National National Mall and Memorial
Washington, DC

National Park Service
U.S. Department of the Interior

Telecommunications Infrastructure Plan

Concept Plan

December 2025

Table of Contents

I. Introduction 5
Project Background 5
Purpose and need 7
Public & Stakeholder Engagement Process 7
Telecommunications Capacity Methodology 7
Planning Principles 8

II. Current Conditions 10
Existing Network Service 10
Existing Architectural Features 12
Resource Considerations 14
Project Area Viewsheds 18
Project Area Visual Character 18
Vegetation and Wildlife Habitat 22
Flood Plains and Water Table 22
Determination of Preffered Concept 22

III. Concept Plan Recommendations 25
Sub-Area Treatments 25
Potential Mobile Network Typologies 30

IV. Conclusion and Implementation 35
Regulatory Requirements 35

V. References 37

I. INTRODUCTION

The National Park Service (NPS) is preparing a telecommunications plan for the National Mall and surrounding NPS park areas in Washington, DC, to evaluate telecommunications infrastructure improvements that will enhance mobile network coverage and capacity while minimizing impacts on the cultural landscape and historic viewsheds.

The Concept Plan outlines feasible locations for the minimum buildout of telecommunication infrastructure across the National Mall and surrounding park areas. The Concept Plan is based on the current limitations of such infrastructure in the Project Study Area and a number of existing constraints. The Concept Plan is not intended to design the infrastructure, but rather to guide where future technologies should be integrated into the Project Study Area.

PROJECT BACKGROUND

The National Mall and surrounding park areas, including the Washington Monument Grounds, Presidents Park, Lincoln Memorial, National Mall East, East and West Potomac Park, and the Tidal Basin, are prominent and heavily visited public spaces administered by the National Mall and Memorial Parks (Park), a unit of the national park system. The purpose of the Park is to preserve and interpret these symbolic spaces while supporting public gatherings, national events, recreation, and cultural engagement. These areas are the focus of this Plan.

Mobile phone networks (Networks) operated by AT&T, Dish, T-Mobile, and Verizon Wireless (collectively referred to as Carriers), play a crucial role in the experience of visitors to the National Mall and its surrounding areas. As one of the most visited national parks in the country, the National Mall regularly attracts large crowds for daily tourism, recreation, and significant public events. These gatherings place considerable demand on the commercial Networks, and many park visitors frequently experience degraded service across the area, particularly during periods of peak use.

During large-scale events, federal agency staff helping to manage the gatherings also experience degraded service. The resulting limitations to communications reduce the effectiveness of agency staff, including public safety officers.

The NPS seeks to accommodate growing data demands within the Project Study Area, as defined below, while preserving the cultural and visual character of the Park. The Concept Plan examines the following:

- The current distribution and limitations of Carrier infrastructure, including towers, rooftops, and building facades, across, and adjacent to the Project Study Area.
- The potential for additional cell sites external to the Project Study Area to expand coverage and capacity.
- The viability of smaller footprint network enhancements, including both “small cell” installations supporting one or more Carriers and shared “neutral host” systems capable of serving all Carriers.

The Project Study Area is bound to the north by Constitution Avenue NW between 23rd and 17th Streets NW; E Street NW between 17th and 15th Streets NW; Constitution Avenue NW between 15th and 4th Streets NW; and Pennsylvania Avenue NW between 4th and 3rd Streets NW. 3rd Street NW/SW forms the eastern boundary. To the south, Project Study Area is bound by Maryland Avenue between 3rd Street SW and 4th Street SW; Independence Avenue SW between 4th Street and 15th Streets SW; 15th Street SW between Independence Avenue SW and Ohio Drive SW; and the Potomac River. Southeast of the 14th Street Bridge, the Washington Channel forms the eastern site boundary. The Potomac River forms the western boundary of the project. Project Study Area is shown in Figure 1.

For the purposes of this study, the NPS has divided the Project Study Area into five sub-areas to make the analysis easier to understand. These five sub-areas are the National Mall East, the Washington Monument Grounds and Presidents Park South, West Potomac Park – Lincoln Memorial, West Potomac Park – Tidal Basin, and East Potomac Park (Figure 1).

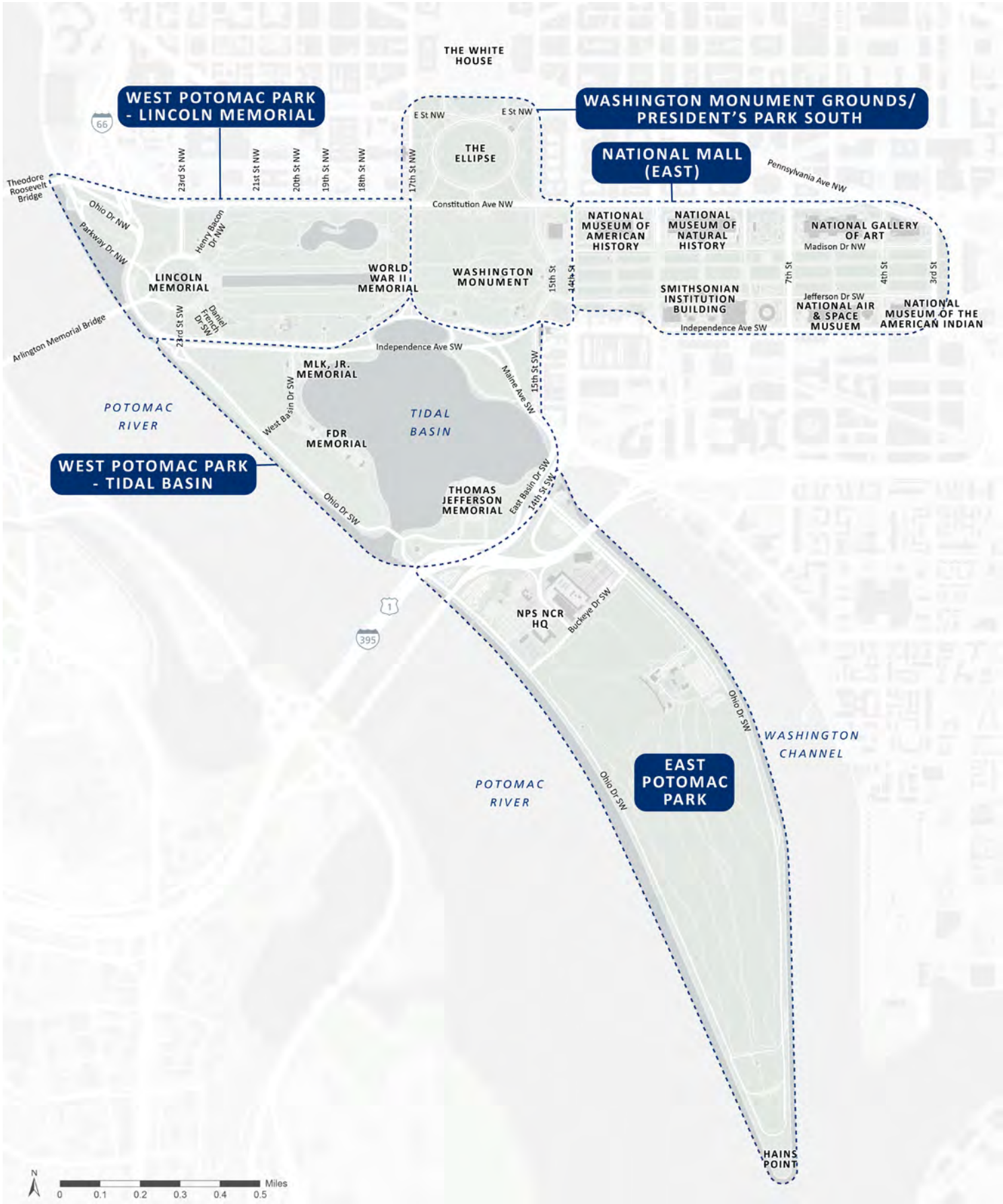


Figure 1 Project Study Area

PURPOSE AND NEED

Purpose

The purpose of the project is to develop a planning and technical framework to guide improvements to Networks across the Project Study Area.

The study aims to achieve the following objectives:

- Increase the telecommunications capacity by five times it's current capacity.
- Outline the minimum telecommunications build-out within the Project Study Area necessary to achieve a potential fivefold ("5x" or 400%) increase in capacity.
- Support the NPS mission by improving public safety, connectivity, and visitor experience.

Need

The Concept Plan is needed to address the following key concerns:

- Inadequate Network Coverage and Capacity: Current networks do not adequately meet the needs of the high number of daily visitors, event participants, and federal agencies operating within the Project Study Area.
- Demand for Modern Telecommunications Services: There is growing demand for reliable wireless telecommunications services, including 4G-LTE, 5G-NR services, and future technologies that support both routine public use and large-scale national events. Existing networks are unable to meet this need.
- Non-conforming Infrastructure: Temporary or outdated telecommunications installations may not align with federal aesthetic and safety standards.
- Operational and Maintenance Challenges: The lack of a coordinated, long-term plan for telecommunications infrastructure has led to inconsistent equipment types and siting practices; streamlining infrastructure can reduce long-term maintenance demands and improve reliability.

PUBLIC & STAKEHOLDER ENGAGEMENT PROCESS

The minimum build-out objective of "five times (5x) current capacity" was developed by the National Capital Region Wireless Infrastructure Design Working Group, which was led by the Cybersecurity and Infrastructure Security Agency (part of the Department of Homeland Security) and included representatives from:

- The NPS
- Carriers
- Third-party telecommunications companies (these companies build network infrastructure for the Carriers)
- Federal review agencies
- Congressional staff
- District of Columbia government
- Potomac Electric Power Company (PEPCO)
- Smithsonian Institution

In 2024, the group met four times: January 25th, February 29th, August 1st, and September 26th. The Carriers and third-party telecommunications companies participated in additional update meetings with the NPS to provide input and review technical requirements as related to this plan. These groups did not provide specific guidance on locations or number of facilities needed.

The NPS initiated Section 106 consultation with the District of Columbia State Historic Preservation Office (SHPO) on May 13, 2025. This consultation will continue as part of the concept planning process.

The NPS released a Draft Concept Plan for public comment on October 6, 2025. The 30-day comment period closed on November 6, 2025.

The NPS provided informational presentations to the National Capital Planning Commission (NCPC) and the U.S. Commission of Fine Arts (CFA) on July 10, 2025 and July 17, 2025, respectively. The NPS will submit the Final Draft Concept Plan for NCPC and CFA review and consideration prior to finalizing the plan.

TELECOMMUNICATIONS CAPACITY METHODOLOGY

An initial test of existing conditions was conducted to collect key data which was used to determine the existing capacity of each telecommunications Carrier per sub-area identified in Figure 1. For the study, each Carrier was analyzed independently, using the average test results for each individual Carrier and their associated bandwidth. These results were then used to establish the overall 1x capacity results for each Carrier as baseline existing conditions.

As mentioned previously, the purpose of the project is to establish 5x telecommunications capacity. The results of the existing capacity results were multiplied by five to calculate the 5x capacity for each sub-area. This is documented in the Cellular Study Report dated September 25, 2023 and attached as Appendix "A".

PLANNING PRINCIPLES

Based on the project's technical requirements and constraints, the Concept Plan recommends telecommunications infrastructure based on the following standards:

- Enable the goal of 5x telecommunications capacity
- Minimize adverse impacts on resources, with special consideration for cultural resources
- Avoid or limit changes to contributing cultural resources, including views, structures, and lighting
- Use existing non-contributing architectural features when possible
- Reduce maintenance requirements
- Minimize long-term maintenance needs by standardizing infrastructure types and siting practices
- Consider the total number of required sites, aiming to balance network performance with visual and operational simplicity. The network infrastructure should use similar equipment and parts, when possible, to reduce maintenance needs
- Consider the number of sites. If appropriate, having fewer infrastructure locations is preferred
- Extension of fiber optic and power infrastructures will be required. These extensions will require careful planning and coordination with stakeholders including Pepco, Verizon, and the Smithsonian Institute.

II. CURRENT CONDITIONS

Network coverage and capacity across the Project Study Area varies significantly depending on location, existing infrastructure, and crowd levels. In general, the networks are strained during peak visitation periods and large public events, with widespread reports of degraded voice and data service. The following provides more information on the existing network service and architectural features in the area.

EXISTING NETWORK SERVICE

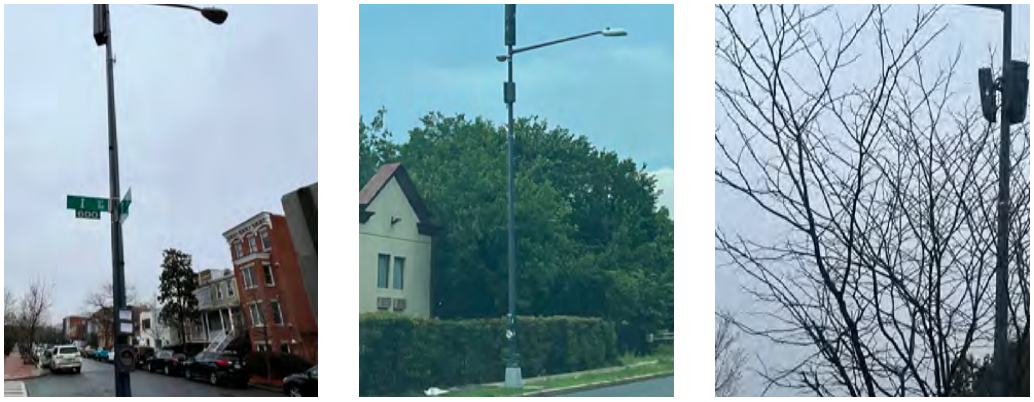
The existing telecommunications infrastructure in the Project Study Area includes a wide variety of equipment types, described below, including temporary or outdated installations that detract from the visual quality of the landscape. Over time, this infrastructure has developed inconsistently within and surrounding the Project Study Area without the Park having a coordinated long-term strategy for its telecommunication needs. These temporary and outdated sites also create operational inefficiencies and increased maintenance burdens for both the Carriers and, by extension, the NPS.

Telecommunications Infrastructure Types

Telecommunications infrastructure types found in and around the Project Study Area, including permanent and temporary facilities, are defined below and examples shown in Figure 2. An assessment of current conditions and feasibility for use is also provided.

- Permanent: Permanent cell sites can take two forms:
    - Macro: Provides extensive coverage through a high-power cell site and primarily includes large antenna systems mounted on a cell tower or building. A macro site provides service over a much larger area than a small cell.
    - Assessment: The collection of high-power network sites are located on buildings surrounding the Project Study Area, but signal into the core of the National Mall is limited by topography, tree canopy, and visual resource constraints. Some low-scale buildings within the Project Study Area, such as kiosks and comfort stations, have been evaluated for use but lack the necessary elevation and visibility. Multiple cell sites currently serve the Project Study Area from the rooftops of nearby buildings, such as Smithsonian Institution museums and other federally owned properties. These sites have been updated where possible, but improvements are often constrained by building owner preferences and aesthetic concerns. Some efforts by Carriers to expand coverage from adjacent buildings have been unsuccessful due to inability to secure site leases.
- Small Cell: Lower-power network cell sites have compact antenna systems which are placed near the ground, typically mounted lower than 30 feet.
    - Assessment: Within the District, small cell infrastructure is present on streetlights operated by the District Department of Transportation (DDOT) and third-party poles. However, the existing locations contain gaps in small cell infrastructure within the study area.
- Temporary: Cell sites which provide rapidly deployed, short-term network connectivity and are often transportable.
    - Assessment: Temporary solutions, such as COWs (Cells on Wheels), are occasionally deployed in the Project Study Area during major events but present aesthetic, logistical, and operational challenges. These temporary systems are not viable as long-term solutions and do not align with NPS policies for cultural resource protection.

Multiple cell sites currently serve the Project Area from the rooftops of nearby buildings, such as Smithsonian Institution museums and other federally-owned properties. These sites have been updated where possible, but improvements are often constrained by building owner preferences, regulatory review requirements, and aesthetic concerns. Some efforts by carriers to expand coverage from adjacent buildings have been unsuccessful due to inability to secure site leases.



