# A Framework for Benchmarking Municipal Asphalt Paving Investment Using Tax Levy and Paving Tonnage Data

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## ABSTRACT

Municipalities across Ontario collectively pave Millions of tonnes of asphalt annually with different paving investment strategies, yet there's no standardized method to compare their resurfacing and paving investment relative to their funding capacity, population, and network size. Existing performance indicators, such as pavement condition indices, provide useful snapshots of network health but do not capture a municipality's resurfacing output per dollar of available revenue. This paper introduces the **Municipal Paving Investment** index **(MPI)**, a benchmarking tool that relates annual HMA paving tonnage to the municipal tax levy normalized per the road network size.

Using data compiled in the 2025 Ontario Paving Report, combined with financial metrics from the provincially reported Ontario Financial Information Returns, the **MPI** index normalizes HMA paving and resurfacing activity and enables meaningful cross-municipal comparisons regardless of size, population, or network scale. The paper outlines the data collection process, methodological considerations, limitations, and formulae used to compute the indicator. Followed by a comparative analysis of a large sample of Ontario municipalities. Results are expected to highlight differences in investment intensity across the municipalities, comparing rural municipalities to urban centres, and steady growth municipalities to high-growth ones to identify strategic opportunities for enhanced pavement funding.

The MPI index provides a helpful framework and decision-support tool for municipal engineers, asset managers, and policymakers. It can help identify under-investment, support budget requests, and benchmark HMA paving investment against peers. The indicator represents a scalable national framework for linking transportation asset renewal to municipal fiscal capacity.

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## INTRODUCTION

Municipal governments across Ontario are collectively responsible for managing and maintaining an extensive transportation network totaling approximately 301,886 lane-kilometres of roadway. This scale corresponds to a Road Length per Capita (RLC) value of 18.5—among the highest observed globally—indicating a high infrastructure maintenance burden relative to the municipal tax base. Maintaining such a network requires continuous, multi-year optimization of maintenance and rehabilitation investments to achieve and preserve target service levels. In practice, this task is further complicated by limited in-house technical capacity, unharmonized data, competing capital priorities, and uncertainty in long-term financial planning, in addition to political interests. While municipalities increasingly adopt asset management frameworks, translating technical condition data into defensible funding strategies remains a persistent challenge.

Historical assessments have long warned of a widening infrastructure maintenance gap, identifying tens of billions of dollars in unfunded needs as early as the early 2000s (Federation of Canadian Municipalities & National Research Council Canada, 2003). Significant challenges were introduced to Ontario municipalities after the province ended the conditional infrastructure funding in 1995. Recent estimates of $15.5B suggest that this challenge persists, underscoring the chronic difficulty municipalities face in sustaining safe and reliable roadway systems under constrained fiscal environments (James Smith, 2021). However, such estimates were typically derived from engineering-based needs assessments framework which does consider available funding levels. In the absence of a simplified, strategic-level metric linking investment to available funds, it remains difficult for senior decision makers to determine whether observed deficits are attributable solely to funding constraints or, in part, to how available resources are prioritized and allocated.

Over the past decade, numerous performance metrics and key performance indicators have been developed to support asset-level decision-making across customer values such as safety, reliability, mobility, and condition. For example, Asset Management Ontario has identified dozens of metrics applicable across municipal asset classes (Asset Management Ontario, 2018). Despite this abundance of analytical tools, a critical disconnect remains between practitioners who understand infrastructure condition and operational risk, and decision-makers responsible for allocating financial resources. As a result, discussions surrounding infrastructure investment often struggle to distinguish between two fundamentally different problems: insufficient funding versus suboptimal prioritization of infrastructure maintenance/rehab.

