EnviroMedia Social Marketing, LLC

2016 Tennessee Statewide Litter Study

Final Report

October 2, 2016

nFront Consulting LLC
Power Industry Planners • Analysts • Advisors

October 2, 2016

Ms. Valerie Davis
EnviroMedia Social Marketing, LLC
2021 E. Fifth Street, Suite 150
Austin, TX 78702

Subject: 2016 Tennessee Statewide Litter Study, Final Report

Dear Ms. Davis:

EnviroMedia Social Marketing, LLC ("EnviroMedia") retained nFront Consulting, LLC ("nFront") to undertake a statewide litter study for the state of Tennessee over the period May 2016 – August 2016 (the "Study"). The Study was conducted based on sampling of 120 roadway segments, divided equally between four roadway classifications, specifically, Interstates, U.S. Highways, State Highways, and Local Roads. nFront coordinated closely with the Tennessee Department of Transportation ("TDOT") over the course of the Study on both logistical issues and the overall Study results and conclusions.

This comprehensive report ("Report") summarizes: (i) the purpose and objectives of the Study; (ii) our approach to Study execution, including development of the sample and logistics plan; (iii) our data collection and analysis methodologies; (iv) detailed results tables for litter per mile, litter composition, and brand name metrics, on both a statewide and by roadway classification basis (as applicable); and (v) the results of our econometric analysis and the key litter abatement policy findings (derived directly from the econometric results) associated with the Study.

The results and findings presented in this Report are reflective of prevailing conditions over the period during which litter data collection and analysis was conducted, specifically the period of May 2016 through August 2016. Changed conditions that occur or that become known after that period could affect the findings based on such changes. Refer to the Key Study Assumptions and Limitations subsection below for a complete listing of other factors that could have an impact on the results presented herein.

Respectfully submitted,

Robert L. Davis
Executive Consultant
nFront Consulting LLC

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EXECUTIVE SUMMARY

STUDY APPROACH

EnviroMedia retained nFront to undertake the Study over the period May 2016 through August 2016. The Study sought to identify and determine significant relationships between the roadside litter and site characteristics, including physical attributes, nearby business and infrastructure prevalence, and socioeconomic variables of the surrounding area, in order to foster actionable policy findings that will strengthen litter prevention efforts. The Study was conducted based on sampling of 120 roadway segments, divided equally between four roadway classifications, specifically, Interstates, U.S. Highways, State Highways, and Local Roads.

Within the Report, basic Study results have been categorized into the following broad range of outcomes associated with the collection of raw data for each of the 120 samples in the field.

- Reported estimates of litter per mile for each of the four roadway classifications as well as a statewide estimate of litter per mile, where litter per mile reflects an extrapolation based on the edge distance and the existence and length of the median for a given sample;
- Reported litter per mile as bifurcated into two key metrics, each of which was modeled separately in a downstream econometric analysis, as follows: (i) litter counted along the edge of the sample site only ("Visible Litter"), and (ii) litter counted along the edge of the sample site and all additional litter counted as part of the meander count ("Total Litter");
- A comparison of litter per mile estimates (both Visible Litter and Total Litter) from the Study to the database maintained during the 2006 Litter Study;
- A characterization of litter into one of 30 categories, with each of the 30 categories assigned a preponderance-based cause of either deliberate (intentional) or negligent (accidental) litter; and
- A count of the number of cigarette butts associated with each site, which has been averaged and presented herein for each roadway classification.

In addition to these basic results, the Study aimed to determine and catalogue, whenever possible, the brand name associated with each item of litter encountered in the field. The brand names were grouped and ranked, both on a roadway classification and total basis, and the top brand names encountered are presented and discussed herein. In order to enhance the insights associated with the brand names encountered, nFront also engaged in a brand-name cross-walk analysis that identified the most prevailing brand names in several "universes" of brands, and then researched estimated revenues for each brand (based on publically available sources) to derive "revenue adjusted" frequencies for each brand that reflect the relationship between revenue and counts encountered. In theory, there should be a strong relationship between the revenue of a brand (in relative terms within a given brand universe) and the frequency with which that brand was encountered in the litter stream. The purpose of the revenue adjusted values was to test this theory, such that the actual counts were divided by the relative revenue contribution to determine what brands were over-littered (or had a large raw count relative to their proportion of universe revenue) and what brands were under-littered (or had a small raw count relative to their proportion of universe revenue).

Brand universes were categorized based on readily discernable brand names and types of litter encountered across all samples, as follows.

- Fast food
- Alcoholic beverages
- Cigarette packaging
- Soda/soft drinks
- Snacks

The brand name analysis has certain key limitations, most notably that: (i) no large scale market research has been conducted and the analysis and determinations of brand universes has been executed at a planning-level; (ii) there is some chronological diversity and uncertainty in the revenue estimates derived from various sources, which has been assumed to have a limited impact on the top-level goal of this analysis; and (iii) revenue estimates are generally not available at the more granular state level, and consequently, the relationship between brand revenue nationwide has been assumed to reasonably reflect the extent to which such brands are consumed within the state of Tennessee. These limitations notwithstanding, the analysis does provide additional information that can be useful for understanding what brands are most susceptible to being littered.

BASIC STUDY RESULTS AND FINDINGS

Statewide Litter Prevalence

On an overall basis, Visible Litter and Total Litter have declined over the period 2006 to 2016 by 23% and 53%, respectively. This finding is consistent with the findings for individual roadway classifications (described more fully in the Report), wherein, with the exception of Interstates, litter per mile across roadway classifications has declined. This finding, coupled with the fact that Interstates do not represent a large portion of total roadway miles in the state, results in a statewide litter per mile metric that more closely resembles local roads than Interstates. Figure ES-1 compares estimated Visible and Total litter items, in millions of items, for the 2006 and 2016 litter studies.

As evidenced by Figure ES-1, Visible Litter has declined from an estimated 44 million items to an estimated 34 million items, and Total Litter has declined from an estimated 212 million items to an estimated 100 million items. ***It is critical to maintain the appropriate perspective regarding these estimates, as they are based on a weighted average derived from the total number of miles of each roadway classification in the state, which, as noted above, favors local roads.***

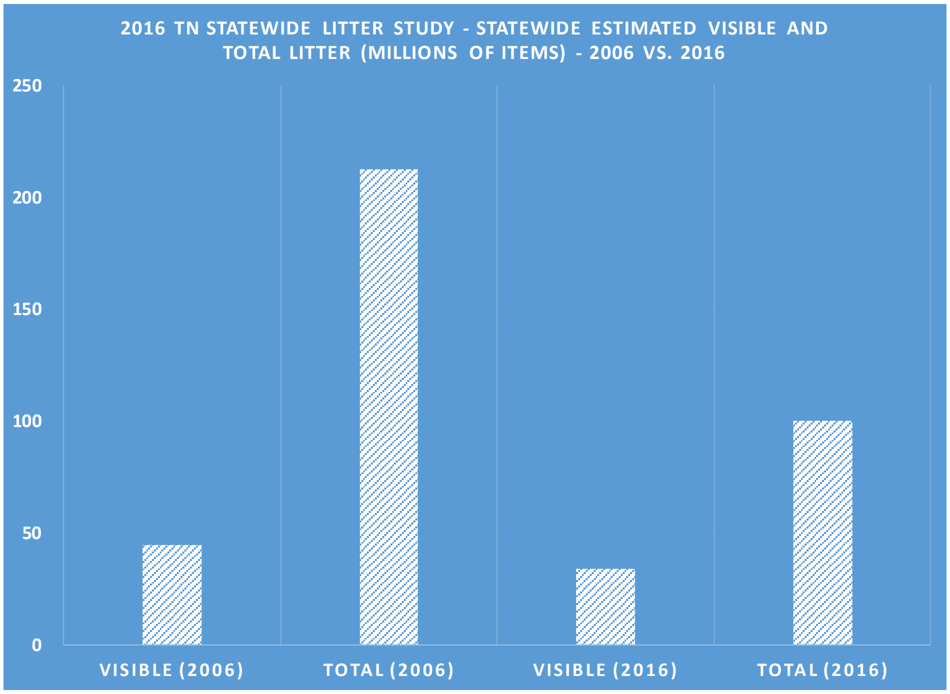

Figure ES-1 – Statewide Litter Prevalence Results

Litter Per Mile and Cigarette Butt Counts

Figures ES-2, ES-3, and ES-4 provide the results for both 2006 and the 2016 litter studies with respect to litter per mile, the split between negligent and deliberate litter, and the number of cigarette butts found by roadway classification.

