Assessing the Broadband Service Gaps and Affordability Barriers in BEAD-Eligible Areas

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ABSTRACT

The Broadband Equity, Access, and Deployment (BEAD) program represents the largest federal broadband infrastructure investment in U.S. history, with $42.45 billion allocated to expand high-speed internet access in underserved communities. This study establishes baseline conditions in BEAD-eligible areas using the Broadband-plan Querying Tool (BQT) to collect pricing and service quality data from over 60,000 addresses across California, Michigan, Oklahoma, and Virginia. Our analysis reveals significant service and affordability gaps in targeted areas, with 65-86% of representative plan prices exceeding 2% of the monthly income for low-income households across all study states. Speed deficiencies range from 18.5% of census block group (CBG) representative plan speeds dropping below 100 Mbps in Michigan to 85% in Oklahoma. States exhibit distinct patterns: Oklahoma primarily faces infrastructure deficiencies with relatively more affordable connectivity for inadequate services, while Michigan and California confront affordability barriers despite adequate high-speed infrastructure availability. These variations underscore the importance of state-specific program designs that address local market conditions. This study establishes a replicable methodology for systematic BEAD monitoring by combining automated broadband plan querying with demographic analysis to equip policymakers with evidence-based tools for tracking program effectiveness as BEAD implementation progresses.

1 INTRODUCTION

The digital divide in the United States (U.S.) represents one of the most persistent infrastructure challenges of the 21st century, with millions of Americans lacking access to reliable, affordable broadband service: 20.9% of tribal residents and 17.2% of rural residents do not have 25/3 Megabits per second (Mbps) High-Speed Internet [23]. In response to this challenge, the federal government created the Broadband Equity, Access, and Deployment (BEAD) program—established under the Infrastructure Investment and Jobs Act (IIJA)—as its flagship initiative, with an unprecedented $42.45 billion federal investment aimed at addressing disparities in broadband access. Administered by the National Telecommunications and Information Administration (NTIA), the BEAD program provides funding to states and U.S. territories to expand high-speed internet access, primarily through direct grants to service operators [21].

As states begin selecting BEAD subgrantees and deploying federally-funded networks, establishing comprehensive baseline conditions in targeted areas becomes critical for multiple reasons. First, understanding current market conditions—including pricing, service quality, and provider availability—is essential for assessing whether federal investment is directed towards areas with genuine service gaps rather than areas with adequate market provision. Second, establishing baseline measurements enables rigorous evaluation of program impact by distinguishing changes attributable to BEAD investments from broader market trends affecting broadband accessibility. Third, comprehensive pre-deployment data informs implementation strategies by revealing the specific nature of service deficiencies that federal investments must address, whether primarily infrastructure gaps, affordability barriers, or competition limitations.

Despite this clear need, systematic data on broadband pricing and service quality in BEAD-eligible areas remains limited. Existing federal data collection efforts rely primarily on self-reported information from Internet Service Providers (ISPs) [14], while independent price surveys focus on urban markets that differ substantially from the rural and underserved areas targeted by BEAD. This data gap hampers both program design decisions and the development of appropriate monitoring frameworks as the largest federal broadband investment in U.S. history proceeds toward implementation.

To ensure the affordability of federally funded networks, Congress established that BEAD recipients must offer at least one low-cost service option for eligible subscribers throughout the network's lifespan [10]. Originally, key parameters of this requirement—such as the target price of low-cost service, price indexing rules, and cost benchmarks—were left for states to determine in their BEAD proposals to the NTIA. Following NTIA guidance, most states set ambitious price targets, with many choosing to align maximum prices for low-cost service with the $30/month benefit of the Affordable Connectivity Program (ACP) [7], despite the program being discontinued in early 2024 [24].

The BEAD framework was subsequently revised through the Department of Commerce's June 6, 2025 letter [22], which rescinded all non-statutory requirements related to low-cost broadband for BEAD recipients. The letter prohibits states from setting target prices or other parameters for low-cost service. Though BEAD recipients must still offer a low-cost service option as required by the IIJA, it is now up to each operator to determine pricing parameters for the service. Another notable change in the June 6 letter is the reduction of the income threshold from 200% to 135% of the federal poverty line (FPL) for low-cost service eligibility. These revisions underscore the urgent need for comprehensive analysis of both the demand implications of these policy changes and the current service conditions in areas likely to receive BEAD funding.