Municipal road asset management decisions can be understood as occurring across three interrelated levels—Strategic, Tactical, and Operational as presented in **Figure-1**. While existing metrics effectively inform operational, tactical on asset and corridor-specific choices, they rarely provide a clear line of sight to strategic funding decisions. This study proposes a simplified metric to bridge the Tactical–Strategic gap, enabling municipalities to better answer a central question: **Is the observed infrastructure**

**maintenance gap driven primarily by resource limitations or by how available resources are prioritized?**

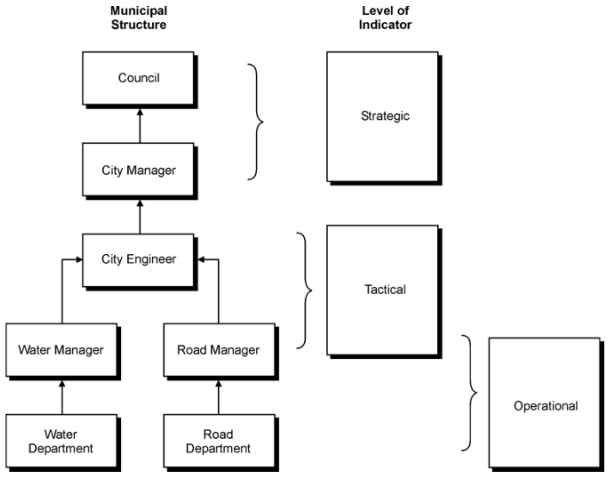


*Figure 1 - Hierarchy of Indicators in a Typical Municipality (FCM & NRC 2003)*

## METHODOLOGY

- Conceptual Approach

Existing municipal indicators evaluate asset condition or operational outputs, but few connect these outputs to a municipality's fiscal capacity. Senior decision-makers often require a simplified lens through which technical information can be translated into funding and policy discussions. This study's approach therefore focuses on developing a practical strategic-level index that links financial capacity to observable rehabilitation activity with the purpose of supporting clearer dialogue between Strategic and Tactical levels of governance, aligning actual paving outputs with available revenue.

The (Federation of Canadian Municipalities & National Research Council Canada, 2003) indicator-development framework was followed to ensure the resulting index is manageable, relevant, and well-defined. To maintain practicality, the index relies on data that is already collected or publicly reported.

- Indicator Development (Municipal Paving Investment index – MPI)

The MPI index relates a municipality's actual paving output to its primary revenue source: the municipal tax levy. While paving is often funded through a mix of levies and reserves, the tax levy serves as the most stable proxy for a municipality's long-term internal investment capacity. The MPI is calculated as the ratio of annual HMA tonnage per lane km to the total municipal tax levy. This provides a clear metric of "paving output per dollar of tax capacity." It provides CAOs and City Councillors with an immediate, non-technical understanding of investment intensity locally and in comparison, with similar jurisdictions. The formula for the index is defined as:

$$MPI = \frac{Annual\ HMA\ Paving\ Tonnage\ per\ Lane\ Kilometers\ (\frac{Tonne}{km})}{Municipal\ Tax\ Levy + PILS\ (\$M)}$$

- Data Collection

The analysis utilized two primary data streams to ensure a comprehensive view of Ontario's municipal landscape.

- HMA Paving Data

Data was sourced from the 2025 Ontario Paving Report (Mneina et al., 2025), which utilized the "Municipal Paving Forecast" survey circulated to all 444 Ontario municipalities. The survey collected responses from 74 municipalities. Although this represents 17% of the total number of municipalities, the responding municipalities account for **83% of Ontario's total population**, providing a statistically significant representation of the province's capital paving activity. Collected data included annual expected HMA paving tonnage for the year of 2025, total potholes fixed in the previous year, and overall network condition score (PCI).

- Financial Capacity Data

Financial metrics were extracted from the Ontario Financial Information Returns (Ontario Ministry of Municipal Affairs and Housing, 2025), to define the total local revenue capacity, this study combined:

  - Municipal Tax levy (Part-1, Column-O, Schedule-A26),
  - Municipal PILS levy (Part-2, Column-O, Schedule-A26)

Due to reporting lags, 14 of the 74 responding municipalities had not yet published their most recent FIR data at the time of this study. Consequently, the final analytical sample consists of **60 municipalities**.