Examples of existing small cells in DC

Examples of existing Macro infrastructure in DC

Temporary COW within the project area

Figure 2 Examples of Cell Site Types

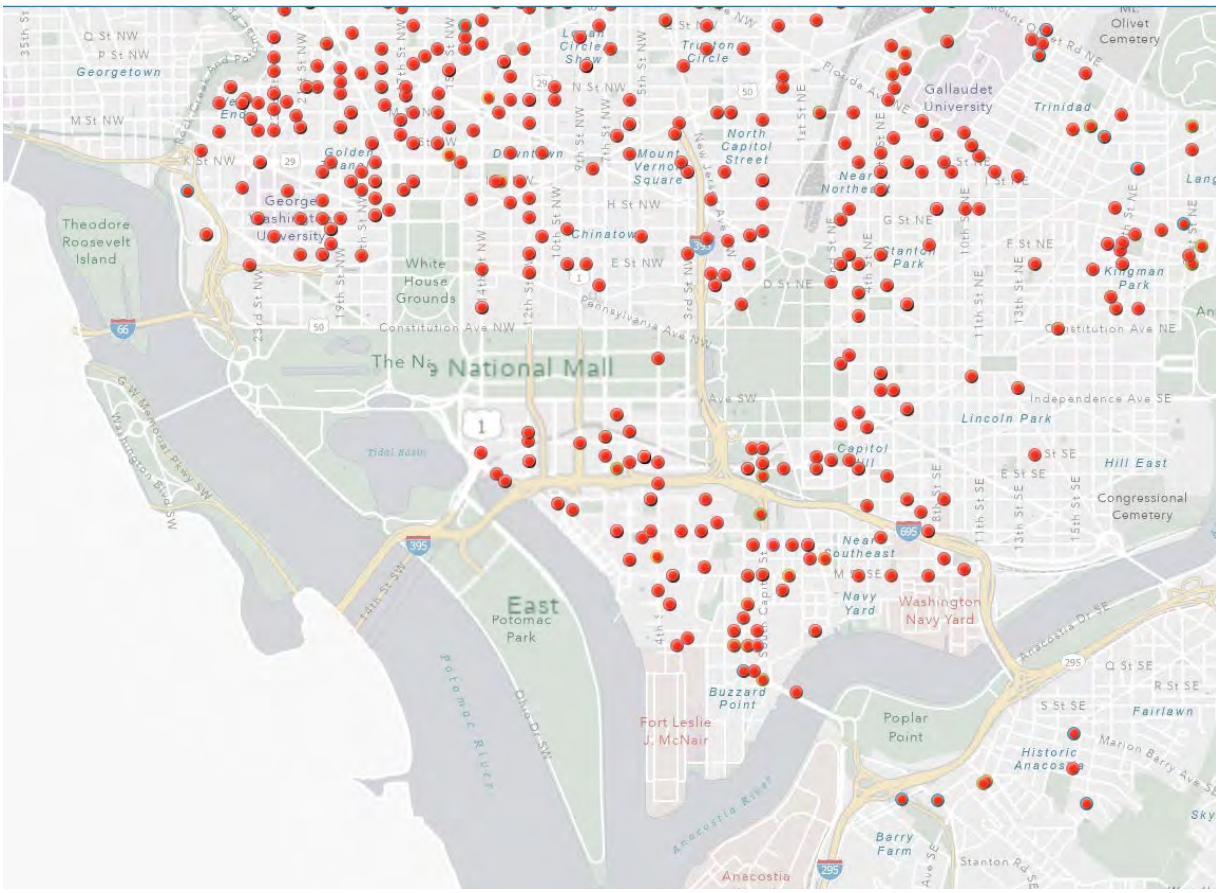


Figure 3 Small Cell Infrastructure in the District

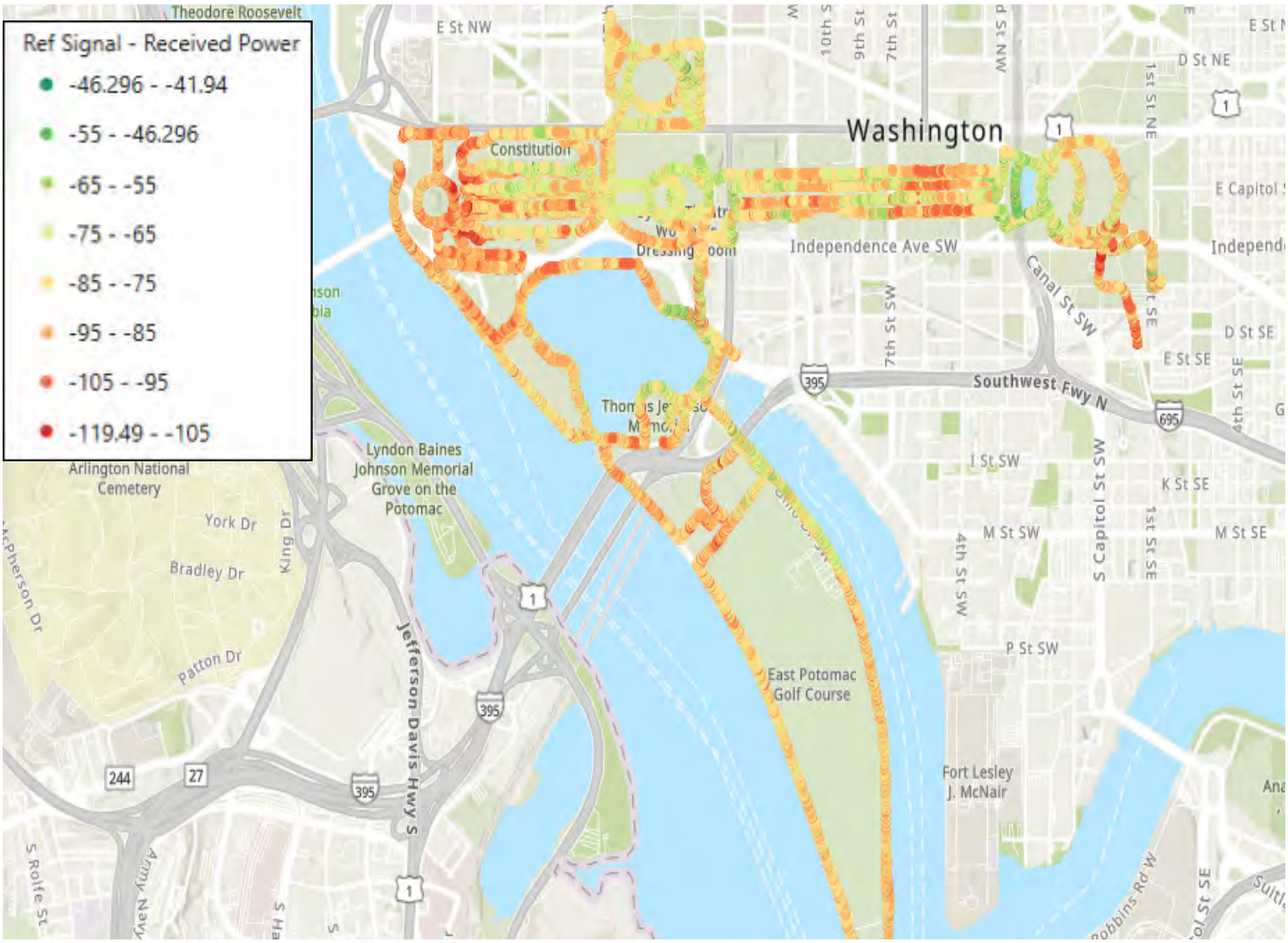


Figure 4 Example of Operator Coverage or Signal Strength

Within the District, small cell infrastructure is present on streetlights operated by the District Department of Transportation (DDOT) and third-party poles. However, the existing locations contain gaps in small cell infrastructure within the study area (Figure 3).

Telecommunications Service

Using their unique site configuration data (including power, frequency, bandwidth, technologies, etc.), each Carrier was independently evaluated to calculate the number of "nodes" (small cell and/or neutral host sites) necessary to achieve the required capacity increase ("5x"). While the node counts for each Carrier are not necessarily equal, the node counts for each Carrier are the minimum required to allow them to reach the capacity goal for their network (Figure 4).

EXISTING ARCHITECTURAL FEATURES

Existing architectural features within the Project Study Area offer the potential for collocation of macro or small cell telecommunication infrastructure. Although multiple features are found within the Project Study Area, three types of features offer feasible solutions: light poles, memorial lighting stanchions, and buildings. Within each category of these architectural features, numerous varieties are present. The locations of these items are depicted in Figure 5.

Light Poles

Within the Project Study Area there are eight different types of light poles. The three most common light pole types are the Washington Globe (766 fixtures), Twin Washington Globe (310 fixtures), and Olmsted (191 fixtures). Washington Globe and Twin Washington

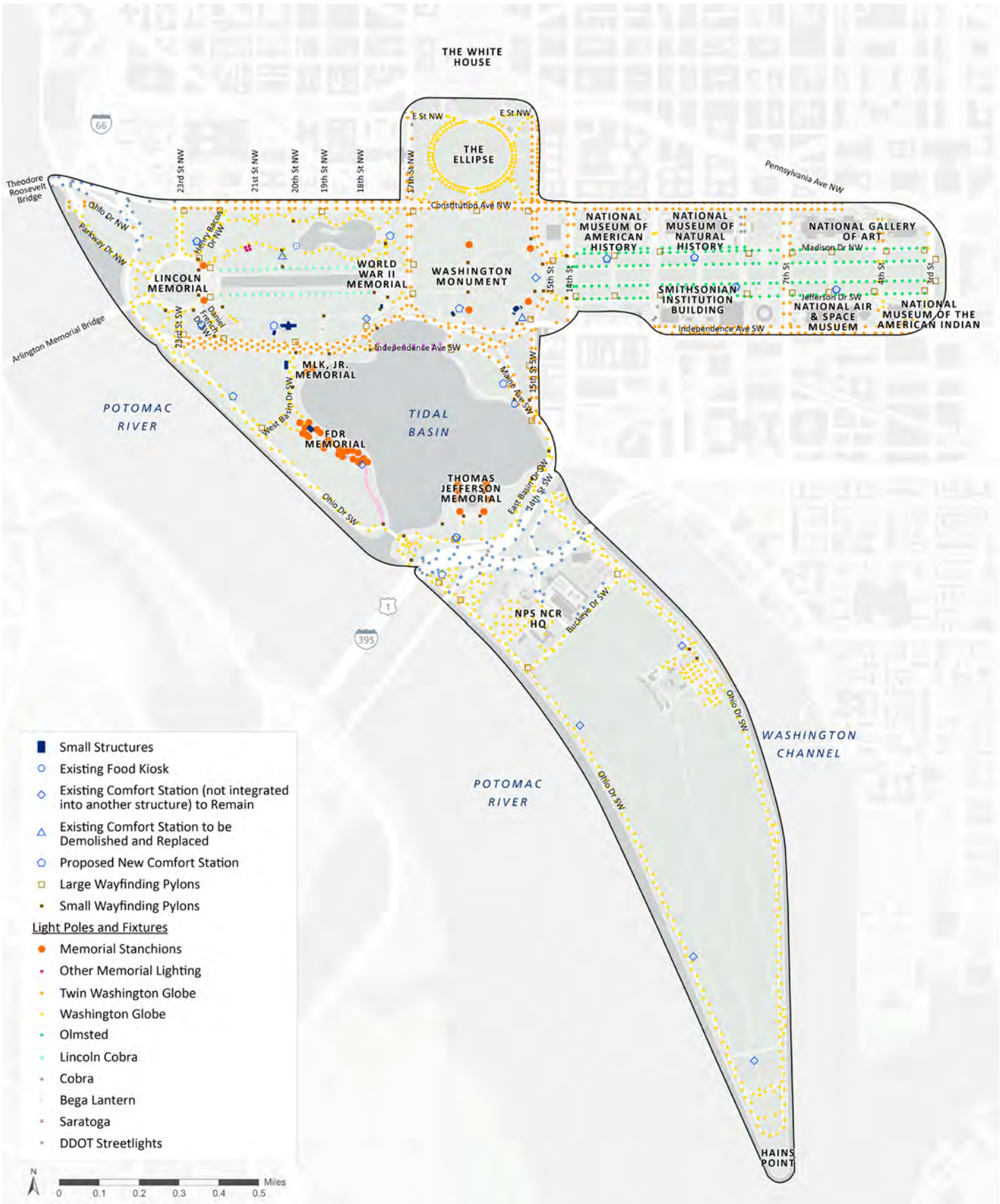


Figure 5 Existing Architectural Features

Globe lights are primarily found in East and West Potomac Parks. Olmsted lights are found along the pathways of the eastern portions of the National Mall. Additional light fixture types found around the Park include Cobra lights, Bega Lantern lights, and Saratoga lights. With the exception of Cobra lights located primarily along roadways, light poles in the Project Study Area are intended to illuminate pedestrian areas and are contributing features of historic properties.

Memorial Lighting Stanchions

Many of the memorials and commemorative works within the Project Sutdy Area require special lighting stanchions in order to provide illumination at night. This inludes the Lincoln Memorial, Jefferson Memorial, and the Washington Monument (Figure 6). These lighting stanchions are not contributing features of historic properties, providing greater flexibility for possible additional use.

Buildings

The Project Study Area includes multiple types of buildings based on the variety of NPS facilities and operations. Currently, the Project Study Area contains nine stand-alone comfort stations (non-contributing). Of these, most are circular in form. The NPS is currently advancing a plan to replace or add 15 comfort stations and kiosks with new, expanded facilities within the study area. Additionally, the Project Study Area contains multiple food, information, and souvenir kiosks. Most feature a consistent design style (Figure 7 and Figure 8).

RESOURCE CONSIDERATIONS

The Project Study Area contains a variety of cultural and natural resources. The development of this Concept Plan reviewed the presence of these resources and considered the associated potential impacts.

Cultural and Historic Resources

As defined by 36 CFR 800.16(d), the Area of Potential Effect (APE) represents "the geographic area within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." Historic properties in the APE (Figure 9) are discussed below.


Lincoln Memorial Lighting Stanchion


Washington Memorial Lighting Stanchion


Jefferson Memorial Lighting Stanchion

Figure 6 Memorial Lighting Stanchions

National Mall (Historic District)

The National Mall, which is listed in the National Register of Historic Places (NRHP) as an historic district, extends west from the U.S. Capitol grounds to the Potomac River and south from Constitution Avenue NW to Independence Avenue SW and west of 15th Street around the Tidal Basin to the 14th Street Bridge (see Figure 2). The National Mall also includes the Washington Monument Grounds and West Potomac Park, as well as individually listed museums:

- National Museum of Natural History
- National Gallery of Art
- U.S. Department of Agriculture Building
- Arts and Industries Building
- Smithsonian Institution Building
- Freer Gallery of Art

Comfort Station

Comfort Station (Future)

Figure 7 Example of Existing and Proposed Comfort Stations

Concessions Kiosk

Figure 8 Example of Visitor Service Kiosk

Washington Monument Grounds

The Washington Monument Grounds, part of the National Mall, is located approximately in the center of the National Mall and is listed in the NRHP at the level of national significance.

East and West Potomac Parks

The East and West Potomac Parks are listed together in the NRHP.

East Potomac Park is one of the largest recreational spaces in the Washington, DC core, occupying most of Hains Point between the Washington Channel and the Potomac River. It is almost 330 acres in size and extends southeast of West Potomac Park. East Potomac Park has been primarily developed for active recreation uses. This park currently contains a golf course with food service, one of the country's oldest miniature golf courses, and a tennis facility. The area's roads are well used by bicyclists. Visitor services also include picnic facilities, restrooms, and a playground.

West Potomac Park provides the setting for such nationally recognized memorials and landscape features as the Lincoln Memorial and Reflecting Pool, Thomas Jefferson Memorial, Franklin Delano Roosevelt (FDR) Memorial, Vietnam Veterans Memorial, Korean War Veterans Memorial, World War II Memorial, Martin Luther King, Jr. (MLK) Memorial, Constitution Gardens and the 56 Signers of the Declaration of Independence Memorial, and several other memorials or features. West Potomac Park encompasses the Tidal Basin, with its three memorials, views, and spectacular Japanese flowering cherry trees, and features public parking, floral library, seasonal concession stand, and recreation rentals.