This paper examines both the current state of broadband availability, quality, and affordability in BEAD-eligible locations and the implications of the recent changes in NTIA guidelines for low-cost service for BEAD-funded networks. More concretely, it examines how existing prices in BEAD-eligible locations compare to broadband quality and affordability benchmarks, with particular attention to the affordability benchmark of 2% of monthly income for low-income households. This analysis is based on a novel dataset created by querying a representative sample of BEAD-eligible addresses using the Broadband-plan Querying Tool (BQT) [25], a tool that takes a street address as input and returns the broadband plans (i.e., maximum upload speeds, download speeds, and corresponding prices) offered by major ISPs at that address. We study four selected states—California, Oklahoma, Michigan, and Virginia—chosen for their diverse geographic, political, and demographic attributes.

Our analysis reveals that most BEAD-eligible locations currently exhibit a pattern where high-speed service availability does not align with affordability benchmarks. In California, among census block groups where at least 80 percent of broadband-serviceable locations (BSLs) are BEAD-eligible, 65% are offered representative plans at prices above the 2% income threshold, and 40% currently receive representative plans at speeds below the 100/20 Mbps speed threshold. This pattern suggests that the deployment of BEAD-funded networks will need to address both technical service quality and affordability considerations to achieve the program's dual objectives.

This research seeks to support state policymakers in their assessment and monitoring of low-cost services by proposing benchmarks and offering evidence-based recommendations to help strike the appropriate balance between service affordability and the long-term sustainability of BEAD recipients. Our key contributions to broadband policy analysis are the following: (1) we establish comprehensive baseline measurements of speed and price conditions in BEAD-eligible areas, and (2) we provide evidence-based insights into the relationship between policy changes, demand patterns, and current market conditions that can inform implementation strategies as states begin selecting BEAD subgrantees.

2 BACKGROUND

2.1 BEAD Program Structure and Process

The BEAD program represents the largest federal investment in broadband infrastructure in U.S. history, providing $42.45 billion to states and U.S. territories to expand high-speed internet access. Administered by the NTIA, the program operates through a state-led approach, with funding distributed based on the number of unserved (especially high-cost unserved) and underserved locations within each jurisdiction [16]. The program's primary objective is to achieve universal broadband access by connecting locations that lack reliable high-speed internet service, with particular emphasis on rural and economically disadvantaged communities.

BEAD-eligible locations are primarily identified as BSLs that are either unserved (lacking access to 25/3 Mbps service) or underserved (lacking access to 100/20 Mbps service). The Federal Communications Commission (FCC) defines a BSL as "a business or residential location in the United States at which mass-market fixed broadband Internet access service is, or can be, installed" [3]. States utilize federal broadband availability data and conduct their own assessments to identify areas most in need of infrastructure investment. Research and policy analysis often focus on census block groups (CBGs) with high concentrations of BEAD-eligible BSLs, as these areas represent communities most likely to benefit from program investments and provide meaningful demographic context for policy evaluation.

The BEAD program includes a challenge process through which stakeholders can dispute initial location designations, serving to refine funding targets and ensure accurate assessment of infrastructure needs [21]. While primarily intended for program administration rather than ongoing service monitoring, this process also contributes to more precise program implementation across diverse geographic contexts.

2.2 Low-Cost Service Requirements

Policy revision. Recognizing that infrastructure deployment alone would not address the affordability barriers faced by low-income households, Congress required BEAD recipients to offer at least one low-cost service option for eligible subscribers throughout the network's lifespan. Originally, key parameters of this requirement—such as the target price of low-cost service, price indexing rules, and cost benchmarks—were left for states to determine in their BEAD proposals to the NTIA. Following initial NTIA guidance,

most states set ambitious price targets, with many choosing to align maximum prices for low-cost service with the $30/month benefit of the ACP [7], despite that program's discontinuation in early 2024.

The affordability landscape underwent significant revision through the Department of Commerce's June 6, 2025 letter, which rescinded all non-statutory requirements related to low-cost broadband for BEAD recipients. According to the letter, by offering guidance and low-cost model options, the NTIA had engaged in rate regulation—an action explicitly prohibited by the IIJA. The letter prohibits states from "explicitly or implicitly" setting target prices or other parameters for low-cost service, transferring this responsibility to individual network operators [22]. Note that BEAD recipients must still offer a low-cost service option as required by the statute, but pricing parameters are now determined by each operator rather than state mandates.

