I. THE INVESTMENT GAP

Our analysis indicates that there are 7 million housing units (HUs) without access to terrestrial broadband infrastructure capable of meeting the National Broadband Availability Target of 4 Mbps download and 1 Mbps upload. Because the total costs of providing broadband service to those 7 million HUs exceed the revenues expected from providing service, it is unlikely that private capital will fund infrastructure capable of delivering broadband that meets the target.

We calculate the amount of support required to provide 100% coverage to the unserved consistent with the availability target to be $23.5 billion. As shown in Exhibit 1-A, the $23.5 billion gap is the net shortfall, including initial capital expenditures (capex), ongoing costs and revenue associated with providing service across the life of the asset.

Ongoing costs comprise ongoing capex, network operating expenses and selling, general and administrative expenses; the present values of these costs are shown in Exhibit 1-B.

Costs and the gap vary dramatically with population density, with the least densely populated areas accounting for a disproportionate share of the gap (see Exhibit 1-C). As noted in the NBP, and discussed more fully in the *Satellite* portion of Chapter 4, the highest-gap 250,000 housing units account for $13.4 billion of the total $23.5 billion investment gap.

In fact, deployment costs and the gap are driven largely by the density of the unserved, as will be discussed here and in Chapter 2 (see, for example, Exhibits 1-F and 2-D). Therefore, satellite-based broadband, which can provide service to almost any subscriber regardless of location and at roughly the same cost, could be an attractive part of the overall solution.

We rely on these results to represent an aggregate, nationwide figure. We are more cautious with results in specific geographies because the estimates of the availability of broadband capable networks are in part based on a statistical model (see Chapter 2 for more detail). When examined at a very granular level, the availability model will sometimes overestimate and sometimes underestimate service levels, but should tend to balance out when aggregated to larger geographic areas. In the maps throughout this section we aggregate outputs to the county, but data should still be considered only directionally accurate. Further analysis and improved source data would be required to refine estimates for particular geographies.

The map in Exhibit 1-D presents the Investment Gap for each county in the country. The gap in each county is calculated by adding the gap of all census blocks in that county. Since most counties have at least some census blocks with a net present value (NPV) gap, most counties have an NPV gap. Census blocks with a positive NPV (i.e., blocks where the gap is negative) offset losses in census blocks that are NPV negative. Thus, counties can have no gap if they are currently fully served (i.e., have no unserved), or if the total NPV in the county is positive. Note that dark blue counties have a gap at least 20 times higher than the gap in the light green counties.

Exhibit 1-A: Base-case Broadband Availability Gap—Cash Flows Associated With Investment Gap to Universal Broadband Availability[1]

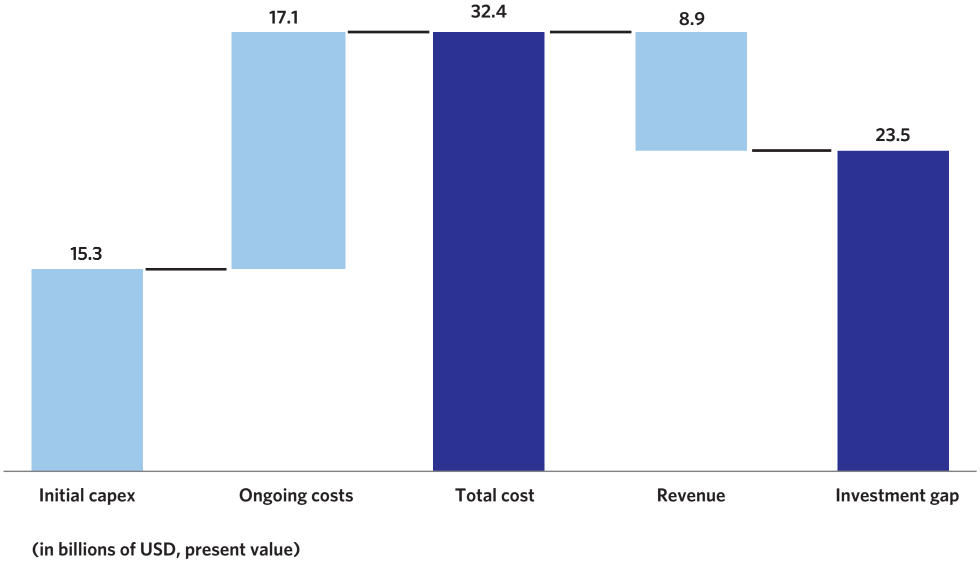
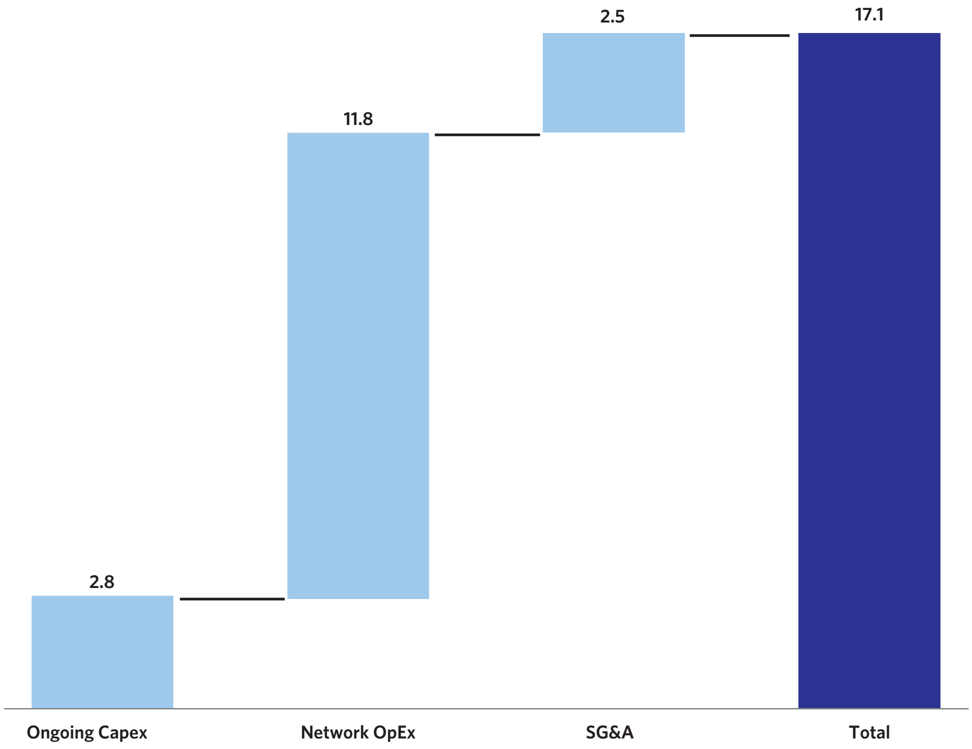