The White House and President's Park

Included as part of the National Mall historic district, located north of the Washington Monument Grounds, is the White House and President's Park. President's Park South includes the area bounded by State Place, South Executive Avenue, and Alexander Hamilton

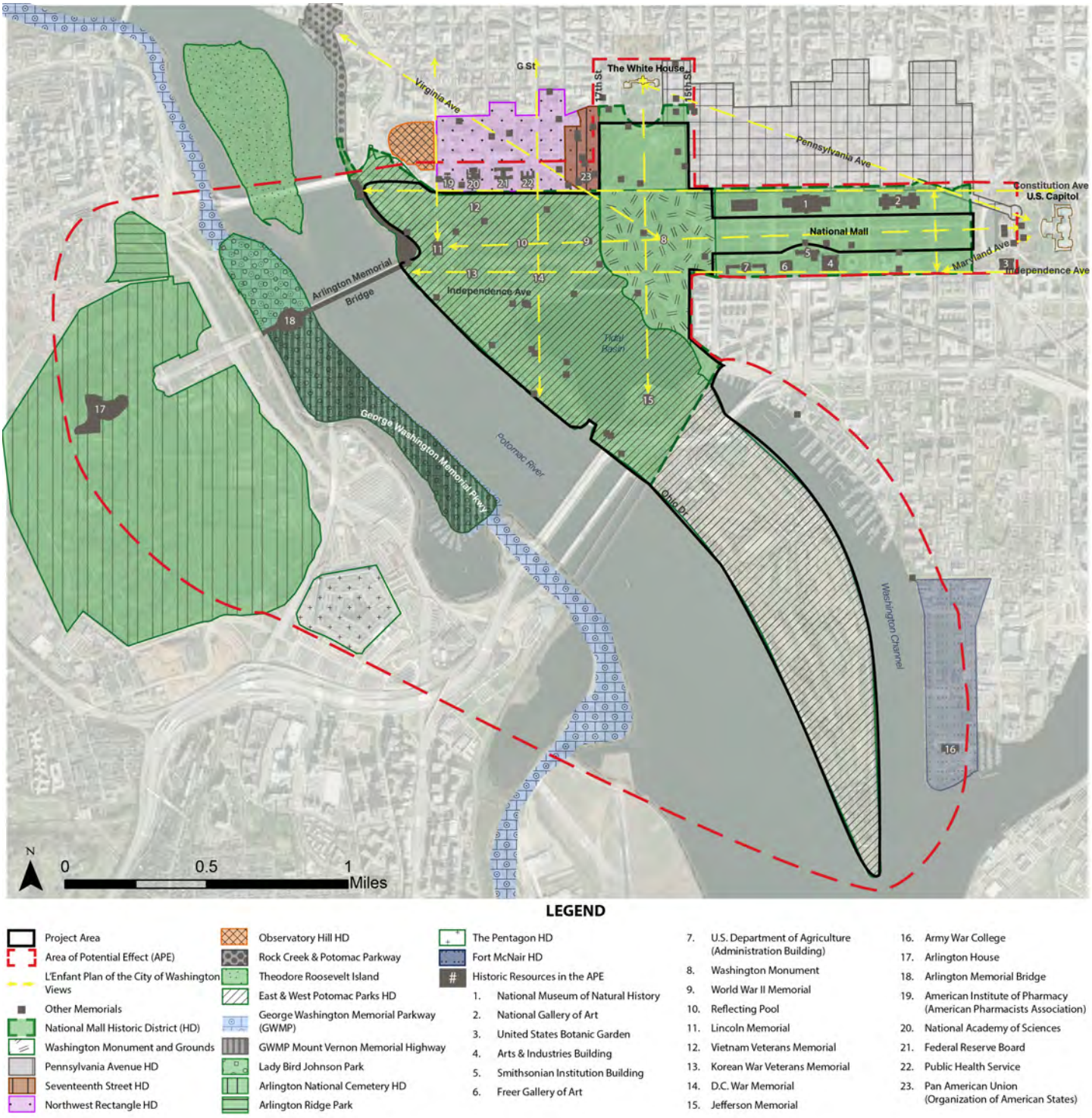


Figure 9 Area of Potential Effect

Place on the north, 15th Street N.W. on the east, Constitution Avenue N.W. on the south, and 17th Street N.W. on the west.

The White House and President's Park is listed in the National Registry of Historic Places (NRHP). The Project Study Area is one of the oldest federal reservation in the nation, and it is a nationally significant historic landscape that continues to reflect the design principles of Pierre Charles L'Enfant in 1791, Andrew Jackson Downing in 1851, and the Olmsted brothers in the 1930s—design principles that have withstood the test of time. President's Park is integral to the historic layout of the city, which was

initially designed to physically represent the functional relationships of the three branches of our government. Memorials that have been incorporated into the historic landscape design commemorate significant events and individuals in the nation's history.

Multiple physical attributes—both view sheds and the natural and built characteristics—contribute to the character and significance of the Project Study Area.

Other Resources Within APE

Other resources within the APE could include potential effects on historic properties due visual changes within the Project Study Area. The other properties identified in the APE include the following:

- Pennsylvania Avenue Historic District
- Seventeenth Street Historic District, including individually listed building
  - Pan American Union
- Northwest Rectangle Historic District, including individually listed buildings
  - American Institute of Pharmacy
  - National Academy of Sciences
  - Federal Reserve Board
  - Public Health Service
- Observatory Hill Historic District
- Rock Creek and Potomac Parkway
- Theodore Roosevelt Island
- George Washington Memorial Parkway (GWMP)
- GWMP Mount Vernon Memorial Highway
- Lady Bird Johnson Park
- Arlington National Cemetery Historic District
- Arlington Ridge Park
- The Pentagon Historic District
- Fort McNair Historic District, including individually listed building
  - Army War College
- United States Botanic Garden
- Arlington House
- Arlington Memorial Bridge

PROJECT STUDY AREA VIEWSHEDS

One of the key features of the National Mall is the visual relationships established as part of the original plan and expanded and embellished in subsequent plans and efforts. These include, described as key resources in the 2016 NRHP nomination for the National Mall, planned vistas along the principal north-south and east-west axes of the National Mall, reciprocal views between major memorial sites, extended views along contributing streets and avenues, multi-directional views across open expanses, and periodic views of resources from circulation routes.

Views and their related spaces help organize the landscape and create visual and thematic relationships between important governmental and commemorative features in the landscape. The 1791 L'Enfant Plan of the City of Washington and the 1902 McMillan Plan (collectively referred to as the L'Enfant Plan) established many significant views within the Project Study Area. The views within the Project Study Area listed in the L'Enfant Plan NRHP nomination (1994) are shown in Table 1.

The National Mall NRHP nomination (2016) included multiple contributing buildings and sites that incorporate views in the Project Study Area as part of the visual experience of the National Mall in addition to those identified in the L'Enfant Plan, listed in Table 2.

The Project Study Area includes other views not specifically identified in the L'Enfant Plan or National Mall NRHP nominations as historically significant but are part of the viewer experience within the National Mall. For example, the view of Ohio Drive along the Potomac River in West Potomac Park includes roadways, sidewalks, and trails that access open recreation areas with fencing and a maintenance route, flanked by the open water of the river.

PROJECT STUDY AREA VISUAL CHARACTER

The overall visual character of the Project Study Area presents a cohesive design with multiple qualities. The site is an entirely designed and constructed landscape, and therefore functions as a cultural

PRIMARY VIEWS	OTHER VIEWS
• View west from the U.S. Capitol to the Lincoln Memorial and the western horizon • View south from the White House to the Jefferson Memorial and the southern horizon	• Reciprocal view east from the Washington Monument to Union Square and the Capitol • View radiating from Virginia Avenue, including the Washington Monument • North-south views along 4th Street, SW, and 4½ Street, NW, toward Judiciary Square • View along 6th Street NW, toward the National Gallery of Art • View along 8th Street NW-SW, toward the National Archives • View along 10th Street, NW-SW, toward the National Museum of Natural History (NMNH) and the Smithsonian Institution Building. • View along 23rd Street • Views to the elms and the buildings along the National Mall from its walks and grass panels

Table 1 Views Listed in L'Enfant NRHP Nomination

WASHINGTON MONUMENT	LINCOLN MEMORIAL	CONSTITUTION GARDENS	TIDAL BASIN CLUSTER
• Reciprocal views to the Lincoln Memorial, White House, Thomas Jefferson Memorial, and the U.S. Capitol • Views of the Washington Monument from the city and surrounding region	• Views between the memorial and the radial roads from Lincoln Circle • Views between the memorial and the Ericsson Monument • Views between the memorial and Constitution Avenue along 23rd Street NW	• Views east to the Washington Monument • Views from within the Project Area to the Vietnam Veterans Memorial • Views from the Vietnam Veterans Memorial to the Washington Monument • Views to the Lincoln Memorial and the Lincoln Memorial Reflecting Pool area • Views to the District of Columbia War Memorial • Internal views of the pond and the 56 Signers Memorial and from the overlook terrace	• Reciprocal views between the memorials, such as the views between the Thomas Jefferson Memorial and the Martin Luther King, Jr. Memorial, among others • Periodic views from various locations along the Tidal Basin's path of the surrounding Japanese cherry trees and nearby memorials

Table 2 Views Listed in National Mall NRHP Nomination

landscape. For the purposes of this analysis, the natural and cultural visual environments are treated as a single combined visual environment. Many types of built features within the Project Study Area help define the landscape's views: distinctive landforms, vegetation, buildings, infrastructure, structures, and other artifacts and art. These are described in the visual inventory below.

- Primary East-West and North-South Views: The primary east-west and north-south views have few intrusions or interruptions. The corridor edges maintain relatively consistent lines, reinforced by buildings, structures, linear pathways, and vegetation. The views' key anchoring features (Lincoln Memorial, Washington Monument, U.S. Capitol, Jefferson Memorial, and White House) are generally built of light stone, placed at slightly higher elevations, and are the most prominent visual elements within the Project Study Area.
- Land (Topography): The designed environment of the Project Study Area consists of relatively flat turf panels bordered by trees. The topography has been modified with subtle elevation changes at particular locations, such as the Vietnam Veterans Memorial, Constitution Gardens, levees along the east-west axis of the National Mall, and gentle slopes toward the Tidal Basin and Potomac River.
- Water: The Potomac River is a wide tidally influenced river, with both natural and constructed stream banks and the Tidal Basin.
- Vegetation: The land is largely vegetated within the built environment. Vegetation reinforces the designed cultural landscape within the Project Study Area. The Lincoln Memorial to U.S. Capitol axis features open turf panels flanked by parallel rows of trees that reinforce the visual corridor. Other landscaped vegetation includes deciduous trees, turf fields, and memorial-specific designs. The view corridor between the White House and Jefferson Memorial is intended to be 150 feet wide, although mature trees have grown into the space.
- Structures: The Project Study Area contains multiple structures, ranging from national memorials to levees and seawalls. The most prominent structures within the Project Study Area are the Lincoln Memorial, the Washington Monument, and the Jefferson Memorial, which are large-scale iconic nationally significant structures of white stone. Other memorials—which range in materials, color, form, and scale—are generally placed to avoid interruption of the primary axial views; however, these memorials often provide additional visual and thematic connections to the landscape's primary axis points. The Tidal Basin and its associated seawall, bridges, and other features cover a large area but are located at a relatively low elevation.
- Buildings: The Project Study Area contains an extensive collection of buildings that represent a diverse range of styles and characters. In addition to the National Mall's iconic memorials and view corridors, the museum complex of the Smithsonian Institution and National Gallery of Art lining the National Mall's central greensward form a consistent visual line, although the buildings range in height, color, and materials. The Project Study Area also includes utilitarian buildings, such as concession stands and comfort stations that support the needs of visitors.
- Circulation Features and Systems: Many of the orthogonal streets and diagonal avenues that characterize the L'Enfant Plan for Washington intersect with and cross the Project Study Area. In addition to these road corridors, other historic circulation features include elements such as the Ellipse road and its associated walks and the rectilinear system of pedestrian paths along the National Mall.
- Small Scale Features: The National Mall has only a few types of small-scale features. Contributing features include benches, streetlights, and trash receptacles. Non-contributing small-scale features include drinking fountains, fire hydrants, post-and-chain barriers, and bike racks.

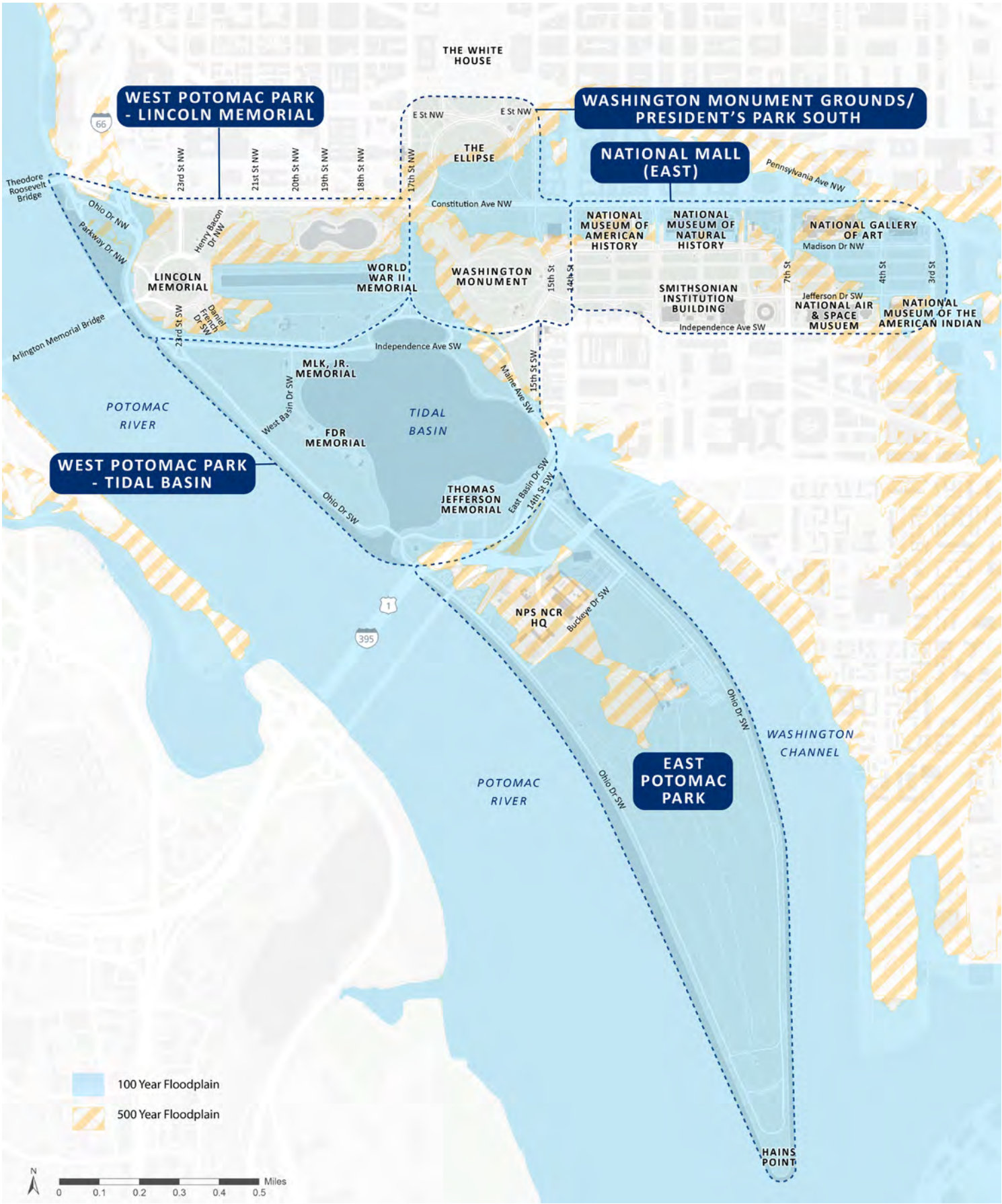


Figure 10 Floodplain Areas

VEGETATION AND WILDLIFE HABITAT

The Project Study Area contains hundreds of mature trees, turf fields, planting beds, and other vegetation that provides wildlife habitat. Tree types include American elm, bald cypresses, cherry, willow oak, chestnut, star magnolia, and maple. Turf fields cover much of the Project Study Area, including at the Washington Monument, hockey fields, rugby fields, and ball fields near Ohio Drive. Planting beds are found throughout the Project Study Area, including at the German-American Friendship Garden, Sylvan Theater, and multiple memorials.

The mature trees include extensive critical root zones, which limit the locations of potential excavation for telecommunications equipment infrastructure.

FLOOD PLAINS AND WATER TABLE

Most of the Project Study Area lies within the 100- and 500- year floodplains; the Lincoln Memorial grounds, Washington Monument grounds, and the Mall between approximately 7th and 14th Street NW are outside the floodplains. Similarly, much of the Project Study Area is in an area with a high water table (Figure 10). These conditions limit the potential for below-grade vaults due to the potential for water damage. As a result, the conditions call for resilient, above-ground infrastructure designs.