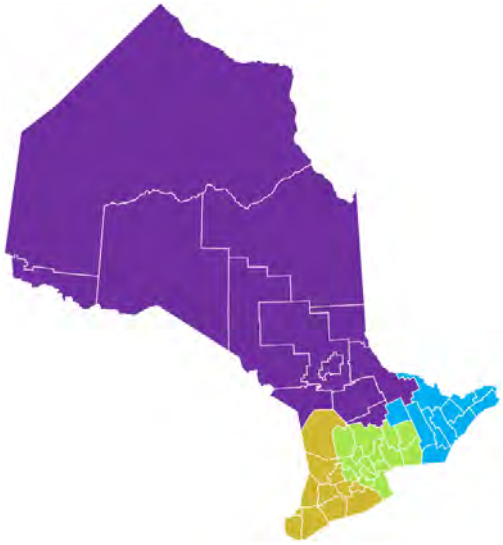

*Figure 2 - Response rate: 2% North zone, 15% southeast zone, 57% central zone, and 7% southwest zone*

## DISCUSSION

The population of the sampled municipalities ranged from 586 to 2,794,356 residents. To support interpretation of the results, municipalities were categorized using the rural–urban working definition referenced by Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). Under this definition, a municipality is considered rural if it has population of less than 100 000 **and/or** population density of 100 people/km² or less.

The calculated Municipal Paving Investment (MPI) Index ranged from 0 to 0.437 across the sample. For visualization clarity, a scaling factor of 10 was applied in graphical representations. Conceptually, an MPI value of 1 indicates that for every $1 million of municipal tax levy, approximately one tonne of new hot-mix asphalt (HMA) was placed per lane-kilometre within that jurisdiction. For reference, a 50mm overlay is 480 tonnes/lane km. This standardized expression allows direct comparison of renewal intensity relative to municipal revenue capacity.

The analysis of the MPI index relative to population density reveals a divide in infrastructure burden between rural and urban Ontario. As shown in **Figure 2**, rural municipalities (smaller bubbles) exhibit disproportionately higher MPI values, indicating their allocation of a significantly larger share of their local tax revenue toward paving compared to urban municipalities.

