RSRP, typically serves suburban residential and light commercial buildings (stronger coverage levels may be needed for proper evaluation in urban applications or where more substantial building construction exists)
Yellow = -95dBm RSRP, typically serves most rural/suburban-residential and in car applications
Orange = -105dBm RSRP, rural highway coverage, subject to variable conditions including fading and seasonality gaps
White = <-105dBm RSRP, variable to no reliable coverage gap area

More detailed, site-specific coverage slides are later in the presentation
*Signal strength requirements vary as dictated by specific market conditions

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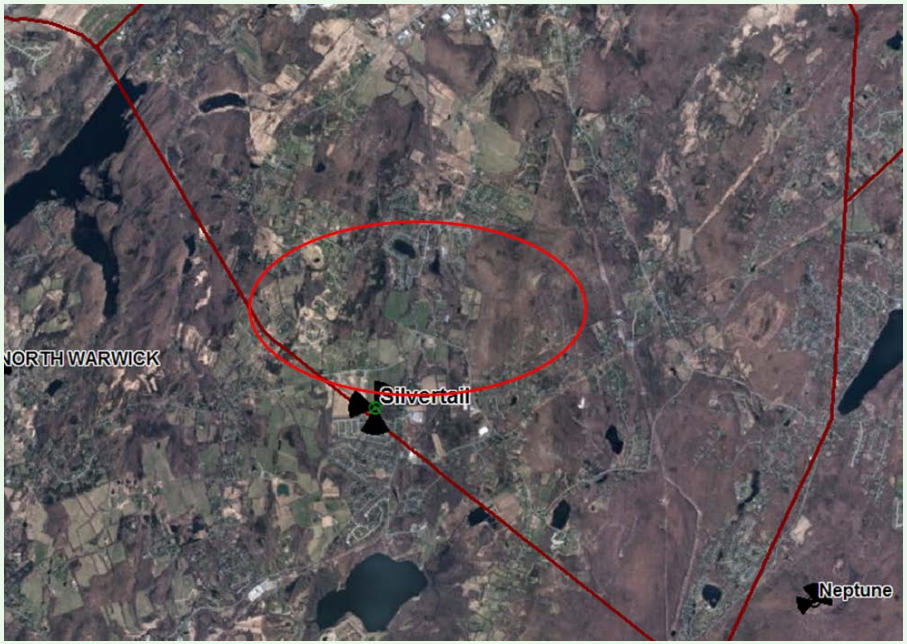
Explanation of this Search Area



Silvertail Search Area

A **Search Area** is the geographical area within which a new site is targeted to solve a coverage or capacity deficiency. The search area is created to help RF Engineering communicate where the site acquisition team should be focusing their search for solutions. Three of the factors taken into consideration when defining a search area are topography, user density, and the existing network.

- **Topography** must be considered to minimize the obstacles between the proposed site and the target coverage area. For example, a site at the bottom of a ridge will not be able to cover the other side from a certain height.
- In general, the farther from a site the **User Population** is, the weaker the RF conditions are and the worse their experience is likely to be. These distant users also have an increased impact on the serving site's capacity. In the case of a multi sector site, centralized proximity is essential to allow users to be evenly distributed and allow efficient utilization of the site's resources.
- The existing **Network Conditions** also guide the design of a new site. Sites placed too close together create interference due to overlap and are an inefficient use of resources. Sites that are too tall or not properly integrated with existing sites cause interference and degrade service for existing users.
- Existing co-locatable structures inside the search area as well as within a reasonable distance of the search area are submitted by site acquisition and reviewed by RF Engineering. If possible RF will make use of existing or nearby structures before proposing to build new towers.

To resolve the coverage and capacity deficiencies previously detailed, Verizon Wireless is seeking to add one new 'macro' cell facility within or as near as possible to this centrally and strategically located area to improve wireless service capacity and coverage. By offloading traffic from the overloaded sector with the proposed site, adequate and reliable service will be provided. **Bellvale Gamma** sector will be offloaded. The new **Silvertail** site will provide dominant and dedicated signal to portions of South-Western Chester helping to improve not only the area roads but also adjacent populated areas as mentioned earlier.

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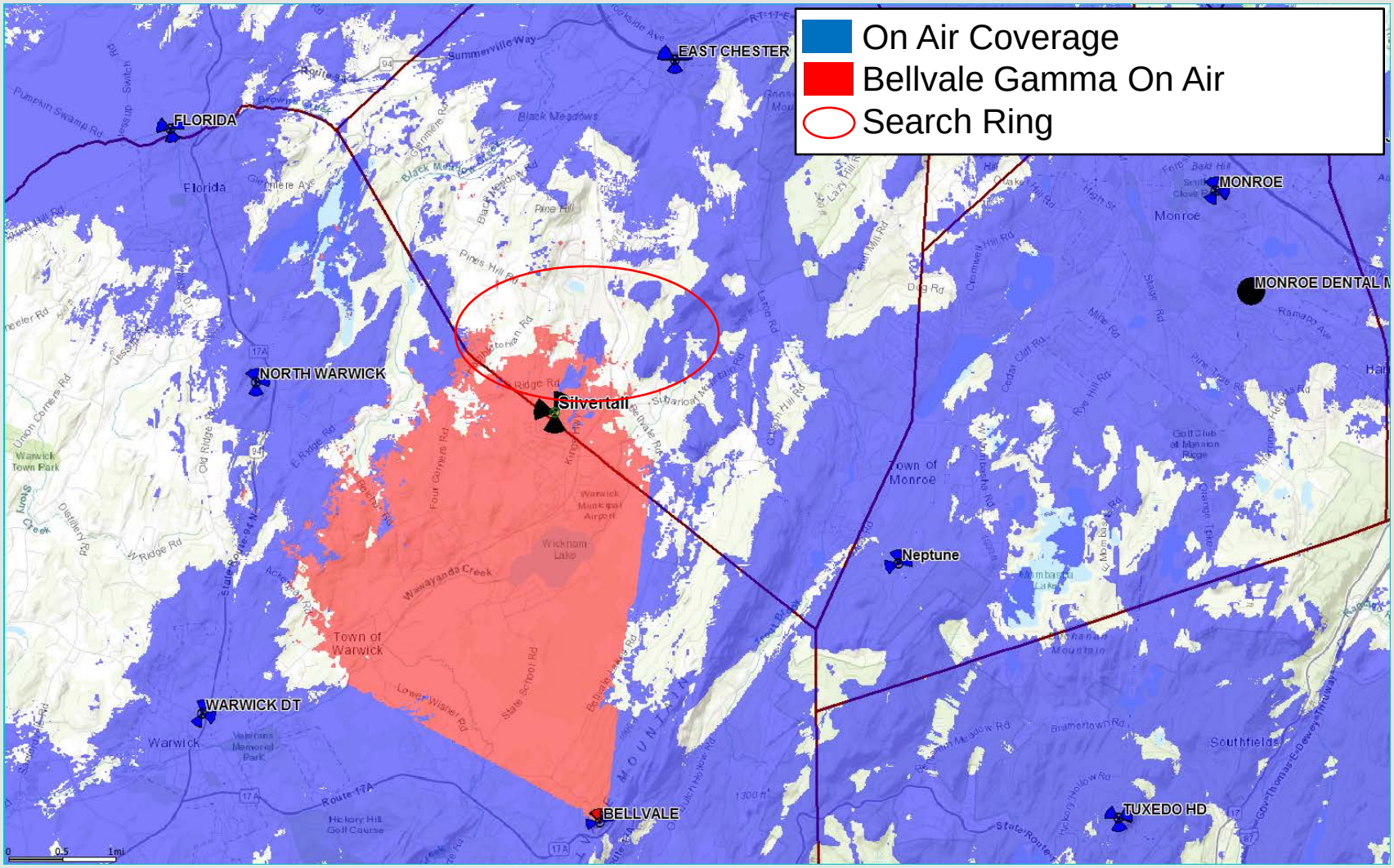
Existing 700MHz Best Server -95dBm RSRP

Best Server plots depict the actual best server or dominant footprint of each sector in question. The following map shows one threshold so the viewer can accurately evaluate where primary offloading will occur as a result of the new site's dominant signal area.



The map above represents coverage from existing sites/cells, with the cell in need of capacity offload in red (Bellvale Gamma) Blue coverage is from other on air sites/sectors.