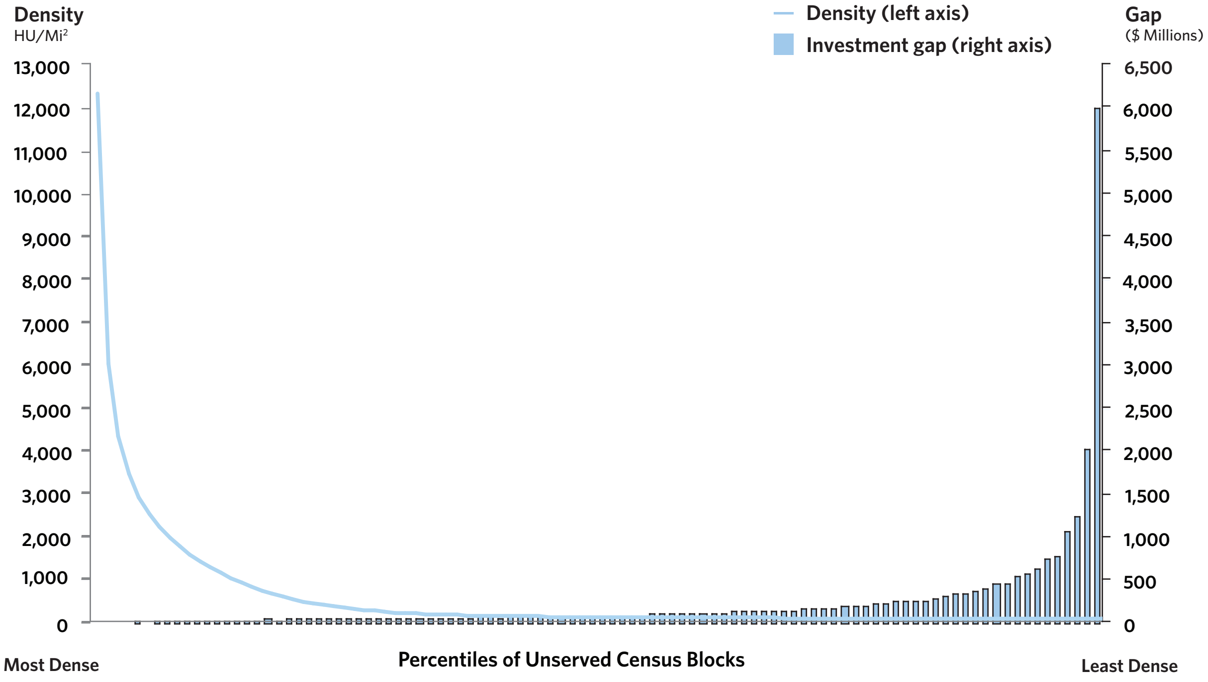
Exhibit 1-B:
Breakout of Ongoing Costs by Category



(in billions of USD, present value)

Numbers do not sum due to rounding.