Another significant change involves income eligibility thresholds for low-cost services. Previously, NTIA guidelines established that households at or below 200% of the FPL or those enrolled in qualifying safety net programs were eligible for low-cost service, thus matching the criteria used in the ACP. The revised guidance lowers the income threshold to 135% of the FPL, aligning with the eligibility criteria of the federal Lifeline program [6], designed to subsidize access for various sectors of the community. Additionally, the letter eliminates previous NTIA guidance related to middle-class affordable service options, finding that "this non-statutory provision was confusing, arbitrary, impossible to operationalize, and deterred provider participation in the program" [22].

Broadband affordability benchmarks. Researchers and policymakers have developed income-based affordability benchmarks to assess broadband accessibility for low-income households. Although not part of statutory law, the 2% of monthly income benchmark has gained widespread acceptance in both federal policy discussions and academic research as a reasonable approximation to broadband service affordability for low-income households [4, 5, 12]. This benchmark often refers to 2% of disposable (after-tax) income, though low-income households typically have higher post-tax than pre-tax incomes due to tax credits and refunds, creating some measurement complexity. Research applications typically calculate this benchmark for households at the 20th income percentile (upper limit of the bottom income quintile) using American Community Survey (ACS) data.

2.3 Prevailing Broadband Data Gap

Effective broadband policy implementation requires accurate, granular data on service availability and pricing, yet existing data collection mechanisms face significant limitations that undermine policy analysis and program targeting. Federal broadband datasets rely heavily on ISP self-reporting, which can be strategically influenced by regulatory and competitive considerations. The FCC's National Broadband Map [8], which serves as the foundation for the BEAD program targeting, exemplifies these limitations. The map combines two primary data sources: (1) fabric location data from CostQuest Associates that identifies BSLs such as homes and buildings across the United States, and (2) broadband service availability data that ISPs must report every six months, detailing which locations their networks can serve and at what speeds.

While the fabric data represents a significant improvement in identifying potential service locations, the availability component remains entirely dependent on ISP self-reporting through regulatory filings. Unfortunately, ISP self-reported information has been shown time and time again to be flawed [1, 11, 15, 17]. ISPs report service availability based on their network equipment capabilities, but these reports may be influenced by competitive positioning, regulatory compliance considerations, or strategic business interests. Moreover, the reporting framework captures only whether service can theoretically be provided to a location, not the actual terms, conditions, or pricing of available service. The lack of granular pricing data at the address level represents a particularly acute challenge, as broadband service plans and prices can vary significantly even within small geographic areas. Traditional data collection methods for broadband pricing [9], including periodic surveys and regulatory filings, often lack the geographic precision and temporal frequency necessary to support community-level policy analysis.

The need for independent baseline data becomes particularly critical in the context of BEAD program implementation, where $42.45 billion in federal investments will be targeted based on assessments of current service conditions. States use the data from the FCC's National Broadband Map to determine if locations are served, unserved, or underserved, and to identify locations eligible for BEAD funding [2]. The NTIA will allocate a base fund plus additional funds proportionate to the state's share of unserved locations within the state. Reliable pre-deployment data serves multiple policy functions: validating program targeting to ensure funds reach communities most in need of infrastructure improvements, establishing baselines for longitudinal impact assessment, and enabling ongoing monitoring of program effectiveness. Without independent verification of service conditions, policymakers cannot adequately assess whether federal investments are addressing the most acute infrastructure gaps or achieving intended affordability outcomes.

2.4 Bridging the Data Gap with BQT

BQT is an automated data collection platform developed by our team, designed to address the lack of reliable, comprehensive data on residential broadband prices through the

automated collection of broadband plan information directly from ISP websites. Taking a residential address as input, BQT mimics a human user's broadband plan shopping and programmatically navigates an ISP website to gather information about available plans, including speeds, prices, and the type of broadband service available. This approach provides independent verification of advertised broadband service while achieving scalability across large geographic areas and multiple ISPs. The methodology enables researchers to collect comprehensive pricing and speed data at scale without relying on ISP cooperation or self-reported data.

BQT learns from human interactions with ISP websites. For any ISP, the workflow requires a human user to query the ISP's website for a small set of addresses to extract advertised broadband plans. BQT records these sessions and then uses the recordings to synthesize a finite state machine (FSM), learning how to effectively identify the current state and sequence of actions to allow transitioning to the "right" next state. BQT leverages off-the-shelf computer vision tools to identify the location of unique keywords for each state in the ISPs' FSM and uses PyAutoGUI to realize automated state transitions. BQT supports re-querying addresses, which is particularly useful when an address is initially classified as not found. On the initial query, the dropdown may fail to load, causing the address to be incorrectly marked as invalid. In such cases, requerying the address often resolves dropdown menu issues on the ISP's website. To ensure accuracy, address results can also be manually validated as a sanity check.

