



PSPS Risk Model Documentation

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Prepared By: PG&E's Electric Risk Mgmt & Analytics: Risk and Data Analytics (RaDA) Team

Revision History

Rev	Date	Comment
1		Initial Release
1.3	2026-03-03	See details in revision notes below

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Revision Notes (v1.3)

- 1. Added Non-Core fallback, mileage fallback hierarchy, and ancestry depth up to 11 generations.
- 2. Documented Dx-only/Dx+Tx filtering and exclusion of Tx-only events; added SCADA 2023–2024 data.
- 3. Maintaining unified VoS rates (Residential, Non-Residential) across territories; no HFTD/HFRA split.

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1 Executive Summary

The Public Safety Power Shutoff (PSPS) Risk Model provides the dollarized risk of PSPS outages on circuit segments, including the risk associated with downstream outages. It is used as a component of the overall Outage Risk Model, which is used by the Electrical Undergrounding Plan (EUP) project for prioritizing high risk circuit segments for undergrounding. The PSPS Risk model is a deterministic mathematical model derived from the customer-experienced outage risk on each circuit segment. In order to reflect the full risk (and thus the value of undergrounding) for each circuit segment, the model incorporates several factors: the segment's historical likelihood of appearing in a PSPS event polygon, its exposed length in miles, the geometry of both its upstream and downstream circuit segments, and the customer base served by all of these interrelated segments.

This model was developed to meet the requirements of SB884, which governs the EUP project. It also serves as a component of PG&E's broader strategy to mitigate wildfire risk while maintaining continuous and reliable electrical service to its customers.

Deleted: This document describes the PSPS Risk Model development by the Electric Risk Management and Analytics: Risk and Data Analytics (RaDA) team. It discusses the model's mathematical derivation in detail, and it provides information about its future updates. [¶](#)

2 Introduction

2.1 Model Overview

The PSPS Risk Model estimates the dollarized risk of PSPS outages at the circuit segment level, accounting for both direct customer impacts and the risk of causing downstream outages. The model uses outage durations that include patrol and restoration time as provided by the PSPS team, and it incorporates only PSPS events with a distribution footprint (Dx-only or Dx+Tx), excluding transmission-only events. The seven-year lookback period combines the formal PSPS Lookback Study (2018–2022) with SCADA-captured PSPS events from 2023–2024, scoped under Plan C (PSPS event used for analysis as defined by the PSPS team).

The PSPS Risk Model is used as a component of the Outage Risk Model during wildfire season planning and regulatory reporting to assess the tradeoff between wildfire mitigation and customer reliability impacts. It is a deterministic mathematical model with no machine learning component. PSPS risk on a given circuit segment is modeled as a nonlinear function of likelihood and consequence factors. Likelihood factors include historical presence within a spatiotemporal PSPS event polygon, minutes of resulting outage, miles of exposed circuit, and circuit geometry both upstream and downstream. Consequence factors include the number of customers affected by historical outages, customer segmentation factors, and the service cost for each affected customer.

Along with the EPSS Risk Model, the PSPS Risk Model is one of two models that feed into the Outage Risk Model. These models evaluate the risk associated with circuit segments using a circuit-based, “source-based” approach, quantifying the dollar value of risk that could be avoided if a circuit segment were undergrounded and thereby removed from exposure to the two preventative service outage programs.

2.2 Document Suite

This document is part of the documentation suite for the Outage Risk Model developed in support of the EUP project:

- Outage Risk Model v1.1 Documentation
- PSPS Risk Model v1.3 Documentation (this document)
- EPSS Risk Model v1.3 Documentation

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3 PSPS Risk Model Derivation

This section outlines the PSPS Risk Model, which serves as an input to the broader Outage Risk Model. The current model provides a dollarized risk and outage prediction on each circuit segment based on their historical likelihood of being present in a geo-temporal PSPS event polygon. The model outputs three key predictions for each circuit segment:

1. Dollarized PSPS Circuit-Based Risk
2. Annual PSPS Customer Minutes of Interruption (CMI)
3. Annual PSPS Likelihood

As stated in previous sections, the PSPS Risk Model is a deterministic mathematical model. It uses a rule-based formulation to compute the expected number of sustained outages based on circuit geometry, aggregated customer value-of-service data, and historical PSPS event polygons. The PSPS Risk Model does not involve simulation, machine learning, or statistical inference.

It is also a nonlinear model. Unlike customer-experienced risk, which can be expressed as the product of a separable Likelihood model and Consequence model, there is no possible separable standalone Consequence model for PSPS risk. Instead, Derived Consequence may be used as an equivalent.