DETERMINATION OF PREFERRED CONCEPT

To identify the preferred concept, analysis of existing site conditions, network modeling, and design feasibility was conducted. The solution balances technological performance, resource protection, and minimizing visual intrusion.

Constraints and Considerations

The Project Study Area presents multiple challenges for increasing Network coverage and capacity. The planning process identified the following constraints and considerations.

- Tree Canopy: Existing tree canopy may obstruct signal transmission from either macro or small cell sites and therefore limits viable site locations for needed infrastructure. In order to provide effective Network coverage and capacity, the areas between the infrastructure and the service areas should have as few trees as possible. The existing tree canopy within the Project Study Area limits the locations that could potentially place sites because the trees would block signals. For instance, locations along Madison and Jefferson Drives were considered as part of the planning process in order to minimize potential impacts on cultural resources. However, locations on these roadways flanking the National Mall East area would not provide the required signal levels in the center of the National Mall lawn panels due to the alleés of trees.
- Cultural Resources: The Project Study Area contains a dense fabric of cultural resources as noted under Resource Considerations. In addition to the physical components of the resources, views and the visual settings of the resources are also important components. Examples of contributing views include the reciprocal view to the Lincoln memorial, White House, Thomas Jefferson Memorial, and the U.S. Capitol and views of the Washington Monument from the city and surrounding areas. In addition to the views specifically documented, the overall visual character of the Project Study Area functions as a cultural landscape. Similarly, the placement of telecommunications infrastructure at contributing features could affect the cultural resources. As a result, locations that could be most effective in achieving the technical requirements of the project would not be appropriate.
- Low-Scale Existing Buildings Without Network Sites: One option for locating network sites is to use existing buildings found within the Project Study Area, such as information kiosks and comfort stations. However, existing small buildings like kiosks and comfort stations are too low and often surrounded by trees, and therefore are unable to provide the necessary signal within the Project Study Area.
- Existing Macros Located on Buildings: Large-scale network infrastructure sites are already located on multiple buildings within or adjacent to the Project Study Area, such as the Smithsonian Institution

museums. Carriers have been working to upgrade these large-scale network infrastructure sites to better serve the Project Study Area but may have been limited by the owners due to aesthetic and other concerns. Suitable buildings adjacent to the Project Study Area have been approached, but in some cases the Carriers have been unable to obtain site leases.

- Below-Grade Infrastructure Limitations: The Project Study Area, as a whole, has a relatively high water table that limits the widespread use of below-grade vaults for infrastructure. Similarly, portions of the Project Study Area are within the floodplain, further limiting below-grade infrastructure.The Project Study Area includes below-grade utilities and other structures, including a tunnel between the National Museum of Natural History and the Smithsonian Castle; new stormwater management infrastructure around the Hirshhorn Sculpture Garden; and other utilities. These utilities and below-grade structures should be avoided.
- Physical Site Properties: Antenna and housing size, along with mounting constraints, affect visual integration and influence the technical approach (referred to as topology) and site selection. Antenna Size: Depending on the pole design, small cell antennas may require larger antenna shrouds (coverings) and therefore, may not be able to be visually integrated as well as a neutral host antenna.
    - Housing Size: Each technology has a unique required equipment housing size. Some of the housing sizes can be better visually integrated into some areas than others, which is a consideration for the Network topology for the infrastructure.
    - Antenna Mounting: The ability to integrate a site design visually has a large impact on selection. Where it is believed that antennas can be integrated in a way that closely mimics the existing architecture of the area, the visual impact of the site is anticipated to be minimal. Where sites need to differ from the existing architecture (e.g., luminaires enlarged to house antennas), some visual impact is anticipated. Where poles (with or without a luminaire) have independent shrouds for the antenna, a greater visual impact is anticipated.
- Site Coverage: Because some topologies have a smaller coverage radius per site, the efficiency of the design for that technical approach may be reduced (e.g., a DRAN-2 design may have almost twice as many sites as an SASC design due to the power losses associated with combining two Carriers into one node). The relative visual impact of the extra infrastructure locations is considered in the selection process.

III. CONCEPT PLAN RECOMMENDATIONS

The concept plan outlines the placement of telecommunication infrastructure across the National Mall and surrounding areas based on the principles identified earlier in the document. The Concept Plan also outlines the potential topologies considered and what the relative considerations would be. The Concept Plan is not intended to design the infrastructure, but rather to guide how existing and future technologies should be integrated into the Project Study Area.

SUB-AREA TREATMENTS

National Mall East

The Concept Plan identifies potential locations for new telecommunications infrastructure placed along the exterior edges of the National Mall's turf panels. This location may impact the primary reciprocal views between the Lincoln Memorial, Washington Monument, and U.S. Capitol. These locations would be roughly aligned with the existing Olmsted light poles, which are contributing features of the historic landscape. The Park could consider the replacement of existing Olmsted light poles that seamlessly incorporate telecommunications infrastructure while also offering lighting, or an as-yet-to-be-developed method. Locations directly on the 10th Street axis, a contributing viewshed, should be shifted east or west as needed, depending on the type of pole used, to avoid adverse effects on historic resources. Furthermore, the equipment could be replicated at multiple locations, thereby minimizing maintenance challenges. Additional consideration should be given to using existing traffic signal poles, which would require coordination with DDOT.

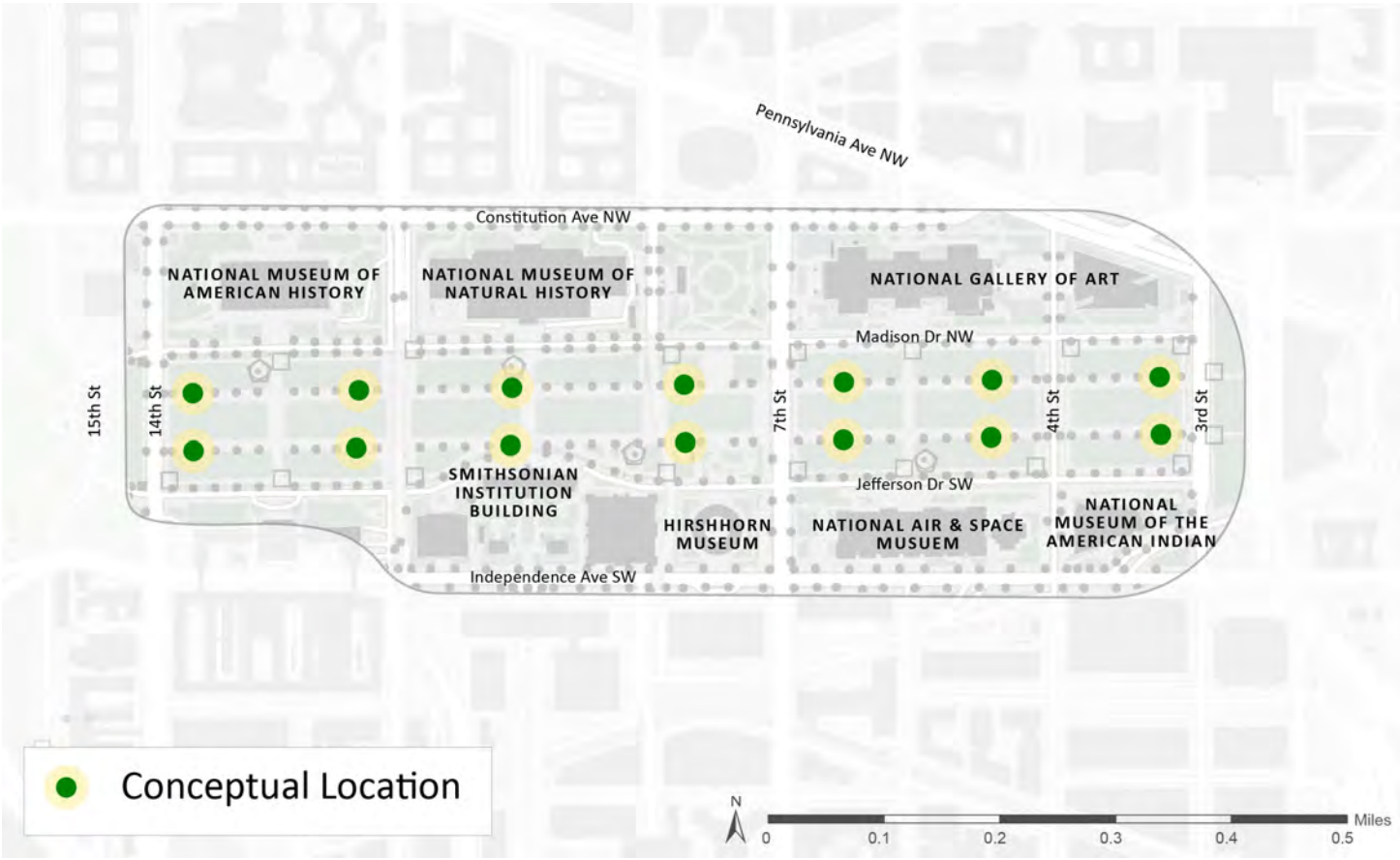


Figure 11 National Mall East Concept Layout

Consideration was given to the placement of telecommunications infrastructure elsewhere within the National Mall East sub-area, including along Madison and Jefferson Drives. These Locations dismissed due to the existing elm trees lining the National Mall block signals, making these locations technically infeasible. Existing kiosks would be too low and would experience substantial blockage from elm tree canopies.

Washington Monument Grounds/President's Park South

The Concept Plan identifies multiple locations for new telecommunications infrastructure within the Washington Monument Grounds/President's Park South sub-area. At President's Park South, telecommunications infrastructure would be placed along the roadway encircling the Ellipse, in line with Washington Globe light poles. It is anticipated that these would likely be standalone poles, replacement of existing Washington Globe light poles that seamlessly incorporate telecommunications infrastructure while also offering lighting, or an as-yet-to-be-developed method.

If the telecommunications infrastructure varies in appearance from the Washington Globe, the locations would be placed at the eastern- and western-most points of the Ellipse to minimize impacts on the White House and the Thomas Jefferson Memorial 150-foot reciprocal view corridor. Within the Washington Monument Grounds, the telecommunications infrastructure would be located on existing light stanchions and the existing screening facility. The large-scale light stanchions illuminate the Washington Monument at night and are not contributing features

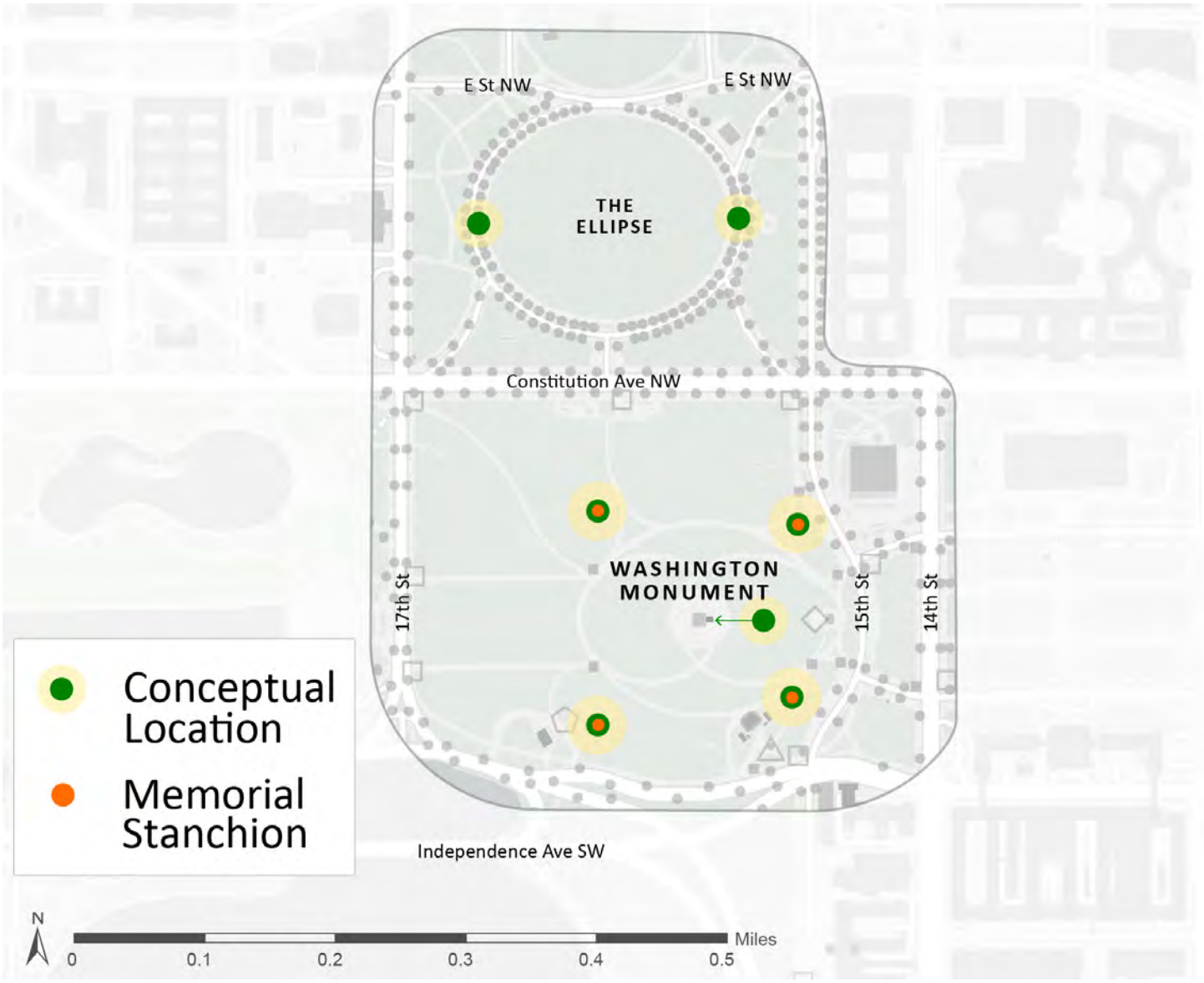


Figure 12 Washington Monument Grounds/President's Park South Concept Layout

to cultural resources. Furthermore, their location within the open expanse of the grounds would offer uninterrupted signals. The screening facility at the base of Washington Monument would also offer the opportunity to place telecommunications in an open area with few obstructions. The monument screening facility, which is not a contributing building to cultural resources, would host an antenna.

West Potomac Park - Lincoln Memorial

The Concept Plan identifies locations for new telecommunications infrastructure along 17th Street NW, Parkway Drive NW, and Ash Road; around the Lincoln Memorial; and within Constitution Gardens. Along 17th Street NW and Parkway Drive NW, at least one new telecommunications node would be installed along the walkway near the entrance to the World War II Memorial and along the eastern sidewalk, respectively. The Ash Road locations would similarly be placed along the pathway to avoid interrupting recreation fields to the north. At least one telecommunications infrastructure node would be placed along sidewalks at the northeast edge of Lincoln Circle.

Similarly, new telecommunications infrastructure would be placed along walkways within Constitution Gardens. In each of these cases, the new telecommunications infrastructure would be in line with existing Washington Globe or Washington Twin Globe (for 17th Street) light poles.

It is anticipated that it would likely be a standalone pole, replacement of an existing Washington Twin Globe or Washington Globe light pole that seamlessly incorporates telecommunications infrastructure while also offering lighting, or an as-yet-to-be-developed method.

Each of these locations would avoid canopies of street trees. Although these sites are all within a cultural landscape and the existing lights are contributing features, the placement of facilities near walkways and existing lighting would integrate the telecommunications infrastructure within the visual landscape. New telecommunications infrastructure would also be placed on Lincoln Memorial lighting stanchions, which are not contributing features. These large light poles, which extend above the tree canopy, would be adapted to host telecommunications infrastructure. The stanchions are outside primary views, and could therefore accommodate new telecommunications infrastructure.

