

# Appendix O: Needs – Signs and Pavement Markings



Kentucky's Long-Range  
Transportation Vision



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## INTRODUCTION

This technical memo summarizes the Kentucky Transportation Cabinet's (KYTC) spending needs for sign and pavement marking maintenance between 2022-2045. The technical memo has three primary sections including this Introduction. The Methodology section describes the data used in the needs assessment, assumptions, and data processing steps. The Results section presents the needs. Unless otherwise stated, all dollar amounts are in 2022 U.S. dollars (USDs).

## METHODOLOGY

### Overview

The following steps allow for pavement marking and sign maintenance needs to be estimated. First, historical spending for sign and pavement marking maintenance is converted to constant 2022 USDs and used to extrapolate baseline needs. These needs are adjusted for other factors, which may affect spending in ways that are not reflected in historical data, such as policy changes related to striping width, and the increasing use of thermoplastics. These components of sign and pavement marking maintenance needs are added to the baseline extrapolation to estimate total needs. The following sections detail each of these steps.

### Data Sources

Data on historical maintenance spending for signs and pavement markings is extracted from the Operations Management System (OMS) and for the state-owned non-rural secondary system, and from the KYTC Office of Budget and Fiscal Management (OBFM) for the rural secondary system under FE01. Please see the Appendix M for details about these data sets and processing steps. Analysis by KYTC has shown the decline in its maintenance budget's purchasing power between 2012 and 2017, and this decline is used as the basis to estimate currently unfunded needs for some maintenance categories, including signs. Currently unfunded pavement marking needs were estimated by KYTC subject matter experts. The Consumer Price Index (CPI) from the U.S. Bureau of Labor Statistics is used to calculate past inflation and convert historical spending from year-of-expenditure to constant 2022 USDs, while several KYTC data sets related to the extent of the state-owned system are used to estimate the shares of the state-owned system subject to changes in pavement marking policies. A report from the Federal Highway Administration (FHWA) serves to estimate changes in striping costs associated with KYTC's policy changes regarding striping width. Finally, conversations with KYTC subject matter experts provided guidance, context, and additional resources for the analysis. The primary data sources used in this analysis are in Table 1.

Table 1: Primary Data Sources

Description	Source	Purpose in Methodology
Historical maintenance spending between fiscal years (FY) 2006 and 2020 (in-house labor, equipment, and materials for state-owned non-rural secondary system) and FYs 2007 and 2021 (rural secondary system using FE01)	State-owned non-rural secondary system <ul style="list-style-type: none"> <li>• <b>In-house labor, equipment, and material costs:</b> Operations Management System (OMS)<sup>1</sup></li> <li>• <b>Contract costs:</b> OMS</li> </ul> Rural secondary system <ul style="list-style-type: none"> <li>• KYTC Office of Budget and Fiscal Management (OBFM)</li> </ul>	Establish trends in historical maintenance spending as basis for extrapolating baseline maintenance needs.
Spending by activity code for FE01 for FY 2021.	KYTC Office of Budget and Fiscal Management (OBFM)	Divide FE01 spending into categories (e.g., pavement marking, signs)
District striping contracts from FY 2013 to FY 2021	KYTC Construction Procurement Website <sup>2</sup>	Estimate pavement marking contract costs
Decline in KYTC maintenance budget's purchasing power between 2012 and 2017.	One-Pager on the Allocation of KYTC Maintenance Budget <sup>3</sup>	Estimate sign maintenance need that is not met by historically derived spending trends.
Multiplier to convert historical amounts to 2021 USDs based on Consumer Price Index (CPI).	U.S. Bureau of Labor Statistics <sup>4</sup>	Convert historical spending to 2021 USDs
Statewide travel demand model network shapefile	Kentucky Transportation Cabinet <sup>5</sup>	Estimate share of state-owned highways affected by striping policy change widening striping from 4 inches to 6 inches.
Shapefile of state-owned roadway systems	Kentucky Transportation Cabinet <sup>6</sup>	
Comparison of labor and material costs for striping	Federal Highway Administration <sup>7</sup>	Estimate share of maintenance costs that may be impacted by policy change.