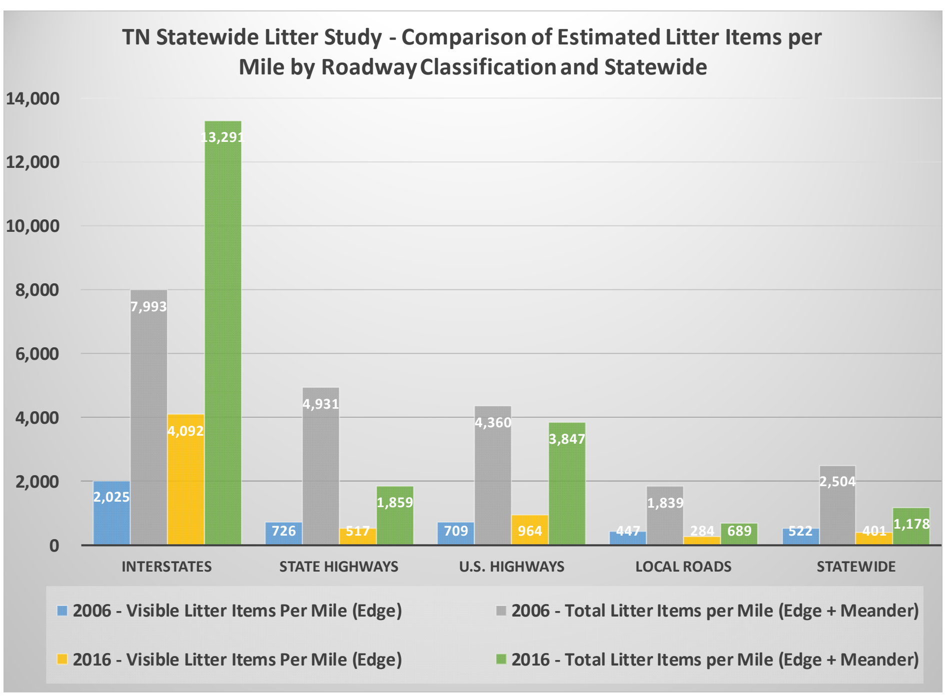

Figure ES-2 – Litter Per Mile Results

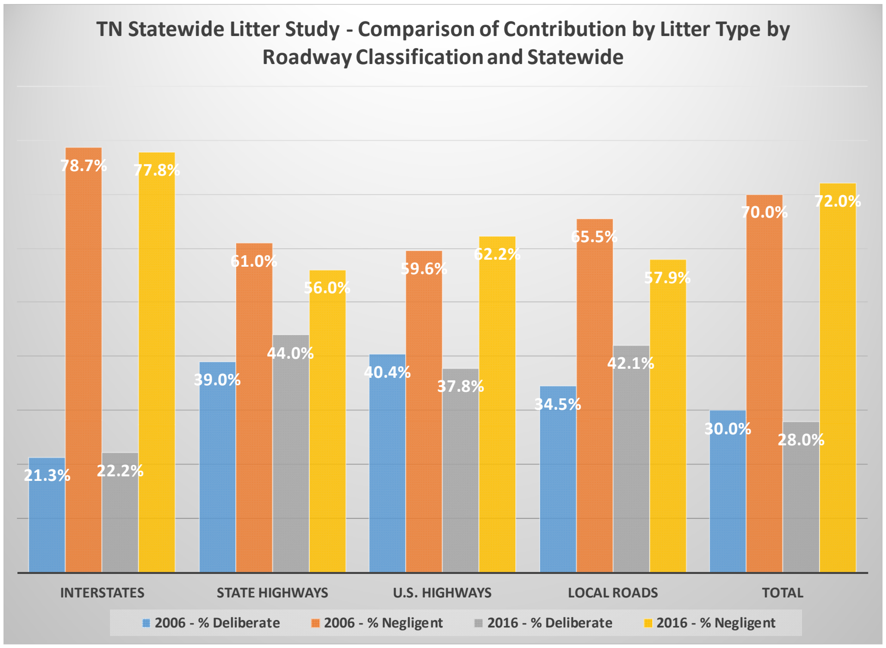

Figure ES-3 – Negligent vs. Deliberate Litter Results

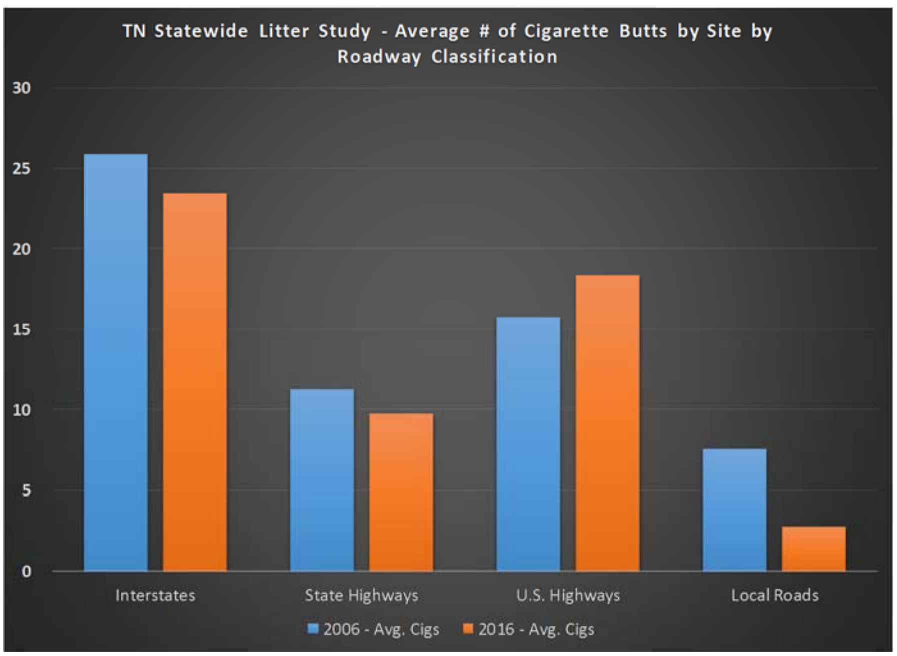

Figure ES-4 – Cigarette Butt Counts Results

As evidenced by the above figures:

- Litter per mile is dramatically higher for Interstates as compared to other roadway classifications. A compartmentalized approach to analysis and development of abatement tactics and messaging is described further below in this Report under the Abatement Policy & Tactics subsection.

- Litter per mile has declined across all roadway classifications, with the exception of Visible Litter per mile and Total Litter per mile on Interstates.
- There has been no material shift across all samples or with respect to a given roadway classification with respect to the split between negligent and estimated litter. While there is some fluctuation, negligent litter remains the majority component of all roadway classifications across both the 2006 and the 2016 data.
- Cigarette butt counts have fluctuated across roadway types, but are not subject to material long-term shifts in relative terms.

Litter Composition

Figures ES-5 and ES-6, below, summarize the composition results at a high level (reflective of rolled up categories for illustrative purposes) for all samples and local roads. The *all samples* composition has been weighted based on the litter per mile for Total Litter in order to provide a realistic depiction of composition that takes the amount of litter found for each sample into account.

Notwithstanding the results for *all samples*, it is important to note that the individual roadway classification results reflect considerable diversity (albeit the quantity of litter found for samples other than Interstates is considerably smaller), and that on a total roadway mileage basis, local roads represent a far larger proportion of the state than Interstates. The Econometric Analysis subsection details models inclusive of all samples as well as isolated to individual roadway classifications, each of which results in unique insights regarding the drivers of litter in a given context. Appendix B of this Report provides full composition results by roadway classification and across all samples for the 30 Study categories.

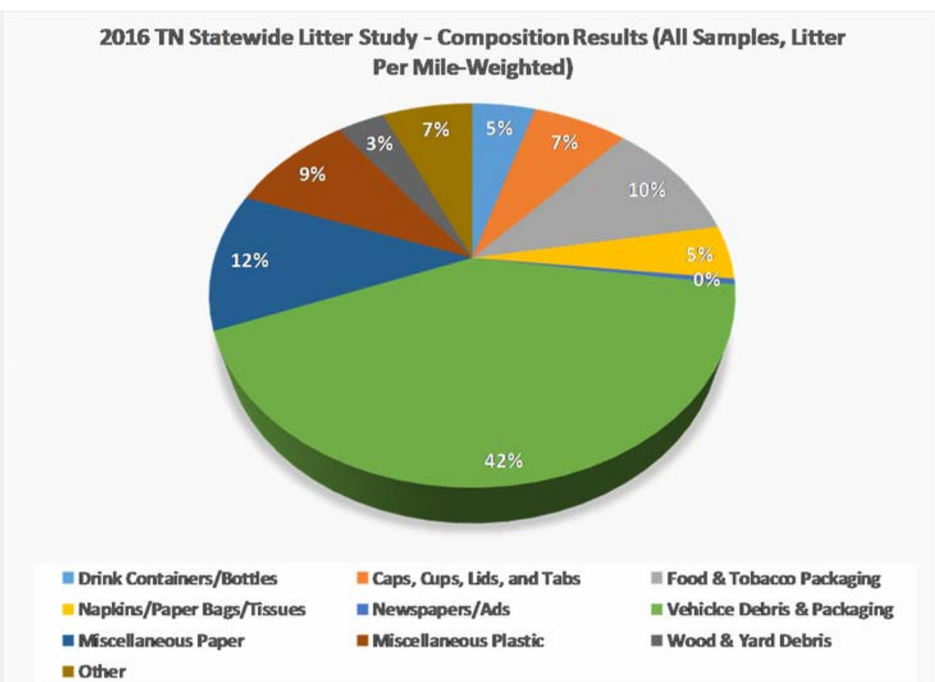

Figure ES-5 – Litter per Mile-Weighted Composition Results

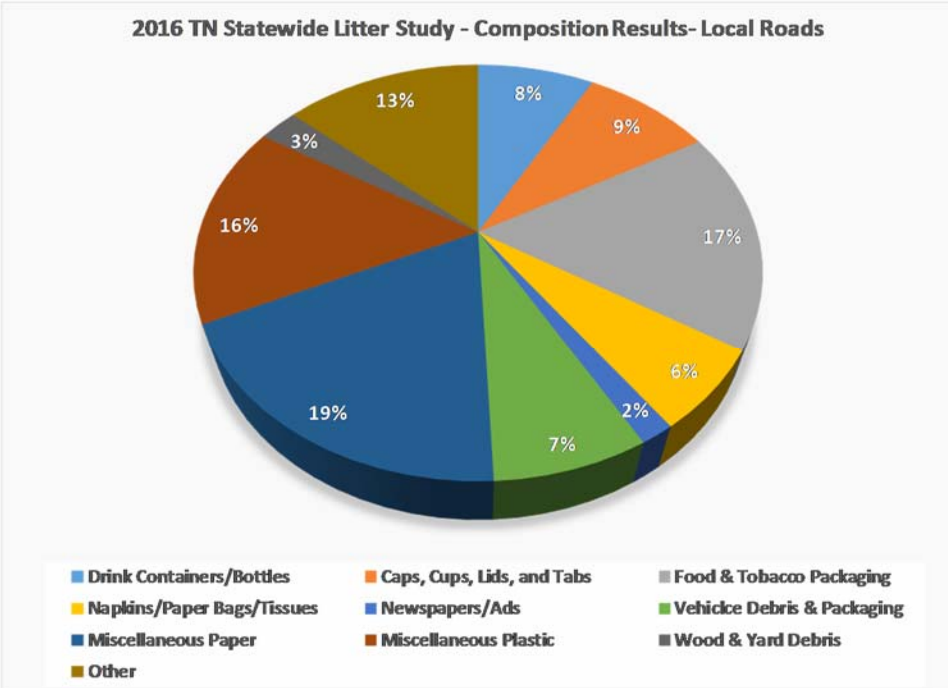

Figure ES-6 – Composition Results – Local Roads

Brand Name Analysis

Figures ES-7 through ES-12, below, summarize the top ranked brand names found across the Study, and the results of the revenue adjusted frequency analysis by brand universe.