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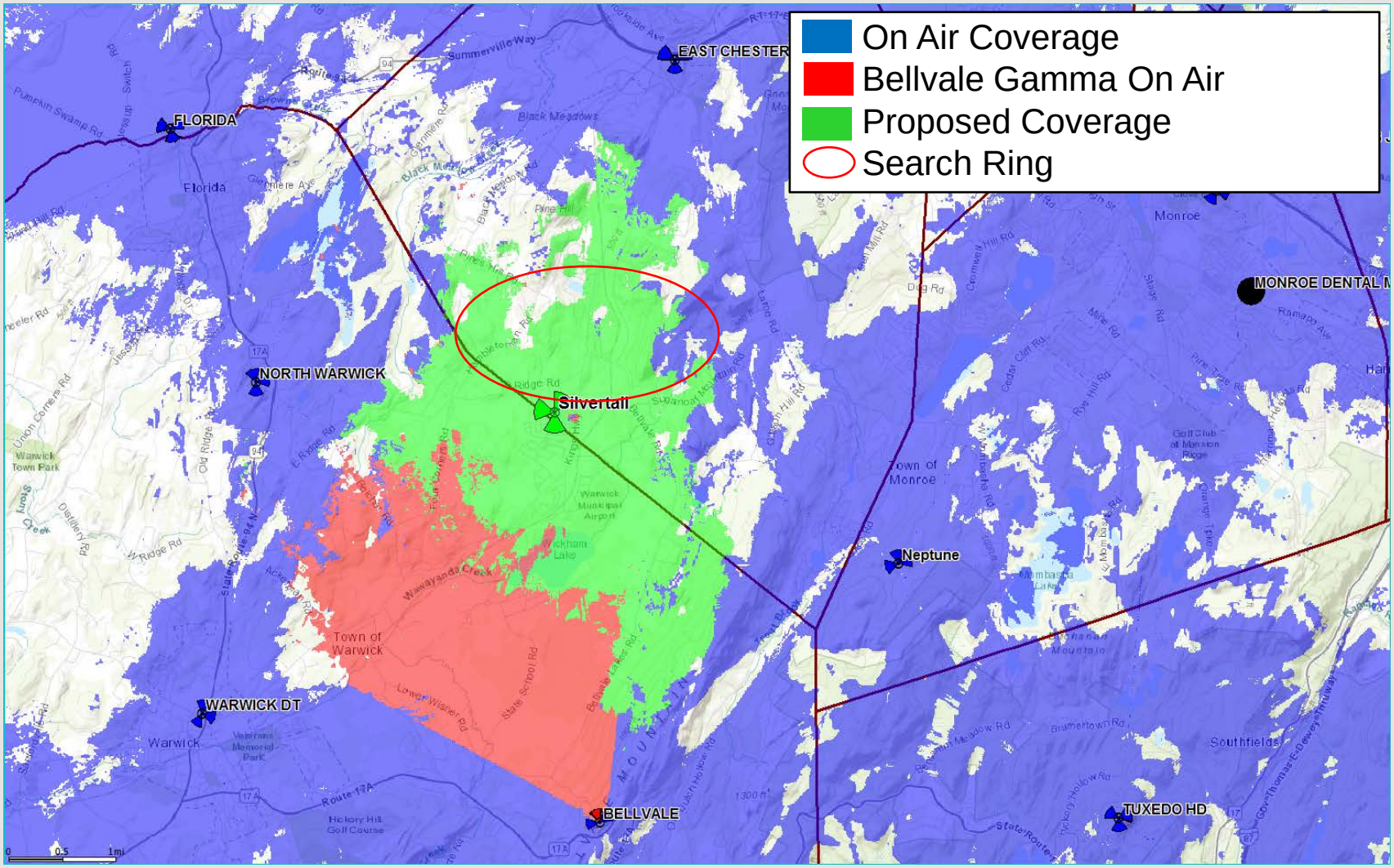
Proposed 700MHz Best Server -95dBm RSRP

Best Server plots depict the actual best server or dominant footprint of each sector in question. The following map shows one threshold so the viewer can accurately evaluate where primary offloading will occur as a result of the new site's dominant signal area (at 100' ACL).



The map above adds the footprint of the proposed Silvertail site in green. The green best server footprint significantly overlaps the red cell helping to offload weak and distant users improving capacity and coverage.

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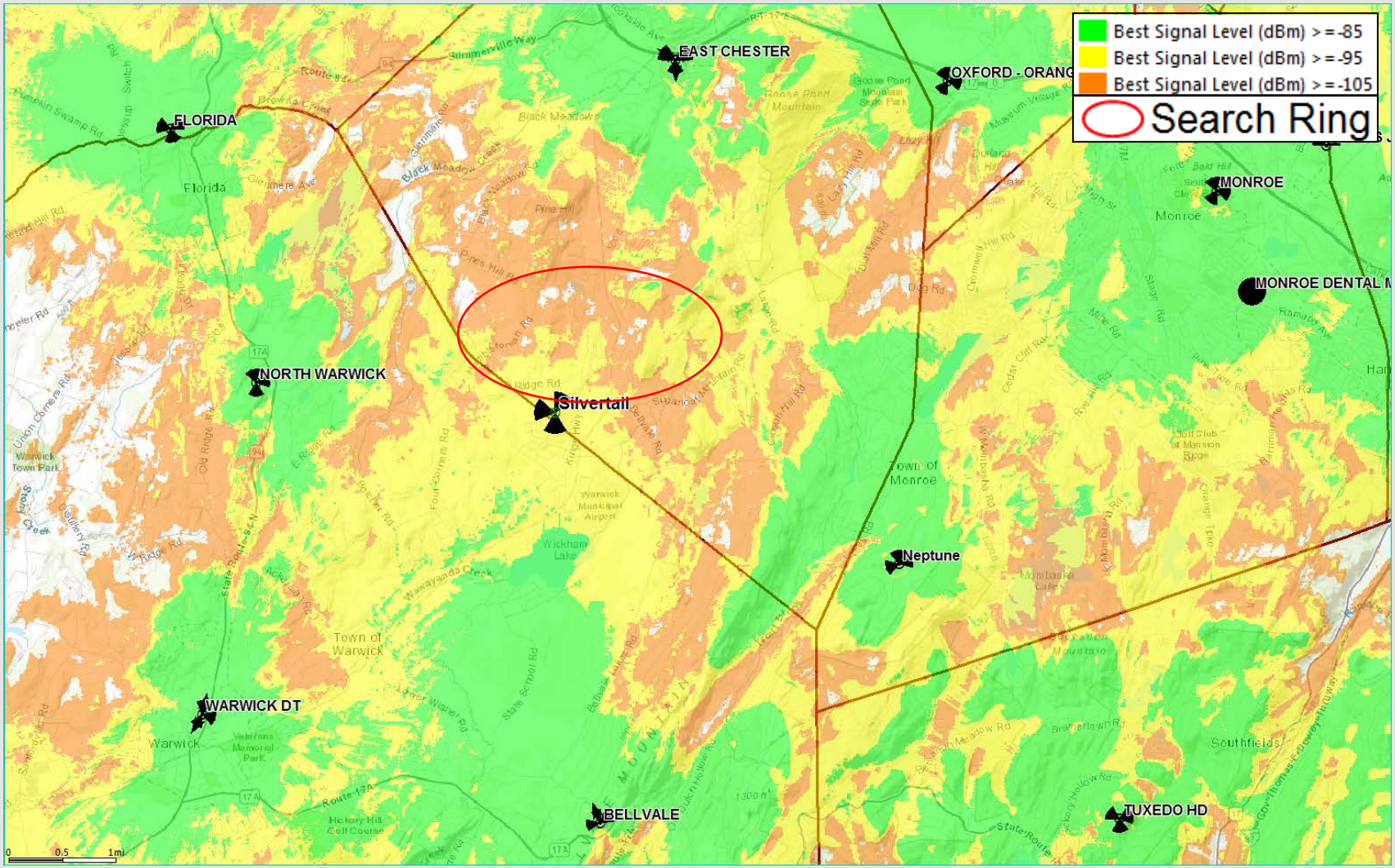
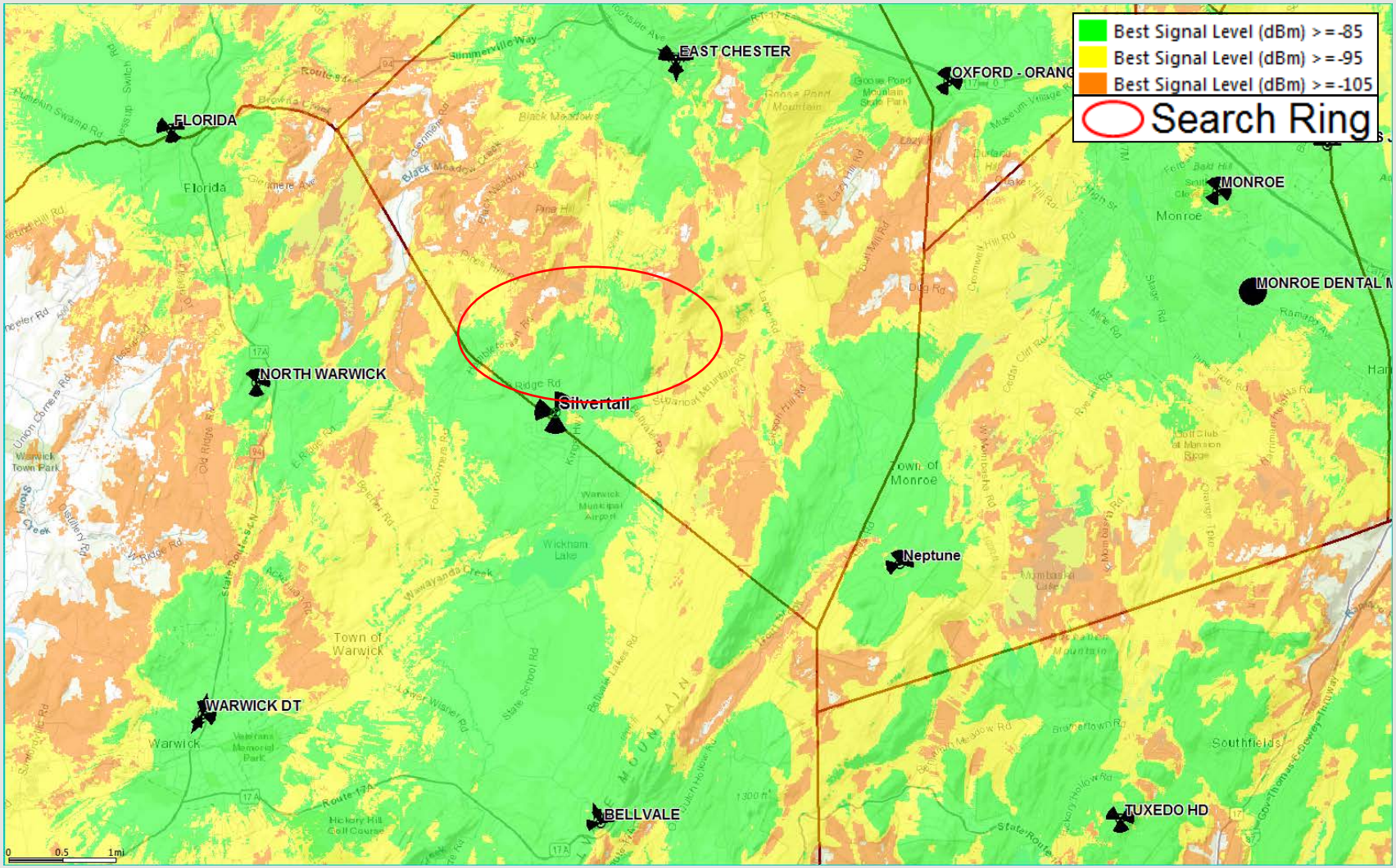
Existing 700MHz Coverage

This coverage map shows existing low band RF conditions in and around the Silvertail site area.