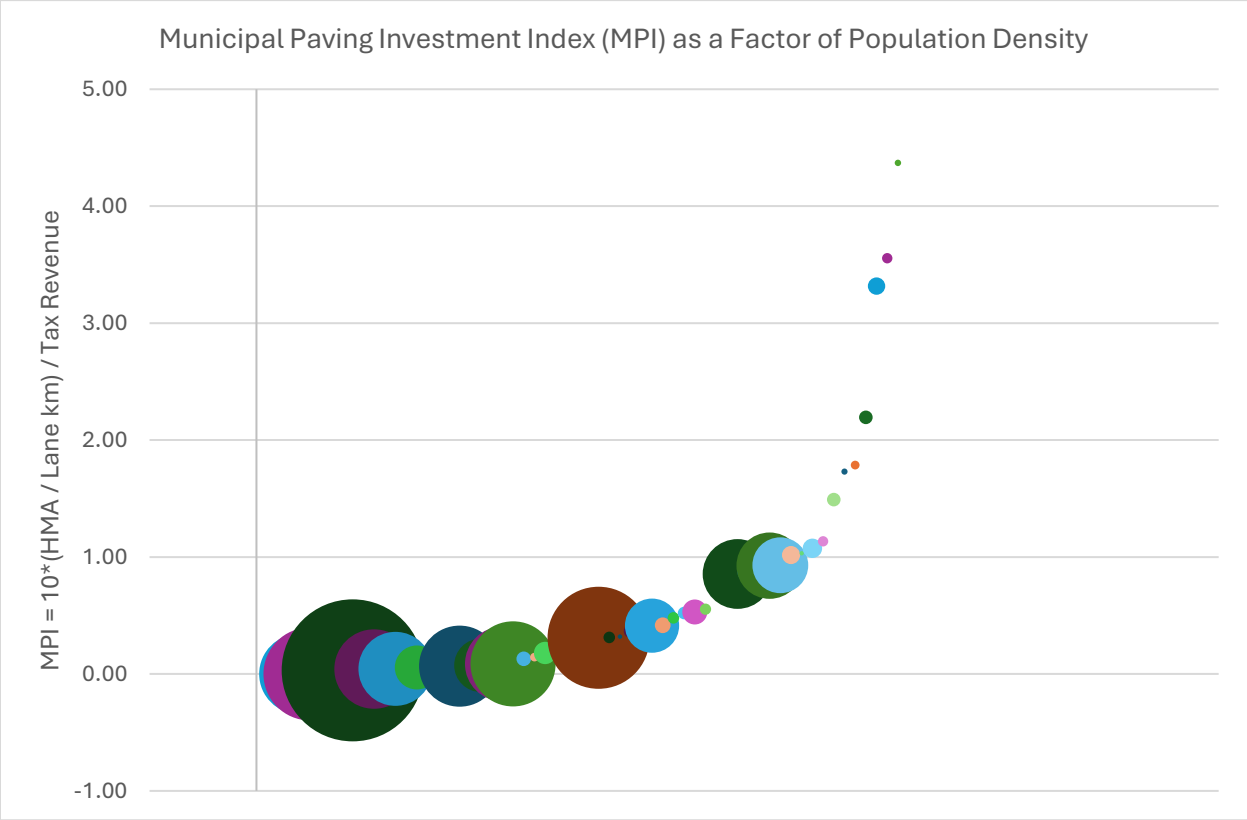


*Figure 3 - Municipalities with Smaller Population Density (Rural) Allocating More Revenue-Share Towards Paving Than Larger Population Municipalities (bubble size represents population density)*

To better visualize the drivers behind the MPI index, **Figure 3** plots 2025 Paving Renewal Intensity (HMA Tonnes per Lane Km) against Municipal Fiscal Capacity (Annual Tax Levy). The resulting scatter plot, with bubble sizes representing population, is divided into four quadrants based on median values for rural and for urban. It is important to note that these zones do not represent definitive performance thresholds, but rather serve as a **comparative framework** for individual municipalities paving investment relative to their peers:

- **Upper-Left (Fiscally Constrained / High Intensity):** This zone indicates an aggressive paving program relative to a limited tax base. These agencies are likely operating at the edge of their fiscal capacity to sustain current service levels.
- **Lower-Left (Resource Shortage / Low Intensity):** Municipalities in this quadrant lack both the revenue capacity and the current paving output of the peer group, representing a high risk for a widening infrastructure gap if external funding is not secured.
- **Upper-Right (Well-Funded / High Intensity):** Typically, larger urban or high-growth centers, these municipalities leverage a strong tax base to support high-volume renewal, indicating a current state of alignment between revenue and asset activity.
- **Lower-Right (Resource Abundance / Under-Investing):** This zone identifies municipalities with significant fiscal capacity reporting relatively low paving outputs compared to the provincial average. This suggests available resources may be diverted to other priorities, potentially masking a growing deferred maintenance backlog.

When considering the full dataset collectively, rural municipalities appear more represented in the Lower-Right quadrant relative to urban municipalities, suggesting that, in aggregate, rural jurisdictions may exhibit comparatively higher renewal intensity relative to their tax base compared to urban municipalities. This pattern aligns with the higher average MPI values observed among rural municipalities. However, when the rural and urban samples are examined independently using their respective central tendency thresholds, the quadrant distributions become more similar across groups.