BQT has demonstrated its policy relevance through applications to major federal broadband programs, providing independent assessment capabilities that complement traditional regulatory oversight mechanisms. More concretely, it supported three major studies: (1) enabled the contextualization of crowdsourced speed test data, leading the FCC to update its BEAD program challenge process [19]; (2) enabled the collection of broadband plan data for over 1 million addresses across thirty cities and exposed disparities in broadband plans and monopolistic practices, providing evidence used by policymakers to address digital discrimination [18]; and (3) facilitated the evaluation of the FCC's multi-billion dollar Connect America Fund (CAF) program, revealing that only 33% of targeted addresses actually received the promised service levels and demonstrating the need for independent verification of ISP claims in federal broadband programs [14].

The tool's unique ability to collect real-time pricing and availability data at scale offers researchers and policymakers unprecedented opportunities to monitor market conditions, assess program effectiveness, and identify areas where policy interventions may be needed to achieve broadband equity objectives.

3 METHODOLOGY

3.1 Data Sources and Integration

National Broadband Serviceable Location (BSL) Fabric. Compiled by CostQuest Associates, a broadband consulting firm contracted by the FCC and NTIA, the National Broadband Serviceable Location Fabric is a dataset of all residential and business locations within the U.S. where fixed broadband internet is or can be installed [13].

National Broadband Map. The FCC's National Broadband Map [8] displays the locations, at a street address level granularity, where broadband service is available in the U.S. This information is self-reported by ISPs to the FCC through the FCC's Broadband Data Collection (BDC) program [8], which requires ISPs to file data with the FCC twice a year about locations where they offer broadband service. We use the FCC National Broadband Map in our study to identify the corresponding ISPs associated with each BSL in our sample, enabling analysis of available plans by specific service providers and assessment of market structure in BEAD-eligible areas.

BEAD-Eligible Location Identification. Each state published lists of location IDs that are characterized as unserved, underserved, and served. BEAD-eligible location identification relies on merging the National Broadband Serviceable Location Fabric data from CostQuest with the list of pre-challenge BEAD-eligible locations published by the four study states. This process identifies CBGs where at least 80% of BSLs are BEAD-eligible (underserved or unserved), following NTIA guidance, which defines a BEAD project as "as an undertaking by a subgrantee to construct and deploy broadband infrastructure, which may serve a single broadband-serviceable location or a group of such locations - provided that at least 80 percent of the locations served are unserved (lacking access to 25/3 Mbps service) or underserved (lacking access to 100/20 Mbps service)" (NTIA Notice of Funding Opportunity [20]).

Demographic and Income Data. Demographic and income data are sourced from the ACS 2019-2023 5-year estimates to calculate the 2% of monthly income affordability benchmark. We calculate 2% of the monthly income for households at the 20th income percentile (upper limit of the bottom income quintile) for each CBG.

Street-level Broadband Plan Dataset. This analysis integrates multiple datasets to provide a comprehensive assessment of broadband service conditions in BEAD-eligible areas. The primary data source is broadband plan information (i.e., download/upload speeds, and prices for residential addresses) collected using BQT. We merge the National

Broadband Serviceable Location Fabric and National Broadband Map dataset to identify BSLs of interest for our study, which are used as input for BQT.

3.2 Study Scope and Geographic Selection

We selected four states for this analysis—California, Michigan, Oklahoma, and Virginia—chosen for their diverse geographic, political, and demographic attributes. These states provide representation across different regional contexts and broadband infrastructure challenges, enabling analysis of how baseline service conditions vary across different policy and market environments. At the time of data collection, these states had not yet selected BEAD grantees, making them suitable for establishing baseline broadband supply attributes, including speeds and prices that can be monitored over time as BEAD-funded networks are deployed.

3.3 BQT Data Collection Methodology

To evaluate the real-world serviceability of addresses targeted by federal broadband programs, we developed a systematic data collection methodology using BQT. This approach enables independent verification of ISP service claims across geographic areas most likely to receive BEAD funding.