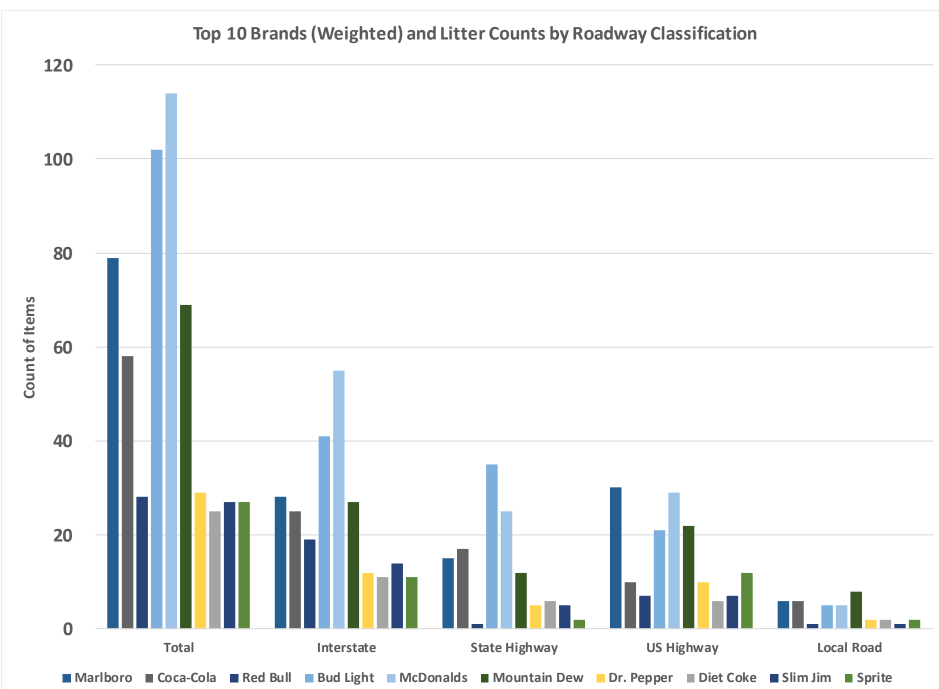

Figure ES-7 – Top 10 Brands and Litter Counts

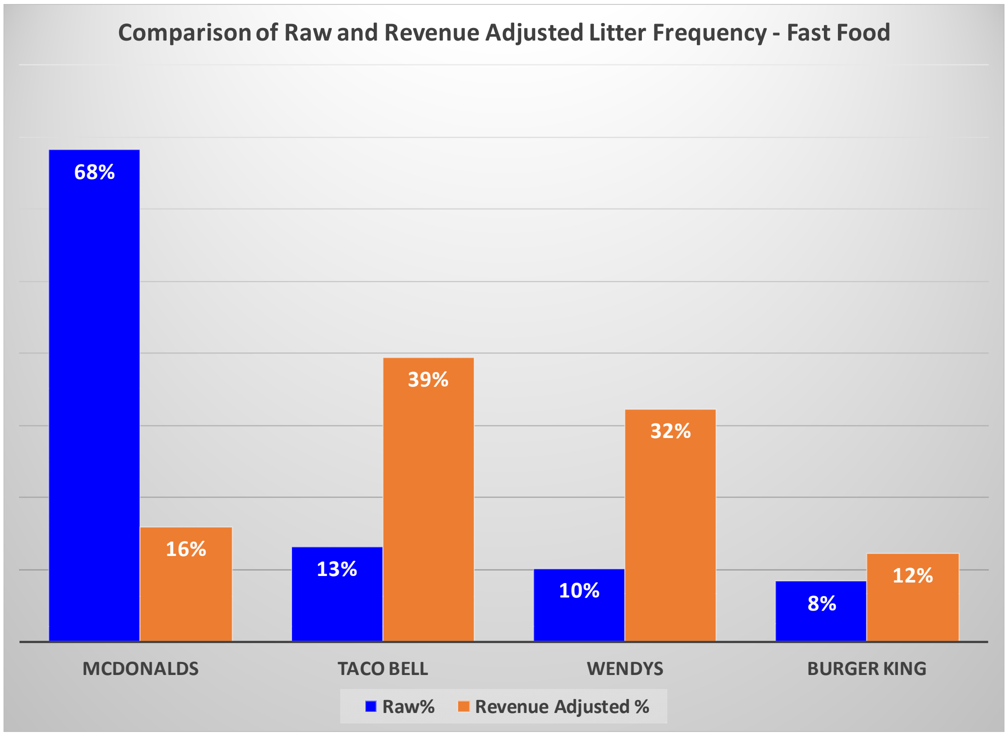

Figure ES-8 – Brand Name Cross-Walk Results – Fast Food

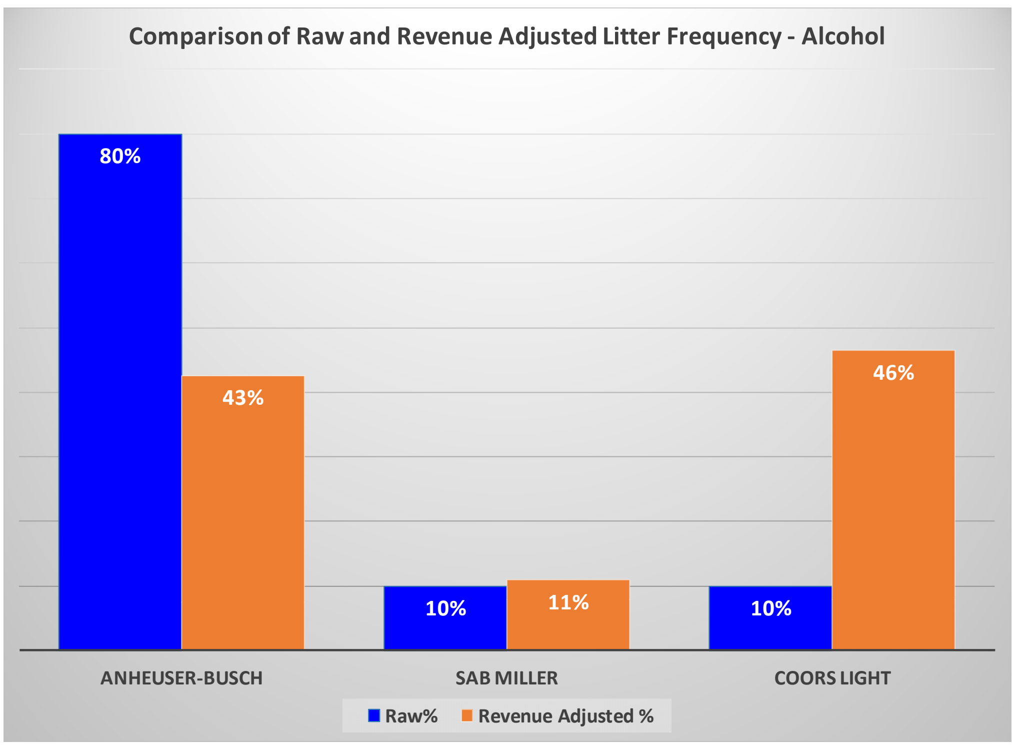

Figure ES-9 – Brand Name Cross-Walk Results - Alcohol

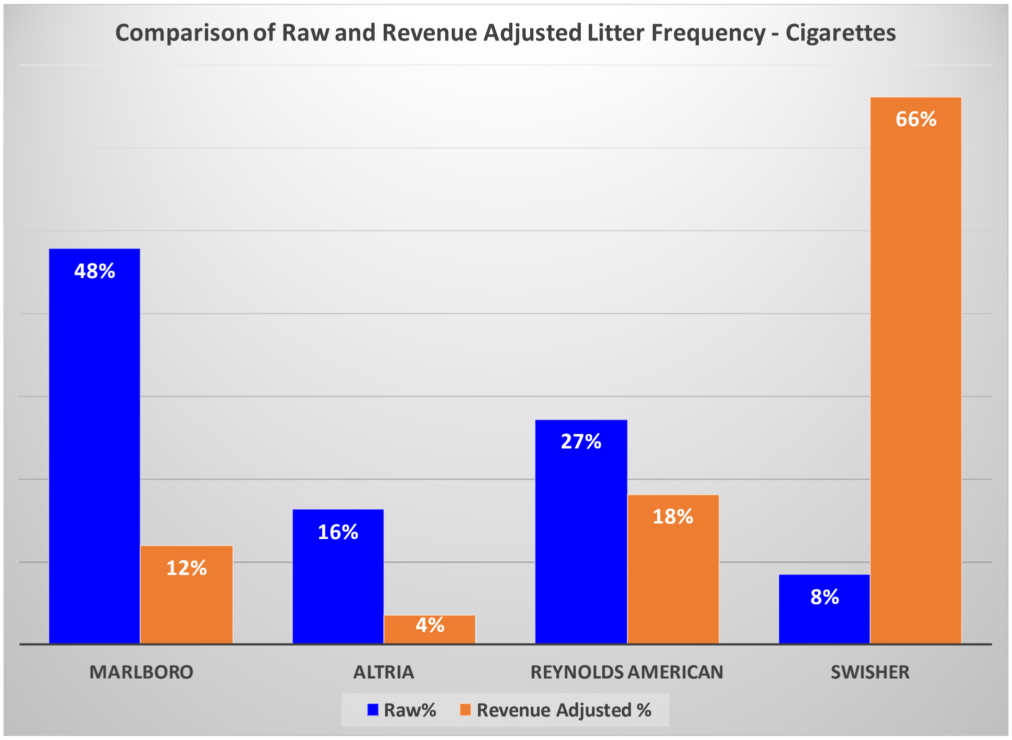

Figure ES-10 – Brand Name Cross-Walk Results - Cigarettes

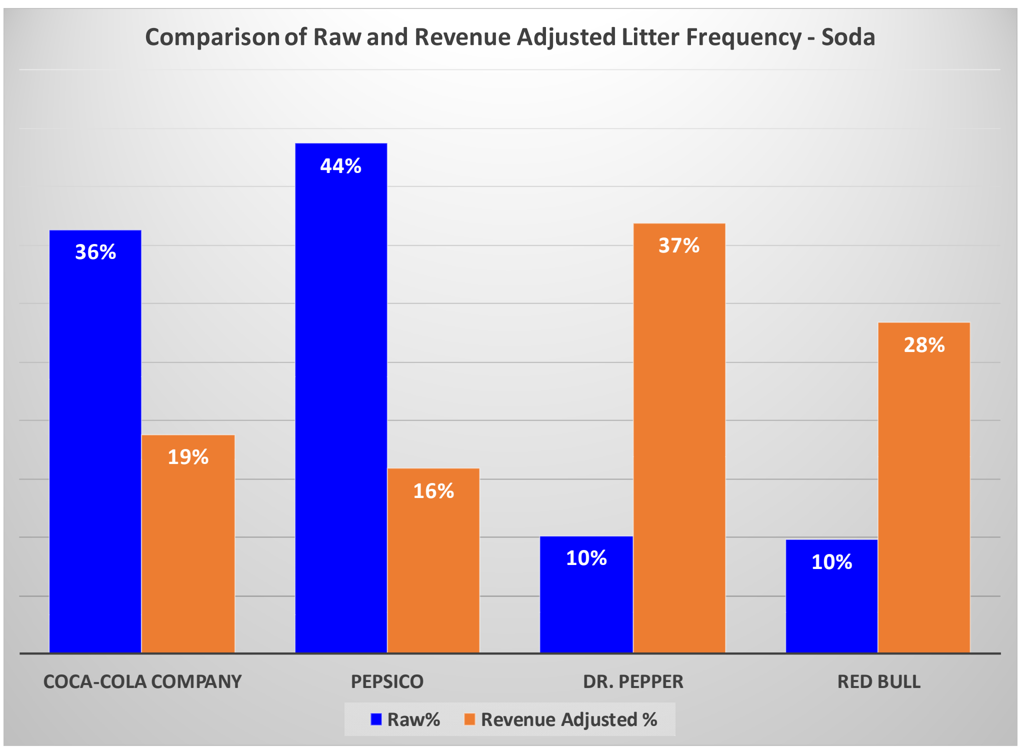

Figure ES-11 – Brand Name Cross-Walk Results - Soda

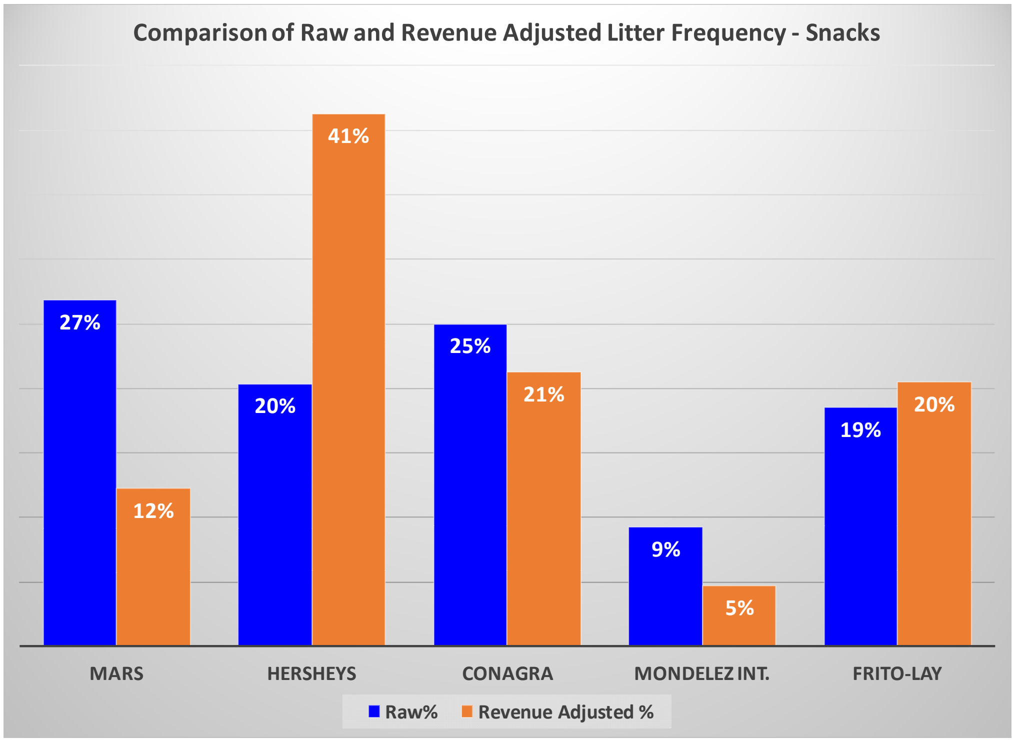

Figure ES-12 – Brand Name Cross-Walk Results - Snacks

Based on the range of results presented in Figures ES-7 through ES-12, above, the brand name analysis suggests the following conclusions.

- The most frequently encountered brands in raw total and weighted form were McDonalds (#1), Bud Lite (#2), and Marlboro (#3).
- If you combine the sub-brands for soda, the Coke brand (reflective of Coke, Diet Coke, and Sprite) eclipses Marlboro and Bud Lite and is only marginally less frequently encountered than McDonalds.
- Mountain Dew (a Pepsi product) was just less than Marlboro in the tally.
- The most prominent litter items are in the soda/soft drink universe (the less frequently encountered soda brands contribute to this total).
- Over 272 unique brand names were encountered in the field. The grouping of brand names into overarching universes (as defined above) was intended to determine whether brands that may not have been found as frequently add up to something more material if sub-brands are combined. However, some brands were only encountered a few times, whether tallied in total or by universe, indicating that the top brands identified in each universe reflect a significant portion of the brands encountered in total.
- After adjusting for revenue, brands such as Coke, Pepsi, McDonalds, and Marlboro were littered less frequently than what would be expected as a function of their revenue contribution to that particular brand universe. Conversely, brands such as Wendy's, Taco

Bell, Swisher Sweets, and Coors Light, among others, were littered more frequently than what would be expected as a function of their revenue contribution to that particular brand universe.

ECONOMETRIC ANALYSIS

nFront deployed Econometric Views™ ("Eviews") software to develop a series of statistically valid models of causal effects for litter rates, negligent litter percentages, and cigarette butt counts. The Eviews software has been used in the industry for over 30 years, and combines spreadsheet and relational database technology, as well as advanced visualization tools, with the traditional functionality found in statistical software. The econometric process involved testing a variety of combinations of potential variables for their ability to explain variations in litter rates, negligent litter percentages, and cigarette butt counts. The variables examined included primary data collected on site for each sample and a series of secondary data items covering a range of demographic and socioeconomic factors for the geographic areas encompassing the roadway, as detailed further in the body of this Report.

Consistent with the Premise Document (included as Appendix C of this Report) and discussions with TDOT at project inception, nFront engaged in a comprehensive search to extract a wide range of secondary data for deployment in the downstream econometric analysis. Well over 1,000 potential explanatory variables were gathered, either at the county or Census Tract level, and were compiled into individual analytical files and scrubbed for purposes of inclusion in the econometric analysis.

An econometric model allows the analyst to answer in-depth questions regarding statistically significant drivers of litter accumulation because it allows for the evaluation of multiple factors concurrently. As a result, the outcome of the models can directly drive recommendations for TDOT regarding education, enforcement, and eradication policies that may be most effective in reducing litter rates in the short term and sustaining reductions in the long-term. An analysis that attempts to be comprehensive in terms of compiling candidate data points and then testing this data for its ability to explain variations in litter rates and negligent litter percentages is defensible, and is not subject to intuition or guesswork when developing study conclusions. Furthermore, the Study design was predicated upon the ability to derive models using all samples as well as models isolated to specific roadway classifications in order to ensure that differentiators within a roadway classification could successfully be identified.

ABATEMENT POLICIES & TACTICS

Based on the range of econometric models developed for this Study, as well as the contributions of deliberate and negligent litter to the overall Study results, the following are the prevailing themes associated with litter relationships and the abatement and policy tactics that are suggested by the modeling across all collected samples.

Prevailing Themes

The following are the prevailing themes uncovered by the econometric analysis.

- **Abatement messaging and policy should take a compartmentalized, prioritized approach.**

  Based on the range of analysis conducted, it is clear that factors that impact litter are different in magnitude and makeup by roadway classification. While litter per mile on Interstates far outpaces the same metrics on other roadways, the same tactics and messaging cannot unilaterally be applied to mitigate long-term litter accumulation on Interstates as on other roads. Additionally, the econometric analysis can be used to prioritize the types of messaging and resource allocations afforded a particular roadway classification.

- **The most prevailing meta-theme is ownership.**

  Across all of the analysis conducted, there is a strong relationship between variables that define a sense of personal ownership (or lack thereof) and the amount of litter found on a given roadway.

- **Socioeconomics matters, but primarily closer to home.**