<sup>1</sup> Provided by Aaron Collins on December 1, 2021.

<sup>2</sup> <https://transportation.ky.gov/Construction-Procurement/Pages/default.aspx>.

<sup>3</sup> Kentucky Transportation Cabinet (2021). Allocation of KYTC Maintenance Budget. One-Pager. Provided by Assistant State Highway Engineer (Tracy Nowaczyk) on November 29, 2021.

<sup>4</sup> U.S. Bureau of Labor Statistics (n.d.). CPI Inflation Calculator. Retrieved from [https://www.bls.gov/data/inflation\\_calculator.htm](https://www.bls.gov/data/inflation_calculator.htm).

<sup>5</sup> Kentucky Transportation Cabinet (2020). "Statewide mileage report." Updated April 2, 2020. Retrieved from <https://transportation.ky.gov/Planning/Pages/State-Primary-Road-System.aspx>.

<sup>6</sup> Kentucky Transportation Cabinet (n.d.). "Download GIS Shapefile of SPRS data." Retrieved from <https://transportation.ky.gov/Planning/Pages/State-Primary-Road-System.aspx>.

<sup>7</sup> Federal Highway Administration (2005). *Enhanced Night Visibility Series: Phase II—Cost-Benefit Analysis*. Report number FHWA-HRT-04-142. Retrieved from <https://trid.trb.org/view/804698>

## Assumptions

The following primary assumptions ground the analysis.

- The currently unfunded need for sign maintenance is approximately equal to the unfunded need for highway maintenance, which was approximated based on the lost purchasing power for KYTC's maintenance budget between 2012 and 2017.<sup>8</sup>
- Inflation will average 6.0% between calendar years 2021 and 2022, 3.0%<sup>9</sup> from 2022 to 2024, and 2.0% subsequently. The first two rates are provided by the 1-year and 3-year inflation expectations reported by the Federal Reserve Bank of New York.<sup>10</sup>
- The resurfacing contract is approximately 10% the cost of the total striping contract.

## Processing

### Estimate Baseline Signs and Pavement Marking Needs Derived from Historical Spending

Maintenance spending for signs and pavement marking is extrapolated from historical spending and adjusted in accordance with the CPI index to account for lost purchasing power. The processes are summarized below. Table 2 shows the baseline sign and pavement marking needs resulting from these steps.

Table 2: 2022-2025 Baseline Sign and Pavement Marking Maintenance Needs (2022 USDs)

Category	Baseline Historically Derived Needs
Signs	\$348,732,184
Pavement Markings	\$268,517,813

<sup>8</sup> Kentucky Transportation Cabinet (2021). Allocation of KYTC Maintenance Budget. One-Pager. Provided by Assistant State Highway Engineer (Tracy Nowaczyk) on November 29, 2021.

<sup>9</sup> As of December 20, 2021, the 3-year inflation expectations reported by the Federal Reserve Bank of New York are 4.0%, while the 1-year inflation expectations are 6.0%. 3.0% is the inflation rate used for 2023-2024 and 2024-2025 because the average of two years of 3.0% inflation with one year of 6.0% inflation equals 4.0%, which is the 3-year inflation expectation.

<sup>10</sup> Federal Reserve Bank of New York (2021). Inflation Expectations. Accessed December 20, 2021. Retrieved from <https://www.newyorkfed.org/microeconomics/sce#/inflexp-1>.

## Categorize Historical Maintenance Spending by Activity Code

Each OMS activity code was matched with a key word to group similar activities together. Subappendix A shows the alignment between each of these key words and the OMS activity codes. Similarly, FE01 activity codes were matched with one following key words shown in Subappendix B. For this needs category, only key words associated with signs and pavement markings were retained.