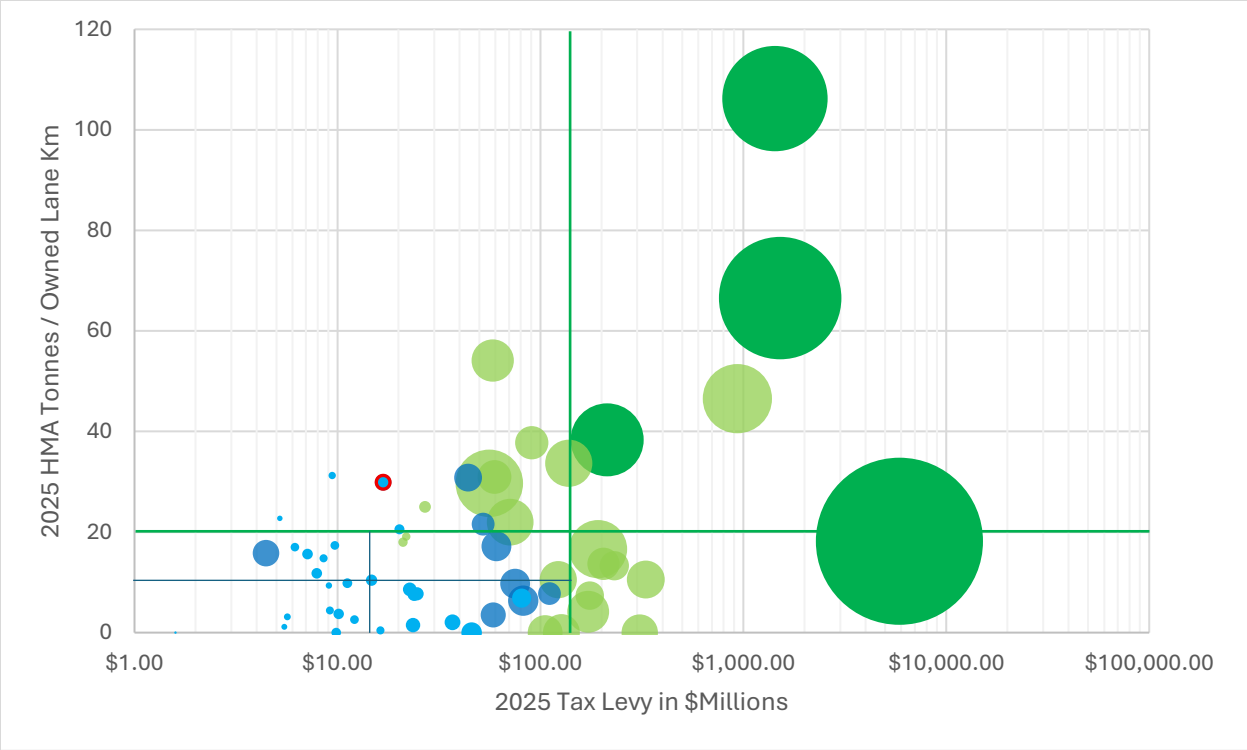


*Figure 4 - Comparison of HMA paving renewal intensity and fiscal capacity across municipalities, with population reflected in the bubble size*

*Table 1 - Percent of Municipalities in Each Quadrant of Figure-3*

| | LOWER LEFT | LOWER RIGHT | UPPER LEFT | UPPER RIGHT | Avg MPI |
|---|---|---|---|---|---|
| URBAN | 5 (21%) | 8 (33%) | 7 (29%) | 4 (17%) | $2.7 \times 10^{-2}$ |
| RURAL | 9 (26%) | 12 (34%) | 9 (26%) | 5 (14%) | $9.3 \times 10^{-2}$ |

While the comparative results above provide useful insight into how municipalities position themselves relative to their peers, additional analysis is needed to understand what MPI values mean in practical terms. The following section therefore examines **paving renewal periods compared to current investment under the lens of the MPI Index**. By analyzing three municipalities in greater detail, their theoretical paving renewal cycle is compared with their current paving activity to better interpret how MPI values relate to long-term infrastructure sustainability.

Municipality **D3** was selected for a deeper look into the network and road asset management practice. This municipality is highlighted in Red border in **Figure-4.** The municipality of **D3** is classified as Rural based on its population and population density according to the definition Government of Ontario (2025). However, it falls between Urban and Rural classification based on population and road network. It's population density of 82.7 is close to the Urban threshold of 100 people/km$^2$ and its road network

consists of 64% Urban-Road environment, while the total population of 27,000 falls way under a 100,000 threshold of Urban classification.

In 2025, the municipality reported paving 12,000 tonnes of HMA (Mneina, et. al, 2025). With a road network of 401 paved lane km out of total 665 lane km, the Municipal Paving Intensity index is 2.71 putting it in the Upper-Right rural quadrant reflecting high-paving intensity compared to other rural municipalities according to the proposed framework.