Identifying target CBGs. We conduct this data collection across two geographic scopes to understand variations in service conditions between the most concentrated areas of need and the broader universe of locations that may receive BEAD funding. Phase 1 examines CBGs where at least 80% of BSLs are BEAD-eligible (the highest-need areas), while Phase 2 expands to include areas where at least 50% are BEAD-eligible (broader areas of potential BEAD investment). The 80% threshold for Phase 1 aligns with NTIA guidance that defines BEAD projects as serving areas where "not less than 80 percent of broadband-serviceable locations served by the project are unserved locations or underserved locations." We implement this by merging broadband fabric data from CostQuest with pre-challenge BEAD-eligible location lists published by our four study states.

Sampling strategy within target CBGs. Given computational constraints and the need for statistically meaningful results, we employ stratified random sampling within each identified CBG. Without sampling, Phase 1 would require querying 225,068 addresses across the four states, and Phase 2 would involve 490,604 addresses. We randomly select 10% of BSLs per CBG to query with BQT, with a minimum threshold of 30 queried locations per CBG to ensure statistical significance for any aggregation within a CBG. This sampling approach balances computational feasibility with analytical rigor, ultimately yielding 20,948 total addresses across 471 CBGs in the four study states, served by 33 unique ISPs (with some ISPs present in multiple states) for Phase 1 data collection. For Phase 2 data collection, there are 62,675 addresses across 1,051 CBGs, covered by 64 ISPs.

Classifying BQT results. We classify the service status of BQT results into three broad categories: (1) Serviceable, (2) No Service, or (3) Unknown. An address is classified as Serviceable if BQT successfully navigates to the broadband plans page on an ISP's web interface for an address, enabling us to extract broadband plans. Within the Serviceable category, we distinguish between addresses with advertised plans and those without. Some ISPs (e.g., Brightspeed) do not display plans for an address on their website and instead recommend that customers call for more information about the plans offered at the address. Although we cannot extract specific plan details in these cases, we still classify the address as Serviceable with no plans, since the ISP confirms that service is available.

If we can enter an address into an ISP's website, select it from the dropdown, and proceed, but the ISP indicates that the address is not within their service area, we classify the address as "No Service". Finally, if BQT cannot reach the plans page—either because the address is not listed in the ISP's dropdown menu (rendering it invalid) or because the ISP may claim to serve the address but offers no specific speed tier or pricing information—we classify the address as "Unknown".

Table 1 shows the detailed breakdown by state, including the number of BSLs queried, CBGs covered, and ISPs serving these addresses for Phase 1 of data collection (CBGs where at least 80% of BSLs are BEAD-eligible). Table 2 shows the same information for Phase 2 of data collection (CBGs where at least 50% of BSLs are BEAD-eligible). The data collection for Phase 2 subsumes data collection for Phase 1 (i.e., the CBGs and addresses in Phase 1 are a subset of CBGs and addresses in Phase 2). The tables distinguish between BSLs that are found to be Serviceable by at least one ISP (whether or not information about the advertised plans was effectively collected), those that have No Service, and those that offered no conclusive information about service status (Unknown).

3.4 Data Analysis Framework

Following data collection, we compute a representative plan (i.e., download speed and price) for each CBG. BQT extracts both promotional and regular pricing information for an address; however, BQT's ISP parsers extract only the regular pricing (post-promotions) pricing in order to accurately reflect the long-term cost to consumers. For each BSL, we select the plan that most closely aligns with the BEAD requirement of at least 100 Mbps download speed. More specifically, if a BSL is offered multiple plans that exceed the 100 Mbps download speed, we choose that plan with a speed larger than and

Table 1: (Phase 1) Total number of queried BSLs, CBGs, and ISPs by state.

State	Total Addresses	CBGs	ISPs	"Serviceable" BSLs (with plans)	"Serviceable" BSLs (no plans)	"No Service" BSLs	"Unknown" BSLs
CA	7,999	239	14	66.7%	1.89%	10.0%	21.4%
MI	11,790	200	18	50.3%	7.91%	10.5%	31.2%
OK	575	19	7	68.3%	2.96%	12.8%	16.5%
VA	584	13	8	12.5%	47.4%	5.82%	34.2%
Total	**20,948**	**471**	**33**	—	—	—	—

Table 2: (Phase 2) Total number of queried BSLs, CBGs, and ISPs by state.