## Convert Historical Spending to 2022 USDs

Historical OMS and FE01 spending are converted from year of expenditure to 2022 USDs by applying multipliers derived from the CPI Inflation Calculator to convert the amounts to 2021 USDs, and then assuming a 6.0% inflation rate between 2021 and 2022 to convert to 2022 USDs. The multipliers go from July in the year of expenditure to July 2021. Historical spending was originally reported in fiscal years rather than calendar years. Therefore, annual fiscal year spending was converted to annual calendar year spending prior to conversion to 2022 USDs by assigning half of the fiscal spending to the same calendar year and half to the next calendar year.

## Extrapolate Historical Maintenance Spending

### In-House Costs for State-Owned Non-Rural Secondary Roads

2006-2020 spending in constant 2022 USDs for each sign and pavement preservation maintenance is linearly extrapolated through 2045. When linear extrapolation leads to a decrease in annual signs or pavement preservation needs, they are replaced with the average spending between 2006 and 2020 in 2022 USDs.

### Rural Secondary Roads

Total FE01 historical spending in constant 2022 USDs is linearly extrapolated through 2045. The extrapolated annual spending amounts are converted from total spending to the spending categories based on the share of FE01 FY 2021 spending that is associated with each category. The share for each category is multiplied by the extrapolated annual spending. Table 3 shows the spending share by activity category. The maintenance need for each year is the share of categories included in the maintenance need as listed in Table 3 times the FE01 spending for that year. The total maintenance need for the rural secondary system between 2022 and 2045 is the sum of the relevant annual needs between these years.

Table 3: Share FY 2021 FE01 Spending on the Rural Secondary System by Category

Category	Share
Signs	0.86%
Pavement Markings	5.53%

### Estimate Contract Costs

Contract costs for signs are estimated by multiplying the baseline historically derived needs by the multiplier that was derived for signs. The multiplier was derived for FY2011-2020 based on the difference between reported total costs and in-house costs for labor, equipment, and materials. Contract costs are 1% of sign spending. Using the equation below, the multipliers derived for signs and pavement spending are 1% and 188% respectively.

$$\text{multiplier} = \frac{\text{average}}{1 - \text{average}}$$

Where,

- *average* is the FY2011-2020 average of contract costs to total costs for the given category (i.e., signs, pavement markings).

Contract costs for pavement markings are derived from historical long-line striping contract amounts. Contract amounts from 2013 to 2021 were converted to 2022 USDs using a multiplier derived from the U.S. Bureau of Labor Statistics' CPI Inflation Calculator and linearly extrapolated through 2045. The contracts do not include striping done within resurfacing work, which is estimated to be 10% of the total amount,<sup>11</sup> so the extrapolated amounts are grown by 11.11% to make them equal to 10% of the total.

### **Pavement Marking – Adjust Needs for Striping after Road Widening**

Road widening projects and new routes will increase the amount of pavement markings that need to be maintained. A multiplier to account for costs associated with new roads being built and existing roads being widening was derived. Between 1980 and 2020, the population in the United States has grown at 4.22 times the rate of the number of lane-miles.<sup>12</sup> Assuming that this difference in the rate of population growth and lane-mile growth is accurate and remains accurate in Kentucky, then the forecasted 8.93% population growth in Kentucky between 2021 and 2045 may be associated with a growth in lane-miles of 2.12%. This growth in lane-miles of course depends on KYTC's investment decisions in the interim. Baseline pavement marking needs and contract costs for pavement marking are multiplied by half of 2.12% to account for the fact that lane-mileage will be added progressively over the forecast period.

### **Pavement Marking – New Need Associated with Striping Width Policy Change**

KYTC has recently changed its policies regarding striping width. Whereas previously all stripes were 4 inches wide, now striping on Interstates, Parkways, State Primary routes, and other state-owned roads where Average Daily Traffic (ADT) exceeds 1,000 will receive 6-inch stripes. This

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<sup>11</sup> Email from Charlie Briggs, March 23, 2022.