Exhibit 1-C:
Gap by Census Blocks Ordered by Population density

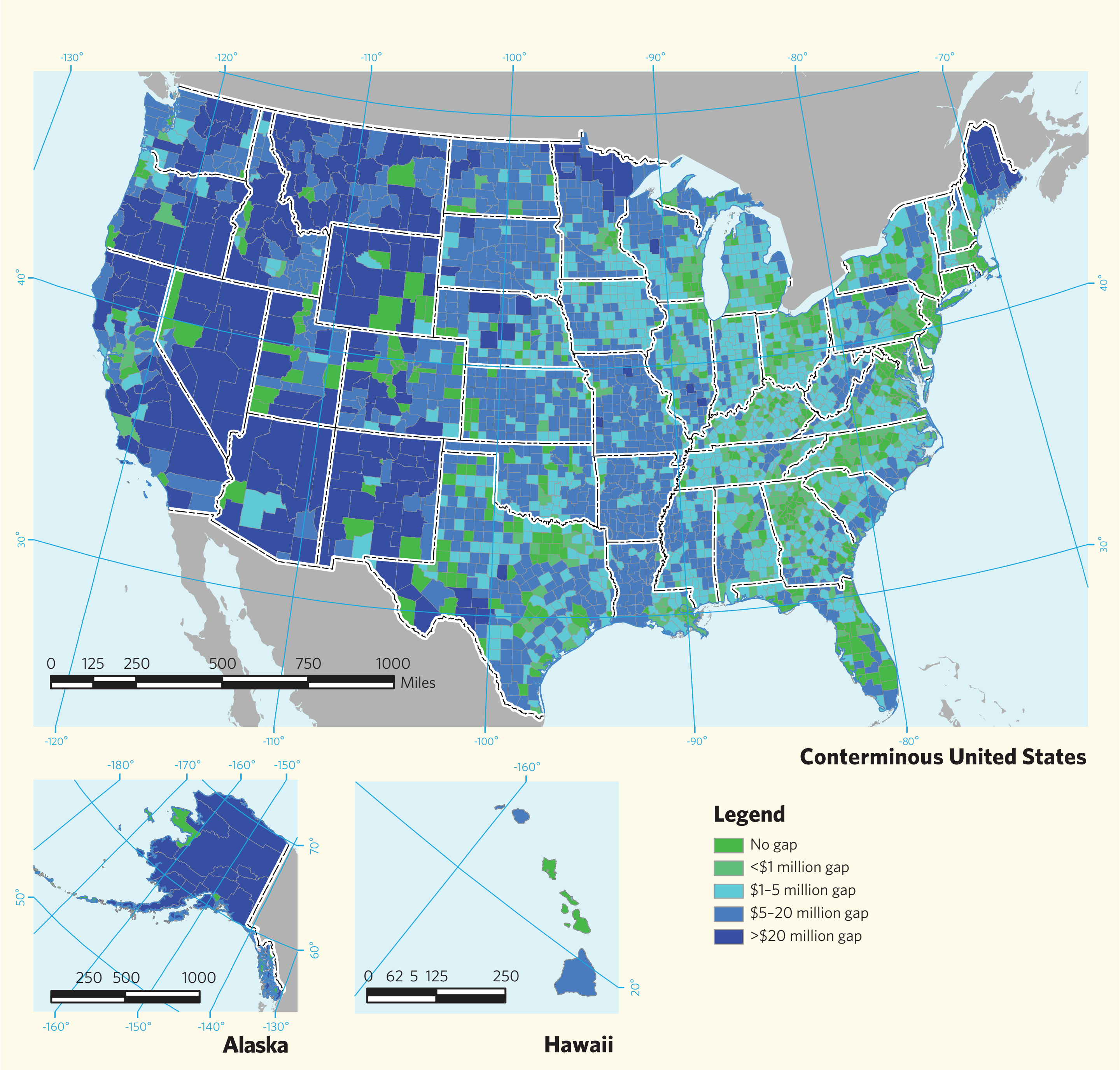


(in millions of USD, present value)

However, the total gap per county tells only part of the story. High county-level gaps can be driven by large numbers of relatively low-gap housing units and/or by small numbers of very high-gap housing units. Examining the gap per housing unit, as shown in Exhibit 1-E, highlights counties where the average gap per home is particularly high. This calculation simply takes the total gap in each county as described above, and divides by the number of unserved housing units in that county. The dark blue counties have a gap per home at least 10 times higher than the gap per home in the green counties.