State	Total Addresses	CBGs	ISPs	"Serviceable" BSLs (with plans)	"Serviceable" BSLs (no plans)	"No Service" BSLs	"Unknown" BSLs
CA	20,183	454	19	72.08%	2.34%	15.97%	9.61%
MI	35,884	479	18	57.36%	5.32%	13.21%	24.11%
OK	2,490	60	11	82.35%	5.87%	10.21%	1.57%
VA	4,118	58	16	35.42%	47.34%	8.82%	8.42%
Total	**62,675**	**1,051**	**64**	—	—	—	—

closest to 100 Mbps. Conversely, if all available plans for a BSL fall below 100 Mbps, we select the highest-speed plan. Based on this methodology, for each BSL within a CBG, we select the plan (speed and price) with a speed tier closest to 100 Mbps; we call this the "representative plan." For each CBG, we first compute the median speed across all representative BSL plans. We then identify all BSLs with this median speed and analyze the corresponding prices across the CBG. We compute the median of these prices to determine the representative plan price. Finally, we assess affordability by comparing the price of this plan at the CBG level to the 2% of monthly income affordability benchmark calculated for each CBG.

4 CURRENT STATE OF BEAD-ELIGIBLE AREAS

4.1 Overview

Our analysis of the four study states reveals significant affordability and speed gaps in areas most likely to receive BEAD funding. As shown in Table 3, our findings demonstrate that a substantial fraction of BSLs in BEAD-eligible areas stand to benefit from federal investment, though the nature of these benefits varies considerably across states. While some states primarily face affordability challenges with adequate speeds, others confront fundamental service quality deficiencies alongside pricing barriers.

Our analysis employs two complementary metrics to assess current market conditions. First, income-based affordability assessment determines what percentage of representative plans exceed 2% of monthly income for households at the 20th income percentile—a benchmark commonly used by researchers and policymakers to assess broadband affordability for low-income families. Second, speed deficiency analysis identifies CBGs where the representative plan falls below a download speed of 100 Mbps, which serves as the minimum performance requirement for BEAD-funded networks.

4.2 Visual Analysis

Figure 1 presents a comprehensive visual comparison of service conditions across all study states for both analysis phases. Each subfigure displays a scatterplot where the horizontal axis shows representative plan prices for each census block group, and the vertical axis shows the corresponding 2% income affordability threshold for that area. The diagonal dashed line represents the affordability boundary—dots below this line indicate areas where broadband prices exceed what low-income households can reasonably afford.

The color coding reveals critical information about service quality: green dots represent CBGS where the representative plan meets or exceeds the 100 Mbps download speed, while red dots indicate CBGs where the representative plan falls below 100 Mbps. The size of each dot reflects the quality of data collection, with larger dots indicating areas where BQT successfully gathered pricing information from a higher percentage of sampled addresses. BQT is unable to collect plan information for an address when it falls into one of three categories: (1) "No Service", (2) "Serviceable (No Plans)", or (3) "Unknown".