<sup>12</sup> This rate was determined by comparing decennial national population counts from the U.S. Census Bureau (U.S. Census Bureau (2021). Population Change. Retrieved from <https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html>) and estimated lane-mileage from the Bureau of Transportation Statistics (Bureau of Transportation Statistics (2021). Estimated U.S. Roadway Lane-Miles by Functional System. Retrieved from <https://www.bts.gov/content/table-1-6-estimated-us-roadway-lane-miles-functional-systema>).

policy will increase material costs for affected roadways without significantly affecting labor or equipment costs. Since it is a recent change, most historical spending reflects costs associated with 4-inch stripes.<sup>13</sup>

To estimate the increase in pavement marking needs associated with the striping width policy change, it is necessary to estimate the share of state-owned lane-miles likely to be affected by the change in policy, estimate the share of pavement marking costs associated with materials instead of labor or equipment, and then pair these percentages with the 50.0% increase in material costs brought about by 50.0% wider striping on affected striping. The team estimated the number of lane-miles affected by the policy by assigning the number of lanes from the statewide travel demand model network to the shapefile of state-owned roadway systems using a 10-foot buffer around the travel demand model network. When a segment from the state-owned roadway systems file<sup>14</sup> intersected the buffer for more than one travel demand model segment, then the number of lanes of all applicable segments were averaged. The share of lane-miles affected by the new policy is the estimate lane-mileage of Interstates, Parkways, and State Primary roads (16,935) divided by the total estimated lane-mileage (61,348), with the result being 27.6%. Table 4 shows the mileage by roadway system. The condition of ADT exceeding 1,000 was not accounted for because ADT was not available at the segment level.

Table 4: Mileage by Roadway System

System	Estimated Lane-Miles	Striping-Width
Interstate	4,061	6"
Parkway	2,224	6"
State Primary	10,650	6"
State Secondary	16,050	4" unless ADT > 1,000
Rural Secondary	25,277	4" unless ADT > 1,000
Supplemental Roads	3,086	4" unless ADT > 1,000
<b>Total</b>	<b>61,348</b>	<b>Not applicable</b>

Note: Rows may not sum due to rounding.

Next, the share of striping costs associated with materials is estimated. A Federal Highway Administration (FHWA) report<sup>15</sup> has provided low-end and high-end material and labor unit costs for white and yellow conventional thermoplastic and conventional paint pavement markings. These unit

<sup>13</sup> Meeting with Brian Schroeder, Charlie Briggs, and Andrew Mitchell, KYTC, on November 29, 2021.

<sup>14</sup> Kentucky Transportation Cabinet (2020). "Statewide mileage report." Updated April 2, 2020. Retrieved from <https://transportation.ky.gov/Planning/Pages/State-Primary-Road-System.aspx>.

<sup>15</sup> Federal Highway Administration (2005). *Enhanced Night Visibility Series: Phase II—Cost-Benefit Analysis*. Report number FHWA-HRT-04-142. Retrieved from <https://www.fhwa.dot.gov/publications/research/safety/humanfac/04142/costest.cfm>.

costs are in Table 5. The material share of total unit costs was calculated for each combination, and the average was taken. The result is that 25.4% of unit costs are for materials and 74.6% are for labor and equipment.<sup>16</sup>

Table 5: Striping Unit Costs

	Unit Costs of Conventional Thermoplastic				Unit Costs of Conventional Paint			
	White Conventional Thermoplastic		Yellow Conventional Thermoplastic		White Conventional Paint		Yellow Conventional Paint	
	Low-end	High-end	Low-end	High-end	Low-end	High-end	Low-end	High-end
Material Cost	0.096	0.126	0.096	0.126	0.0097	0.0104	0.0122	0.0133
Labor and Equipment Cost	0.2	0.2	0.2	0.2	0.0635	0.0635	0.0635	0.0635
Material Share	32.4%	38.7%	32.4%	38.7%	13.3%	14.1%	16.1%	17.3%
Labor and Equipment Share	67.6%	61.3%	67.6%	61.3%	86.7%	85.9%	83.9%	82.7%

Finally, the change in pavement marking maintenance needs due to the striping width policy change is estimated by multiplying the share of state-owned lane-miles that are affected by the policy change, the share of striping costs associated with materials (25.4%), and the increase in material costs for striping for roads affected by the change in policy (50.0%). The resulting cost increase of 4.1% is multiplied by baseline pavement striping maintenance needs to estimate the change in needs due to the policy change.