Exhibit 1-D:

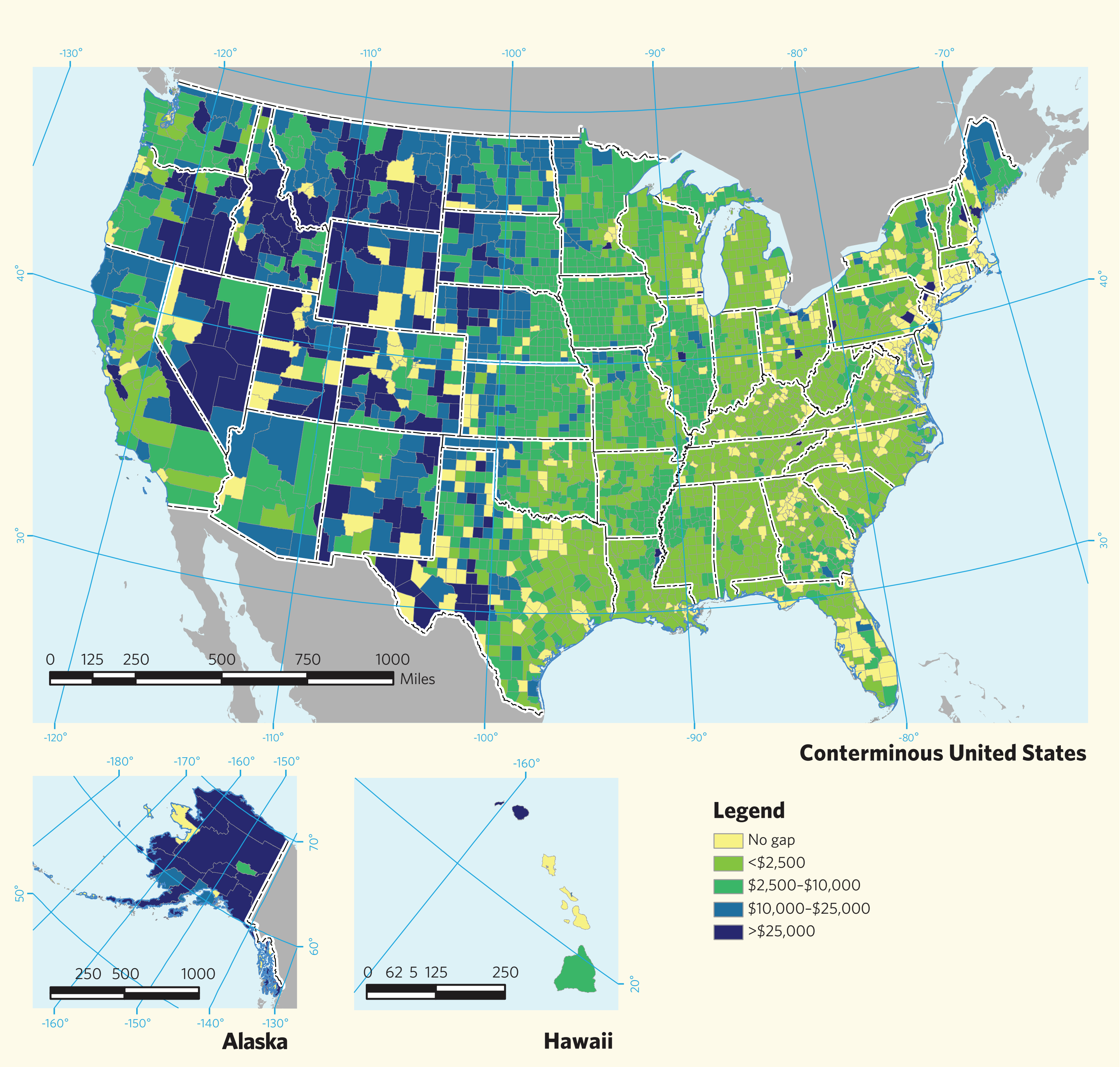
Broadband Investment Gap per County



As one might expect, one of the major drivers of cost, and consequently the gap, is the density of unserved housing units (i.e., the number of unserved housing units per square mile, averaged across each county). Areas with higher density as shown in Exhibit 1-F generally have lower gaps per housing unit; note the correlation between low densities in Exhibit 1-F with higher gap per housing unit in Exhibit 1-E. Although density is not the only driver of gap, it is a significant one.

Exhibit 1-E:

Broadband Investment Gap per Housing Unit in Each County



In some areas, the gap exceeds the initial capex required to build out the area. These areas have ongoing costs that are in excess of their revenue—meaning even a network with construction fully subsidized by public funds will not be able to operate profitably. Exhibit 1-G shows the gap for each county, highlighting those where the gap is larger than the initial capex (i.e., markets that require ongoing support), colored in light blue. Areas that require ongoing support generally have larger gaps.

Exhibit 1-F:

Density of Unserved Housing Units per Square Mile

The map in Exhibit 1-H shows the distribution of counties requiring ongoing support across the country. Ongoing support is the monthly annuity required per unserved housing unit to offset ongoing losses (i.e., the amount by which ongoing costs exceed revenues, assuming the network build out is fully subsidized). The darkest colors indicate areas where the highest levels of ongoing support are needed; counties shaded in pink will not need ongoing support.