Proposed 700MHz Coverage

This coverage map shows how improved the low band RF conditions will be in and around the Silvertail site area (at 100’ ACL).



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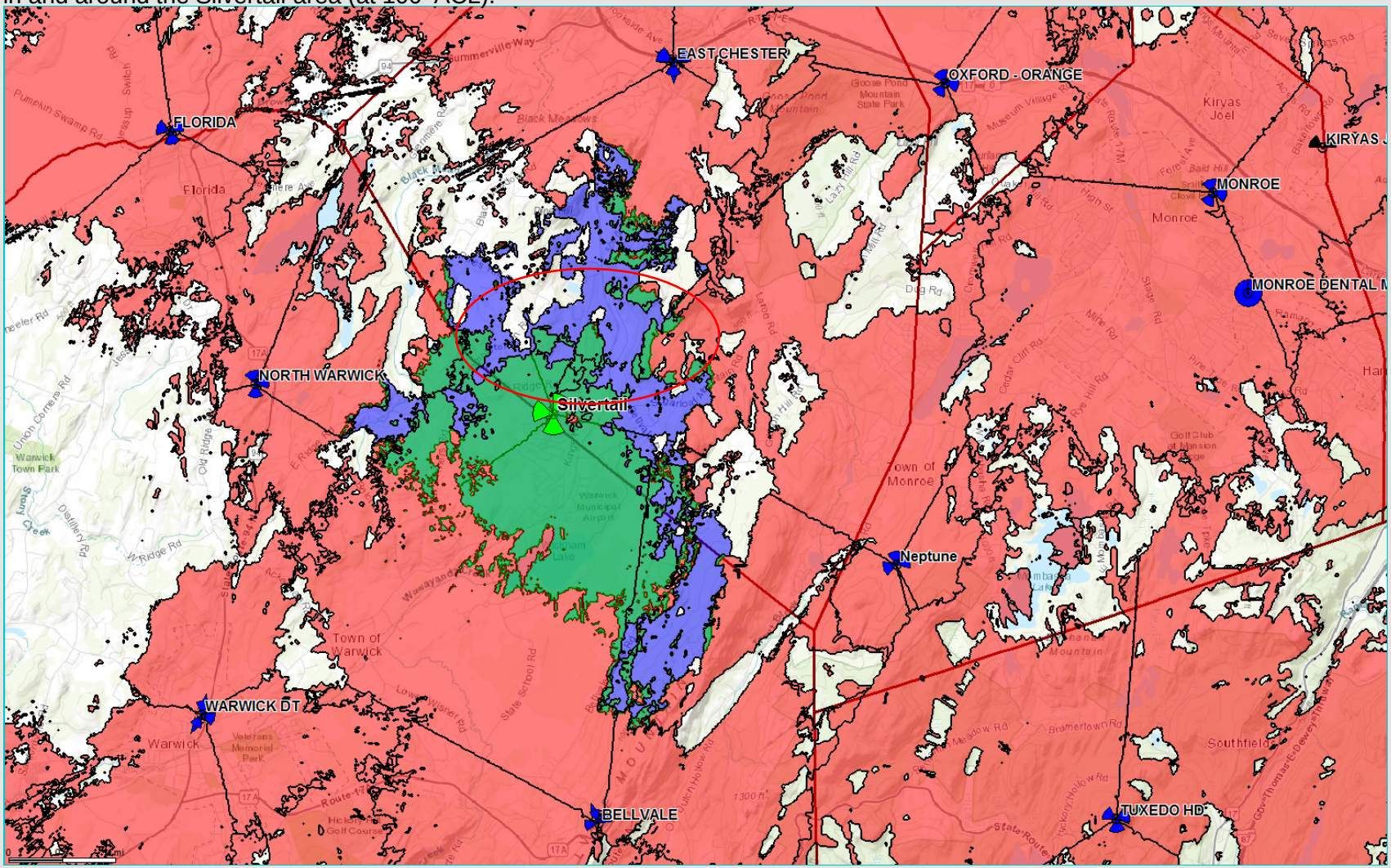
Proposed 700MHz Coverage

This coverage map shows dominant cell footprints along with comparison of existing versus proposed coverage layers on low band in and around the Silvertail area (at 100' ACL).



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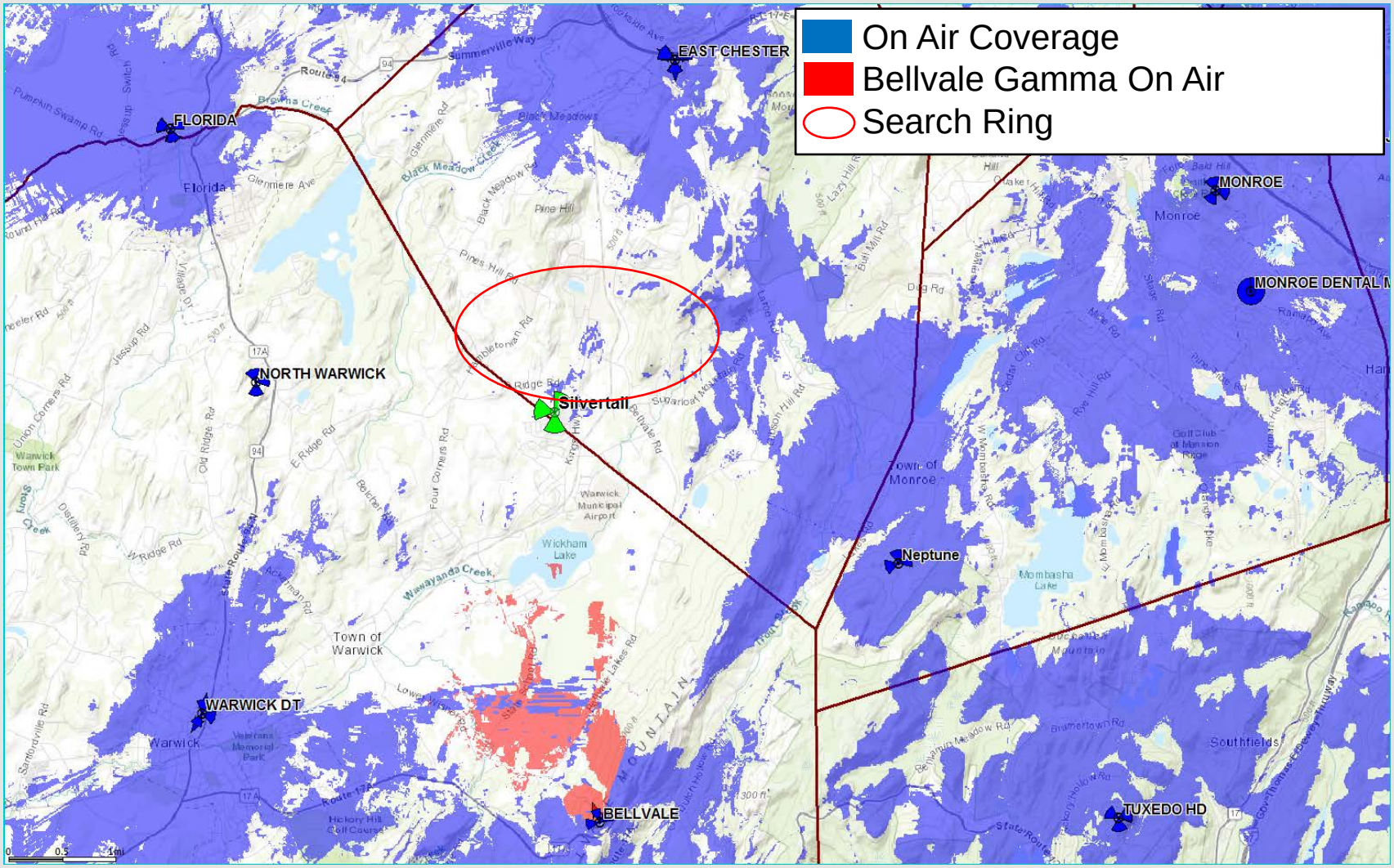
Existing 2100MHz Best Server -105dBm RSRP

Best Server plots depict the actual best server or dominant footprint of each sector in question. The following map shows one threshold so the viewer can accurately evaluate where primary offloading will occur as a result of the new site's dominant signal area.



The map above very clearly demonstrates the lack of acceptable high band (2100MHz) coverage from existing sites/cells. The coverage from the cell in need of capacity offload is shown in red (Bellvale Gamma), blue coverage is from other on air sites/sectors. Moreover, due to the nature of this frequency, it is impossible to provide service in the 2100MHz frequency to the target area.