### Pavement Marking – Need Reduction due to Thermoplastics

KYTC is starting to use thermoplastic markings on many Interstates, Parkways, and Primary Routes. While their costs are five to six times higher than conventional striping, they are expected to last much longer than conventional paint, with restriping required only once every four to eight years.<sup>17</sup> This may lower overall costs compared with conventional paint, which can require restriping as often as annually. Assuming that thermoplastic unit costs are six times higher than for conventional paint, and that thermoplastic striping will last eight times as long as conventional striping on average, this produces a reduction in cost of 25.4% for relevant roads ( $1 - (6 \text{ times the cost} / 8 \text{ years to restripe})$ ). An estimated 27.6% of the state-owned network by estimated lane-miles is eligible for thermoplastics since Interstates, Parkways, and State Primary

<sup>16</sup> Federal Highway Administration research groups equipment and labor costs together. FHWA (2005). *Enhanced Night Visibility Series: Phase II–Cost-Benefit Analysis*. Report number FHWA-HRT-04-142. Page 11. Retrieved from <https://www.fhwa.dot.gov/publications/research/safety/humanfac/04142/costest.cfm>.

<sup>17</sup> Meeting with Brian Schroeder, Charlie Briggs, and Andrew Mitchell, KYTC, on November 29, 2021.

Roads are eligible. The reduction in needs is described by the following equation. This reduction is subtracted from baseline pavement marking needs.

$$\text{cost reduction} = (\text{historical need} + \text{widening need}) \times \left(1 - \frac{6 \text{ times the cost}}{8 \text{ years to restripe}}\right) \times 27.6\% \times 25.4\%$$

Where,

- *historical need* is the need derived by extrapolating historical spending in dollars.
- *widening need* is the need in dollars associated with widening some striping from 4 inches to 6 inches.
- 27.6% is the estimated share of state-owned lane-miles eligible for thermoplastics.
- 25.4% is the estimated share of pavement marking costs associated with materials (described on page 7).

### Pavement Marking – Additional Unfunded Needs

There are additional pavement marking needs that are not currently able to be funded, which are estimated to be between \$5 and \$10 million annually.<sup>18</sup> The middle of this range (\$7.5 million) is applied to all years between 2022 and 2045 to estimate the currently unfunded need for pavement marking.

### Signs – Additional Unfunded Needs

Baseline sign maintenance needs are multiplied by 33.4% to estimate the lost purchasing power for KYTC's maintenance spending between 2012 and 2017. For details on the calculation of this multiplier, please see Appendix M.

## RESULTS

Twenty-four year needs for signs and pavement markings are \$1.47 billion. Sixty-eight percent is for pavement markings, and the remainder (32.0%) is for signs. Table 6 summarizes needs associated with signs and pavement markings by category, where the categories match the processing steps. The plurality of needs (46.9%) are derived from historical spending, with the remainder coming from contract costs, adjustments to account for currently unfunded needs, or policy changes associated with striping.