  The econometric results suggest that as you move down from Interstates to Local Roads, socioeconomic factors are far more influential in determining differences between one sample and another. In contrast, contextual variables that provide an opportunity for litter to accumulate have a significant impact irrespective of socioeconomic or demographic makeup as you move away from localities. This is a critical distinction, in that the analysis conducted in this Study suggests that opportunities for litter to accrue that reflect primary conditions associated with a roadway outweigh economic distinctions surrounding the roadway for the majority of samples evaluated. Demographics, in general, also reflected limited significance, and the impact of younger cohorts was mixed to insignificant.

Policy Implications

The following summarizes major policy implications indicated by the litter composition and econometric analysis applicable to all roadway and litter types.

- Advertising and messaging should solicit the same sense of respect/ownership for Interstates as the street you live on. Ownership related variables can help solicit a sense of pride in surrounding roadways and a higher overall aesthetic standard. Areas where building distance from roads is smaller, and which are predominantly residential in nature have dramatically less litter, which could serve as the messaging benchmark.
- Interstate litter per mile far outpaces other roadway classifications. Interstate litter should be a top abatement and messaging priority.
- Low-Income and public housing neighborhoods should be targeted for strategies. These areas correspond to the overall theme that limited feelings of ownership are related to higher litter per mile, all else equal.

- The econometric analysis suggests that TDOT and supportive partners can target certain types of businesses in messaging to engage in ways to improve ownership of areas. These businesses may also have specific ideas regarding how to better contain litter that can be gleaned through more direct interaction.
- Proximity to rest stops was found to significantly impact litter per mile (as applicable). Tactics to better address this contextual variable include the following:
    - Littering Signage (littering fine notice, checking truck beds for loose trash, etc.)
    - Adequate and maintained trash/recycling receptacles (among parking lots and not just by restrooms/indoor facilities)
    - Improved overall rest stop maintenance
- Proximity to interstate and highway on-ramps and exit ramps and proximity to traffic lights and stop sign intersections heading into and out of higher density commercial areas were another major contextual variable that related strongly to increased litter prevalence. These situations provide an excellent target for signage, advertising and messaging in terms of location/context.
- General aesthetic variables and conditions were strongly related to litter prevalence, which supports the notion that community condition does beget litter. Improved roadside maintenance, fines for derelict buildings, and providing incentives for re-development of brownfield sites can help reduce the impact of environmental conditions on litter per mile.
- Consistent with the Premise Document, designated truck routes were found to have higher litter per mile, all else equal. There may not be any direct control of such routes as it relates to TDOT activities, but TDOT should investigate ways to target messaging on such routes.
- Proximity to littered material sources, such as fast food restaurants, and their significant impact on litter per mile, suggest the following tactics.
    - Creation and enforcement of rules associated with trash receptacles at fast food/convenience stores (e.g. outdoor receptacles must be available by building egress points and in parking lot and maintained).
    - Targeted campaigns regarding littering in concert with fast food providers (e.g., drive-through packaging with anti-littering messaging).
- TDOT should consider re-evaluating the efficacy of anti-litter signage. The econometric analysis indicates that anti-litter signage has limited to no impact on litter, and in the case of US Highways, may be serving the converse purpose relative to its intent.
- Negligent vehicle debris and packaging was the single most contributory component of litter per mile across all of the roadway types. The following tactics may help mitigate this class of litter.
    - Improve vehicle cleanups after wrecks in order to reduce negligent litter.

  - Utilize abatement crews to regularly drive the Tennessee Interstate system to pick up vehicle debris on the edge of roadways.
  - Consider a mobile reporting system (e.g. information derived from Waze or a similar application) where drivers can report the location of their wrecks/blowouts, in order to support more comprehensive cleanup of such events.
  - Improve road surface transitions for paving/lane closures.
  - Re-evaluate efficacy of anti-litter signage around work zones, as the signage may in fact be serving the converse purpose relative to its intent.

- Increase policing and partnerships to reduce negligent litter. Negligent litter constitutes 72% of total litter across all of the roadway types (and between 56% and 80% for specific roadway types).

  - Increase secure loads enforcement by state highway patrol.
  - Partner with the waste collection industry to reduce unsecured waste in hauling vehicles.

- Target Adapt a Highway ("AAH") and maintenance efforts to high traffic volume roadway stretches (e.g., inside and heading into/out of high density areas).

  - AAH activity at the county level corresponds with measurements of higher litter per mile, which supports the notion that AAH efforts are being strategically targeted towards areas that are known to be more littered.
  - Investigations of AAH activity suggest that TDOT should look to enforce actual cleanups, as feedback from representatives suggested that certain clean-ups were not being performed.
  - TDOT has indicated that there may be a possibility that AAH activity could be extended to Interstates.

Refer to the body of this Report for a more detailed discussion of the technical nuances of econometric modeling, as well as additional discussion regarding key abatement issues and tactics derived directly from the econometric analysis on a roadway classification basis.