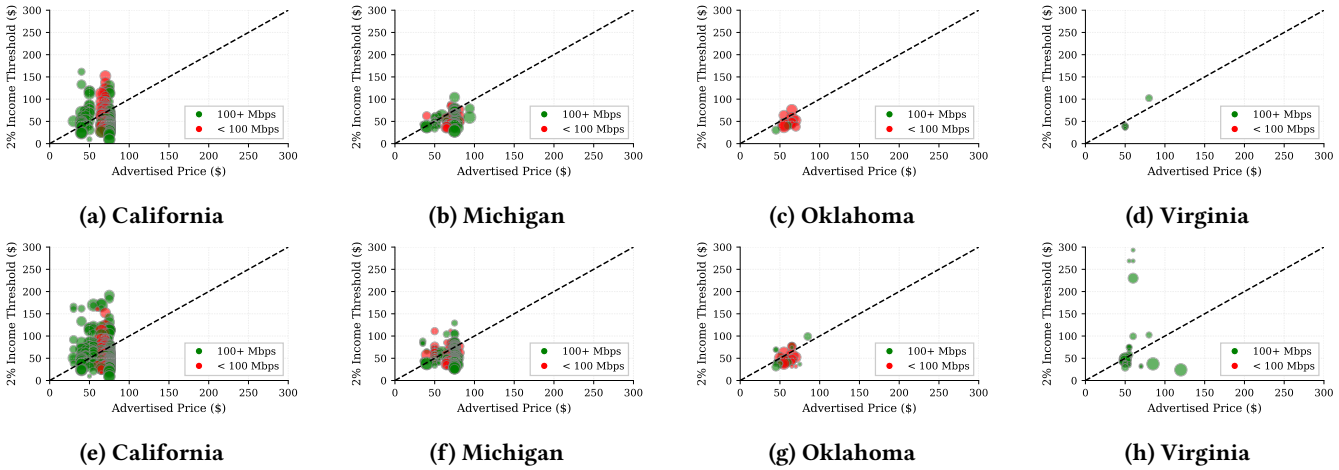
4.3 An In-depth Analysis of California

Here, we focus on California for a deep dive to offer clear insights into our methodology and how we extend it to other states. California's BEAD-eligible areas reveal a market characterized primarily by affordability challenges rather than speed challenges. In the highest-need areas (Phase 1), 65% of representative plan prices exceed the 2% income benchmark, meaning that for two-thirds of these communities, current broadband prices would consume more than 2% of monthly income for households in the bottom income quintile. In Phase 2, 98% of representative plan prices exceed the 2% benchmark, indicating that broadband remains unaffordable in nearly all of these areas for low-income households.

California's speed profile presents a mixed picture, with 40% of representative plan speeds in Phase 1 areas falling

Table 3: Summary of baseline service conditions by analysis phase.

	Phase 1 (≥80% BEAD-eligible)		Phase 2 (≥50% BEAD-eligible)	
	Above 2% income threshold	Below speed threshold (100 Mbps)	Above 2% income threshold	Below speed threshold (100 Mbps)
California	65%	40%	60%	36%
Michigan	84%	18.5%	77%	19.3%
Oklahoma	85%	85%	74%	50%
Virginia	86%	0%	61%	0%



(a) California (b) Michigan (c) Oklahoma (d) Virginia

(e) California (f) Michigan (g) Oklahoma (h) Virginia

Figure 1: Broadband affordability analysis across four states. Top row: Phase 1 (≥80% BEAD-eligible); Bottom row: Phase 2 (≥50% BEAD-eligible). Each dot represents a CBG, with green indicating representative plans ≥100 Mbps and red indicating representative plans <100 Mbps. Dot size reflects data coverage quality. Diagonal dashed lines indicate income affordability boundaries (dots below diagonal exceed the 2% income threshold).

below the 100 Mbps threshold that BEAD-funded networks must meet. This suggests that while many areas have access to high-speed infrastructure, a significant portion still rely on legacy technologies or lower-tier service that will require upgrading to meet BEAD standards.

The comparison between Phase 1 and Phase 2 results demonstrates the targeting effectiveness of the BEAD program. Phase 2 areas show modest improvements across all metrics. In Phase 2, 60% of representative plan prices are above the income threshold and 36% of representative plan speeds are below the speed threshold. This indicates that the most concentrated areas of BEAD eligibility correspond to the most severe market failures. This pattern validates the program's geographic targeting while highlighting the breadth of affordability challenges that extend beyond the highest-priority areas.

4.4 Cross-State Comparison

Michigan presents a contrast to California through its combination of universal pricing challenges with superior speed performance. The income-based affordability assessment reveals even more severe conditions, with 84% of Phase 1 CBG representative plan prices exceeding the 2% benchmark—the highest rate observed across study states.

However, Michigan's speed infrastructure significantly outperforms other states, with only 18.5% of CBGs having a representative plan speed below 100 Mbps. This pattern suggests a market where high-speed infrastructure is widely available but priced beyond the reach of low-income households. The implications for BEAD implementation are clear: while infrastructure investment may be less critical in many Michigan communities, aggressive low-cost service requirements will be essential for program success.

Oklahoma exhibits the most distinctive profile among the study states, characterized by fundamental infrastructure deficiencies rather than primarily pricing challenges. 85% of

Phase 1 CBGs have a representative plan speed below 100 Mbps, indicating that BEAD's infrastructure investments will address core service quality gaps rather than simply adding competitive alternatives to existing high-speed plans. Oklahoma's pricing landscape reflects its focus on lower-tier services. However, income-based affordability remains challenging, with 85% of CBG representative plan prices exceeding the 2% benchmark.

The Phase 2 comparison in Oklahoma reveals dramatic improvements (74% of CBGs having a representative plan price above the income threshold, 50% of CBGs having a representative plan speed below the speed threshold), indicating that BEAD targeting is effectively focused on areas with the most severe infrastructure and affordability deficiencies. This pattern validates the program's geographic prioritization while highlighting the stark differences in service quality between targeted and non-targeted areas.