3.1 Customer-Experienced vs Circuit-Based Risk

To understand the PSPS Risk model, it is important to make a distinction between *in situ* or “customer-experienced” risk versus source-based or “circuit-based” risk. Many PG&E circuit risk models predict risk from the customer’s point of reference, at the location of a potential outage. This *in situ* risk’s core relationship is simply the likelihood of an outage event at the location of a given circuit segment multiplied by the dollarized consequence of loss of service to the customers served by that segment. Therefore, the basic customer-experienced risk formula is:

$$Risk_{customer-experienced} = Likelihood \times Consequence$$

This relationship quantifies the predicted loss of value for a given circuit segment. If outages across circuit segments were entirely independent, this same relationship would also express the risk of each circuit segment as a distinct *source* since each segment could only be serviced-energized by its own unique risk factors.

However, circuit segment outages are *not* independent. An outage in an upstream segment will inevitably propagate to all downstream segments. Therefore, to accurately assess the risk reduction achieved by replacing or hardening any segment that may serve as a source of outages, the risk averted at downstream sites must also be factored in.

The PSPS Risk Model is designed to assign a risk value to each circuit segment as a potential *source* of outage, supporting prioritization decisions for undergrounding of circuit segments and segment portfolios. Within a PSPS event, it is common for a circuit segment to have

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downstream segments, some included in the event region and others outside, that nonetheless experience outages due to upstream de-energization. The model attributes the customer-experienced risk of these downstream segments across their upstream segments. To avoid bias, this attribution is weighted by the length of exposed circuit upstream.

Attributing this downstream risk to upstream source segments adds nonlinearity to the model. Accordingly, risk is calculated holistically as a nonlinear function of historical likelihood data, circuit geometry, event polygon geometry, and the single-circuit consequence of the circuit segment and all subsequent downstream segments.

Certain circuit segments have zero customers yet intersect PSPS polygons. While they exhibit no onsite customer-experienced risk, they can still serve as upstream sources of downstream outages. These segments are included so their downstream risk can be properly attributed within the circuit-based model.

In addition, the consequence component incorporates updated customer-segmentation practices: Road/Highway SPIDs are excluded from risk and CMI computations, and ICE 2.0 value-of-service rates are unified into one system-wide Residential rate and one systemwide Non-Residential rate (shared by Small and Medium C&I customers), with no HFTD/HFRA split.

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3.2 Data Sources

The data sources for this model include:

The PSPS Lookback Study, provided by the PSPS team. This dataset provides seven years of PSPS event data such as event polygons, outage duration in minutes, and affected circuit segments and SPIDs. Data includes a retrospective lookback for 2018-2022 data (scoped using late-2024 PSPS guidance applied to historical weather conditions), and actual PSPS events for 2023-2024 data (scoped using live guidance at the time of each event, filtered to SCADA-enabled devices). Customer impacts are based on Plan C scoping (the most comprehensive scoping plan, including both distribution and downstream transmission impacts), filtered to Dx-only or Dx-and-Tx events.

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The Wildfire Distribution Risk Model (WDRM) V4, provided by the RaDA WDRM team and updated on a three-year cycle. The WDRM is the PSPS Risk Model's source of record for circuit segment geometry.

PG&E Customer Segmentation Data, which identifies the customer service classes and critical customer factors associated with the SPIDs affected by PSPS events.

3.3 Customer-Experienced PSPS Risk Derivation and Example Calculations

The derivation of the full circuit segment mileage-weighted PSPS Risk Model begins with the customer-experienced risk of a single event on a single circuit segment. This is defined as the circuit segment's likelihood of outage (in minutes) for that single event, multiplied by the customer consequence.

Specifically, the PSPS likelihood for a circuit segment during a single event is modeled as the total outage minutes for that event divided by the seven-year PSPS lookback period. In

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practice, this is implemented by summing all CMI associated with the event and dividing by the product of the number of SPIDs involved and the seven-year lookback period. This formulation simplifies the coding process while preserving the temporal scaling of the model.

$$PSPS\ Likelihood_{CS, single\ event} = \frac{Outage\ Minutes\ on\ CS}{PSPS\ lookback\ period} = \frac{1}{7\ years * N_{SPIDS\ on\ CS}} \sum_{SPIDS\ on\ CS} CMI$$

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Concurrently, customer-experienced consequence on a single circuit segment (CS) is calculated as the number of SPIDs served by the circuit segment, multiplied by the value of service per CMI (\$/CMI) as defined by ICE 2.0 calculator for each SPID's customer class (e.g. residential, small C&I, medium/large C&I), and further adjusted by a weighting factor according to the class of critical customer served at that SPID.