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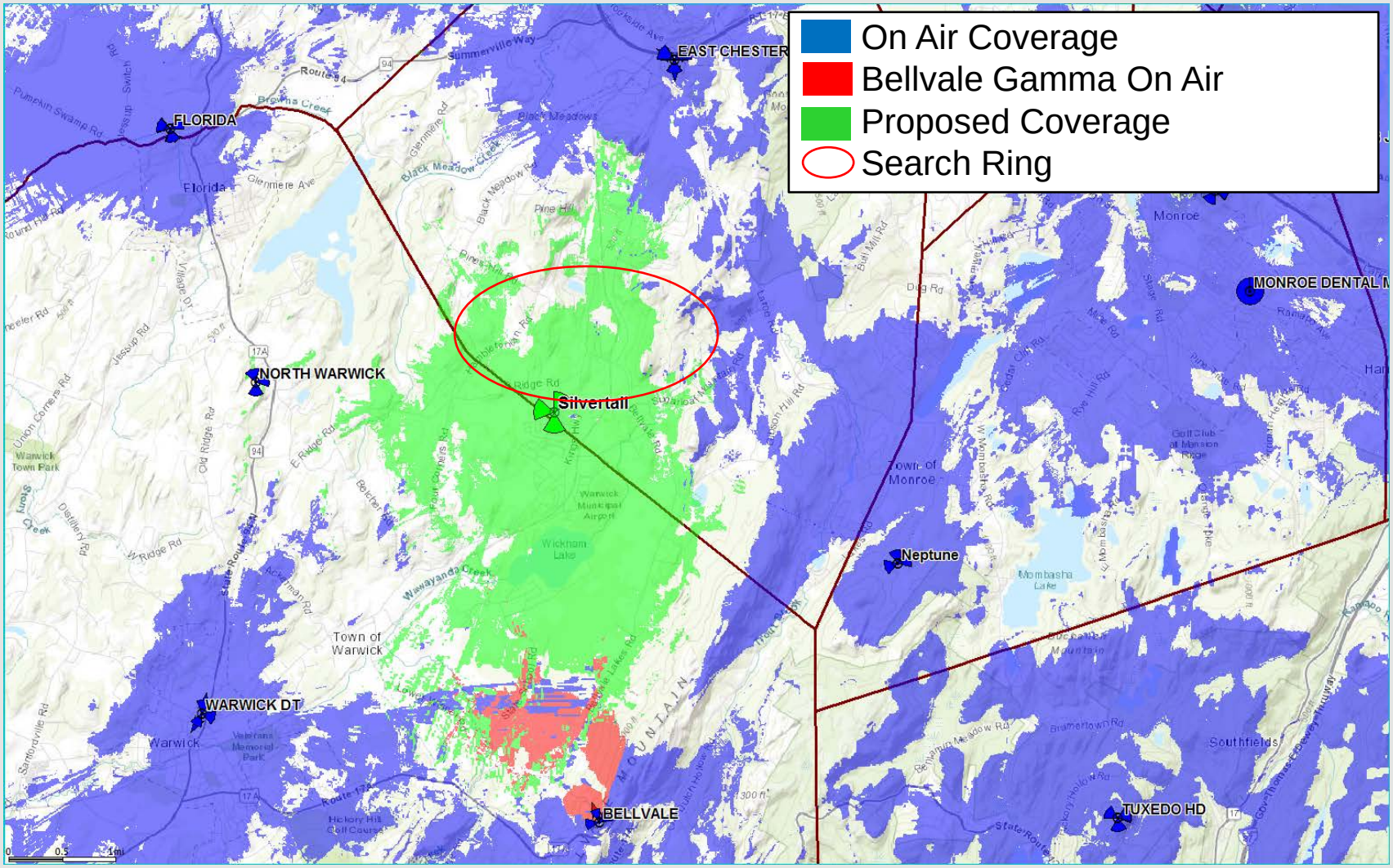
Proposed 2100MHz Best Server -105dBm RSRP

Best Server plots depict the actual best server or dominant footprint of each sector in question. The following map shows one threshold so the viewer can accurately evaluate where primary offloading will occur as a result of the new site's dominant signal area (at 100' ACL).



The map above adds the footprint of the proposed Silvertail site in green. The green best server footprint provides primarily new AWS band coverage which will significantly offload Bellvale 700MHz which is part of the primary the objective for the new Silvertail site.

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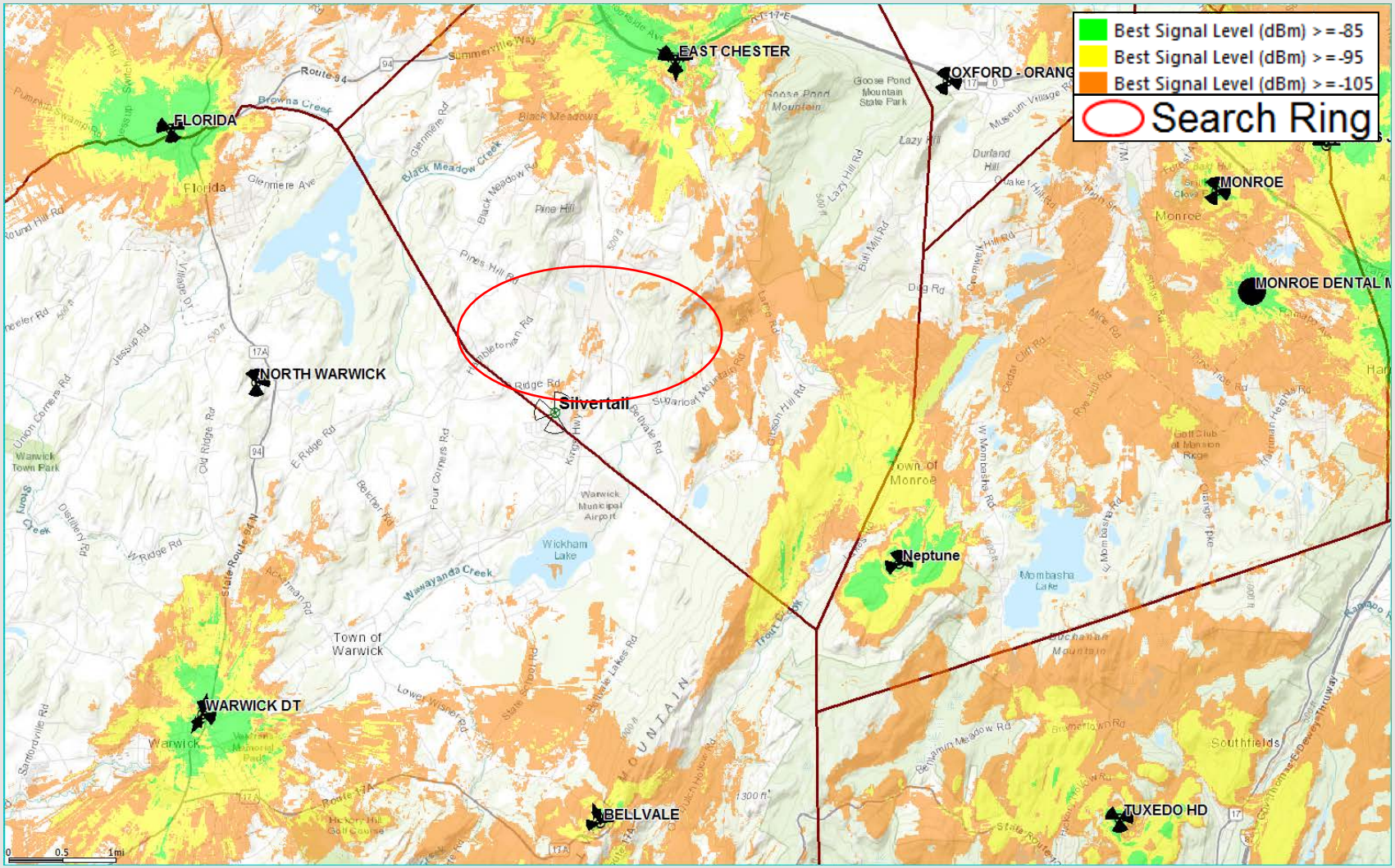
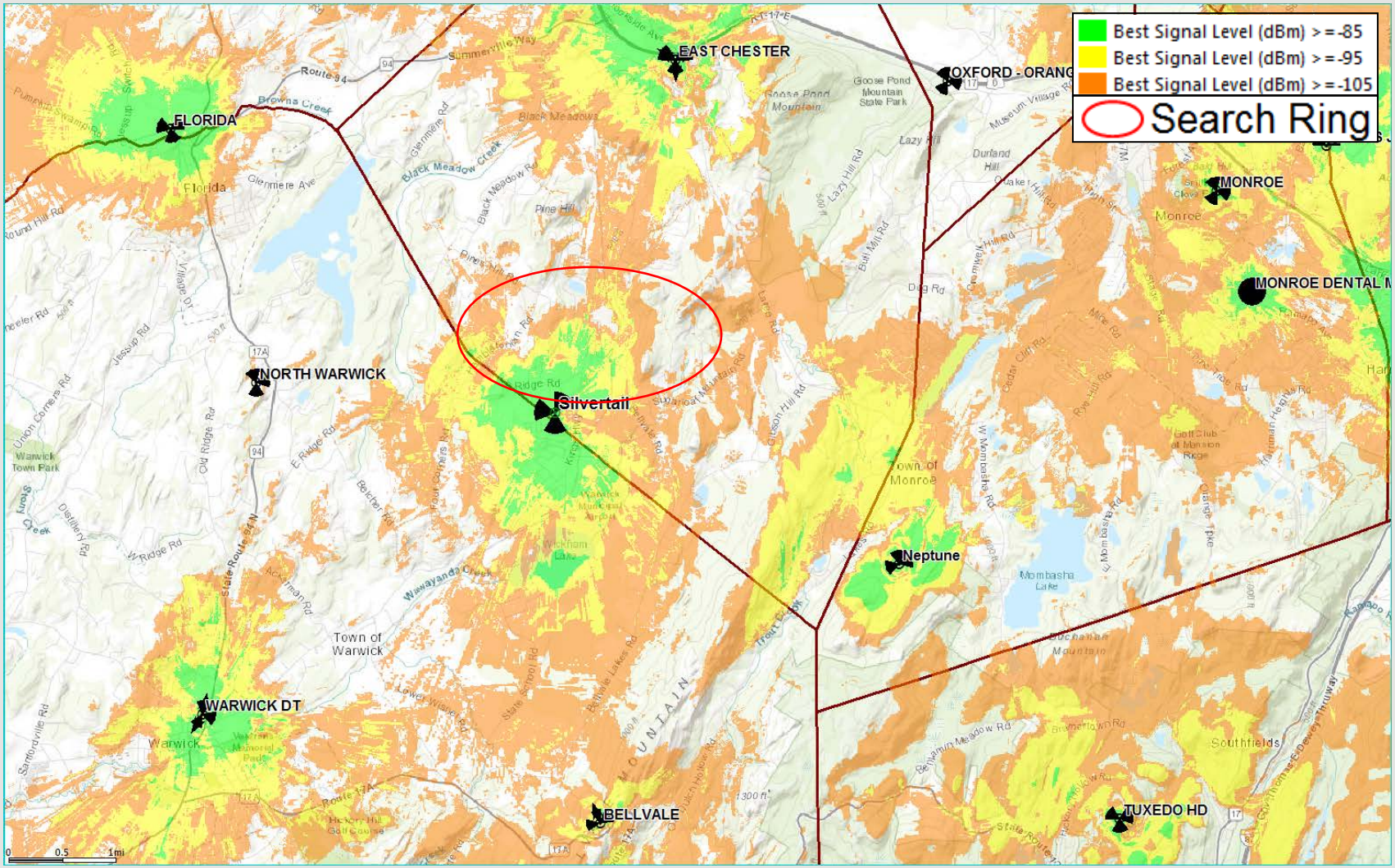
Existing 2100MHz Coverage