2016 TENNESSEE STATEWIDE LITTER STUDY

INTRODUCTION

TDOT estimates that it spends approximately $15 million annually on litter cleanup and litter abatement efforts. In order to foster the most efficient and effective use of abatement and cleanup resources for the beautification program, TDOT retained EnviroMedia to develop a litter abatement messaging campaign predicated on a series of studies aimed at understanding the driving factors and individual behaviors/motivations associated with litter. These undertakings include focus groups, the development of an attitudinal survey, and the Study. Deriving the campaign from the data and perspectives resulting from multiple analytical approaches is intended to ensure as objective an approach to messaging development as possible.

EnviroMedia retained nFront to undertake the Study over the period May 2016 – August 2016. The Study sought to identify and determine significant relationships between the roadside litter and site characteristics, including physical attributes, nearby business and infrastructure prevalence, and socioeconomic variables of the surrounding area, in order to foster actionable policy findings that will strengthen litter prevention efforts.

The Study was conducted based on sampling of 120 roadway segments, divided equally between four roadway classifications, specifically, Interstates, U.S. Highways, State Highways, and Local Roads. The primary goals of the Study were to (i) provide a quantitative measurement of litter and (ii) to determine the relationships between roadside litter and variables that play a role in generating litter. The Study gathered data on the number of items, types of items, and when possible, brand names of items found at a given site. Detailed composition analysis of the types of litter found have been combined with sophisticated analytics and realistic abatement option evaluations to produce findings that will help align TDOT's financial expenditures, outreach, and grant programs with the key drivers of litter accumulation. The Study will serve as a benchmark for future studies and has been designed to be highly replicable and comparable to the 2006 litter study and associated database, which nFront has leveraged for purposes of determining key changes between the current state of litter and metrics collected ten years ago, as summarized later in this Report.

Importantly, the Study was also tasked with the determination of whether geographic (urban, rural), population (increase, decrease, demographics), source (e.g. unsecured truck trash), or location-based (proximity to a food service facility, landfill, school, etc.) factors contribute to greater or lesser rates of accumulation. This analysis can directly drive abatement messaging and empower TDOT to optimally deploy resources by identifying the best opportunities to strengthen litter prevention efforts. As detailed later in this Report, nFront developed a customized econometric modeling approach to achieve this objective that considered well over 1,000 potential driving factors and millions of combinations of those factors to derive statistically meaningful results that prioritize and quantify the impact of key variables on litter metrics.

In order to meet the objectives of the Study, the nFront team engaged in the following chronological steps.

1. Extracted a randomly generated sample of 120 roadway segments, split equally amongst the four roadway classifications, as based on Geographic Information System ("GIS") data provided by TDOT;
2. Designed a daily sampling schedule that optimized the traversal of statewide road segments to ensure field data could be collected over a continuous stretch of 14 work days;
3. Designed a site log that supported the collection of detailed site-specific ("primary") data for each site (as summarized later in this Report) in support of the econometric analysis;
4. Led, with support from TDOT staff, an extensive external research effort to gather data regarding the conditions near the roadway segment, using both Census-tract and county-level information from a wide range of credible sources ("secondary data") to support detailed econometric analysis of the litter per mile, cigarette butt counts, and negligent litter composition data derived from the field work;
5. Executed field work (as described in detail further below in this Report) and conducted detailed data entry and quality control measures using a combination of a customized Microsoft Access® database and supportive spreadsheet tools, which enabled the development of the basic study results (litter per mile, litter composition, negligent (accidental) vs. deliberate (intentional) litter determinations, and brand name accounting and metrics);
6. Developed a customized econometric analysis framework that allowed for the efficient filtration and estimation of statistically significant factors, as derived from a combination of primary and secondary data that, all else equal, resulted in higher or lower amounts of litter per mile, cigarette butt counts, and negligent litter; and
7. Developed suggested abatement messaging targets and tactics derived directly from the results of the econometric modeling.

The remainder of this Report is organized as follows.

- The **Study Design and Logistics Planning** section details the mechanics of sample selection and provides an overview of the key field and logistical issues associated with site work. Secondary data sources subject to parallel data collection are also summarized.
- The **Basic Study Results** section provides a range of graphical exhibits that detail all basic study results, including litter per mile, litter composition, determinations regarding negligent vs. deliberate litter, cigarette counts, and the results of the brand name analysis.
- The **Econometric Analysis** section details the technical approach to development of each econometric model, and presents the results of each model, including supportive discussion related to interpretation of each model.
- The **Key Study Assumptions and Limitations** section provides a listing of key caveats and limitations associated with the Study.

- The **Abatement Policy and Tactics** section summarizes the prevailing themes, specific suggested abatement approaches, and roadway classification-specific tactics derived from the results of the econometric modeling.
- **Appendix A** provides the field forms utilized to gather data in the field.
- **Appendix B** provides the detailed litter composition results in tabular format for all samples as well as for individual roadway classifications.
- **Appendix C** represents the list of data and the anticipated relationship of each data point to litter prevalence, both primary and secondary, that was discussed with TDOT at project inception and which served as the basis for data collection ("Premise Document"). Primary and secondary data collected for purposes of the Study has been made available to TDOT as a separate archive deliverable.

STUDY DESIGN AND LOGISTICS PLANNING

The purpose of this section is to summarize the sampling, communications, and field logistics plan for the Study, as well as to detail the field work methodology (including primary data collection related to each site), and to summarize the main sources of secondary information gathered for each sample. The information presented herein is consistent with the Sampling, Communications, and Field Logistics Plan previously relayed to TDOT in advance of the field work, which was intended to ensure that TDOT was aware of the locations where sampling would take place, the approach taken to generate samples, the data sources relied upon to vet each selected sample, the mechanisms in place to foster communication during the field work, and certain logistical considerations related to safety and risk mitigation during the field work period. Additionally, samples that were suggested targets for taking promotional video or otherwise being observed for purposes of the broader beautification campaign were highlighted in the original logistics plan to support appropriate scheduling/planning, the highlighting for which has been retained herein.

Sample Plan and Summary of Selected Samples

Figure 1, below, provides a map-based overview of the randomly selected samples, including a color code associated with each roadway classification. Table 1, below, summarizes all 120 randomly selected samples, comprising 30 samples each from the four roadway classifications, specifically Interstates, U.S. Highways, State Highways, and Local Roads[1]. Table 1 summarizes the FID and ID number corresponding to the GIS roadway segment in question and the unique identifier of that roadway segment in the GIS database, respectively. Table 1 also shows the roadway classification, the roadway name/description, the county in which the roadway exists, the latitude and longitude point where the segment approximately begins, and a randomly selected number between 1 and 3

[1] Based on the Google Earth© safety review of Local Roads, there is a mixture of commercial and residential portions of these stretches of roadway. As codified during the kickoff meeting and preceding discussions with TDOT, this Roadway Classification took the place of "Farm to Market Roads" as was originally listed in the project request for proposals.

signifying whether the sampling team began collection at the start (1), middle (2), or end (3) of the log mile duration representing the segment in question.

Samples have been sorted according to the estimated day on which they would be sampled, with "day 1" signifying the first day of the sort and a baseline assumption of ten sites sampled per day. By design, there were more samples targeted per day than are necessary relative to the 14-day sampling window in order to afford the field team flexibility with regard to travel times. Suggested target samples for videography (the ultimate sample used for videography was resolved in partnership with TDOT) have been highlighted in blue below. nFront field staff coordinated with TDOT in advance of the videography day to ensure that adequate time was set aside for videography. The samples summarized in Table 1 were reviewed and approved for sampling by TDOT in advance of the field work.

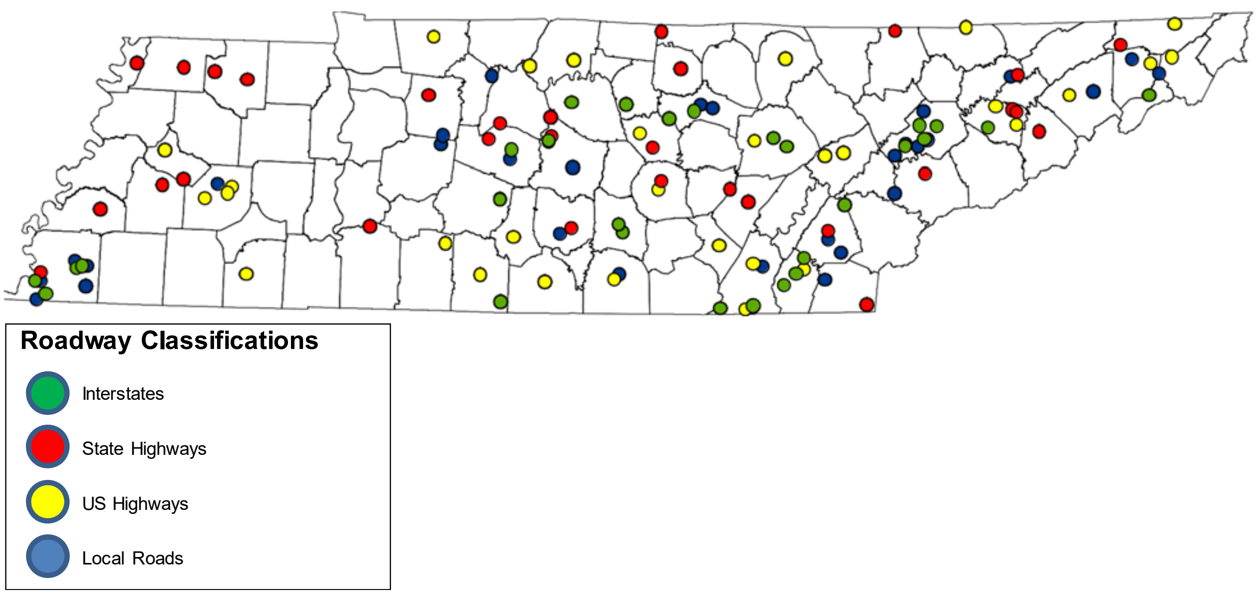

Figure 1 – Summary of Selected Samples

Table 1 – Summary of Selected Samples for 2016 TN Statewide Litter Study

Sample #	Estimated Day	FID	ID Number	Roadway Classification	Route Name	County	Latitude/Longitude	Log Mile Section
1	1	46393	470E055001	Local Road	PARIS LN.	KNOX	36.1116488325, -83.9572840117999	2
2	1	60213	47I0075001	Interstate	I-75	KNOX	36.0457062596999, -83.9991446573999	3
3	1	146627	47I0640001	Interstate	I-640	KNOX	36.0319802699999, -83.8866432468	1
4	1	181026	47I0040001	Interstate	I-40	KNOX	35.9570302054999, -83.9706685711999	1
5	1	82731	470A135001	Local Road	CLINCH AVE.	KNOX	35.9557359817, -83.9399904972	3
6	1	38058	470A337001	Local Road	CRAIG RD.	KNOX	35.9110809013999, -84.0015216314999	3
7	1	125470	47I0040001	Interstate	I-40	KNOX	35.9181030267999, -84.0904513581999	2
8	1	49101	470E704001	Local Road	FINCH RD.	KNOX	35.8626531164999, -84.1632665250999	2