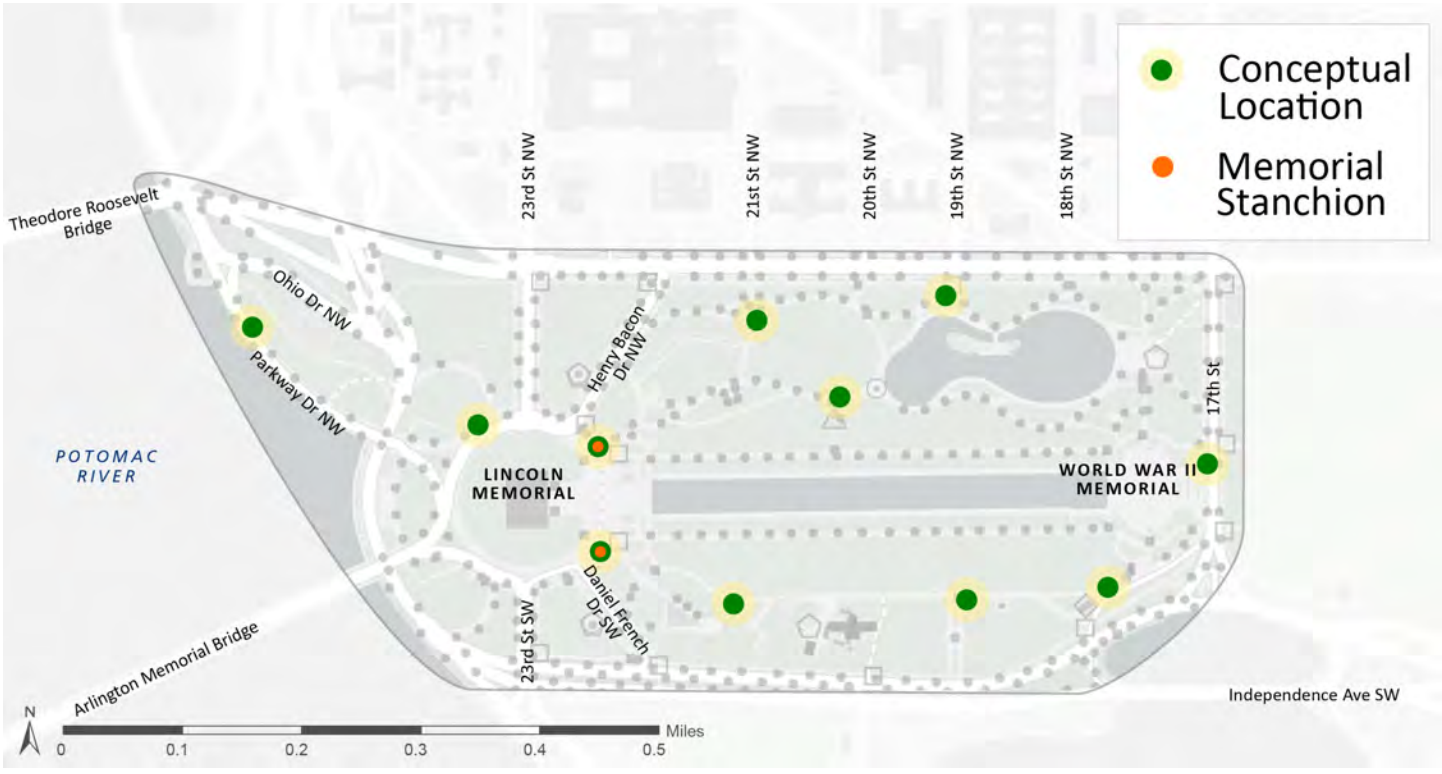


Figure 13 WWest Potomac Park - Lincoln Memorial Concept Layout

West Potomac Park - Tidal Basin

The Concept Plan identifies multiple locations for new telecommunications equipment within the West Potomac Park – Tidal Basin sub-area, including around the Tidal Basin and its associated memorials and along Ohio Drive. At least four new nodes of telecommunications infrastructure would be placed along sidewalks and paths near the Tidal Basin, but would not be placed between these sidewalks and paths and the Tidal Basin, thereby minimizing visual and physical obstructions to the water. At the northeast portion of the Tidal Basin between Independence Avene and 15th Street, the telecommunications infrastructure would be located outside the White House and the Thomas Jefferson Memorial 150-foot reciprocal view corridor.

Light stanchions at the Jefferson and Franklin Delano Roosevelt Memorials would offer opportunities for location new telecommunications infrastructure on existing, non-contributing features within the sub-area. Changes to these light stanchions would be minimally visible to visitors.

New telecommunications infrastructure would be placed along sidewalks of West Basin and Ohio Drives SW, in line with existing Washington Globe light poles to minimize impacts on cultural resources.

East Potomac Park

The Concept Plan identifies locations for new telecommunications infrastructure in East Potomac Park along Ohio Drive. The locations would be in line with the existing Washington Globe light poles flanking Ohio Drive. It is anticipated that these

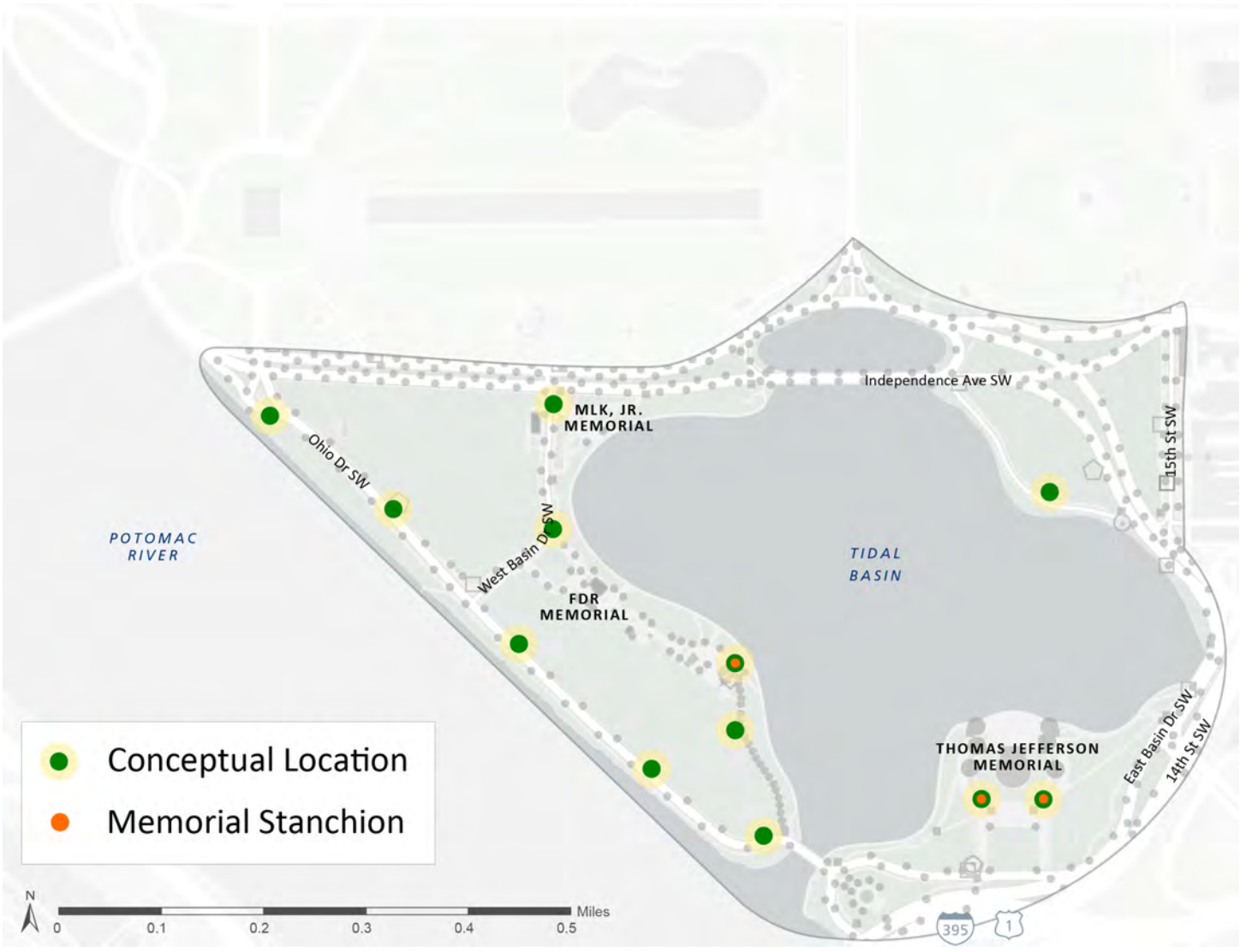


Figure 14 West Potomac Park - Tidal Basin Concept Layout

Figure 15 East Potomac Park Concept Layout

would likely be standalone poles, replacement of existing Washington Globe light poles that seamlessly incorporate telecommunications infrastructure while offering lighting, or an as-yet-to-be-developed method. Furthermore, the equipment could be replicated at multiple locations, thereby minimizing maintenance challenges.

POTENTIAL MOBILE NETWORK TOPOLOGIES

Macro, small cell, and neutral host sites were each evaluated as potential solutions to achieve 5x capacity; temporary sites were not considered as these will only be used to augment capacity during large-scale, planned events due to their temporary nature. Macro sites were ultimately excluded from inclusion due to the complexities of obtaining leases, inherent capacity limitations associated with larger sites, and the lack of suitable locations for these sites within the Project Study Area. Under specific circumstances, Carriers may find suitable macro locations to provide sufficient capacity to portions of the Project Study Area thus eliminating the need for sites within that section of the Project Study Area.

The Concept Plan ultimately identified four potential Network topologies to achieve 5x capacity, listed in detail below. These options vary in equipment and implications for site design and range from stand-alone poles to an antenna integrated into an existing feature, e.g. light pole and an adjacent equipment cabinet to house necessary electronics, power, and fiber connections. It is anticipated the network design solutions would likely include a mix of topologies.

The Concept Plan does not recommend specific topology approaches. Instead, the Concept Plan lays out the considerations for each topology. It is anticipated that Carriers will propose technical solutions based on the principles identified in this document.

Final proposed solutions also may vary slightly from those listed here (e.g., using of sectorized instead of omni antennas, or hybrid sites with multiple topologies collocated on a pole) but should be designed to meet the principles identified in this document.

Stand Alone Small Cell

The SASC topology accommodates one Carrier at each telecommunications infrastructure node. As a result, this approach would require the greatest number of sites, although with the smallest equipment cabinet size.

Distributed Radio Access Network (DRAN-2)

The DRAN-2 topology accommodates two Carriers at each telecommunications infrastructure node. As a result, this approach requires fewer sites than the SASC configuration and simplifies maintenance. The equipment cabinets volume would be larger than the SASC. The DRAN-2 provides slightly less coverage per site.

(DRAN-4)

The DRAN-4 topology accommodates four Carriers at each telecommunications infrastructure node. As a result, this approach requires the fewest sites than the SASC configuration and further simplifies maintenance. DRAN-4 would also have the smallest coverage area of any of the small cell Topologies. The equipment volume would be the largest of the options.

Neutral Host

Like DRAN-4, the Neutral Host topology accommodates four Carriers at each infrastructure node and would require a smaller number of sites. The Neutral Host topology would likely to use a smaller antenna than SASC, DRAN-2, or DRAN-4 topologies, thereby making a future design of a custom pole easier. In contrast to DRAN-4, the equipment volume would be much smaller. The Neutral Host topologies require coordination among multiple Carriers, adding an additional level of complexity.

PRINCIPLES	SASC	DRAN-2	DRAN-4	NEUTRAL HOST
Enable 5x Capacity	Yes	Yes	Yes	Coverage at edges of area substantially worse
Number of Sites	28	14	11	17
Avoid or limit changes to contributing cultural resources, including views, structures, and lighting	Align with Olmsted lights at edge of lawn panels; smallest cabinet size	Align with Olmsted lights at edge of lawn panels; largest cabinet size	Align with Olmsted lights at edge of lawn panels; largest cabinet size	Align with Olmsted lights at edge of lawn panels; smallest cabinet size
Use existing non-contributing architectural features when possible	No (due to height and foliage issues)	No (due to height and foliage issues)	No (due to height and foliage issues)	No (due to height and foliage issues)
Reduce maintenance requirements	Use consistent poles	Use consistent poles	Use consistent poles	Use consistent poles

Table 3 National Mall – East: Topologies Screened against Criteria

PRINCIPLES	SASC	DRAN-2	DRAN-4	NEUTRAL HOST
Enable 5x Capacity	Yes	Yes	Yes	Too much capacity lost at lighting stanchions
Number of Sites	28	14	7	7
Avoid or limit changes to contributing cultural resources, including views, structures, and lighting	Places new nodes within primary view corridor	Places new nodes within primary view corridor	Avoids primary view corridor	Avoids primary view corridor
Use existing non-contributing architectural features when possible	Uses lighting stanchions and screening facility	Uses lighting stanchions and screening facility	Uses lighting stanchions and screening facility	Uses lighting stanchions and screening facility
Reduce maintenance requirements	Use consistent poles	Use consistent poles	Use consistent poles	Use consistent poles

Table 4 Washington Monument/ President's Park South: Topologies Screened against Criteria

PRINCIPLES	SASC	DRAN-2	DRAN-4	NEUTRAL HOST
Enable 5x Capacity	Yes	Yes	Yes	Too much capacity lost at lighting stanchions
Number of Sites	40	20	11	11
Avoid or limit changes to contributing cultural resources, including views, structures, and lighting	Places multiple new nodes within primary view corridor; new features along Ash Woods Drive avoid contributing views	Places multiple new nodes within primary view corridor; new features along Ash Woods Drive avoid contributing views	Places one new node within primary view corridor; new features along Ash Woods Drive avoid contributing views	Avoids primary view corridor; new features along Ash Woods Drive avoid contributing views
Use existing non-contributing architectural features when possible	Uses lighting stanchions	Uses lighting stanchions	Uses lighting stanchions	Uses lighting stanchions
Reduce maintenance requirements	Use consistent poles	Use consistent poles	Use consistent poles	Use consistent poles

Table 5 Potomac Park West – Lincoln Memorial: Topologies Screened against Criteria

PRINCIPLES	SASC	DRAN-2	DRAN-4	NEUTRAL HOST
Enable 5x Capacity	Yes	Yes	Yes	Yes
Number of Sites	40	22	12	12
Avoid or limit changes to contributing cultural resources, including views, structures, and lighting	Places multiple new nodes within landscape	Places multiple new nodes within landscape	Places multiple new nodes within landscape	Places multiple new nodes within landscape
Use existing non-contributing architectural features when possible	Uses lighting stanchions	Uses lighting stanchions	Uses lighting stanchions	Uses lighting stanchions
Reduce maintenance requirements	Use consistent poles	Use consistent poles	Use consistent poles	Use consistent poles

Table 6 Potomac Park West – Tidal Basin: Topologies Screened against Criteria

PRINCIPLES	SASC	DRAN-2	DRAN-4	NEUTRAL HOST
Enable 5x Capacity	Yes	Yes	Yes	Yes
Number of Sites	40	20	13	13
Avoid or limit changes to contributing cultural resources, including views, structures, and lighting	Places multiple new nodes within landscape	Places multiple new nodes within landscape	Places multiple new nodes within landscape	Places multiple new nodes within landscape
Use existing non-contributing architectural features when possible	No (due to height and foliage issues)	No (due to height and foliage issues)	No (due to height and foliage issues)	No (due to height and foliage issues)
Reduce maintenance requirements	Use consistent poles	Use consistent poles	Use consistent poles	Use consistent poles

Table 7 Potomac Park East: Topologies Screened against Criteria

IV. CONCLUSION AND IMPLEMENTATION

The Concept Plan outlines minimum building scenarios for the location of telecommunications infrastructure within the Project Study Area in a way that meets technical requirements and minimizes impacts on resources.

The Concept Plan does not propose a specific design but rather general guidance for the quantity and types of telecommunications infrastructure that may be constructed. The Concept Plan also provides examples for illustrative purposes. After the adoption of the Concept Plan, each Carrier would be responsible to developing their own proposals that meet the requirements of this plan. The location, design, and number of the infrastructure would conform to the guidelines and require approval by NPS and other stakeholders to be permitted for construction. Carriers would be encouraged to partner with one another to share infrastructure and minimize construction impact on the Park. Similarly, a third-party telecommunications company could construct the infrastructure based on specific Carrier-provided requirements or the Carriers could form a consortium to design and build a system that meets the needs of each network.