In Exhibit 1-I, areas in blue are more economic to serve with wireless, and areas in red are cheaper to serve with DSL. For each, darker colors indicate counties with a higher gap per unserved housing unit. This technology comparison is made at the county level, not at a more granular level (See Chapter 3).

Wireline tends to be cheaper in low-density areas (compare Exhibit 1-I with Exhibit 1-F), particularly where terrain drives the need for smaller cell sites that drive up the cost of wireless (see Chapter 4 on wireless technology).

To establish the $23.5 billion gap, it is necessary to make a determination as to which last mile technology is likely to be least expensive given existing infrastructure, density, terrain and other factors. These estimates notwithstanding, this approach and the NBP are technologically neutral: These estimates do ***not*** reflect choices ***or*** recommendations that a particular last mile technology be utilized in any given area. Note, that as described later in this section in "**Creating the base-case scenario and output**," the focus in this analysis is on 12,000-foot-loop DSL and fixed wireless.

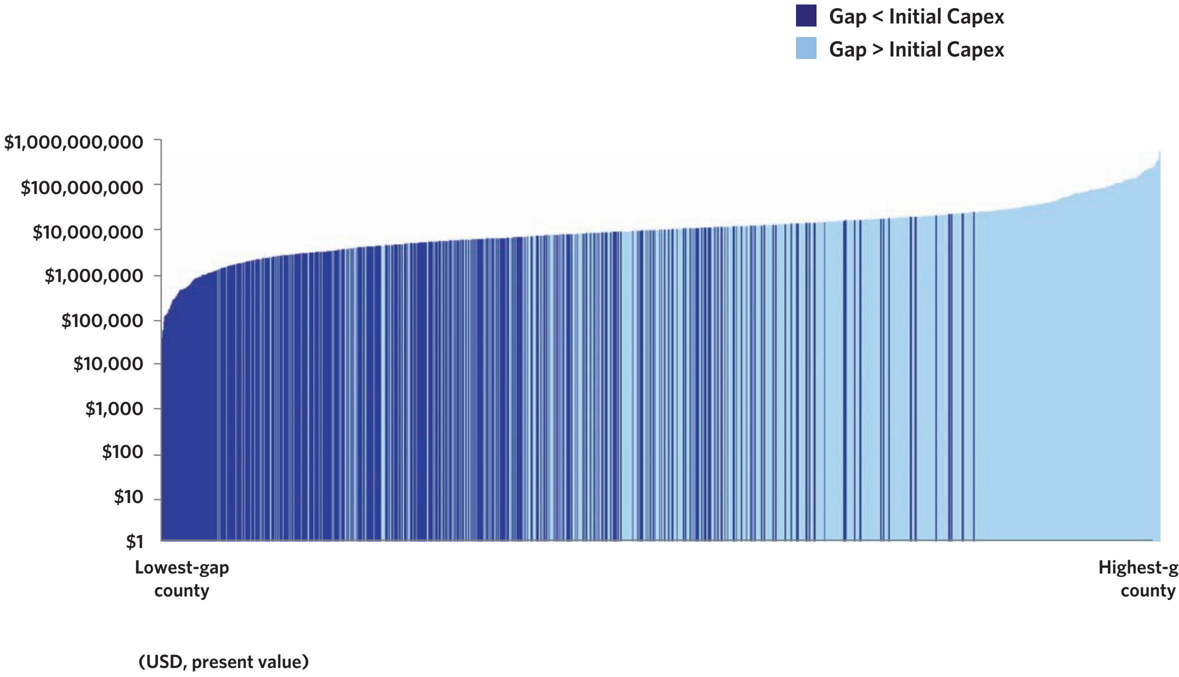
The map is somewhat misleading about the number of unserved housing units where wireline service is cheaper. In fact, while 42% of the geographic area is covered by counties where wired service has a lower gap, only 15% of counties with only 10% of the unserved housing units are in these areas; see Exhibit 1-J. Over time, these figures, which are based on the calculation of the investment gap for different technologies, may over- or under-estimate the role of any technology for a number of reasons. End-user behavior, specifically take rates or revenue per user, could differ from assumptions made in the model (see Chapter 3). In addition, the capabilities of different technologies could improve more or less quickly than assumed, or their costs could differ from what is modeled (see Chapter 4 for detail about capabilities and costs of different technologies). Finally, the impact of the disbursement mechanisms on individual service providers is impossible to include in these calculations.

The assumptions that underlie each of these calculations, and the method by which these technologies' costs are combined to reach the $23.5 billion gap, are discussed across the remainder of this document.