$$Consequence_{CS} = \sum_{SPIDS\ on\ CS} CMI\ cost\ by\ customer\ class * Critical\ customer\ weighting\ factor$$

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Thus, the customer-experienced risk on a single circuit segment, for a single event, is the product of the annual likelihood of that event on that circuit segment and the consequence experienced on that circuit segment.

$$Risk_{customer-experienced, CS, single\ event} = PSPS\ Likelihood_{CS, single\ event} \times Consequence_{CS}$$

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3.4 By-Count Circuit-Based PSPS Risk Derivation and Example Calculations

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If a given circuit segment has multiple upstream segments (possibly including itself) that are affected by a PSPS event, each of these segments is considered an equal *source* of risk, even if the circuit segment itself is the site of the outage. Refactoring the site-based customer risk to a source-based risk model requires attributing the customer-experienced risk equally to all directly affected upstream circuit segments, including the segment itself if directly impacted. This is done by allocating equal proportions of risk to each affected upstream segment. The equations to derive circuit-based risk from customer-experienced risk, based on segment counts, are as follows:

$$Circuit\ Segment - based\ risk\ for\ a\ single\ event, by\ segment\ count: R_{CS, e, SB} = \sum_i \frac{1}{N_{i, A}} R_{i, e};$$

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Core spreading may traverse up to 11 upstream generations when allocating downstream risk to upstream segments. In cases where a CS/event pair appears in the customer-experienced dataset but does not appear in the upstream ancestor tree, the model applies a **noncore fallback**, assigning the event's circuit-segment-level risk directly to that CS without upstream spreading.

When mileage information is required for attribution and multiple mileage measures are available, the model applies a **mileage fallback hierarchy**, using the best available mileage in the following order:

- 1. Intersection HFTD/HFRA miles
- 2. Intersection total miles
- 3. PRIOH HFTD/HFRA miles
- 4. PRIOH total miles
- 5. Default of 0 miles

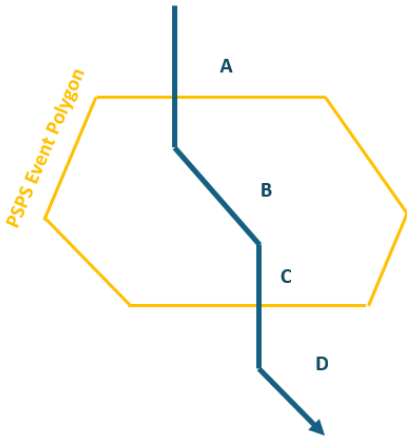
Total risk on CS for all events in lookback period = $\sum_E R_{CS,E,SB} = \sum_E \sum_i \frac{1}{N_{i,A}} R_{i,e}$

Where:

- i* = set of all downstream segments, including CS
- E* = set of all events that directly affected CS during lookback period
- R_{CS,e}* = Customer Experienced risk for single CS and event (i.e. Likelihood x Consequence)
- N_{CS,A}* = Number of ancestors of CS within single PSPS event polygon, including CS itself

To illustrate circuit-based-based/ risk by circuit count, consider this example calculation of risk from a single PSPS event illustrated in Figure 1.

Figure 1: Example set of PSPS-affected circuit segments



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Table 1 Example set of PSPS-affected circuit segments based on Figure 1

CS	$R_{CS,e}$	$N_{CS,A}$	Risk Source Attribution	Circuit-based/ Source-based risk on Segment
A	R_A	1	A has no upstream ancestors in the event. The only source of outage on A is A's own presence in the PSPS event polygon.	$R_A + \frac{1}{2}R_B + \frac{1}{3}R_C + \frac{1}{3}R_D$
B	R_B	2	The source of outage risk on B is equally attributed to A's outage and B's outage within the polygon.	$\frac{1}{2}R_B + \frac{1}{3}R_C + \frac{1}{3}R_D$
C	R_C	3	The source of outage risk on C is equally attributed to A's outage, B's outage, and C's own outage within the polygon.	$\frac{1}{3}R_C + \frac{1}{3}R_D$
D	R_D	3	The source of outage risk on D is equally attributed to outages on A, B, and C. D itself is not a source of outage risk because it lies outside the event polygon.	0

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3.5 Circuit-Based Mileage-Weighted Circuit-Based Risk Derivation and Calculations

A simple method for attributing customer-experienced PSPS risk to upstream circuit segments is to distribute each circuit segment's *in situ* risk equally across all affected segments. However, this introduces bias by treating all circuit segments as equal contributors to risk, when physical geometry also influences the risk each segment carries. Consider a system with an especially long circuit segment, this segment is more vulnerable to inclusion in a PSPS event simply because its length provides a larger exposure surface. From a physical standpoint, circuit segment risk can be modeled as a function of circuit segment length.