Sample #	Estimated Day	FID	ID Number	Roadway Classification	Route Name	County	Latitude/Longitude	Log Mile Section
9	1	47598	470E929001	Local Road	WOOD PARK LN.	KNOX	35.929309156, -84.0866707737	2
10	1	92162	05SR033001	State Highway	E. BROADWAY AVE.	BLOUNT	35.7716764114, -83.9573873486999	2
11	2	38520	45I0040001	Interstate	I-40	JEFFERSON	36.0117726472999, -83.5183660078999	1
12	2	84304	45SR034001	US Highway	E. BROADWAY BLVD.	JEFFERSON	36.1531412999, -83.4289994096999	3
13	2	133533	45SR066001	State Highway	VALLEY HOME RD.	JEFFERSON	36.1149332096999, -83.3395232365	3
14	2	133567	45SR341001	State Highway	ROY J. MESSER HWY.	JEFFERSON	36.1016381689999, -83.3183022891	2
15	2	56463	45SR009001	US Highway	US-25W	JEFFERSON	36.0325936141, -83.3234615836999	2
16	2	171976	15SR160001	State Highway	HWY. 160	COCKE	35.9831769186, -83.1595859004	1
17	2	70068	30SR034001	US Highway	W. ANDREW JOHNSON HWY.	GREENE	36.1863842894, -82.9412114058	3
18	2	99785	300A376001	Local Road	SCOTT FARM RD.	GREENE	36.2005732916, -82.7785880705999	3
19	2	180564	86I0026001	Interstate	JAMES H QUILLEN PKWY.	UNICOI	36.1707054709, -82.3928468807999	2
20	2	90646	100B128001	Local Road	S. HILLS CIR.	CARTER	36.2889195333999, -82.3169045608999	2
21	3	176916	10SR037001	US Highway	US-19E	CARTER	36.3875390497999, -82.2277195086	3
22	3	179314	82SR034001	US Highway	VOLUNTEER PKWY.	SULLIVAN	36.5572083261999, -82.2138918896	1
23	3	173638	82SR347001	State Highway	POPLAR GROVE RD.	SULLIVAN	36.4601028153999, -82.5693063954	3
24	3	81952	900B423001	Local Road	HILLVIEW CT.	WASHINGTON	36.3752538501999, -82.5021350198999	2
25	3	6073	90SR034001	US Highway	N. ROAN ST.	WASHINGTON	36.3462492670999, -82.377812797	2
26	3	27382	290A248001	Local Road	CATAWBA RD.	GRAINGER	36.2961628886, -83.3482064826	2
27	3	55118	29SR375001	State Highway	LAKE SHORE RD.	GRAINGER	36.309041591, -83.2960081007999	3
28	3	114851	13SR032001	US Highway	CUMBERLAND GAP PKWY.	CLAIBORNE	36.5726683920999, -83.6537056526999	1
29	3	167016	07SR297001	State Highway	S. MAIN ST.	CAMPBELL	36.5695852384, -84.1452637818999	1
30	3	38821	25SR028001	US Highway	S. YORK HWY.	FENTRESS	36.4264637682, -84.9205850195999	2
31	4	178238	18SR001001	US Highway	SPARTA HWY.	CUMBERLAND	35.9503060694, -85.1007943457999	3
32	4	171550	18I0040001	Interstate	I-40	CUMBERLAND	35.9810791784, -85.0112816753999	1
33	4	175437	73SR001001	US Highway	ROANE STATE HWY.	ROANE	35.8749139183, -84.6411099424	3
34	4	175070	73SR001001	US Highway	W. RACE ST.	ROANE	35.8861720877999, -84.5225266413	3
35	4	175039	18I0040001	Interstate	I-40	CUMBERLAND	35.9257030122999, -84.9148659411	2
36	4	153677	530A418001	Local Road	CHILHOWEE AVE.	LOUDON	35.6607374247, -84.1695320271	1
37	4	84501	62I0075001	Interstate	I-75	MONROE	35.597801347, -84.5168787462	1
38	4	40787	54SR030001	State Highway	DECATUR PK.	MCMINN	35.4659604147, -84.6488410603	1
39	4	123946	540A606001	Local Road	CR-705	MCMINN	35.3991649649999, -84.6247760045	1
40	4	46779	540A365001	Local Road	CR-797	MCMINN	35.3247168049, -84.5463148601999	1

Sample #	Estimated Day	FID	ID Number	Roadway Classification	Route Name	County	Latitude/Longitude	Log Mile Section
41	5	172089	70SR068001	State Highway	STATE HWY. 68	POLK	35.0330699346, -84.3810392051999	2
42	5	125139	700A567001	Local Road	BENJAMIN PL.	POLK	35.1777105265, -84.6594601187999	3
43	5	167272	06I0075001	Interstate	I-75	BRADLEY	35.2905342259999, -84.8140317012999	1
44	5	167231	06I0075001	Interstate	I-75	BRADLEY	35.2170530129999, -84.8633190957	2
45	5	158863	06SR002001	US Highway	N. LEE HWY.	BRADLEY	35.2404587512, -84.8054901354	2
46	5	168399	06I0075001	Interstate	I-75	BRADLEY	35.1520021605999, -84.9477288683	1
47	5	180554	33I0075001	Interstate	I-75	HAMILTON	35.0349262127, -85.1638485685	1
48	5	33900	330C350001	Local Road	APPLEGATE LN.	HAMILTON	35.0187179234999, -85.1627691739	2
49	5	175155	33SR002001	US Highway	BRAINERD RD.	HAMILTON	35.0164814173, -85.2077971971999	2
50	5	125674	33I0024002	Interstate	I-24	HAMILTON	35.0268114041999, -85.3665457201	3
51	6	133223	330E150001	Local Road	CEDAR LN.	HAMILTON	35.2586657438, -85.0856569639	3
52	6	171509	33SR029001	US Highway	US-27	HAMILTON	35.2761562756, -85.1558112656999	2
53	6	117789	77SR008001	US Highway	RANKIN AVE.	SEQUATCHIE	35.3781570645, -85.3853125509999	2
54	6	157501	04SR030001	State Highway	STATE HWY. 30	BLEDSOE	35.6224395357, -85.1884934982	2
55	6	32536	88SR030001	State Highway	STATE HWY. 30	VAN BUREN	35.6926582784, -85.3093432546999	2
56	6	60699	710B437001	Local Road	JIM ROBERSON RD.	PUTNAM	36.1466818769999, -85.4226585562999	2
57	6	59878	710B295001	Local Road	N. WALNUT AVE.	PUTNAM	36.1653889924999, -85.505629834	1
58	6	111506	44SR135001	State Highway	RIVER RD.	JACKSON	36.3738680402, -85.6375608838999	1
59	6	58934	14SR052001	State Highway	CLAY COUNTY HWY.	CLAY	36.5809144704, -85.7782221356	3
60	6	106087	80I0040001	Interstate	I-40	SMITH	36.1796306876, -85.9520635622999	3
61	7	157640	71I0040001	Interstate	I-40	PUTNAM	36.1362720161, -85.6407165433	3
62	7	157557	71I0040001	Interstate	I-40	PUTNAM	36.1360952989999, -85.5293657386999	3
63	7	91228	21SR026001	US Highway	NASHVILLE HWY.	DEKALB	36.0054783366, -85.9273565411999	3
64	7	20670	21SR146001	State Highway	SHORT MOUNTAIN RD.	DEKALB	35.9323376728, -85.8437388028	2
65	7	6380	89SR001001	US Highway	W. MAIN ST.	WARREN	35.6955797038, -85.8098903538	1
66	7	61946	89SR056001	State Highway	SMITHVILLE HWY.	WARREN	35.7425627949999, -85.7858422978	1
67	7	176446	16I0024001	Interstate	I-24	COFFEE	35.4485712366, -86.0475458785	3
68	7	176599	16I0024001	Interstate	I-24	COFFEE	35.4940203986, -86.0774491429999	1
69	7	6285	260B007001	Local Road	HAYNES CIR.	FRANKLIN	35.2127247677, -86.0715019649999	1
70	7	9990	26SR015901	US Highway	1ST AVE. N.W.	FRANKLIN	35.1862171718, -86.1125349038999	2
71	8	172100	52SR050001	US Highway	LEWISBURG HWY.	LINCOLN	35.1736941894, -86.5801933185999	2
72	8	79470	28I0065001	Interstate	I-65	GILES	35.0491793294999, -86.8801394001	1

Sample #	Estimated Day	FID	ID Number	Roadway Classification	Route Name	County	Latitude/Longitude	Log Mile Section
73	8	59994	28SR007001	US Highway	N. 1ST ST.	GILES	35.2110248609999, -87.0272068984999	1
74	8	10522	59SR011001	US Highway	CORNERSVILLE HWY.	MARSHALL	35.4265582706999, -86.8012064107	3
75	8	135099	020A823001	Local Road	KOLBY CT.	BEDFORD	35.4449019114, -86.4755297088999	2
76	8	179586	02SR064001	State Highway	STATE HWY. 64	BEDFORD	35.4763153303999, -86.4064186022	1
77	8	70402	750D081001	Local Road	GOLDEN BEAR CT.	RUTHERFORD	35.8158056414999, -86.4017889223	2
78	8	180600	75I0024001	Interstate	I-24	RUTHERFORD	35.9677343103999, -86.566621493	3
79	8	157973	19SR171001	State Highway	HOBSON PK.	DAVIDSON	36.1101426112999, -86.5353347665	3
80	8	180551	75I0024001	Interstate	I-24	RUTHERFORD	35.9628101424, -86.5632286835	3
81	9	99462	75SR266001	State Highway	W. SAM RIDLEY PKWY.	RUTHERFORD	35.9962120706, -86.5321069884	3
82	9	85402	95I0040001	Interstate	I-40	WILSON	36.1837367465, -86.4155669359	1
83	9	103361	83SR006001	US Highway	E. BROADWAY ST.	SUMNER	36.4225544586999, -86.3909562966999	2
84	9	175206	83SR041001	US Highway	LOUISVILLE HWY.	SUMNER	36.4082552224, -86.6891940364999	3
85	9	130721	110A194001	Local Road	EAST SIDE RD.	CHEATHAM	36.3273340873999, -86.9629396103999	3
86	9	84319	63SR012001	US Highway	PROVIDENCE BLVD.	MONTGOMERY	36.5456055609, -87.3742684247999	1
87	9	29975	22SR049001	State Highway	STATE HWY. 49	DICKSON	36.2007578706, -87.3704574631999	3
88	9	128565	220A474001	Local Road	WOODLAND WAY	DICKSON	35.9919584475999, -87.297433342	1
89	9	43719	410A049001	Local Road	BLAKE RD.	HICKMAN	35.9339722785, -87.3040426153	2
90	9	62965	19SR100001	State Highway	STATE HWY. 100	DAVIDSON	36.062237213, -86.9047935886	3
91	10	118347	94SR096002	State Highway	NEW HWY. 96 W.	WILLIAMSON	35.9467149274999, -86.9465371034	3
92	10	100495	940C357001	Local Road	FRANKLIN SOUTH CT.	WILLIAMSON	35.8625791449, -86.8284754028999	1
93	10	181325	94I0065001	Interstate	I-65	WILLIAMSON	35.9172632503, -86.8237268851	3
94	10	47908	60I0065001	Interstate	I-65	MAURY	35.6424044163, -86.8935657555	3
95	10	47913	60I0065001	Interstate	I-65	MAURY	35.6384084188999, -86.8939896777999	2
96	10	62882	50SR006001	US Highway	HWY. 43 N.	LAWRENCE	35.3865390472, -87.2754583806	2
97	10	167375	91SR013001	State Highway	WAYNESBORO HWY.	WAYNE	35.4736272760999, -87.7913963313999	2
98	10	94299	55SR015001	US Highway	US-64	MCNAIRY	35.1917533239, -88.6444626332	1
99	10	178435	57SR001001	US Highway	US HWY. 70	MADISON	35.6122868105, -88.9439297416	1
100	10	178228	57SR001001	US Highway	US HWY. 70 / 412	MADISON	35.6754611655, -88.7476159077999	2
101	11	178482	57SR020001	US Highway	NORTH PKWY.	MADISON	35.6450368659999, -88.7781624014999	1
102	11	128034	570B840001	Local Road	ASHTON CV.	MADISON	35.692345965, -88.844255532	1
103	11	97657	38SR054001	State Highway	STATE HWY. 54 N.	HAYWOOD	35.6098148238, -89.2567903787	1
104	11	154764	17SR020001	US Highway	HWY. 412 N.	CROCKETT	35.8937233903999, -89.2395553205	1