Virginia's analysis faces limitations due to data collection challenges with Brightspeed, a prominent service provider in BEAD-eligible locations in the state. Specifically, while this provider's website indicates service availability, it offers no specific broadband speed and pricing information. These data collection constraints significantly limited the sample size and likely affected the representativeness of results, as only 12.5% of queries successfully yielded plans.

The absence of sub-100 Mbps plans in Virginia's sample may reflect either superior infrastructure deployment or limitations in data collection coverage. Given that Brightspeed represents a major service provider in the state, the lack of pricing data from this provider may have skewed results toward areas served by ISPs with more comprehensive online plan information and potentially higher-quality service.

4.5 Policy Implications

Income-based affordability analysis provides a more realistic assessment of accessibility challenges that accounts for local economic conditions rather than arbitrary regulatory thresholds. The finding that 65-85% of representative plan prices exceed the 2% income benchmark across states demonstrates that affordability barriers are pervasive and may require interventions beyond traditional regulatory approaches.

The consistency of affordability challenges across different state regulatory frameworks suggests that local economic conditions and market structure factors may be more determinative of accessibility than state policy choices. This finding has important implications for BEAD implementation, suggesting that program success may depend more on addressing underlying market failures than on setting appropriate regulatory thresholds.

The baseline findings validate BEAD's geographic targeting while highlighting the diversity of market conditions that the program must address. A significant fraction of BSLs in all study states would benefit from BEAD investment, although the nature of these benefits varies considerably. California and Michigan require primarily affordability interventions with adequate infrastructure already available, while Oklahoma needs fundamental infrastructure improvements alongside affordability measures. These variations underscore the importance of state-specific program design that addresses local market conditions rather than applying uniform national standards across diverse geographic and economic contexts.

5 CONCLUSION AND FUTURE RESEARCH

The high-speed affordable Internet challenge. The empirical evidence reveals that achieving BEAD's dual objectives represents a more complex challenge than simply deploying infrastructure or enhancing competition. Current markets consistently fail to deliver either adequate speeds at affordable prices or affordable services at adequate speeds. Oklahoma illustrates one dimension where lower-priced services coincide with inadequate speeds (85% below speed requirements), while Michigan demonstrates the opposite challenge where high-speed infrastructure exists but remains unaffordable.

The June 2025 NTIA guidance changes, which preempted state mandates for low-cost service parameters, heighten the importance of achieving this balance through market-based mechanisms rather than regulatory mandates. The income-based affordability analysis demonstrates that meaningful affordability requires consideration of local economic conditions rather than uniform national standards, suggesting that successful BEAD implementation will require adaptive approaches accounting for regional variations in market structure and household economic capacity.

Framework for continued monitoring. The baseline conditions documented here establish a foundation for systematic monitoring of BEAD program effectiveness as federally funded networks become operational. BQT's methodology provides a replicable framework for tracking changes in service availability, pricing, and quality over time, complementing traditional regulatory monitoring approaches that rely primarily on self-reported industry data.

Future monitoring should focus on three critical dimensions: (1) infrastructure deployment effectiveness through tracking speed availability changes in targeted areas, (2) affordability impact assessment through pricing changes for both market-rate and low-cost plans, and (3) competitive dynamics analysis examining changes in provider diversity as BEAD investments alter local competitive conditions. The geographic scope should extend beyond immediate grant areas to capture spillover effects, while state-specific approaches

should reflect the distinct market conditions identified in this baseline analysis.

Future research directions. Several research priorities emerge that can inform both immediate BEAD implementation and longer-term broadband policy development. The relationship between competitive market structure and affordability outcomes requires deeper investigation, particularly given variations observed across study states. The effectiveness of different low-cost service models represents a critical priority given implementation challenges revealed by this analysis. Since low-cost pricing is now determined by ISPs, it will be important to track these price variations in great spatial detail to understand their impact on affordability and adoption. Geographic analysis of BEAD impact boundaries and integration with complementary digital inclusion initiatives represent important research frontiers as networks become operational.

The methodology and findings presented here provide a foundation for this research agenda while demonstrating the value of independent, systematic monitoring of federal broadband programs. As BEAD implementation proceeds, continued empirical analysis using these approaches can ensure that the largest federal broadband investment in U.S. history achieves its dual objectives of expanding both access and affordability for underserved communities.

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