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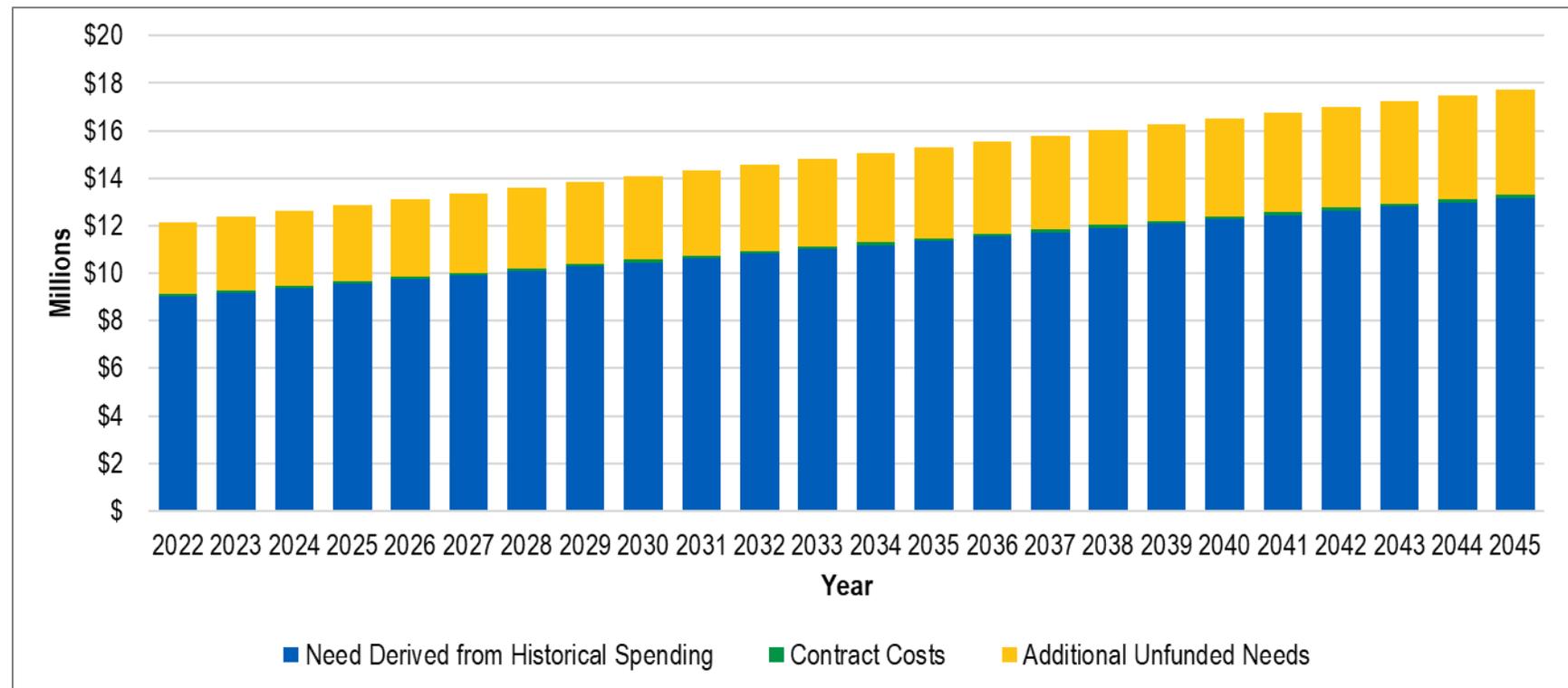
<sup>18</sup> Meeting with Brian Schroeder, Charlie Briggs, and Andrew Mitchell, KYTC, on November 29, 2021.

Table 6: Summary of Sign and Pavement Marking Needs (Millions of 2022 USDs)

Category	Baseline Need Derived from Historical Spending	Contract Costs	Need Associated with Striping Width Policy Change	Need Reduction due to Thermoplastics	Additional Unfunded Needs	Total
Signs	\$266.30	\$2.75	Not applicable	Not applicable	\$89.87	\$358.92
Pavement Markings	\$302.38	\$635.61	\$10.59	\$(13.28)	\$180.00	\$1,115.30
<b>Total</b>	<b>\$568.68</b>	<b>\$638.36</b>	<b>\$10.59</b>	<b>\$(13.28)</b>	<b>\$269.87</b>	<b>\$1,474.21</b>