Sample #	Estimated Day	FID	ID Number	Roadway Classification	Route Name	County	Latitude/Longitude	Log Mile Section
105	11	163273	17SR088001	State Highway	W. MAIN ST.	CROCKETT	35.7122469158, -89.0889160899999	2
106	11	92605	92SR217001	State Highway	COUNTY MAINTENANCE RD.	WEAKLEY	36.2922371521, -88.6644801062	3
107	11	41448	92SR216001	State Highway	MT. PELIA RD.	WEAKLEY	36.3258372872, -88.8814075200999	3
108	11	27972	66SR021001	State Highway	E. STATE HWY. 21	OBION	36.345077902, -89.1482555081999	1
109	11	120675	48SR021001	State Highway	SR-21	LAKE	36.3516853157999, -89.4246226616999	3
110	11	39884	84SR384001	State Highway	MT. CARMEL RD.	TIPTON	35.5329056902999, -89.6500991851	3
111	12	164620	790M735001	Local Road	WHEELERS PL.	SHELBY	35.2349011020999, -89.8106215323	1
112	12	102435	79I0040001	Interstate	I-40	SHELBY	35.1908446122, -89.8015778067999	2
113	12	102546	79I0040001	Interstate	I-40	SHELBY	35.2107910545, -89.7595702235999	3
114	12	47876	790C652001	Local Road	OLD WELL CV.	SHELBY	35.1999070278999, -89.7213283533999	3
115	12	160229	790J850001	Local Road	LONHILL CV.	SHELBY	35.0910128101999, -89.7287733757	3
116	12	132752	79I0055001	Interstate	I-55	SHELBY	35.0624091213, -90.0213090354999	3
117	12	77597	790E781001	Local Road	DRIVER ST.	SHELBY	35.1111388648999, -90.0460530167	3
118	12	92907	79I0055001	Interstate	I-55	SHELBY	35.1145058038, -90.0732280733	3
119	12	70852	79SR003001	State Highway	N. THIRD ST.	SHELBY	35.1599926305, -90.0441829807	2
120	12	169093	790H439001	Local Road	CHAMPA RD.	SHELBY	35.0123006675, -90.0597443064	2

Each of the samples that were generated were vetted for reasonableness as a function of the following protocol:

- TDOT provided a list of regional construction projects on roadways in the state, which was reviewed by nFront in an effort to understand whether there were any significant road blockage constraints across the selected samples. This effort did not uncover any significant issues (see notes further below on safety and risk mitigation planning).
- The latitude and longitude of each road segment was researched and appended to the master GIS data table using the data provided by TDOT. This information was entered into Google Earth© in order to perform a first-pass review of each stretch of roadway in street view. This exercise allowed the team to ensure that there was adequate stopping space and that there were no other discernable obstructions that would hinder the process of data collection. In certain instances, randomly selected samples were replaced with alternates (also randomly selected) in order to avoid such factors from preventing the field team from gathering the data safely.

Field Work Methodology

Litter was divided into one of 30 categories in advance of the start of field work, as based on detailed discussions with TDOT staff and the desire to maintain comparability with the litter categories deployed in the 2006 study. Table 2 summarizes each of the Study categories. Each category was assigned to either the intentional ("deliberate") or accidental ("negligent") grouping based on the preponderance of assumed causes as derived from prior studies/observations of litter and discussions with both EnviroMedia and TDOT. While there is no guarantee that an individual item of litter was either deliberately or negligently littered, the associations made herein are consistent with the 2006 study and with prevailing solid waste industry expectations regarding the likelihood of littering behavior in each case.

Table 2 –2016 TN Statewide Litter Study Litter Categories

Category No.	Category	Category Type
1	Juice & Soft Drink Containers	DELIBERATE
2	Beer, Wine, & Liquor Containers	DELIBERATE
3	Water Bottles	DELIBERATE
4	Bottle Caps & Seals	DELIBERATE
5	Pull Tabs	DELIBERATE
6	Beverage Containers & Cartons (Milk)	DELIBERATE
7	Cups, Lids, Straws	DELIBERATE
8	Snack Food Packaging (Candy, Gum, etc.)	DELIBERATE
9	Take-out Food Packaging	DELIBERATE
10	Cigarette Packs, Lighters, Matches	DELIBERATE
11	Napkins, Bags (Paper Only), Tissues	DELIBERATE
12	Plastic Bags	DELIBERATE
13	Toiletries, Toys, Drugs	DELIBERATE
14	Newspapers, Magazines, Books	NEGLIGENT
15	Advertising Signs & Cards	NEGLIGENT
16	Home Food Packaging (TV Dinners, etc.)	NEGLIGENT
17	Vehicle Debris & Packaging	NEGLIGENT
18	Tires	NEGLIGENT
19	Construction & Demolition Debris	NEGLIGENT
20	Miscellaneous Paper	NEGLIGENT
21	Miscellaneous Plastic	NEGLIGENT
22	Gas Tanks	NEGLIGENT
23	Miscellaneous Metal & Foil	NEGLIGENT
24	Miscellaneous Glass & Ceramics	NEGLIGENT
25	Wood & Yard Debris	NEGLIGENT
26	Mattresses	NEGLIGENT
27	White Goods	NEGLIGENT
28	Entire 32-gallon Trash Bags	NEGLIGENT
29	Tie-downs for Trucks	NEGLIGENT
30	Other (Carpet, Fabric)	NEGLIGENT

In order to count and characterize litter for each sample, nFront deployed a consistent field procedure relative to the 2006 study, with the appropriate data collection enhancements necessary to meet TDOT's objectives specific to this Study. The procedures involved in auditing a site are listed below.

1. The observer first performs a linear count of all items greater than ½-inch in diameter that can be visually seen within approximately three feet of the edge of the pavement at each site ("edge count"), and records the total number of litter items observed for a pre-determined length of that site. This is intended to provide an initial volumetric assessment of visible litter at the site. Typically, this is done along approximately 500 feet of each specific roadway for traditional roadway classifications2.

2. The observer then traverses the site again ("meander count"), using a meandering count and a more detailed visual inspection process, whereby each item of visible litter within approximately 15 feet of the roadside is matched to a pre-specified litter category (based on 30 litter categories as codified in partnership with TDOT). As part of this phase of data collection, the observer will also assign brand names to each litter item where possible (i.e., when a brand name for a specific piece of litter is discernable).

3. The field team takes photographs of the litter observed at each site, both from the edge count and the meander count, as well as an overall picture of the site.

4. Separate counts are made by another team member of the number of occupants per vehicle, the number of open bed pickup trucks, and the number of pedestrians (if applicable) in the sample zone over a predetermined span of time.

5. Based on a list of variables consisting of desired primary data (refer to the sub-section below for further details), the team recorded data regarding site-specific variables of interest to be deployed in the downstream econometric analysis.

Note that the composition analysis has been based on physical item count as opposed to volume or weight. The rationale for this approach is twofold. First, the level of detail with which density factors would have to be applied to each specific type of litter would require the tracing of an inordinate amount of categories, making representative research prohibitively expensive. Each material in the Study has a unique density, and as such it would be cost prohibitive to spend time researching such densities and converting each material to volume or weight values. The alternative of collecting and weighing litter is also very time consuming and can be dangerous for certain roadway classifications, which requires additional safety precautions and expense that is not warranted relative to the results obtained. Second, it is the *frequency* with which certain litter items are found that should be the focus of abatement strategies (an example is soda bottles, as opposed to construction debris). The state litter profile can be expected to be dominated in both quantity

[2] Refer to the discussion further below regarding the protocol for Local Roads that were deemed to be predominantly residential in nature.

and volume by specific items that are littered most frequently and for which abatement strategies can be most readily designed.

Logistics Plan and Key Field Work Notes

As detailed in Table 1 above, the roadway segments were spread out across the entire state. This geographic dispersion necessitated a daily plan that was based on the field team arriving in the Knoxville area, traveling east from that part of the state initially, and then heading back west towards the Memphis area. In order to accomplish the sort over the budgeted duration of time, the sample planning team leveraged the GIS FID of each individual road segment to plan out the exact sequence with which the 120 samples would be collected. These "day" targets took into account the estimated hours of available daylight, and assumed that after daylight drive times to lodging locations would be planned so as to be as close to the starting sample for the next day as possible. As noted above, the daily log was based on 12 days (as opposed to 14 days) in order to provide the team with some flexibility relative to travel times, traffic, use of daylight hours and other externalities that cannot be fully foreseen in advance of the field work.

Additionally, the following methods related to the field work informed the team's process.

- The field team wore hard hats and vests for personal protection while gathering data and other metrics related to the vicinity of the site.
- Wherever possible, secondary data sources (including primary research related to county and Census Tract level data and the utilization of a more thorough pass at Google Earth©) were used to supplement the field work and ensure timely collection of the most critical field data during daylight hours.
- Given the transition to Local Roads, the team tracked whether the stretch in question was primarily commercial in nature (i.e., commercial businesses or shopping strips) as compared to residential (i.e., residences). This variable was tested in the downstream analytical phase of the project to determine whether a significant difference in litter can be attributed to such characteristics as part of the econometric analysis.
- While care was taken to review the regional construction project list and to buttress this information with a review of Google Earth© for each of the 120 sites in question, the field team also discussed a back-up plan in the event that an unforeseen obstruction is deemed to prevent collection. In such an instance, the team would travel to the closest point near the original coordinates that is not obstructed. The team would ensure that the roadway segment is still the same road via the use of hand-held GPS units. Alternatively, if the sample has been slated to begin at the start of log mile marker, and there is an obstruction, the team would move to another "section" of the road segment, as appropriate.
- Local roads that are deemed to be predominantly residential in nature were subjected to 1,000 feet of observation (versus approximately 500 feet for other roadway classifications),

in order to maximize comparability between the samples collected in this Study and the data available as part of the 2006 study.