Future proposals for new infrastructure within the Project Study Area should address the following criteria:

- Quantity: Proposals should ensure that the quantity of nodes required for all Carriers in each sub-area should not exceed the quantity of nodes recommended in the study for that sub-area. Preference will be given to proposals that can support all Carriers and require less nodes than the study recommends while still meeting the remaining criteria.
- Node Sharing: Preference will be given to proposals which incorporate all Carriers into the design. Strong preference will be given to proposals which share nodes between two or more Carriers while still meeting the remaining criteria.
- Scale: The scale of the proposed nodes, including the height of the element containing the antenna(s) and the size of the equipment enclosure(s), should be minimized and match or be compatible with the scale of the architectural features of the immediate area surrounding each node.
- Architecture: Proposed nodes should be designed to closely match the architectural features of the area surrounding each node. Strong preference will be given to nodes that closely reproduce existing architectural elements (e.g., light poles).
- Location: Proposed nodes should be carefully integrated into the existing architectural landscape, either replacing existing elements with nodes which closely match that element or with nodes that align with and augment existing sets of elements (e.g., a line of light poles). Strong preference will be given to proposals utilizing existing memorial lighting standards and other unique elements which allow the nodes to more easily blend in with the area.
- Capacity: Proposals should include a statement by each applicable Carrier that the design supports a 5x or more increase in Carrier capacity for the proposed area.

REGULATORY REQUIREMENTS

National Environmental Policy Act

Before implementing elements in the Concept Plan, the NPS will work through the process as specified by the National Environmental Policy Act (NEPA) requirements. It is anticipated that the plan would qualify for a categorical exclusion (CE) and that elements of the plan that are implemented may also qualify for a CE based on the following considerations:

- Cultural Landscapes and Historic Buildings, Structures, and Districts. As previously identified, the Project Study Area contains multiple cultural landscapes and historic buildings, structures, and districts, including some of the Nation's most iconic resources. The Concept Plan for locating telecommunications infrastructure within the Project Study Area identifies areas that would minimize impact but still provide effective service. The Concept Plan would not result in impacts on historic buildings, structures, and districts. Instead, the individually proposed telecommunications infrastructure would be evaluated as part of the permit review process.
- Vegetation and Wildlife Habitat. The Project Study Area contains multiple areas of mature trees,

turf fields, planting beds, and other vegetation that provide habitat for wildlife. The Concept Plan identifies locations for telecommunications infrastructure that would minimize changes to vegetation and wildlife habitat. Vaults that could damage critical root zones of mature trees would not be recommended. Individual telecommunications infrastructure would be sited and evaluated as part of the permit review process.

- Floodplains and Water Resources. Much of the Project Study Area is found within the 100- and 500-year floodplains. In addition, the Project Study Area generally has a high water table.

National Historic Preservation Act

As mentioned earlier, the NPS has initiated Section 106 consultation for the project. Prior to finalization of the plan, the NPS would consider the potential effects on historic properties as a result of the Concept Plan. Changes to the Project Study Area would follow The Secretary of the Interior's Standards for the Treatment of Historic Properties to the extent practicable. In cases where this is not possible, the NPS would seek to avoid, minimize, and mitigate potential adverse effects on historic properties. The consultation with the DC SHPO and relevant tribal nations will continue to ensure all federally required historic preservation processes are followed and documented. Additional consultation with the DC SHPO and relevant tribal nations, as well review by NCPC and CFA, would occur during the implementation process.

V. REFERENCES

National Park Service (NPS). 2025 (April). National Mall Minimum Build-Out Study. Prepared by AECOM, Washington, DC.

NPS. 2023a. National Park Service Cultural Landscape Inventory East Potomac Park, National Mall and Memorials Park. Washington, DC.

NPS. 2023b. National Park Service Cultural Landscape Inventory West Potomac Park, National Mall and Memorials Park. Washington, DC.

NPS. 2018. National Park Service Cultural Landscape Inventory The Mall, National Mall and Memorials Park. Washington, DC.

Federal Emergency Management Agency (FEMA).2016 (April). National Flood Hazard Layer (NFHL) Status. Availablehttps://hazards-fema.maps.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd. Accessed September 10, 2025.

AECOM

Cellular Coverage Report

National Mall
NAMA Minimum Buildout Study

National Park Service

Project number: 60702149

September 22, 2023

Delivering a better world

Quality information

Prepared by	Checked by	Verified by	Approved by
Ahmed Chohan - Senior RF Engineer	Michael T. Cassell & Michael Soderman	Michael T. Cassell - Global Wireless Coleader	Michael Soderman PM - Global Wireless Co-Leader

Revision History

Revision	Revision date	Details	Authorized	Name	Position
Draft	09/22/2023	Internal	Internal Only	Michael Cassell	Wireless Co-Lead
Version 1	09/25/2023	Distributed	For Customer	Mike Soderman	Wireless Co-Lead

Distribution List

# Hard Copies	PDF Required	Association / Company Name
N/A		

Prepared for:

National Park Service

Prepared by:

Ahmed Chohan
Senior RF Engineer
E: ahmed.chohan@aecom.com

AECOM
4 North Park Drive
Hunt Valley, MD 21030
aecom.com

Table of Contents

1. Purpose 5
1.1. Introduction 5
1.2. Project Overview 5
1.3. Note Regarding Capacity Requirements 5
1.4. RF Survey Overview 6
2. Definitions 7
2.1. Reference Signal Received Power (RSRP) 7
2.2. Reference Signal Received Quality (RSRQ) 7
2.3. Received Signal Strength Indication (RSSI) 7
2.4. Carrier to Interference plus Noise Ratio (CINR) 7
2.5. Primary Synchronization Signal Received Power (PSS_RP) 7
2.6. Primary Synchronization Signal Received Quality (PSS_RQ) 7
2.7. Primary Synchronization Carrier to Interference plus Noise Ratio (PSS_CINR) 7
2.8. Physical Cell Identity or Physical Cell ID (PCI) 8
2.9. Low, Mid, and High Band Spectrum 8
3. RF Survey Description 9
3.1. Test Setup 9
3.2. RF Survey Route 10
3.3. Definition of Study Sub-Areas 11
3.4. Data Processing 12
4. Data Evaluation 13
4.1. Data Collected 13
4.2. General Data Evaluation Results 14
4.3. Verizon Coverage and Capacity Overview 15
4.3.1. Existing Verizon Coverage 15
4.3.2. Existing Verizon Coverage Tables 16
4.4. AT&T Coverage and Capacity Overview 17
4.4.1. Existing AT&T Coverage 17
4.4.2. Existing AT&T Coverage Tables 18
4.5. T-Mobile 19
4.5.1. Existing T-Mobile Coverage 19
4.5.2. Existing T-Mobile Coverage Tables 20
5. Conclusion 21
Appendix A 22
Coverage Maps 22

Table of Figures

Figure 1: General Survey Area 6
Figure 2: Scanning Receiver Configuration 9
Figure 3: RF Survey Route 10
Figure 4: Study Sub-Areas 11
Figure 5: Sample Survey Results (Reference Signal Received Power) 12
Figure 6: Occupied Bands by Carrier 13
Figure 7: 4G LTE Channels Captured During Survey 13
Figure 8: 5G NR Channels Captured During Survey 14
Figure 9: Verizon 700 Channel 5230 – LTE 16
Figure 10: Verizon 850 Channel 2560 – LTE 16
Figure 11: Verizon 1900 Channel 1125 – LTE 16
Figure 12: Verizon 2100 Channel 2125 -LTE 16
Figure 13: Verizon AWS-3 Channel 67086 - LTE 16
Figure 14: ATT 700 Channel 5780 – LTE 18
Figure 15: ATT 1900 Channel 850 – LTE 18
Figure 16: ATT 2100 Channel 2000 – LTE 18
Figure 17: ATT WCS Channel 9820 – LTE 18
Figure 18: ATT 850 Channel 174770 - 5G NR 18
Figure 19: T-Mobile 600 Channel 68661 – NR 20
Figure 20: T-Mobile 700 Channel 5230 – LTE 20
Figure 21: T-Mobile 1900 Channel 675 – LTE 20
Figure 22: T-Mobile 2100 Channel 2300 -LTE 20
Figure 23: T-Mobile BRS Channel 39750 – LTE 20
Figure 24: T-Mobile 600 Channel 135700 - 5G NR 20
Figure 25: T-Mobile BRS Channel 510270 - 5G NR 20

1. Purpose

1.1. Introduction

The National Mall Cellular Coverage Report provides an overview of the service and signal quality for major wireless carrier, i.e., Verizon, AT&T and T-Mobile, at the historic National Mall and surrounding parks. Based on the data from the report we will determine the best available solution(s) required to provide sufficient coverage and capacity on the National Mall, using the findings in support of the National Park Service Telecommunications Infrastructure Plan.

1.2. Project Overview

The National Park Service (NPS) is proposing to develop a Telecommunications Infrastructure Plan ("Plan") that would provide a framework and guidance for the future construction and operation of communications infrastructure utilizing NPS assets, specifically: roof top antennas, temporary antenna locations, small-cell sites, and fiber optic communications cable (fiber) and power infrastructure. The Plan will encompass the areas shown in Figure 1 including the National Mall and Memorial Parks, as well as the Presidents' Park (including the Washington Monument grounds, Lincoln Memorial and Reflecting Pool, Constitution Gardens, Jefferson Memorial, East Potomac Park, West Potomac Park, Tidal Basin area, and the Ellipse). The Plan intends to provide a proactive approach for determining potentially acceptable telecommunications infrastructure within the park that are consistent with the cultural landscape, NPS mission, enabling legislation, existing park management documents, and future planning considerations.

1.3. Note Regarding Capacity Requirements

In January 2022, the National Security Council's (NSC) National Capital Region (NCR) Security Interagency Policy Committee (IPC) identified that the current wireless infrastructure around the National Mall is insufficient for large emergencies and short-notice events, thereby posing risks to emergency managers, first responders, and civilians. To address the issue, the NSC designated the Cybersecurity and Infrastructure Security Agency (CISA) and the General Services Administration (GSA) to lead a Working Group (WG) comprised of departments and agencies, as well as partners from local government and industry organizations, to examine existing wireless infrastructure challenges and bureaucratic obstacles to wireless infrastructure expansion in Washington, D.C. The group was directed to determine potential solutions to these challenges.

The WG engaged with the wireless infrastructure project approval entities — including the National Capital Planning Commission, Commission of Fine Arts, Advisory Council on Historic Preservation, National Park Service, and Architect of the Capitol — and with the three major wireless carriers in the NCR. From these engagements and further assessment of the current wireless infrastructure, the WG determined that action must be taken to improve the wireless infrastructure around the National Mall, and nearby locations, and has drafted a Corrective Action Plan (CAP). The CAP recommends that the wireless infrastructure capacity must be increased to, at least, five times the current daily busy hour capacity[1] to ensure the safety and security of the area's residents, workers, and visitors. To do this most effectively, the WG recommended the installation of a heterogenous design of macro and small cell systems, combined with use of low-, mid-, and high-frequency bands. In addition, since the capacity threshold increase will not account for large mass gatherings, the WG recommended that mobile antenna locations need to be designated, with permanent power and fiber hookups, to enable the service providers to support high peak demands more effectively and more safely during special events.

[1] The quantified capacity definition has not yet been determined by the WG but is expected in Q4 of 2023.

1.4. RF Survey Overview

AECOM performed cellular signal survey for the purpose of collecting data for the three major carriers covering National Mall and Memorials Parks and President's Park to include the Washington Monument Grounds, Lincoln Memorial and Reflecting Pool, Constitution Gardens, the Jefferson Memorial, East Potomac Park, West Potomac Park and Tidal Basin areas as well as the Ellipse.

The RF signal survey data was collected[2] for the three major carriers using the digital scanner that captured data from the 600 MHz band through the C-Band. The data collected is for all known bands/channels for each of the carriers which helps determine the capacity that a carrier can provide to its users in a giving area. The data also identifies which site the signal is coming from which helps with identifying the coverage from each site and some insight to current capacity. The survey data helps identify the quality of signal which in turn provides an insight to the coverage and capacity each band can provide to the users.

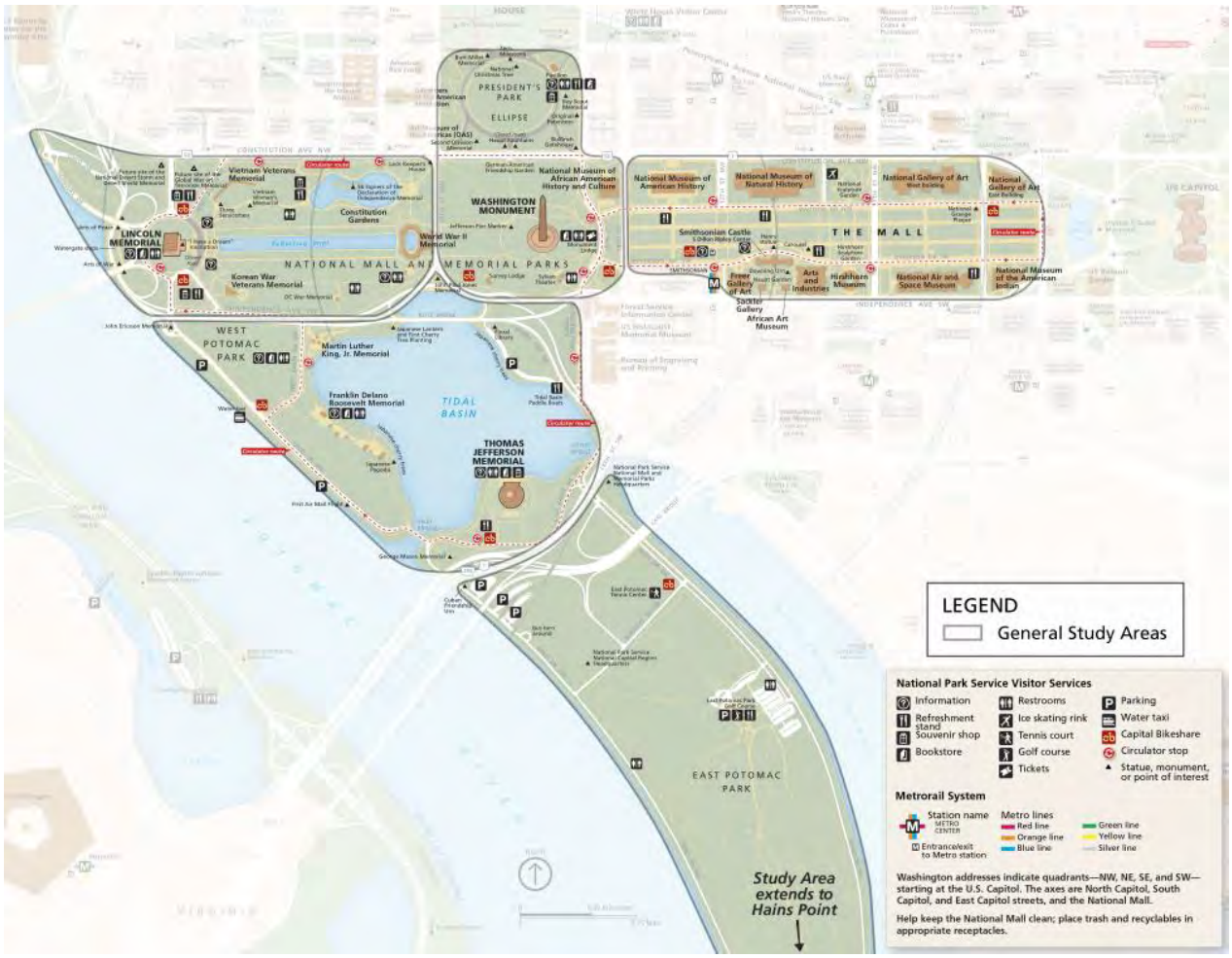


Figure 1: General Survey Area

[2] The data was collected using a PCTEL scanner connected to antennas. A GPS unit attached to the scanner provided the exact location of each data point collected. A computer is connected to the scanner logged the data and allowed for data verification during collection.

[3] The data was collected using a PCTEL scanner connected to antennas. A GPS unit attached to the scanner provided the exact location of each data point collected. A computer is connected to the scanner logged the data and allowed for data verification during collection.

2. Definitions

2.1. Reference Signal Received Power (RSRP)

Reference Signal Received Power is a measure of the power level of a received signal in an LTE cell network. RSRP is the average power of the received pilot signals or the level of the received signal from the base station. RSRP is measured in decibels milliwatts (dBm). Values closer to zero indicate stronger signals. For example, an RSRP of -95 dBm would be a strong signal, while -115 dBm would be very weak.

2.2. Reference Signal Received Quality (RSRQ)

Reference Signal Received Quality is a measure of the signal quality of a cellular connection. RSRQ is calculated using the values of RSSI and RSRP. It's a ratio of the carrier power to the interference power. The closer to zero the RSRQ is, the higher the power of the signal.
RSRQ is typically displayed in a range from 0 dB (highest quality) to -20 dB (lowest quality). Better signal quality results in a more reliable connection.