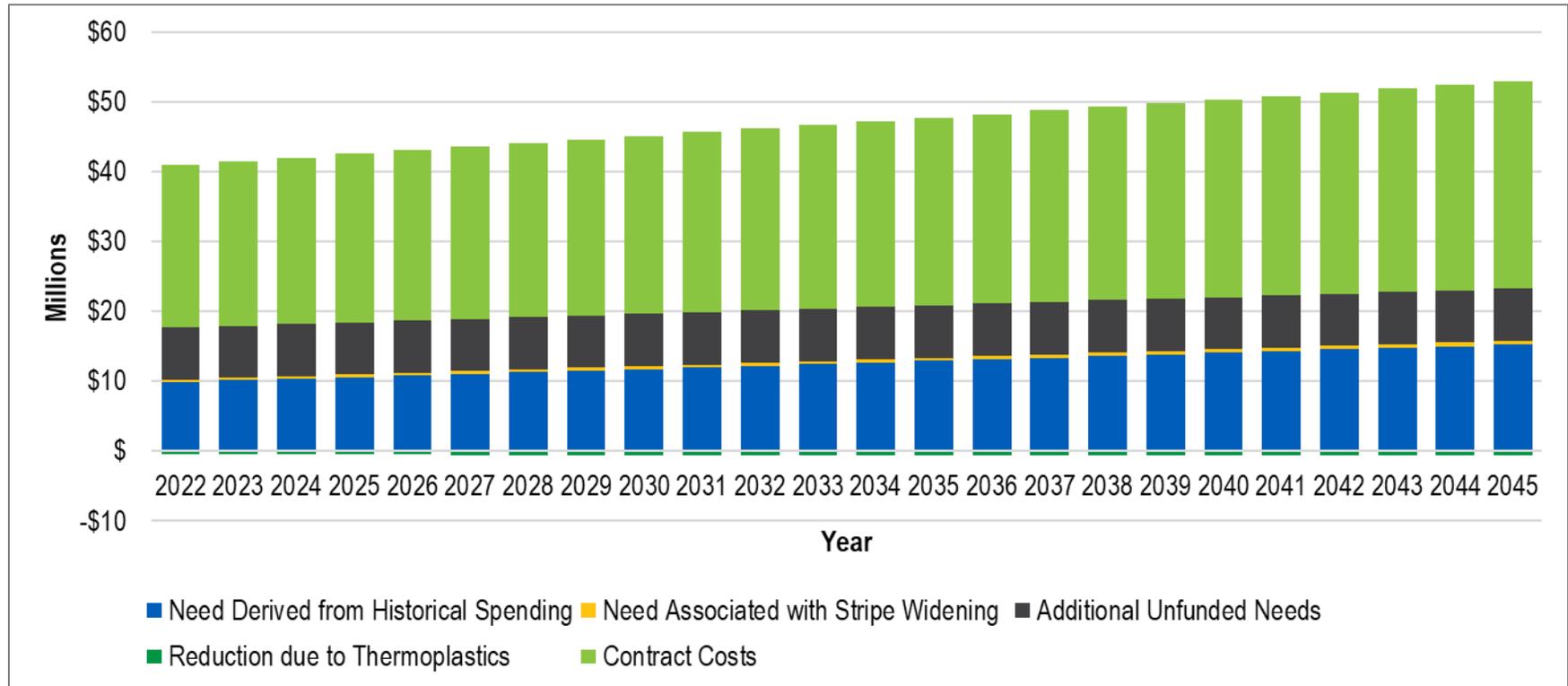
Figure 1 shows annual sign maintenance needs. These range from a low of \$12.16 million in 2022 to \$17.75 million in 2045. They reflect a steady increase which has been observed in historical spending for sign maintenance.

Figure 1: Annual Sign Maintenance Needs (2022 USDs)



Total needs for pavement marking maintenance are estimated at \$1.12 billion. Annual needs are increasing under the pressure of rising material and fuel costs. Annual needs range from \$40.57 million in 2022 to \$52.37 million in 2045, representing a 29.1% increase. Thermoplastics reduce needs by 1.2% compared with what they would otherwise be. Figure 2 shows the annual pavement marking needs.