This coverage map shows existing high band RF conditions in and around the Silvertail site area.



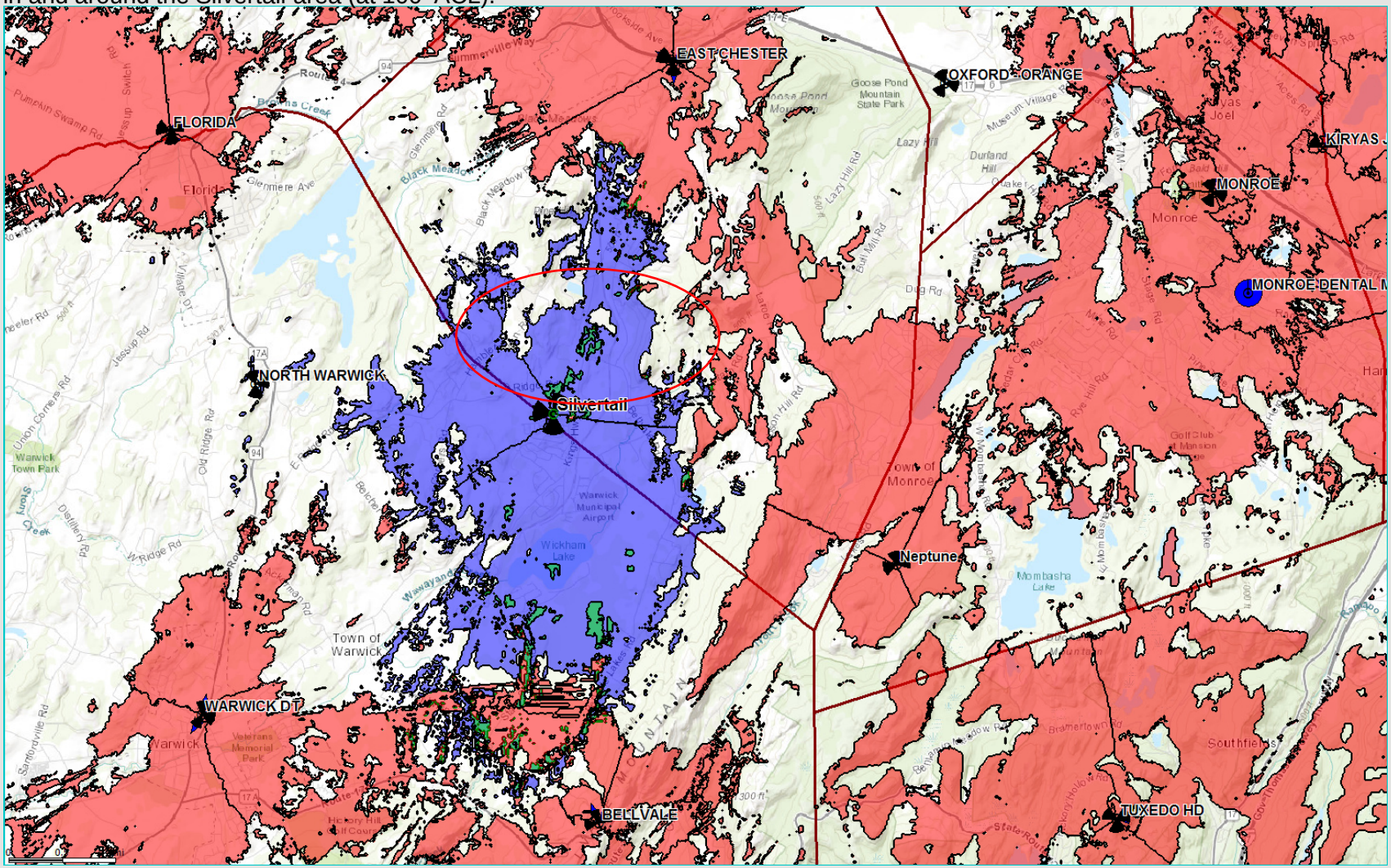
Proposed 2100MHz Coverage

This coverage map shows how improved the high band RF conditions will be in and around the Silvertail area (at 100’ ACL).



Proposed 2100MHz Coverage

This coverage map shows dominant cell footprints along with comparison of existing versus proposed coverage layers on high band in and around the Silvertail area (at 100' ACL).



Existing On Air Coverage (all layers displayed at -105dBm RSRP)

Proposed AWS Coverage (High band dominance will further improve low band capacity offload)

Proposed AWS Coverage (Improved capacity and variable in building coverage)

Search Ring

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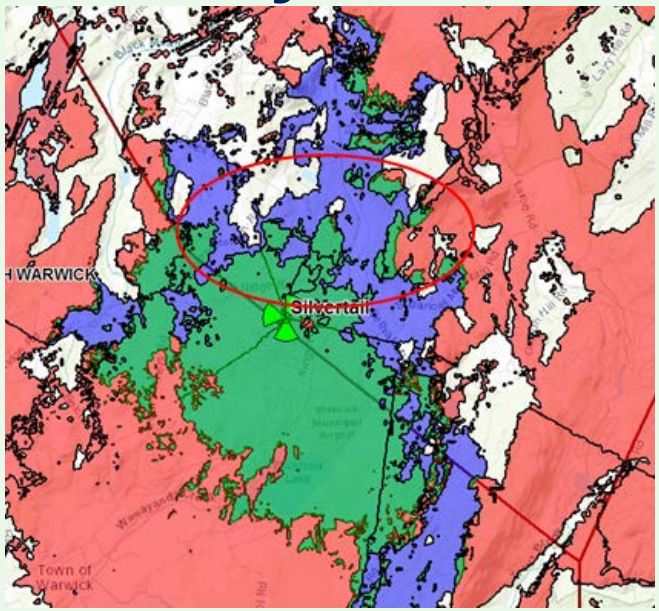
RF Justification Summary



The proposed site at 100' ACL resolves the significant gaps represented within the blue shaded areas above. This site also improves coverage and capacity within the entire blue and green shaded area shown above.

The network was analyzed to determine whether there is sufficient **RF coverage and capacity** in the south western portions of Chester (along with portions of Warwick). It was determined that there are significant gaps in adequate LTE service for Verizon Wireless in the 700 and 2100MHz frequency bands. In addition to the coverage deficiencies, Verizon Wireless' network does not have sufficient capacity (low band or high band) to handle the existing and projected LTE voice and data traffic in the area near and neighboring the proposed Silvertail facility ("targeted service improvement area"). Based on the need for additional coverage and capacity while considering the topography and wide area requiring service, any further addition of capacity to long distance existing sites does not remedy Verizon's significant gap in reliable service. Therefore, the proposed facility is also needed to provide "**capacity relief**" to the existing nearby Verizon Wireless sites, allowing the proposed facility and those neighboring sites to adequately serve the existing and projected capacity demand in this area.

With the existing network configuration there are significant gaps in service which restricts Verizon Wireless customers from originating, maintaining or receiving reliable calls and network access. It is our expert opinion that the proposed height will satisfy the coverage and capacity needs of Verizon Wireless and its subscribers in this portion of Chester and the Silvertail project area. The proposed location depicted herein satisfies the identified service gaps and is proposed at the minimum height necessary for adequate service.