When attributing the *in situ* risk of a circuit segment to its upstream source segments, a more accurate approach is to distribute that risk proportionally based on the total length of affected upstream segments, rather than simply by segment count.

To account for the bias introduced by equal attribution, the PSPS Risk Model used in the Outage Risk Model applies a mileage-weighted circuit-based approach. The model's equations are as follows:

$$\text{Circuit - based risk for a single event, mileage weighted: } R_{CS,e,MW} = \sum_i \frac{M_i}{M_{i,A}} R_{i,e} ;$$

Total risk on CS for all events in lookback period = $\sum_E R_{CS,E,MW} = \sum_E \sum_i \frac{M_i}{M_{i,A}} R_{i,e}$

Where:

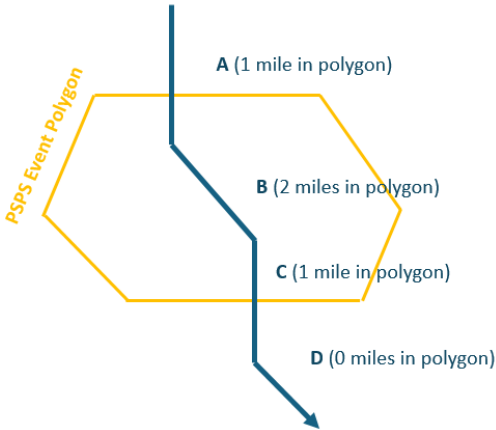
$M_{CS,A}$
= Miles of exposed ancestor CS within event polygon, including CS' own affected mileage

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set of all downstream segments, including original/
source CS
 E =
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 $R_{CS,e}$ =
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To illustrate mileage-weighted circuit-based risk, consider the following example calculation for attributing circuit-based risk for a single event illustrated in Figure 2.

Figure 2: Example set of PSPS-affected circuit segments, including miles of intersection with the PSPS event polygon



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Table 2 Example set of PSPS-affected circuit segments, including miles of intersection with the PSPS event polygon based on Figure 2

CS	$R_{CS,e}$	M_{CS}	$M_{CS,A}$	Risk Source Attribution	Circuit-based/Mileage-Weighted risk on Segment
A	R_A	1	1	A has no upstream ancestors in the event. The only mile of exposed outage source for A is its own mileage within the polygon.	$\frac{1mi}{1mi}R_A + \frac{1mi}{3mi}R_B + \frac{1mi}{4mi}R_C + \frac{1mi}{4mi}R_D$
B	R_B	2	3 (1+2)	The source of outage risk on B is attributed equally across all miles of exposed circuit within the polygon: A's mile of outage and B's two miles of outage within the polygon.	$\frac{2mi}{3mi}R_B + \frac{2mi}{4mi}R_C + \frac{2mi}{4mi}R_D$
C	R_C	1	4 (1+2+1)	The source of outage risk on C is attributed equally across all miles of exposed circuit within the polygon: A's and B's three combined exposed miles, and C's own exposed mile within the polygon.	$\frac{1mi}{4mi}R_C + \frac{1mi}{4mi}R_D$
D	R_D	0	4 (1+2+1)	Segment D itself is not a source of outage risk because its mileage lies outside the event polygon. The source of outage risk on D is attributed equally to the combined four exposed mileage on A, B, and C.	$\frac{0mi}{4mi}R_D$ (= 0)

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In practice, this mileage-weighted calculation produces the **circuit-segment risk per event**, representing the attributed PSPS risk for each CS x event pair under both the core and noncore pathways. This circuit-segment risk per event serves as the foundational output of the mileage-weighted model and is subsequently used to construct all downstream circuit-level annualized metrics.

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3.6 Annual PSPS CMI

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The annual PSPS CMI of a given circuit segment is calculated by summing the CMI experienced on that segment over the lookback period, divided by the number of years in that period (i.e. seven years):

$$\text{Annual PSPS CMI} = \frac{1}{7\text{years}} \sum_{\text{events, PSPS on CS}} \text{CMI}$$

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3.7 Annual PSPS Likelihood

The annual PSPS Likelihood is the annual CMI on a CS divided by its number of SPIDs:

$$\text{Annual PSPS Likelihood} = \frac{1}{7\text{years} * N_{\text{SPIDS on CS}}} \sum_{\text{events, SPIDS on CS}} \text{CMI}$$

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3.8 PSPS Derived Consequence