Figure 2: Annual Pavement Marking Needs (2022 USDs)





## SUBAPPENDIX A: ALIGNMENT BETWEEN OMS MAINTENANCE ACTIVITIES AND MAINTENANCE CATEGORIES

Activity	Activity Code	Category
1401 Painting Centerlines	T010	Pavement Markings
1401 Painting Centerlines	T011	Pavement Markings
1402 Painting Lane Lines	T020	Pavement Markings
1402 Painting Lane Lines	T021	Pavement Markings
1402 Painting Lane Lines	T022	Pavement Markings
1402 Painting Lane Lines	T023	Pavement Markings
1403 Painting Edge Lines	T030	Pavement Markings
1404 Hand-Placing Pavement Markings	T040	Pavement Markings
1405 Pavement Markings	T050	Pavement Markings
1406 Hand-Placing Pavement Markers	T060	Pavement Markings
1407 Hazard Delineation of Roadside Structures Requiring Reflectivity	T070	Pavement Markings
1408 Thermoplastic Pavement Markers	T080	Pavement Markings
1409 Painting Centerlines & Edge Lines	T100	Pavement Markings
1410 Painting Lane Lines & Edge Lines	T110	Pavement Markings
1410 Painting Lane Lines & Edge Lines	T180	Pavement Markings
1411 Traffic Contract Expenditures & Engineering Expenses for Pavement Marking Projects	T190	Pavement Markings
1412 Placement of New Sheeting Signs, Mileposts, & Posts	T200	Signs
1413 Replacement of Signs	T210	Signs
1414 Applying Reflective Sheeting	T220	Signs
1415 Sign Fabrication	T230	Signs
1416 Sign Maintenance	T240	Signs
1417 Maintenance of Panel-Type Signs	T250	Signs
1418 Placement of New Delineators	T260	Pavement Markings
1419 Delineator Maintenance	T270	Pavement Markings
1420 Traffic Contract Expenditures & Engineering Expenses for Traffic Signing Projects	T290	Signs
<i>Not in Field Operations Guide. Manually assigned.</i>	T640	Signs



Activity	Activity Code	Category
<i>Not in Field Operations Guide. Manually assigned.</i>	T650	Signs
<i>Not in Field Operations Guide. Manually assigned.</i>	T820	Signs
<i>Not in Field Operations Guide. Manually assigned.</i>	T900	Signs
<i>Not in Field Operations Guide. Manually assigned.</i>	T910	Signs

Note: This table includes activities in the *Field Operations Guidance Manual*.<sup>19</sup> Some activities present in the historical spending and absent from the *Field Operations Guidance Manual* were assigned manually.

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<sup>19</sup> Kentucky Transportation Cabinet (2011). *Field Operations Guidance Manual*. Retrieved from <https://transportation.ky.gov/Organizational-Resources/Pages/Policy-Manuals-Library.aspx>.



## SUBAPPENDIX B: ALIGNMENT BETWEEN FE01 MAINTENANCE ACTIVITIES, AND SIGNS AND PAVEMENT MARKINGS

Activity	Activity Code	Category
LONG-LINE STRIPING -WITH TRUCK	T010	Pavement Markings
S.F. 4" YELLOW	T020	Pavement Markings
S.F. 4" WHITE	T021	Pavement Markings
S.F. 6" YELLOW	T022	Pavement Markings
S.F. 6" WHITE	T023	Pavement Markings
HAND PLCD PVMT MRK	T040	Pavement Markings
RAISED P-MENT MARKS	T060	Pavement Markings
HZD DLN RDSD ST RF	T070	Pavement Markings
HAND PLACED PAVE MARKING-THERM	T080	Pavement Markings
PLCMNT NEW SHT SIG	T200	Signs
REPLACE SIGN & DEL	T210	Signs
SHEETING APPLICATION	T220	Signs
SIGN FABRICATION	T230	Signs
SIGN MAINTENANCE	T240	Signs
MAINT PANEL SIGNS	T250	Signs
PLACEMENT NEW DELN	T260	Pavement Markings
DELINEATOR MAINT	T270	Pavement Markings
TRAF CT SIGN PROJ	T290	Signs
RDWY SIGN INVTORY	T640	Signs