2.3. Received Signal Strength Indication (RSSI)

Received Signal Strength is a measurement of the total power received by a device. RSSI is a value for determining a good wireless connection. RSSI is indicated by a dBm value, with a higher the number representing a better signal. For example, an RSSI of -40 dBm or better is considered excellent. An RSSI of -95 dBm or worse is considered poor. RSSI typically ranges from -100 dBm to 0 dBm.

2.4. Carrier to Interference plus Noise Ratio (CINR)

Carrier to Interfere Noise Ratio is the ratio of the signal level to the noise level, also known as Signal to Interference plus Noise Ratio (SINR). CINR is measured in decibels (dB). A positive CINR value means that the signal is more effective than the noise. A higher CINR value means that the signal strength is stronger in relation to the noise levels. This allows for higher data rates and fewer retransmissions, which offers better throughput.

2.5. Primary Synchronization Signal Received Power (PSS_RP)

Primary Synchronization Signal reference signal received power is defined as the linear average over the power contributions (in Watt) of the resource elements that carry SS. The SS-RSRP value is used for cell selection, cell reselection, power control, mobility procedures, and beam management procedures. The SS-RSRP value is generated and reported at both Layer 1 (Physical) and Layer 3 (RRC). The reporting range of SS-RSRP for L3 is defined from -156 dBm to -31 dBm. The typical range of RSRP is around -44 dBm (good) to -140 dBm (bad).

2.6. Primary Synchronization Signal Received Quality (PSS_RQ)

Primary Synchronization Signal Reference Signal Received Quality is a measurement of the quality of the synchronization signal received by a device. SS-RSRQ is used in 5G NR networks to determine the quality of the radio channel. It can be used for cell selection, reselection, and mobility (handover) procedures. The 5G RSRQ range is defined as -43 dB to 20 dB.

2.7. Primary Synchronization Carrier to Interference plus Noise Ratio (PSS_CINR)

Primary Synchronization Carrier to Interference-plus-Noise Ratio is the ratio of the signal level to the sum of interference from competing signals and background noise. CINR is measured in decibels (dB). A positive CINR value means that the signal is more effective than the noise. A higher CINR value means that the signal strength is stronger in relation to the noise levels. This allows for higher data rates and fewer retransmissions, which offers better throughput.

2.8. Physical Cell Identity or Physical Cell ID (PCI)

Physical Cell Identity (4G-LTE) and Physical Cell ID (5G-NR) are important parameters used in LTE and 5G networks. These are unique identifiers assigned to each cell within the network used to distinguish between neighboring cells. PCI values (ranging from 0 to 503 in LTE and 0 to 1007 in 5G) are assigned by the network operator and are allocated in a way that minimizes interference (overlap) between cells.

The primary purpose of PCI in both LTE and 5G networks is to ensure that mobile devices can properly identify a cell. Since cells typically use the same frequency in LTE, using unique PCIs helps prevent interference and ensure smooth handover between cells.

2.9. Low, Mid, and High Band Spectrum

Operators use a wide range of spectrum to deliver service to end users. A common misconception is that higher frequencies result in higher throughput, but this is only indirectly the case. In fact, higher frequencies result in more limited propagation (ability for the signal to travel over distance and through obstructions) while higher occupied bandwidth results in higher capacity and throughput. Licenses granted to operators in the higher bands tend to include higher occupied bandwidths and therefore higher capacity and throughput. For applications like the study area, higher frequencies with larger bandwidth and more limited propagation are an ideal combination.

The definition for low, mid, and high band spectrum has changed over time and is not consistent within the industry, so for the purpose of this documentation the following definitions will be used:

- Low band: spectrum lower than 2.3 GHz on the spectrum chart
    - These comprise the traditional bands utilized by the operators (e.g., 700, 850, 1900, 2100 MHz), and is currently the primary spectrum used for serving end users.
- Mid band: spectrum between 2.3 GHz - 6 GHz
    - Mid band is considered perfect for 5G because it can carry plenty of data while traveling significant distances. Because these bands are relatively newly occupied, licenses granted to operators in these bands include higher bandwidths than low band.
- High band: above 24 GHz
    - The GSMA recommends that CSPs support millimeter wave spectrum in the 26 GHz, 40 GHz, 50 GHz, and 66 GHz bands for mobile services. The primary limitation of millimeter wave (high band) spectrum is poor propagation compared to mid and low band signals (e.g., the human body can effectively block signals), while the primary benefit is that large channel bandwidths can result in connection speeds of 3 Gbps and even higher.

3. RF Survey Description

3.1. Test Setup

The survey test setup consists of the following:

- PCTEL Scanner - HBflex device release 3.8.3.0; ESN 051907021
- GPS L1/GLONASS L1; Active Magnetic Mount Antenna
- (2) OP691; Indoor Antenna, 600 MHz - 6 GHz
- (2) OP313-Kit; Omni Antenna including mm-Wave
- OP417; HBflex Battery Pack
- Samsung Galaxy TAB S6 10.5"; Black with Stylus

Figure 2: Scanning Receiver Configuration

3.2. RF Survey Route

The PCTEL test gear for performing survey/data collection was placed in a bag pack that was easy to carry by the Survey Engineer while riding on an electric scooter to be able to efficiently access the busy areas of the mall. The Survey Engineer was able to gather data for the mall, providing a better picture of the overall coverage in and around the study area. The map below shows the route that was used by the survey team to gather data along the highlighted path.

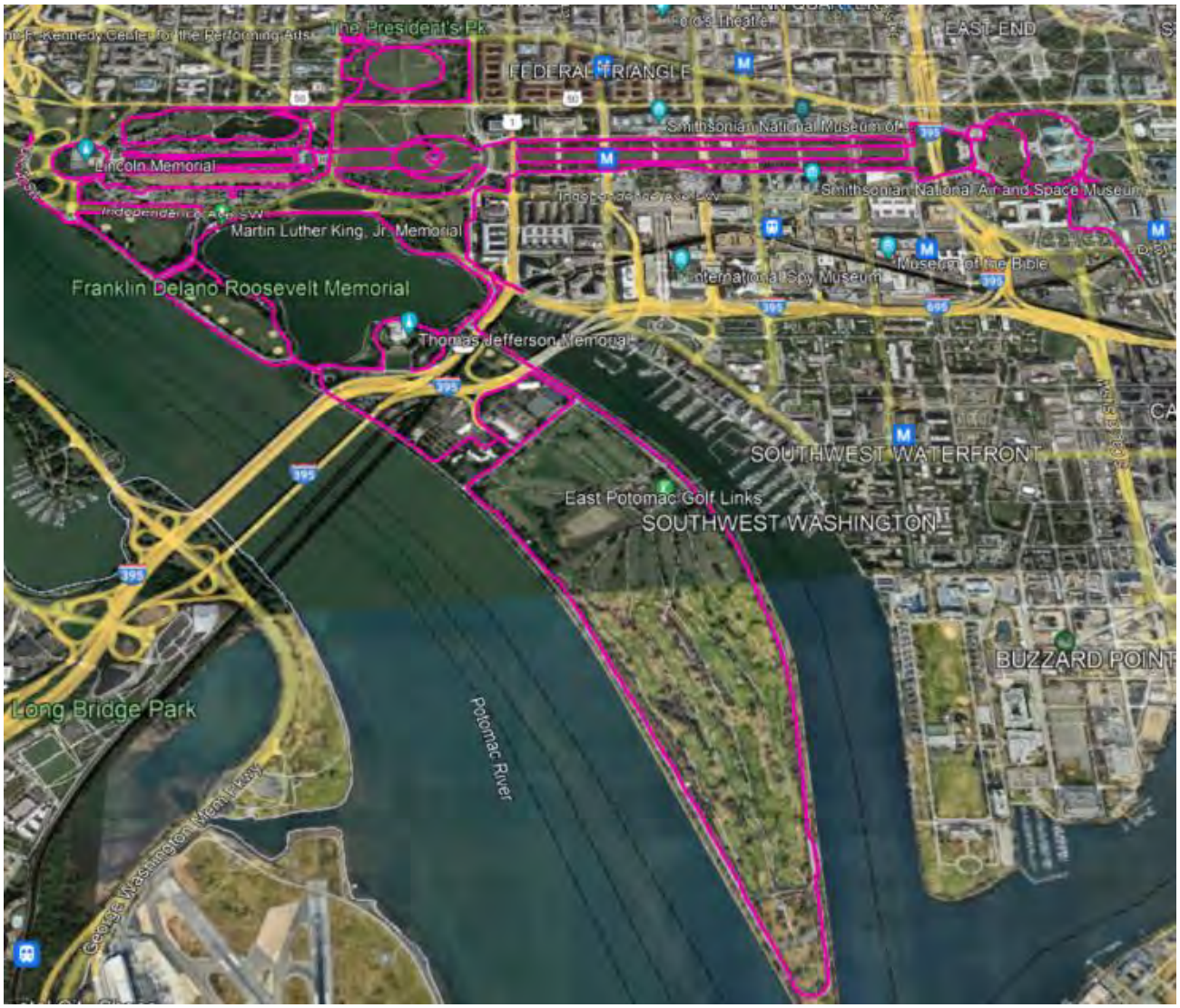


Figure 3: RF Survey Route

Due to the quantity of the data being collected the survey had to be performed twice to capture information for all three carriers. The survey was performed to capture low bands for one walk and capture high bands for the second walk.

To evaluate the RF signal quality, we have divided the entire study area into six smaller portions (“sub-areas”). This will also give us the opportunity to have a closer look at each of the sub-areas and come up with targeted solutions for each.

3.3. Definition of Study Sub-Areas

Below is the representation of each of the areas.

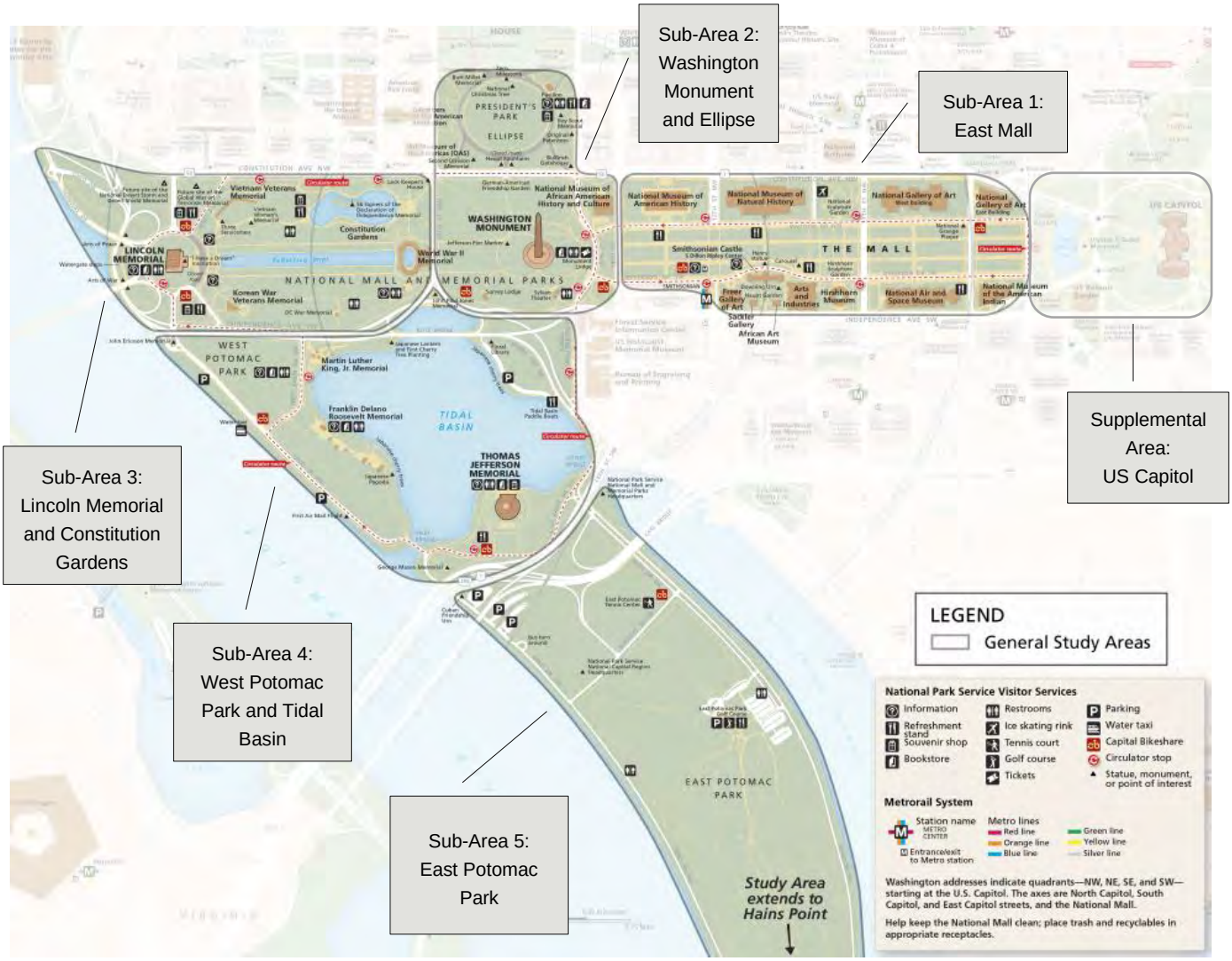


Figure 4: Study Sub-Areas

3.4. Data Processing

The data was processed using SeeHawk Collect software and further moved into the GIS database. Below is a sample of the survey data showing the Verizon 700 RSRP in GIS.

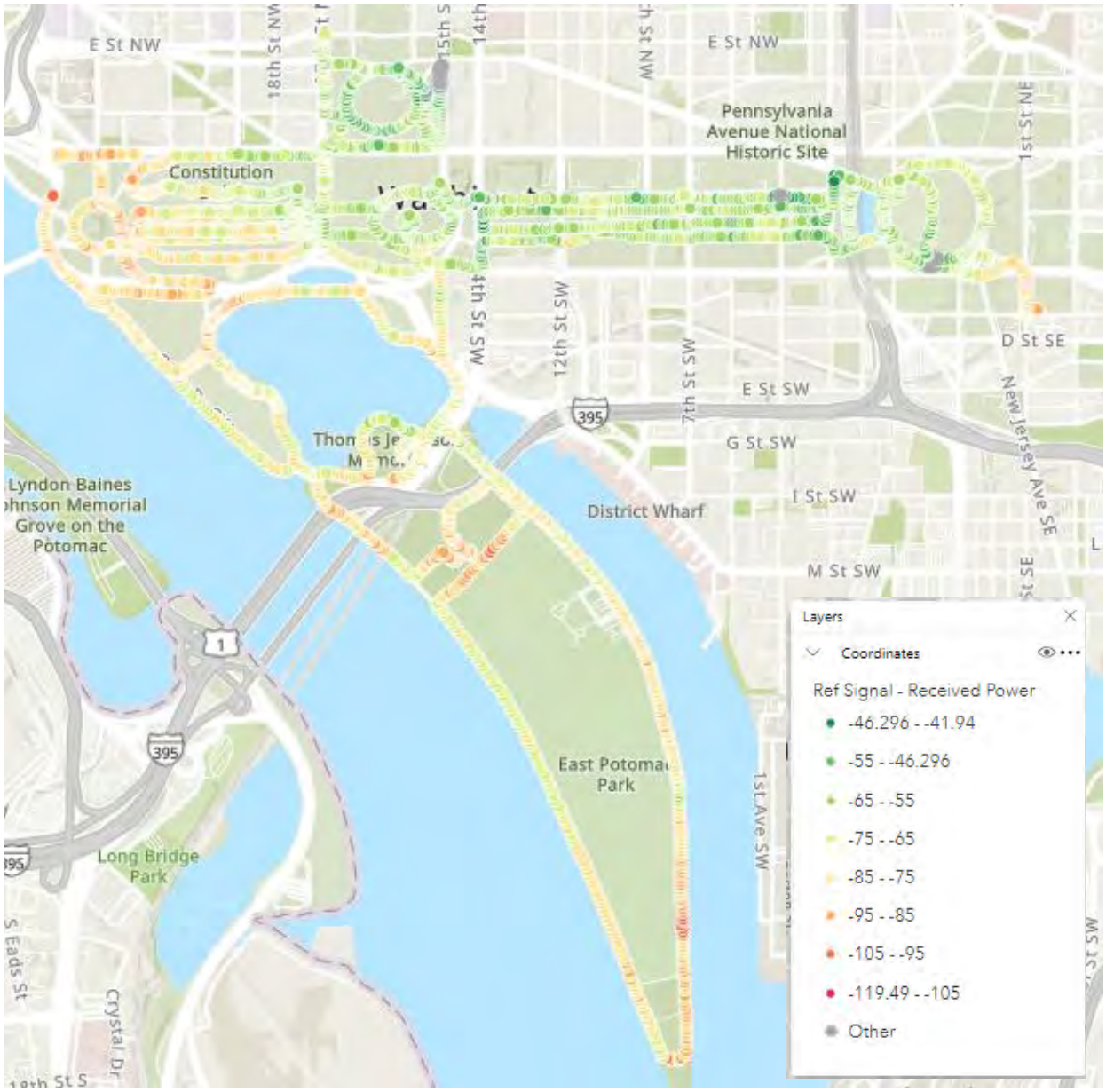


Figure 5: Sample Survey Results (Reference Signal Received Power)

4. Data Evaluation

4.1. Data Collected

The survey was performed to capture data for Verizon, AT&T, and T-Mobile bands that are serving the study area. This included frequency ranges from 600 MHz to 6 GHz. Although the survey was performed to capture all the bands owned by the three carriers, there were no active channels for C-band or mm Wave.