Michael R. Crosby

Michael R. Crosby
Engineer IV – RF Design
Verizon Wireless

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Supplemental: Alternative Candidates

Many candidates were considered throughout the process of developing the Silvertail ring including:

- **A.* 41.315411°, -74.271244° (NEW TOWER) this was RF Approved, not able to obtain ground control**
- **B.* 41.314697°, -74.280219° (NEW TOWER) RF Rejected due to poor coverage (blocked)**
- **C.* 41.311936°, -74.278792° (NEW TOWER) RF Rejected and LL not interested**
- **D.* 41.311064°, -74.293574° (NEW TOWER) RF Approved, LL not interested**
- **E.* 41.310994°, -74.264656° (NEW TOWER) RF Approved, LL not interested**
- F. 41.301599°, -74.294167°, Kings Estates, RF Approved, Primary Candidate
- G. 41.305935°, -74.347606°, Crown Tower, RF Rejected (we're already on it…074369 North Warwick)
- **H.* 41.300473°, -74.287380° (NEW TOWER) Guardian Self Storage, RF Rejected due to poor coverage (too low AMSL)**
- **I.* 41.273137°, -74.309950°, (NEW TOWER Likely) Mid Orange/Homeland, RF Rejected due to poor coverage (too far away)**
- J. 41.315057°, -74.293393°, Creamery Road, RF Rejected due to poor coverage (too low)
- K. 41.300801°, -74.290217°, Orange Rockland Tower, RF Rejected due to poor coverage (too low AMSL)
- **L.* 41.319352°, -74.284823° (NEW TOWER) Sugar Loaf Business District, RF Rejected due to poor coverage (too low)**

- Starred (*) candidates above would require the construction of a new tower structure at each location.
- Candidate F is the only candidate that achieves the site objectives and is able to utilize an existing structure to support the antennas. This solution makes use of existing infrastructure preventing unnecessary towers.

Candidates A-H were formally submitted from Verizon's real estate team to Verizon's RF Engineering team for review prior to zoning. The F candidate was identified as RF Approved and the primary candidate. During the zoning process questions regarding hypothetical candidates located at I, J, K and L have been discussed. Candidates I and J were known and were carefully reviewed internally by Verizon Wireless on multiple occasions. Candidates K and L were suggested by the Chester planning board during the zoning process. Supplemental coverage plots are including following this slide for reference as to why these candidates do not work and are rejected.

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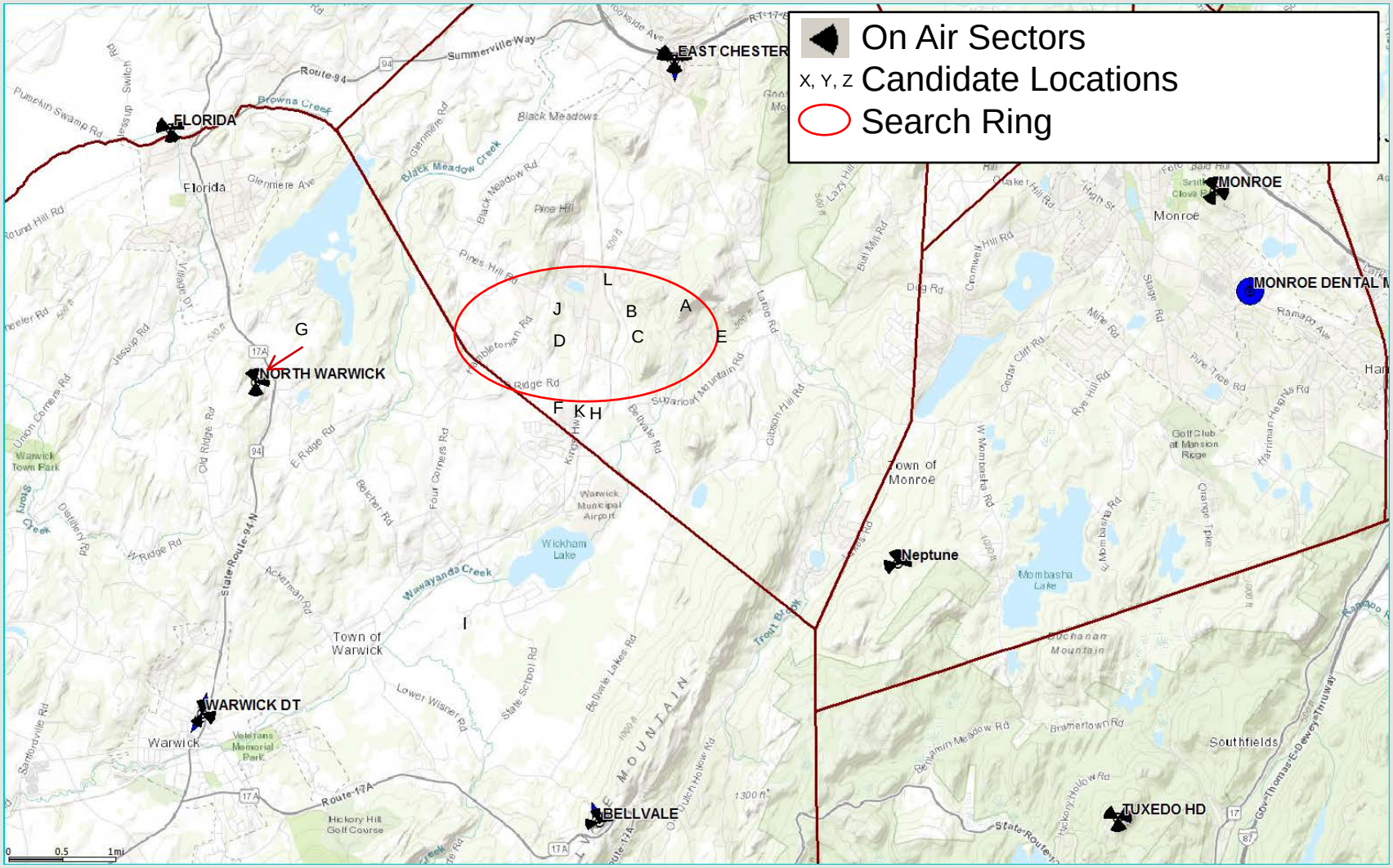
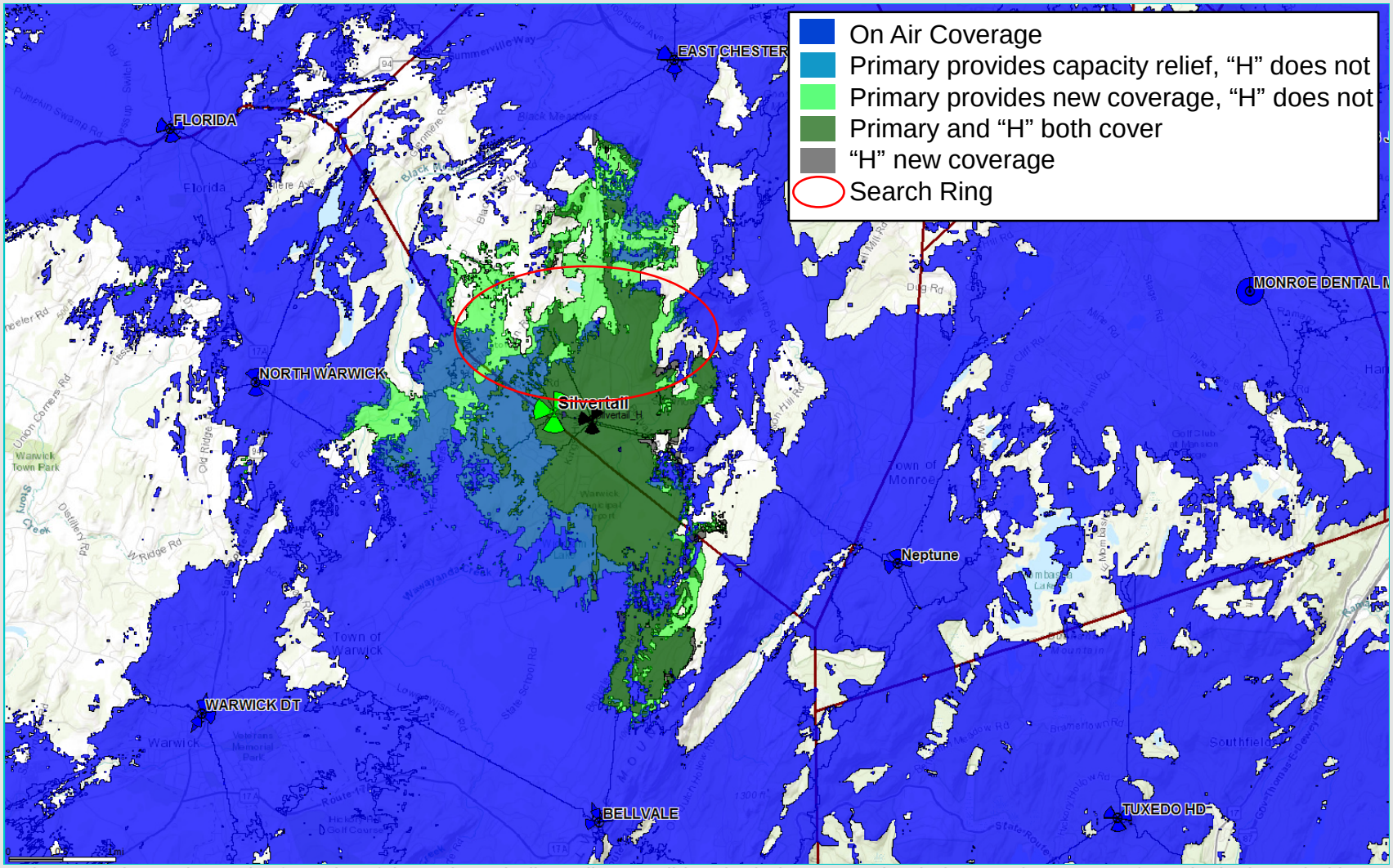
Supplemental: Alternative Candidate Locations

The lettered locations below indicate the locations of those candidates that have been submitted and reviewed by RF.