However, a closer look into **D3**'s pavement management practices revealed that this jurisdiction's pavement management program was - in reality - significantly underfunded. The 2025 road needs study identified a required minimum funding of $4.7M for rehabilitation and $9.7M for annualized reconstruction costs are needed to maintain the current state of road infrastructure, however the municipality's ongoing pavement management budget was $3M. The road needs study recommendations translate to 11,155 HMA tonnes/yr for overlay and minor rehab work in addition to 10,779 HMA tonnes/yr for reconstruction work, which adds up to 21,934 HMA tonnes / year. Contrary to what the MPI index revealed, D3 was 9,934 HMA tonnes/year short of meeting the minimum requirements for maintaining their road network from further degrading. Therefore, D3 is actually underfunding it's road management program.

The MPI index was found to be not appropriate to capture the paving renewal investment practices. The HMA tonnage metric in the index could be reflecting the municipality's road network expansion rather than rehabilitation work which could also falsely influence the network's average PCI. Also, we've found that many rural and semi-urban municipalities have a large percentage of gravel and surface treated roads in their networks which affects the accuracy of the HMA tonnage metric in the MPI index.

## CONCLUSION

This study explored the feasibility of developing and using the Municipal Paving Investment (MPI) Index as a simplified framework for relating municipal paving activity to available fiscal capacity. By normalizing HMA paving tonnage by lane-kilometre and municipal tax levy, the proposed index aimed to provide a simple way to compare paving investment intensity across municipalities with substantially different network sizes and revenue capacities.

The results demonstrate that the MPI can provide useful comparative information and reveal differences in paving investment patterns across municipalities. Rural municipalities generally exhibited higher MPI values than urban municipalities, although the distribution within each group was relatively diverse. The quadrant analysis further demonstrated how paving renewal intensity and fiscal capacity can be viewed together to provide a broader context for interpreting municipal investment patterns.

However, the detailed analysis of individual municipalities demonstrated an important limitation of the index. A MPI value did not accurately capture how a municipality is adequately funding its road network. In the case examined, a relatively high MPI was observed despite the municipality's road needs study identifying a substantial shortfall. This illustrates that HMA tonnage alone may not be a representative metric, particularly where network expansion, other pavement materials, or differences in rehabilitation requirements influence reported paving activity.

Overall, the study demonstrates the potential value of linking observable infrastructure renewal activity with municipal fiscal capacity while highlighting the need for additional variables and validation before any metric or index can be considered a universally applicable benchmark. The proposed framework provides a basis for further investigation into whether differences in municipal infrastructure outcomes are primarily associated with funding capacity, investment prioritization, or the underlying characteristics of the road network.

## APPENDIX

| Municipality | HMA 2025 (Tonnes) | LANE KM (Km) | POPULATION (People) | TAX LEVY 2025 ($M) | MPI (Tonne/Lane Km / $M) |
|---|---|---|---|---|---|
| A1 | 269,000 | 14,804 | 2,794,356 | $ 5,877 | 0.003 |
| A2 | 105,000 | 1,578 | 1,500,000 | $ 1,519 | 0.04 |
| A3 | 368,800 | 3,472 | 1,109,909 | $ 1,432 | 0.07 |
| A4 | 64,835 | 1,691 | 533,169 | $ 213 | 0.18 |
| B1 | 100,000 | 2,149 | 479,650 | $ 935 | 0.05 |
| B2 | 47,000 | 1,583 | 455,526 | $ 56 | 0.53 |
| B3 | 30,000 | 1,807 | 338,503 | $ 192 | 0.09 |
| B4 | 45,000 | 1,336 | 222,726 | $ 138 | 0.24 |
| B5 | 9,600 | 437 | 218,500 | $ 71 | 0.31 |
| B6 | 88,000 | 1,626 | 179,100 | $ 58 | 0.93 |
| B7 | 4,800 | 1,156 | 175,383 | $ 172 | 0.02 |
| B8 | 11,885 | 1,126 | 143,740 | $ 331 | 0.03 |
| B9 | 10,350 | 983 | 138,479 | $ 123 | 0.09 |
| B10 | - | 1,135 | 136,803 | $ 127 | 0.00 |
| B11 | 4 | 1,797 | 132,485 | $ 309 | 0.00 |
| B12 | - | 813 | 121,436 | $ 106 | 0.00 |
| B13 | 60,740 | 1,962 | 114,000 | $ 59 | 0.52 |
| B14 | 48,000 | 1,271 | 110,862 | $ 91 | 0.42 |
| B15 | 14,244 | 1,041 | 104,688 | $ 205 | 0.07 |
| B16 | 25,000 | 1,880 | 85,598 | $ 231 | 0.06 |
| B17 | 6,800 | 924 | 81,032 | $ 175 | 0.04 |
| B18 | 5,377 | 215 | 13,882 | $ 27 | 0.93 |
| B19 | 2,500 | 139 | 8,780 | $ 21 | 0.85 |