CREATING THE BASE-CASE SCENARIO AND OUTPUT

The base-case outputs, including the $23.5 billion gap, represent the shortfall of a particular combination of technologies across all unserved geographies. Since a single model run provides information about a single technology with a single set of assumptions, combining calculations for different technologies

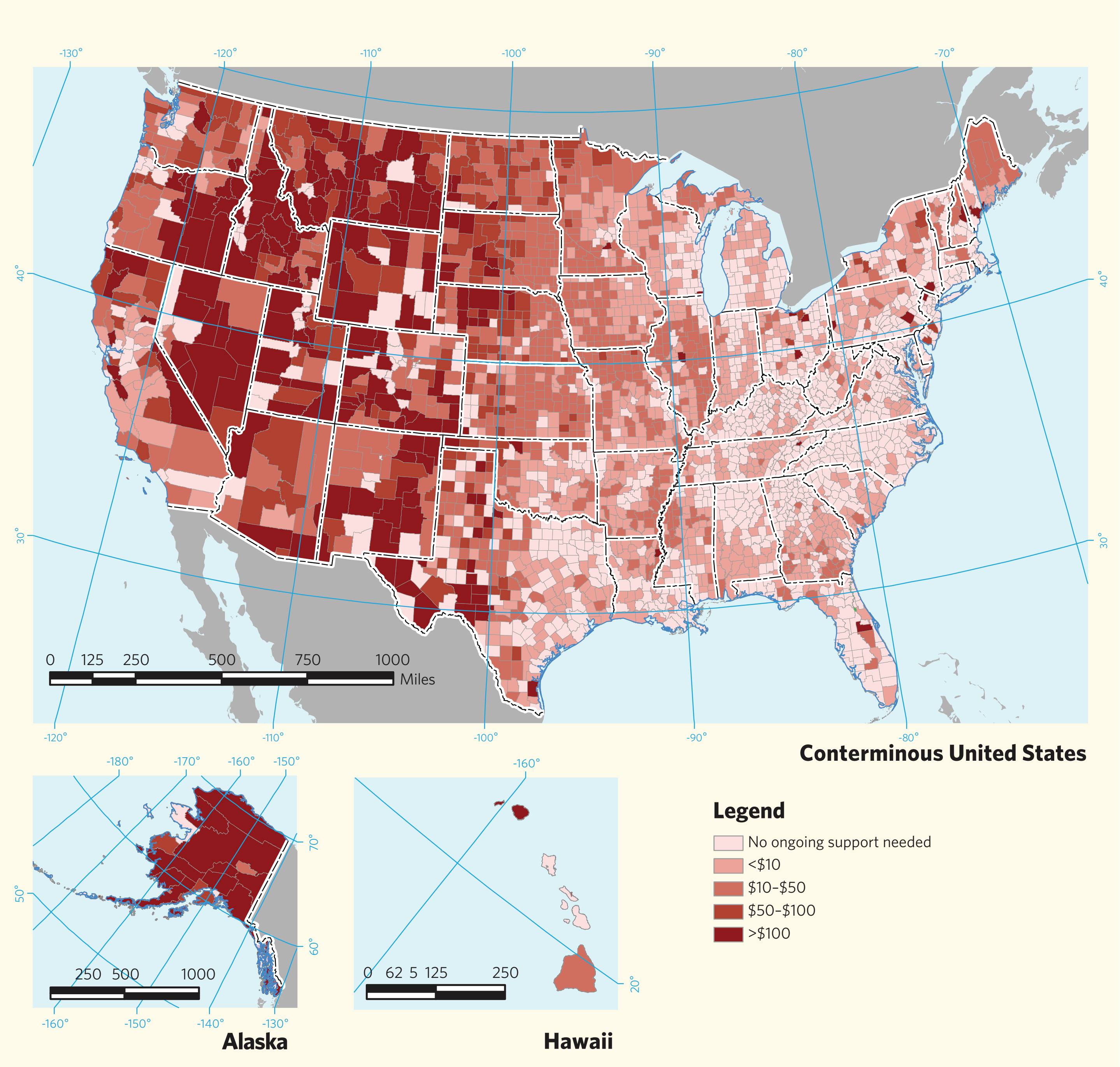
Exhibit 1-G:
Broadband Investment Gap, by County



requires multiple model runs. This section describes the various models run as well as the manual post-processing required to create the single base case of $23.5 billion. Post processing of this type is required for each of the different scenarios and sensitivities shown in this document.

To create the base case, we calculate the gap for each of the two lowest-cost technologies: fixed wireless and 12,000-foot DSL (see Exhibit 4-C). Calculating the fixed wireless gap is quite complex, and requires eight different sets of model output. DSL is less complex, and requires only two sets of model