Alternative H 700MHz Best Server -95dBm RSRP

Best Server-Comparison plots depict the actual best server or dominant footprint of each sector in question when compared with each other. The following map shows the difference of the primary (Silvertail Wt) compared to alternate candidate H (at 100' ACL).



The map above shows the footprint of the Rejected Silvertail H candidate in dark green. The dark green best server footprint is degraded by area terrain significantly more than the primary reducing this candidate's ability to offload weak and distant users throughout the intended area. Too much "blue-gray" and "light green" coverage areas are still shown above indicating this alternate candidate is not capable of the required offload and/or coverage objectives.

RF REJECTED

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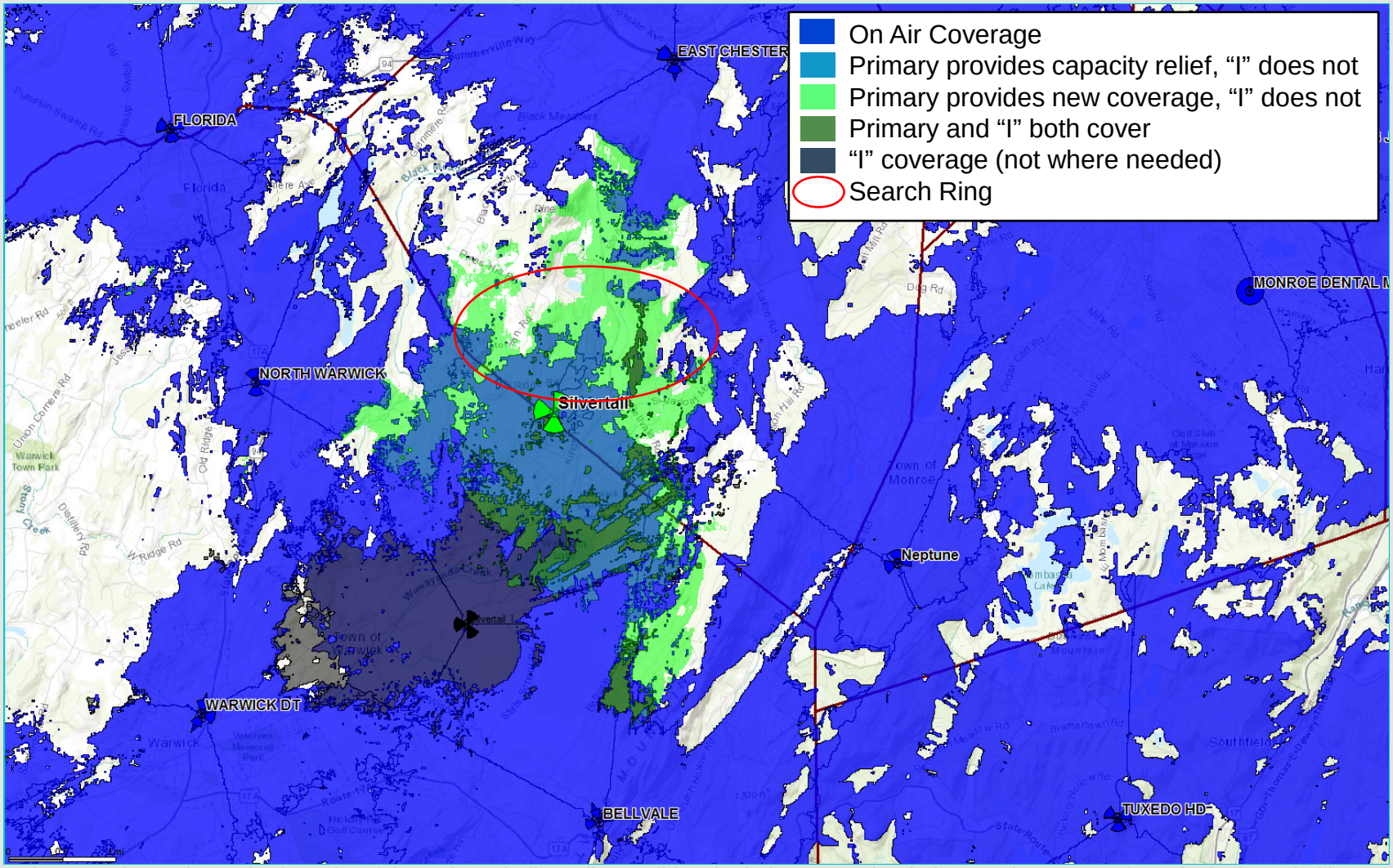
Alternative I 700MHz Best Server -95dBm RSRP

Best Server-Comparison plots depict the actual best server or dominant footprint of each sector in question when compared with each other. The following map shows the difference of the primary (Silvertail Wt) compared to alternate candidate I (at 100' ACL).



The map above shows the footprint of the Rejected Silvertail I candidate in dark green. The dark green best server footprint is degraded by area terrain significantly more than the primary reducing this candidate's ability to offload weak and distant users throughout the intended area. Too much "blue-gray" and "light green" coverage areas are still shown above indicating this alternate candidate is not capable of the required offload and/or coverage objectives.

RF REJECTED

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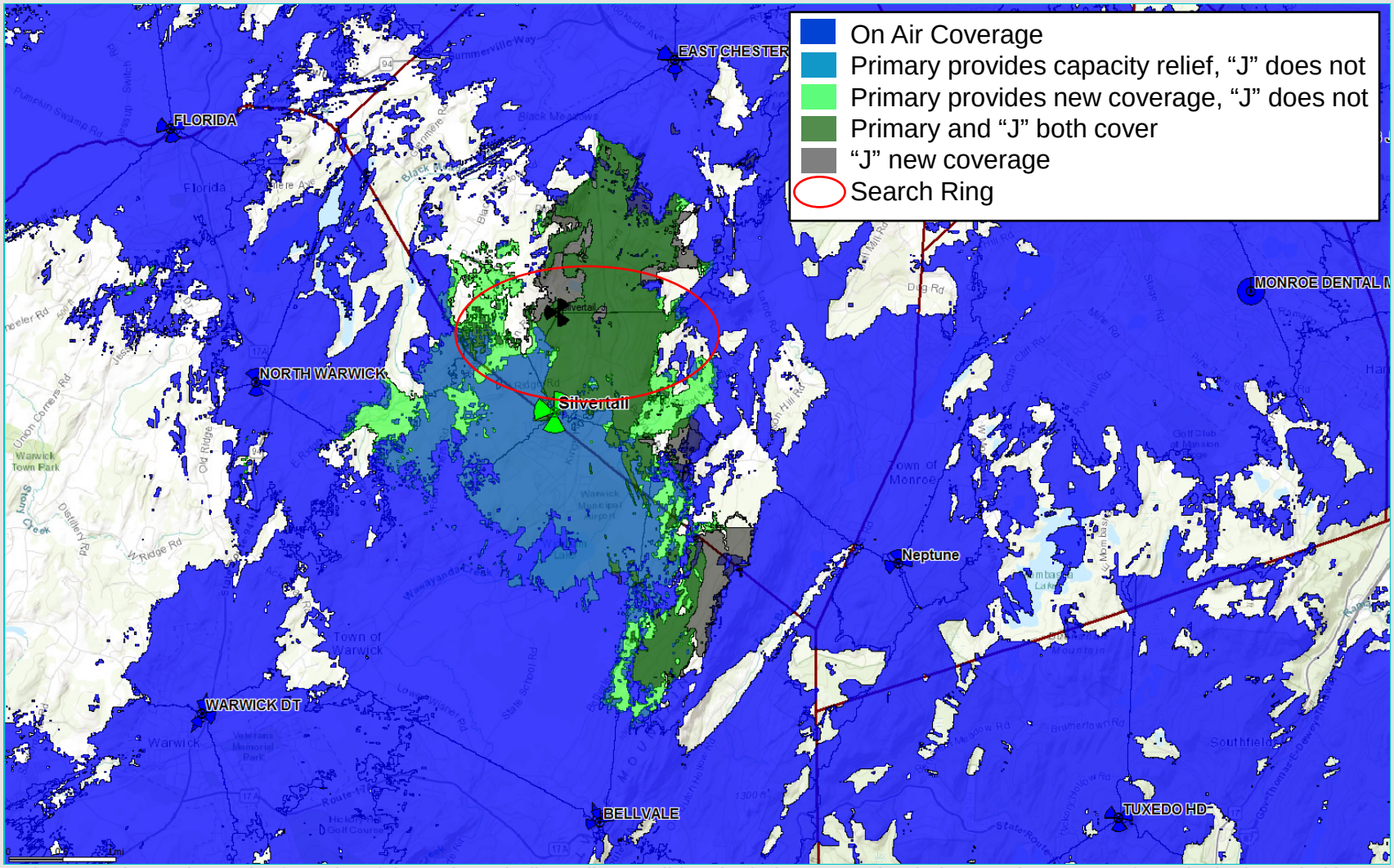
Alternative J 700MHz Best Server -95dBm RSRP

Best Server-Comparison plots depict the actual best server or dominant footprint of each sector in question when compared with each other. The following map shows the difference of the primary (Silvertail Wt) compared to alternate candidate J (at 50' ACL).