This circuit-based, mileage-weighted PSPS Risk Model is a summative nonlinear function of a circuit's linear customer-based risk and that of its affected neighboring circuit segments. Due to the interdependence of risk across a series of circuits, it is not possible to define a circuit segment's consequence independently from its likelihood and the customer-experienced risk of its neighbors. In cases where a standalone measure of PSPS circuit segment-based Consequence is needed, use the Derived Consequence, which calculates consequence as a function of risk and known likelihood:

$$\text{Consequence}_{\text{derived}} = \frac{\text{Risk}_{\text{circuit segment-based}}}{\text{Likelihood}}$$

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4 Model Usage

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4.1 Model Usage

The PSPS Risk Model is applied at the circuit segment level. It is used as a component of the Outage Risk Model used during wildfire season planning and regulatory reporting to assess tradeoffs between wildfire mitigation and customer reliability impacts.

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4.2 Shelf Life

The PSPS Risk Model is structured around the Wildfire Mitigation Plan (WMP) reporting cycle and is refreshed in conjunction with new releases of the WDRM. With each Outage Program Risk Model version, the inputs will be updated accordingly with the WDRM and input data.

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5 Appendix

5.1 Special Case: PSPS Risk on Circuit Segments with No Customers

Certain circuit segments are present exclusively in the geometric (polygon) dataset and do not appear in any other customer data sources used in the PSPS Risk Model due to having zero customers. This is expected behavior, as the PSPS circuit-based risk is derived from customer-experienced risk; these customer-free circuit segments exhibit CMI across all upstream and downstream paths. Their exclusion from customer-experienced risk models is sound, because there is no customer-experienced risk at the location of those circuit segments.

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However, segments without customers can be upstream sources of risk for downstream outages, if the customer-free segment is directly affected by a PSPS event (i.e. its geometry intersects with a PSPS event polygon). In these cases, customer-free circuit segments are reintroduced to the model so that they can have downstream risk attributed to them, despite their lack of customer-experienced risk and CMI.

These customer-free circuit segments are included in this circuit-based PSPS model as a special case, because outages on these circuits can be the source of significant downstream risk even if they are not the site of customer-experienced service discontinuity.

5.2 PSPS Critical Customer Weighting

The PSPS Outage Risk Model incorporates critical customer weighting by applying severity-based multipliers (1, 2, 5, or 100) to each customer's CMI and VoS. These weighted values are then used to proportionally allocate the total dollarized PSPS risk across the system. Rather than inflating the overall risk, this approach redistributes the existing risk "pie" to give larger shares to customers with higher criticality. This ensures that the model reflects the relative impact of outages on the most vulnerable customer segments, thereby prioritizing mitigation efforts where the consequences are greatest.

The weighting framework was developed in 2022 by subject matter experts and approved by PG&E's Wildfire Risk Governance Steering Committee (WRGSC). It was formally incorporated into the PSPS methodology to support risk prioritization for customers and circuits most impacted by PSPS events. In 2025, internal model comparisons and discussions led to refinement in how customer types were classified. Rather than reducing weights, the trend was to elevate certain customer types, such as TT1 and TT2, to the "Extreme" category, recognizing their role as Public Safety Partners. While some test scenarios explored adjusting weights, these were not adopted in the final methodology. The emphasis remained on reinforcing the importance of critical customers in risk modeling, ensuring that their prioritization was both equitable and operationally sound.

Table 3 PSPS Critical Customer Weighting Overview summarizes the meaning of each weight, listing the specific critical customer types used in the PSPS Outage Risk Model, and provides examples of customer types that fall into each category. These classifications ensure that risk is redistributed, and not inflated, based on customer criticality, allowing the model to prioritize mitigation efforts where the consequences of outages are most severe.

Table 3 PSPS Critical Customer Weighting Overview

Weight	Critical Customer Type	Description & Examples
100	CC1, CE1, TE1, TE2, TT1, TT2	Extremely critical infrastructure, public safety partners or provides emergency services (e.g. critical care facilities, emergency services, telecom hubs, transportation terminals, etc.)

5	Life Support Low Income, Medical Baseline Low Income, Life Support	Medically vulnerable and low-income customers (e.g. life support low income, medical baseline low income, etc.)
2	CC2, CC3, CE2, CE3, EE, PR1, SC1, SC2, SC3, SE1, SE2, SE3, Medical Baseline, Self-Identified Vulnerable, Low Income, AFN (Access and Functional Needs)	Moderately vulnerable groups (e.g. medical baseline, self-identified vulnerable, low income, AFN, etc.)
1	Other	Baseline or regular customers without identified critical attributes

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