Exhibit 1-H:
Ongoing Support for Each Housing Unit per Month

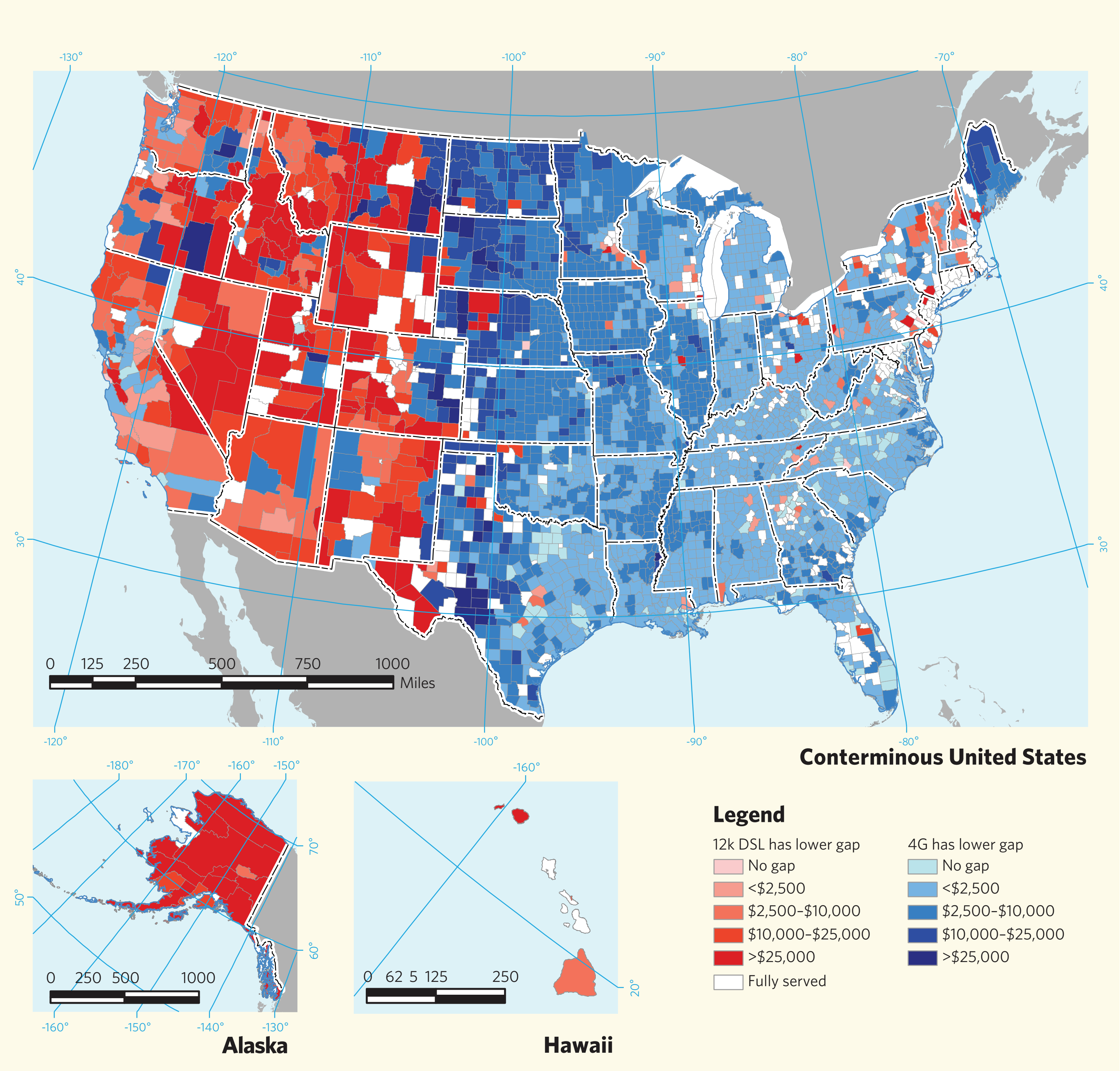


output. Of course, we also calculate the gap for other technologies, which will be discussed in Chapter 4.

For wireless, we require a total of eight different runs to generate the output data and account for two different kinds of information: 1) the presence of planned commercial 4G deployments and 2) which of four different cell radii is required for each census block to provide adequate signal density given terrain-driven attenuation. The base case requires output for each combination.

Exhibit 1-I:

Investment Gap per Housing Unit by Lowest-Cost Technology for Each County



The first issue is the presence of commercial 4G deployments. A substantial fraction of the unserved are in areas we expect will be covered by commercial 4G build-outs. We treat these 4G and non-4G areas differently in our analysis to account for the costs and revenues associated with each and, consequently, need one run for each area. In 4G areas, as noted in the NBP, it is not clear whether these commercial build-outs will provide adequate service without incremental investments. The gap in these 4G areas needs to account for the fact that costs associated with the incremental investments are lower than they would be for a greenfield build. In non-4G areas, we calculate the costs for a greenfield build (note that, as will be discussed in the wireless portion of Chapter 3, we capture the cost savings available from existing cell sites, as appropriate).

Another key driver of the wireless gap is the cell radius in each area. Rather than assume a uniform cell radius across the entire country, the approach is to calculate the cost associated with different cell radii (two, three, five and eight-mile radii) and chose an "optimized" radius, which accounts for topology, for each area.