| | | | | | | |
|---|---|---|---|---|---|---|
| C1 | 11,105 | 1,748 | 92,013 | $ | 82 | 0.08 |
| C2 | 20,000 | 1,165 | 89,333 | $ | 61 | 0.28 |
| C3 | 10,000 | 1,027 | 89,000 | $ | 75 | 0.13 |
| C4 | 34,960 | 1,134 | 77,454 | $ | 44 | 0.70 |
| C5 | 9,324 | 590 | 70,546 | $ | 4 | 3.56 |
| C6 | 5,000 | 1,140 | 63,000 | $ | 59 | 0.14 |
| C7 | 12,470 | 578 | 52,293 | $ | 52 | 0.41 |
| C8 | 8,000 | 1,031 | 51,553 | $ | 111 | 0.07 |
| D1 | - | 375 | 42,200 | $ | 46 | 0.00 |
| D2 | 8,000 | 1,146 | 36,707 | $ | 81 | 0.08 |
| **D3** | **12,000** | **401** | **26,999** | **$** | **17** | **2.71** |
| D4 | 900 | 439 | 24,862 | $ | 37 | 0.06 |
| D5 | 965 | 647 | 20,867 | $ | 24 | 0.06 |
| D6 | 13,800 | 1,604 | 18,646 | $ | 23 | 0.38 |
| D7 | 6,166 | 808 | 18,062 | $ | 24 | 0.32 |
| D8 | 4,500 | 583 | 17,262 | $ | 25 | 0.31 |
| D9 | 9,500 | 911 | 12,808 | $ | 15 | 0.71 |
| D10 | 6,000 | 384 | 11,260 | $ | 7 | 2.19 |
| D11 | 5,000 | 424 | 11,260 | $ | 8 | 1.49 |
| D12 | 1,000 | 269 | 10,942 | $ | 10 | 0.37 |
| D13 | 9,000 | 438 | 10,033 | $ | 20 | 1.02 |
| D14 | 5,200 | 529 | 9,512 | $ | 11 | 0.88 |
| D15 | - | 23 | 9,292 | $ | 10 | 0.00 |
| D16 | 12,000 | 692 | 7,576 | $ | 10 | 1.79 |
| D17 | 1,300 | 503 | 7,576 | $ | 12 | 0.21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| D18 | 1,400 | 118 | 7,353 | $ | 6 | 2.75 |
| D19 | 5,913 | 400 | 6,588 | $ | 9 | 1.73 |
| D20 | 338 | 767 | 6,588 | $ | 16 | 0.03 |
| D21 | 2,255 | 512 | 6,372 | $ | 9 | 0.48 |
| D22 | 5,000 | 160 | 5,364 | $ | 9 | 3.32 |
| D23 | 800 | 255 | 4,700 | $ | 6 | 0.55 |
| D24 | 9,600 | 1,025 | 4,078 | $ | 9 | 1.03 |
| D25 | 675 | 588 | 3,496 | $ | 5 | 0.21 |
| D26 | 10,000 | 440 | 2,990 | $ | 5 | 4.37 |
| D27 | - | 206 | 586 | $ | 2 | 0.00 |

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