The map above shows the footprint of the Rejected Silvertail J candidate in dark green. The dark green best server footprint is degraded by area terrain significantly more than the primary reducing this candidate's ability to offload weak and distant users throughout the intended area. Too much "blue-gray" and "light green" coverage areas are still shown above indicating this alternate candidate is not capable of the required offload and/or coverage objectives.

RF REJECTED

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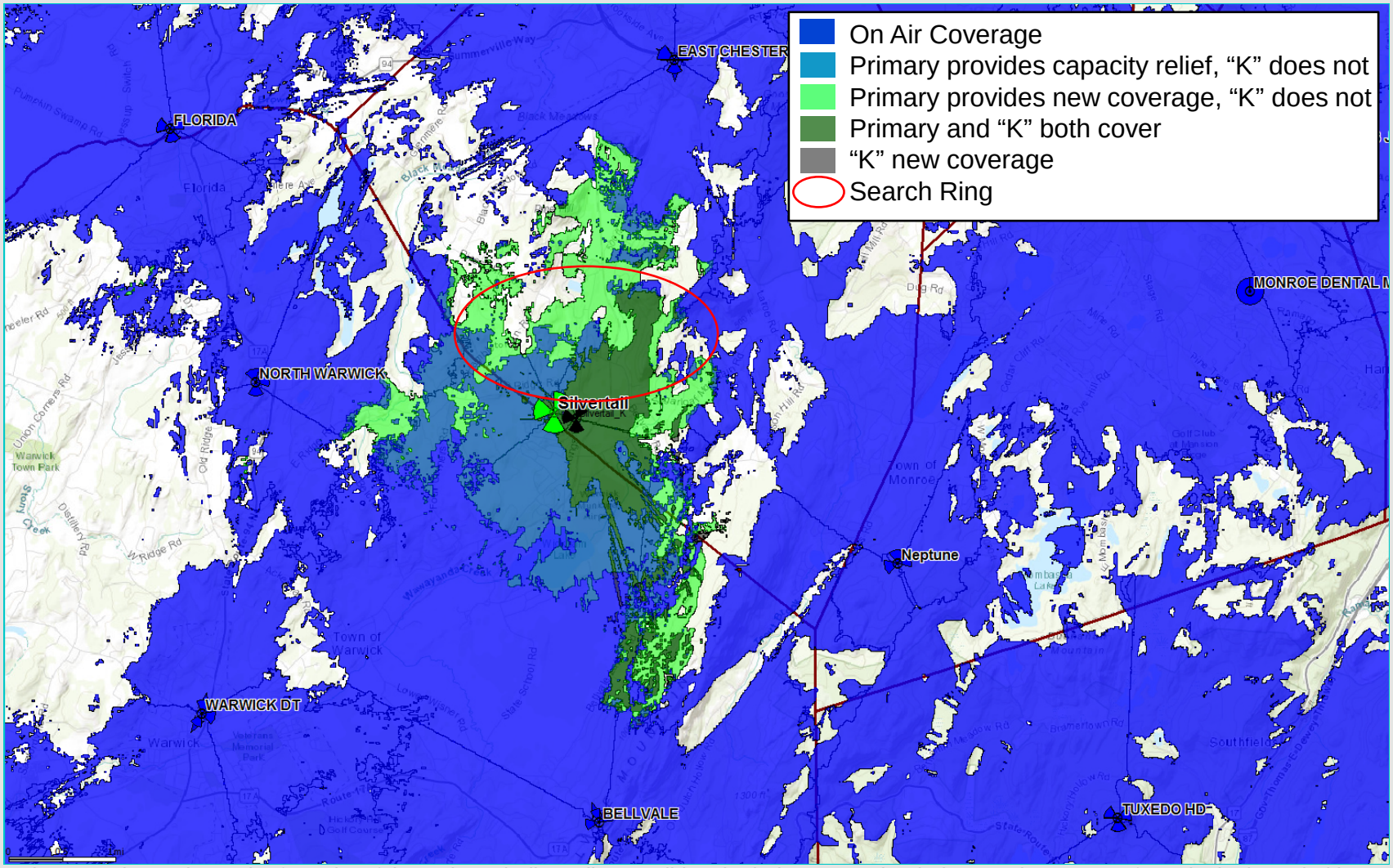
Alternative K 700MHz Best Server -95dBm RSRP

Best Server-Comparison plots depict the actual best server or dominant footprint of each sector in question when compared with each other. The following map shows the difference of the primary (Silvertail Wt) compared to alternate candidate K (at 50' ACL).



The map above shows the footprint of the Rejected Silvertail K candidate in dark green. The dark green best server footprint is degraded by area terrain significantly more than the primary reducing this candidate's ability to offload weak and distant users throughout the intended area. Too much "blue-gray" and "light green" coverage areas are still shown above indicating this alternate candidate is not capable of the required offload and/or coverage objectives.

RF REJECTED

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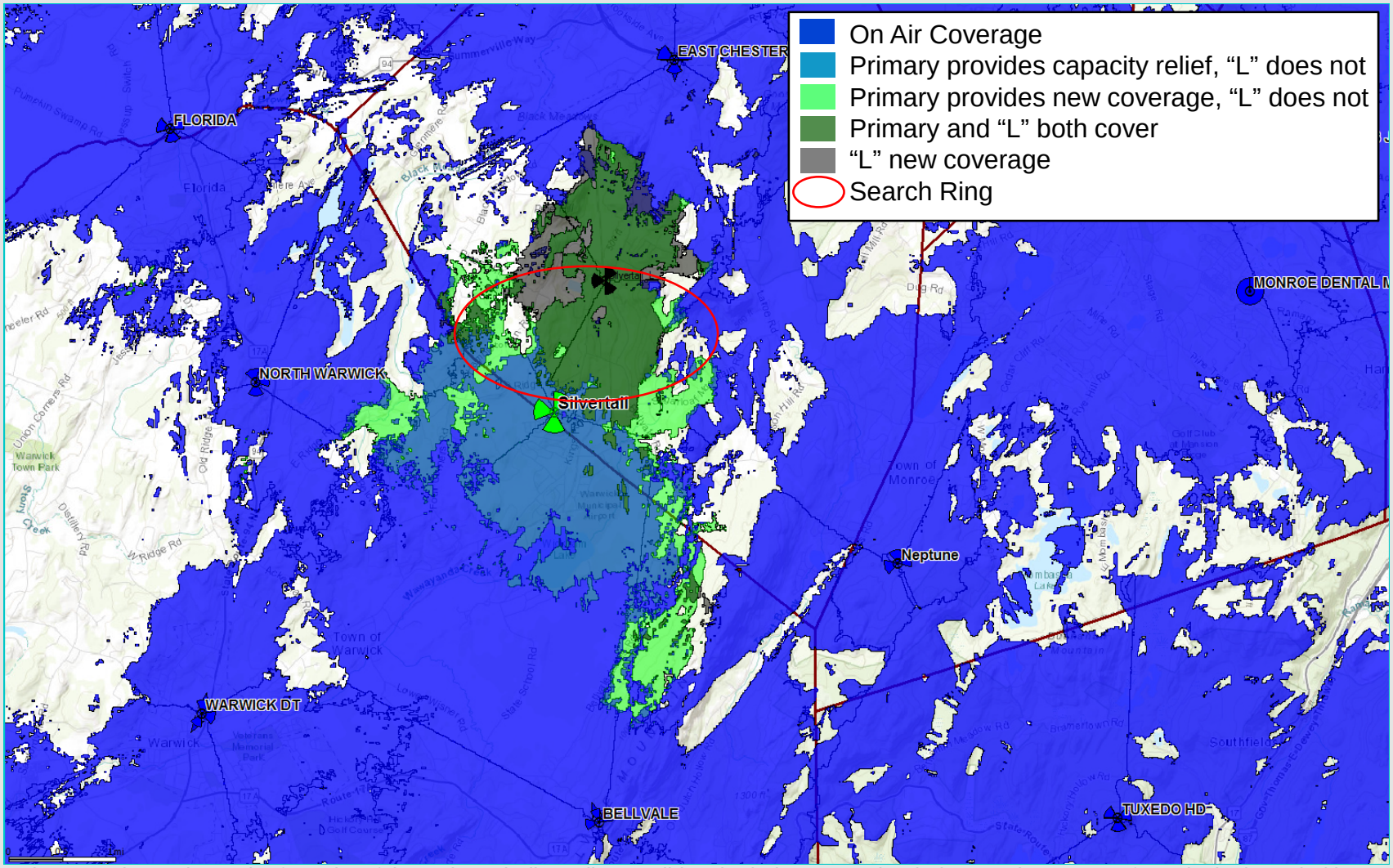
Alternative L 700MHz Best Server -95dBm RSRP

Best Server-Comparison plots depict the actual best server or dominant footprint of each sector in question when compared with each other. The following map shows the difference of the primary (Silvertail Wt) compared to alternate candidate L (at 150' ACL).



The map above shows the footprint of the Rejected Silvertail L candidate in dark green. The dark green best server footprint is degraded by area terrain significantly more than the primary reducing this candidate's ability to offload weak and distant users throughout the intended area. Too much "blue-gray" and "light green" coverage areas are still shown above indicating this alternate candidate is not capable of the required offload and/or coverage objectives.

RF REJECTED

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