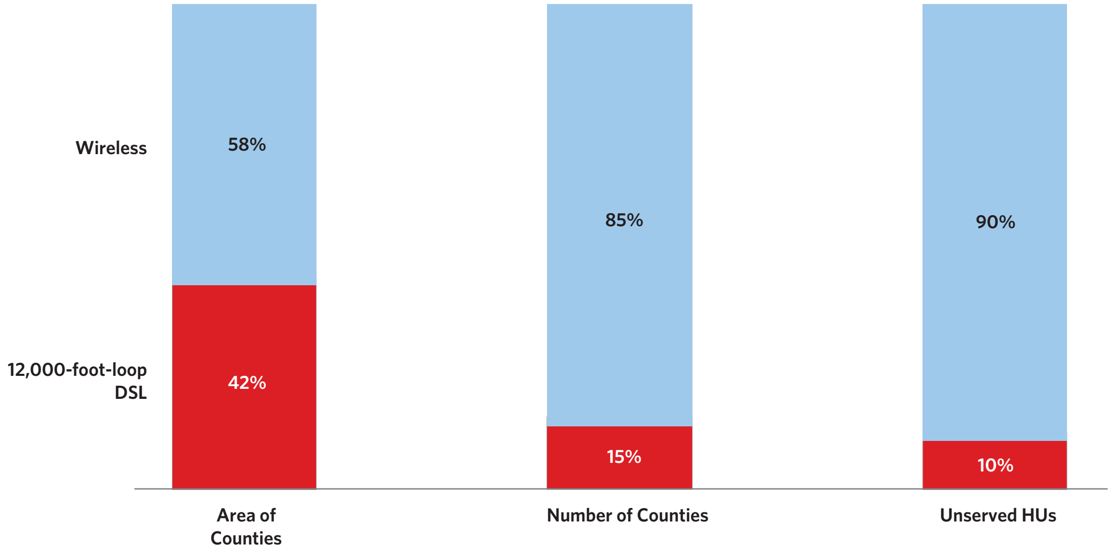
In total, then, there are eight wireless model runs: four runs (one for each radius) for the costs and gap associated with 4G areas; and four runs for the costs and gap associated with non-4G areas. For each geography (census block), we select the costs, revenues and gap from the appropriate run for each census block, depending on whether the area is in a 4G or non-4G area and what the optimized cell radius is.

The wired, 12,000-foot DSL solution is more straightforward and requires only two runs, which are required to account for the potential competitive impact of commercial 4G overlap on end-user revenue for the wired provider. While it is clear that a wireless carrier would need to make incremental investments to serve every unserved housing unit, wireless carriers will be able to serve some potentially large fraction of those within the commercial 4G footprint. Therefore, we assume that within the expected 4G footprint, DSL providers will face one fixed-broadband competitor (i.e., will split the end-user revenue with another carrier); in non-4G areas, we assume that DSL providers will not face any competition. The result is that the wired base case requires two model runs: one for 4G areas (with competition) and one for non-4G areas (without competition). The base case assumes wired solutions are all brownfield deployments where the incumbent builds out DSL service using existing twisted-pair copper.

The base case then involves calculating the lowest-cost and second-lowest-cost technology in each area. To make these comparisons at the service-area level (county level), we roll census blocks up into counties. These geographic roll-ups are made with Structured Query Language or SQL queries of the large, census-block-level output of the model and provide the essential outputs including costs, revenues and the gap for each model run or combination of model runs.

The model uses levelized costs and revenues. Levelization, often used in regulatory proceedings, calculates the annuitized equivalent—i.e., the effective annual value of cash flows—of the costs and revenues associated with building and operating a network. A levelized calculation provides a steady cash-flow stream, rather than trying to model or guess the timing of largely unpredictable yet sizable real-world payouts like those for upgrading and repairing equipment. The net present value (NPV) of a levelized cash flow is equal to the NPV of actual cash flows.

Exhibit 1-J.
Lowest Cost Technology



In order to calculate the Investment Gap as laid out in Exhibit 1-A, one need only make calculations from these market-level outputs. The three most important fields for this calculation are "contribution margin" (actually the levelized monthly gap, noting that a negative contribution margin represents a shortfall or positive gap), revenue (levelized monthly revenue) and initial capital investment.

First, determine the Investment Gap and total revenue by calculating the present value of the levelized contribution margin and revenue respectively. Second, calculate total cost by summing the present values for the investment gap and total revenue (moving from right to left in Exhibit 1-A). Third, the initial capital investment is provided in present value terms and can be taken directly from the query output. Finally, ongoing costs, which include all incremental capital expenses, operating expenses and any network residual value, are simply the difference between total cost and initial capital investment. These calculations are the same at any level of geographic aggregation, whether for the entire country or for any county.

CHAPTER 1 ENDNOTES

[1] Note that this exhibit differs slightly from Exhibit 8-B of the first printing of the NBP. While the gap remains at $24 billion, the data in this paper are updated since the release of the NBP; future revisions of the NBP will include these updated data.