	Band										
	600	700	800	1900	2100	1900 Ext	2100 Ext	AWS-3	WCS	2.5	C-Band
Verizon		✓	✓	✓	✓	✓	✓	✓			
AT&T		✓	✓	✓	✓	✓	✓	✓	✓		
T-Mobile	✓	✓		✓	✓	✓	✓	✓		✓	

Figure 6: Occupied Bands by Operator

The scanner was setup to capture both 4G LTE channels and 5G NR channels, with most of the active channels surveyed being 4G LTE. The 5G NR channels that were surveyed included AT&T 850 MHz and a portion of 2100 MHz; and T-Mobile 600 MHz, 2100 MHz, and 2500 MHz.

Technology	Band	Carrier Number/ Center Frequency	Network
LTE	01 2100 (IMT-2000)	550 / 2165.00	ATT
LTE	01 2100 (IMT-2000)	175 / 2127.50	Verizon
LTE	02 1900 PCS	675 / 1937.50	T-Mobile
LTE	02 1900 PCS	1,125 / 1982.50	Verizon
LTE	02 1900 PCS	850 / 1955.00	ATT
LTE	04 2100 AWS	2,000 / 2115.00	ATT
LTE	04 2100 AWS	2,125 / 2127.50	Verizon
LTE	04 2100 AWS	2,300 / 2145.00	T-Mobile
LTE	05 850 AWS	2,560 / 885.00	Verizon
LTE	10 Ext 2100 AWS	4,200 / 2115.00	ATT
LTE	11 Ext 2100 AWS	4,500 / 2145.00	Verizon
LTE	12 US Lower 700 ABC	5,035 / 731.50	T-Mobile
LTE	12 US Lower 700 ABC	5,110 / 739.00	ATT
LTE	13 US Upper 700 C	5,230 / 751.00	Verizon
LTE	14 US Upper 700 D	5,330 / 763.00	FirstNet
LTE	17 US Upper 700 B C	5,780 / 739.00	ATT
LTE	25 1900 Ext PCS	8,115 / 1937.50	T-Mobile
LTE	25 1900 Ext PCS	8,565 / 1982.50	Verizon
LTE	26 1900 Ext PCS	8,290 / 1955.00	ATT
LTE	29 US 700	9,685 / 719.50	ATT
LTE	66 AWS-3	66,486 / 2115.00	ATT
LTE	66 AWS-3	67,086 / 2175.00	Verizon
LTE	66 AWS-3	66,786 / 2145.00	T-Mobile
LTE	71 600	68,661 / 624.50	T-Mobile
LTE	EB 30: 2.3 GHz (WCS A/B) DL	NA / 9,820.00	ATT
TD-LTE	EB 41: TDD 2.5 GHz	NA / 39,750.00	T-Mobile
TD-LTE	EB 41: TDD 2.5 GHz	NA / 39,948.00	T-Mobile
TD-LTE	EB 41: TDD 2.5 GHz Lower	NA / 39,750.00	T-Mobile
TD-LTE	EB 41: TDD 2.5 GHz Lower	NA / 39,948.00	T-Mobile

Figure 7: 4G LTE Channels Captured During Survey

Technology	Band	Carrier Number/ Center Frequency	Network
NR	FR1 FDD n5 DL	174,770 / NA	ATT
NR	FR1 TDD n41 / n90	510,270 / 2551.35	TM
NR	FR1 TDD n41 / n90	520,110 / 2600.55	TM
NR	FR1 FDD n65 DL	423,150 / 2115.75	ATT
NR	FR1 FDD n65 DL	NA / 2190.15	Dish
NR	FR1 FDD n66 DL	NA / 2115.75	ATT
NR	FR1 FDD n70 DL	NA / 2005.25	Dish
NR	FR1 FDD n71 DL	NA / 632.55	TM

Figure 8: 5G NR Channels Captured During Survey

4.2. General Data Evaluation Results

The Key Performance Indicators (KPI) used to evaluate the availability and quality of the signal for each band are:

- 4G LTE: Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), and Carrier to Interference plus Noise Ratio (CINR)
- 5G NR: Primary Synchronization Signal Received Power (PSS_RP), Primary Synchronization Signal Received Quality (PSS_RQ), and Primary Synchronization Carrier to Interference plus Noise Ratio (PSS_CINR)

Signal quality KPIs are measured by user equipment (UE) equipment at any given point and time. The network can automatically "throttle" speeds to users depending on the signal quality they report back by assigning less "resources" (i.e., bandwidth). Devices reporting low signal quality conditions will experience lower speeds, which typically is caused by low signal strength, high noise, or signal pollution.

While signal quality usually has a direct correlation to signal strength, areas of high signal strength do not always experience high signal quality; too much noise from too many signals in an area will reduce the signal to noise ratio which in turn reduces the quality of the signal. "Pilot Pollution" is a term commonly used when many competing signals result in a lower quality signal.

Where signal quality is poor, the network will reduce modulation rates for a UE to ensure reliability. This not only reduces the throughput for the UE, but also diminishes the spectral efficiency of the network and therefore reduces overall network capacity.

For 4G-LTE channels, we have investigated three of the most important KPIs to evaluate the quality of services (QOS) provided by each of the carriers. These KPIs are the Received Power (RSRP), Received Quality (RSRQ), and Carrier Interference to Noise Ratio (CINR). For the purposes of this analysis, we have set the following thresholds for acceptability:

- RSRP: greater than -90 dBm
- RSRQ: greater than -15 dB (LTE) or greater than -20 dB (NR)
- CINR: greater than 0 dB

For 5G-NR channels, we have investigated the three KPIs which correspond to the 4G-LTE KPIs above: Primary Synchronization Signal Received Power (PSS_RP), Primary Synchronization Signal Received Quality (PSS_RQ), and Primary Synchronization Carrier to Interference plus Noise Ratio (PSS_CINR). For the purposes of this analysis, we have set the following thresholds for acceptability:

- PSS_RP: greater than -90 dBm
- PSS_RQ: greater than -15 dB (LTE) or greater than -20 dB (NR)
- PSS_CINR: greater than 0 dB

Based on these KPIs for each of the bands we have evaluated the signal quality for each of the carriers and its performance and summarized the results below.

4.3. Verizon Coverage and Capacity Overview

The RF survey collected key information for the active Verizon carriers in the subject area. AECOM found active service in the low bands (700, 850, 1900, and 2100 MHz) but were unable to identify any usable carriers in the C-Band or mm-Wave bands.

4.3.1. Existing Verizon Coverage

Although there are many areas of adequate coverage from the Verizon low bands, analysis of the KPIs (see Section 4.2) shows end users are likely to often experience performance issues. In summary, the general level of signal strength and signal quality is insufficient for typical demand in many areas. 700 MHz 4G-LTE service covers the subject area with adequate signal strength at more than 90%, but signal quality is below 70% for three of the five sub-areas. For most of the remaining frequencies, however, KPIs show a consistent failure to provide adequate signal strength and quality with few exceptions.

For a better understanding of the available signal and its quality, refer to the tables below which illustrate the percentage of adequate service for each of the three KPIs (see Section 4.2) in each band for each of the six sub-areas. Adequate performance of meeting a particular KPI over more than 90% of the sub-area is color coded in green, marginal performance of better than 70% is yellow, and poor performance of below 70% is orange. These tables are shown on the following page.

4.3.2. Existing Verizon Coverage Tables

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	100%	100%	100%	98%	97%	90%
RSRQ > -15	93%	94%	92%	50%	65%	66%
CINR > 0	70%	60%	60%	55%	70%	45%

Figure 9: Verizon 700 Channel 5230 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	90%	63%	57%	60%	65%	65%
RSRQ > -15	90%	50%	43%	60%	60%	45%
CINR > 0	70%	40%	55%	45%	50%	55%

Figure 10: Verizon 850 Channel 2560 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	97%	100%	99%	70%	75%	55%
RSRQ > -15	95%	97%	80%	65%	70%	55%
CINR > 0	83%	90%	60%	55%	55%	35%

Figure 11: Verizon 1900 Channel 1125 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	80%	96%	95%	65%	70%	50%
RSRQ > -15	80%	91%	70%	70%	55%	45%
CINR > 0	80%	94%	65%	50%	55%	50%

Figure 12: Verizon 2100 Channel 2125 -LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	95%	35%	75%	73%	70%	35%
RSRQ > -15	97%	80%	80%	70%	73%	30%
CINR > 0	88%	40%	60%	65%	67%	30%

Figure 13: Verizon AWS-3 Channel 67086 - LTE

Note: see Section 3.3 for definition of sub-areas.

4.4. AT&T Coverage and Capacity Overview

The RF survey collected key information for the active AT&T carriers in the subject area. AECOM found active service in the low bands (700, 850, 1900, and 2100 MHz) but were unable to identify any usable carriers in the C-Band or mm-Wave bands.

4.4.1. Existing AT&T Coverage

Like Verizon, AT&T has many areas of adequate coverage from the low bands, but an analysis of the KPIs (see Section 4.2) show end users are likely to often experience performance issues. 700 MHz 4G-LTE service covers the subject area with adequate signal strength at more than 90%, but signal quality is below 70% for all the five sub-areas. For most of the remaining frequencies, KPIs show a consistent failure to provide adequate signal strength and quality with few exceptions.

For a better understanding of the available signal and its quality, refer to the tables below which illustrate the percentage of adequate service for each of the three KPIs (see Section 4.2) in each band for each of the six sub-areas. Adequate performance of meeting a particular KPI over more than 90% of the sub-area is color coded in green, marginal performance of better than 70% is yellow, and poor performance of below 70% is orange. These tables are shown on the following page.

4.4.2. Existing AT&T Coverage Tables

	Supp. Sub-Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	100%	100%	100%	96%	98%	99%
RSRQ > -15	75%	63%	60%	61%	71%	57%
CINR > 0	50%	35%	37%	65%	50%	33%

Figure 14: ATT 700 Channel 5780 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	100%	100%	100%	70%	87%	65%
RSRQ > -15	87%	84%	85%	60%	75%	55%
CINR > 0	70%	68%	62%	64%	70%	45%

Figure 15: ATT 1900 Channel 850 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	80%	95%	85%	50%	30%	40%
RSRQ > -15	70%	85%	55%	70%	30%	45%
CINR > 0	70%	67%	50%	67%	35%	30%

Figure 16: ATT 2100 Channel 2000 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	98%	95%	96%	77%	75%	90%
RSRQ > -15	80%	83%	58%	42%	53%	40%
CINR > 0	62%	52%	41%	37%	55%	35%

Figure 17: ATT WCS Channel 9820 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
PSS_RP >-90	100%	100%	100%	99%	98%	98%
PSS_RQ > -15	92%	88%	95%	92%	95%	96%
PSS_CINR > 0	55%	67%	63%	45%	65%	60%

Figure 18: ATT 850 Channel 174770 - 5G NR

Note: see Section 3.3 for definition of sub-areas.

4.5. T-Mobile

The RF survey collected key information for the active T-Mobile carriers in the subject area. AECOM found active service in the low bands (600, 700, 1900 and 2100 MHz) and mid band (2.5 GHz or BRS) but were unable to identify any usable carriers in the C-Band or mm-Wave bands.

4.5.1. Existing T-Mobile Coverage

Like the other operators, T-Mobile has many areas of adequate coverage from the low bands, but an analysis of the KPIs (see Section 4.2) show end users are likely to experience performance issues. 700 MHz 4G-LTE and 600 MHz 5G-NR services cover the subject area with adequate signal strength at more than 90%, but signal quality is below 70% for most of the five sub-areas. For the remaining frequencies, KPIs show a consistent failure to provide adequate signal strength and quality with some exceptions.

For a better understanding of the available signal and its quality, refer to the tables below which illustrate the percentage of adequate service for each of the three KPIs (see Section 4.2) in each band for each of the six sub-areas. Adequate performance of meeting a particular KPI over more than 90% of the sub-area is color coded in green, marginal performance of better than 70% is yellow, and poor performance of below 70% is orange. These tables are shown on the following page.

4.5.2. Existing T-Mobile Coverage Tables

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
PSS_RP >-90	100%	99%	100%	97%	96%	98%
PSS_RQ > -15	65%	55%	30%	42%	40%	35%
PSS_CINR > 0	60%	30%	33%	38%	33%	34%

Figure 19: T-Mobile 600 Channel 68661 – NR

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	100%	100%	100%	99%	99%	91%
RSRQ > -15	92%	93%	95%	41%	65%	55%
CINR > 0	91%	89%	73%	35%	40%	41%

Figure 20: T-Mobile 700 Channel 5230 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	95%	89%	96%	87%	88%	96%
RSRQ > -15	80%	50%	70%	60%	50%	52%
CINR > 0	55%	27%	55%	60%	42%	35%

Figure 21: T-Mobile 1900 Channel 675 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	95%	93%	97%	75%	70%	94%
RSRQ > -15	80%	50%	43%	42%	43%	50%
CINR > 0	60%	37%	42%	46%	40%	52%

Figure 22: T-Mobile 2100 Channel 2300 -LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
RSRP >-90	50%	40%	65%	35%	58%	39%
RSRQ > -15	95%	87%	91%	80%	85%	80%
CINR > 0	90%	82%	83%	72%	75%	45%

Figure 23: T-Mobile BRS Channel 39750 – LTE

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
PSS_RP >-90	100%	100%	100%	100%	100%	100%
PSS_RQ > -15	94%	97%	99%	97%	97%	98%
PSS_CINR > 0	67%	70%	75%	63%	60%	37%

Figure 24: T-Mobile 600 Channel 135700 - 5G NR

	Supp. Area	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5
PSS_RP >-90	50%	63%	65%	40%	65%	63%
PSS_RQ > -15	94%	96%	99%	96%	97%	95%
PSS_CINR > 0	63%	66%	70%	47%	57%	53%

Figure 25: T-Mobile BRS Channel 510270 - 5G NR

Note: see Section 3.3 for definition of sub-areas.

5. Conclusion

Although there are few coverage gaps for any of the operators, the overall quality of the signal is consistently inadequate for much of the study area. With the RSRQ (and PSS_RQ) performance over the study area consistently falling short of metrics, and the CINR (and PSS_CINR) performance being even worse, end user devices are going to have a difficult time communicating (this will be especially so during periods of heavy foot traffic). During periods of low foot traffic, the carriers appear to have sufficient quality of service such that the end user may have a fair experience across most of the study area.

Another major factor for low QoS is the signal pollution in the study area. Because most of the recorded signals in the are coming from sites that are well away from the study area, many sites are contributing to the overall coverage. With measurable signals from many sites mixing in the study area, the resulting noise may force end user devices to use lower modulation schemes and higher output power resulting in low throughput and shortened battery life.

We believe the results of the study align with the expectations of the parties, which is to say that a mall-centric solution will be required to meet the coverage needs and to provide sufficient capacity with sufficient quality across the study area. Localized coverage solutions will enable the carriers to optimize the macro network (the sites away from the mall), increase spectral efficiencies (due to decreased pilot pollution, more efficient modulation schemes, and potentially better MIMO performance), and simply provide stronger coverage levels. These improvements would substantially improve the end-user experience (particularly reliability, performance, and battery life) as well as increase capacity to better serve the subject area over a wide range of foot traffic volume levels.