Communications and Approval for Field Work

Throughout the 14-day field work period, the field team coordinated as needed with the Litter Study Project Manager on any significant open questions related to the field effort. Additionally, TDOT generated a signed letter authorizing the field team to perform data collection activities on each of the four Roadway Classifications in the study. Table 3 below highlights the key contact personnel from the project team and from TDOT over the course of the field work.

Table 3 – Summary of Key Contact Information for Field Work Period

Name	Organization	Role	Phone #	Email
Navid Nowakhtar	nFront Consulting, LLC	Project Manager	407-718-8641	navidnowakhtar @nfrontconsulting.com
Joe Naveira	Leidos Engineering, LLC	Field Manager	321-217-3649	JOE.M.NAVEIRA @leidos.com
Matt Eckhart	Leidos Engineering, LLC	Field Analyst	239-272-0818	matthew.s.eckhart @leidos.com
Mark McAdoo	TDOT	Primary Contact	615-741-0803	Mark.mcadoo@tn.gov
Shawn Bible	TDOT	Back-up Contact	615-532-3488	Shawn.a.bible@tn.gov
Amanda Snowden	TDOT	Region 1 Director	865-594-2400	Amanda.Snowden@tn.gov
Ken Flynn	TDOT	Region 2 Director	423-510-1217	Ken.Flynn@tn.gov
Mike Brown	TDOT	Region 3 Director	615-350-4305	Mike.Brown@tn.gov
Michael Welch	TDOT	Region 4 Director	731-935-0191	Michael.Welch@tn.gov

As a result of the initial project planning undertaken to select, pre-screen, and coordinate on each of the 120 samples, there were no compromised samples or significant field issues encountered during the field work period.

Primary Data Collection

As detailed above, site surveys were conducted in a similar fashion to the 2006 study. The following list provides an overview of the additional primary data collected at each of the sites.

- A broad range of site-specific characteristics, which were reviewed in cooperation with TDOT during the kick-off meeting, including location based variables (e.g., proximity to schools or certain business types), and other explanatory variables.
- Detailed site reconnaissance related to investigation of the key factors identified as potential causes of negligent litter from the prior body of work in this field, as well as new factors of interest as discussed with TDOT at project inception, including but not limited to the following.
    - Proximity to landfills, transfer stations, or recycling centers, and/or the frequency with which refuse and recycling collection vehicles frequent the road.

- Proximity and count of convenience stores and fast food restaurants to the site being surveyed; documentation included an inventory of such establishments on each roadway sampled within a predetermined radius (no greater than 3 miles) of the site.
- Identification of the number of street trash receptacles (if any, and as applicable) for the stretch of roadway, taking into account the quality of maintenance of each receptacle.
- Count and characterization of the number of pickup trucks, self-haul business trucks, and other potentially uncovered truck bed vehicles traversing the roadway per standardized unit of time.
- Identification of other types of businesses that may contribute to litter.
- Identification and inventory of construction activity in the area or other roadway blockages/traffic which may contribute to litter.

The advantage of combining broader site observations regarding suggested causes of litter (or the domain of primary data items) with detailed litter counts are as follows: (i) a sufficient number of observations were collected for purposes of statistical analysis; (ii) factors were not considered in isolation (e.g., binary comparisons) but were instead used as explanatory factors in a multivariate statistical model (as described later in this Report); and (iii) the level of importance of the factors, if any, can be quantified and compared to a broad range of other causal factors (as described later in this Report).

The field team and analysis team used Google Earth© technology to buttress observations in the field, particularly as it related to determination of proximity/prevalence of certain types of businesses for each sample. As noted above, the full set of primary data has been made available to TDOT as a separate archive deliverable.

Secondary Data Collection

Consistent with the Premise Document and discussions with TDOT at project inception, nFront also engaged in a comprehensive search to extract a wide range of secondary data for deployment in the downstream econometric analysis. Well over 1,000 potential explanatory variables were gathered, either at the county or Census Tract level, and were compiled into individual analytical files and scrubbed for purposes of inclusion in the econometric analysis. Table 4, below, summarizes the key data domains, the sources of the data, and provides a brief description of the types of variables found in each dataset. Refer to Appendix C for the complete Premise Document.

Table 4 – Summary of Key Secondary Data Domains and Sources

Data Domain	Source(s)	Data Description
Adopt-A-Highway Programs	Direct County interfacing/TDOT	Data regarding extent of AAH programs by county
Accidents/TN Traffic & Crash Data	TN Department of Safety & Homeland Security (March 2006 Publication)	County rankings and statistics in key accident types and causes; each county in TN ranked over 2011-2015

Data Domain	Source(s)	Data Description
Census Tract Data	American Community Survey (latest vintage 2014/2015); 2010 Census information	Tract-level match-up (based on Census Tract(s) associated with a given sample) of demographic, housing, educational attainment, population/density, and selected social characteristics
County Business Patterns	County Business Patterns – April 2016 Census Bureau Release	Number of types of business via North American Industry Classification System (NAICS) codes by county
Home Prices	Average List Price of Homes by County (Trulia, June 2016)	County listing of average home price by county
Health Data/Outcomes Data	2016 TN Health Rankings Database	University of Wisconsin Population Health Institute and Robert Wood Johnson Foundation data– health ranks by county across numerous outcome/lifestyle factors
Low-Income Housing	Department of Housing and Urban Development – July 1, 2016 effective date	Low-Income Housing Tax Credit Qualified Census Tracts
TDOT Metadata	TDOT GIS Database	A range of binary fields and traffic metrics derived from the GIS metadata transfer; includes special roadway designations (e.g. scenic route)
Vehicle Registrations	TDOT	Vehicle registration data by type by county
Solid Waste Management Facility Proximity/Counts	Maps provided by TDOT as validated by detailed Google Earth© research	Proximity to and count of nearby landfills, convenience centers, bale facilities, and recycling facilities
Tourism	2014 TN Economic Impact Report (U.S. Travel Association)	Statistics on tourism employment and economic metrics by county
Proximity to tourism/schools/parks	Google Earth© research	Determination of proximity of road segment based on latitude/longitude coordinates and Google Earth© layers
County Level Economic Data	Woods and Poole Economics, Inc. (2016 vintage data)	Wide-ranging county level economic data, including demographics and income/wealth variables
Availability of Waste Collection Services	TDOT interfacing and existing county databases	Determination of availability of curbside waste and recycling services/infrastructure on a county basis

It is important to note the purpose behind the extensive data gathering aspect of the Study design, and to distinguish such activities from typical *data mining* exercises. Gathering an extensive dataset for each site has one central benefit. By bringing together as many factors as possible for each site in our analysis, the team can ensure that the statistical relationships developed will have examined the broad range of potential drivers of litter rates and negligent litter percentages. The broader the range of issues explored analytically, the more likely it becomes to find substantive causes for why an area is littered, which will provide more education, enforcement, and eradication targets for TDOT to focus on (a premise that has been fully validated by the econometric results presented later in this Report). Furthermore, an analysis that attempts to be comprehensive in terms of compiling candidate data points and then testing this data for its ability to explain variations in litter rates and negligent litter percentages is defensible, and is not subject to intuition or guesswork when developing study conclusions.

BASIC STUDY RESULTS

This section provides an overview of the basic Study results and econometric Study results from a conceptual perspective, provides a discussion regarding the quality control procedures undertaken on the raw data during the processing phase of the Study, and provides a series of graphical exhibits with supportive discussion across each of the basic Study outcomes.

Conceptual Overview of Basic Study Results

Basic Study results consist of the following broad range of outcomes associated with the collection of raw data for each of the 120 samples in the field.

- Litter per mile estimates for each of the four roadway classifications as well as a statewide estimate of litter per mile; the latter estimate has been based on a weighted average derived from data provided by TDOT on the total number of miles in the state associated with each of the four roadway classifications. Litter per mile in each instance as presented in this Report reflects an extrapolation based on the edge distance and the existence and length of the median for a given sample. Furthermore, litter per mile has been bifurcated into two key metrics, each of which was modeled separately in the downstream econometric analysis, as follows:
    - Litter counted along the edge of the sample site only (“Visible Litter”), and
    - Litter counted along the edge of the sample site and all additional litter counted as part of the meander count (“Total Litter”);
- A comparison of litter per mile estimates (both Visible Litter and Total Litter) from the Study to the database maintained during the 2006 litter study; nFront engaged in a careful review and cross walk of the site and road segment information associated with the samples from 2006 in order to assign each sample from 2006 to one of the four roadway classifications for the Study; similar to the 2016 weighted average, the number of roadway miles in each roadway classification as provided by TDOT has been used to generate a total statewide litter per mile and total litter items for the 2006 study, the results of which assume no material change in the relative number of roadway segment miles across the four roadway classifications over the duration of the two data sets;
- A characterization of litter into one of 30 categories as detailed earlier in this Report; each of the 30 categories was assigned a preponderance-based cause of either deliberate or negligent litter; nFront also reviewed and extracted the same data from the 2006 litter study in order to provide comparative metrics around how and to what extent the split between negligent and deliberate litter has changed over the course of the two studies; the data is presented in Appendix B for each roadway classification and across all samples for the samples collected during this Study; the total composition reflects a weighted average based on the litter per mile associated with each sample, and consequently the “all samples” composition is highly influenced by samples with far greater litter per mile

averages. Individual roadway classification composition results are also presented herein as example pie charts reflective of high-level (or rolled up) categories; and

- A count of the number of cigarette butts associated with each site, which has been averaged and presented herein for each roadway classification.

Conceptual Overview of Econometric Study Results

In addition to these basic results, the Study aimed to determine and catalogue, whenever possible, the brand name associated with each item of litter encountered in the field. The brand names were grouped and ranked, both on a roadway classification and total basis, and the top brand names encountered are presented and discussed herein. In order to enhance the insights associated with the brand names encountered, nFront also engaged in a brand-name cross-walk analysis that identified the most prevailing brand names in several *universes* of brands, and then researched estimated revenues for each brand (based on sources such as Forbes and other readily available public sources) to derive *revenue adjusted* frequencies for each brand that reflect the relationship between revenue and counts encountered. In theory, there should be a strong relationship between the revenue of a brand (in relative terms within a given brand universe) and the frequency with which that brand was encountered in the litter stream. The purpose of the revenue adjusted values was to test this theory, such that the actual counts were divided by the relative revenue contribution to determine what brands were over-littered (or had a large raw count relative to their proportion of universe revenue) and what brands were under-littered (or had a small raw count relative to their proportion of universe revenue).

The brand universes, which were determined based on the majority of readily discernable brand names across all samples, were designated for this analysis are as follows.

- Fast food
- Alcoholic beverages
- Cigarette packaging
- Soda/soft drinks
- Snacks

The analysis has certain key limitations, most notably that (i) no large scale market research has been conducted, and the analysis and determinations of brand universes has been executed at a planning-level, (ii) there is some chronological diversity and uncertainty in the revenue estimates derived from various sources, which has been assumed to have a limited impact on the top-level goal of this analysis, and that (iii) revenue estimates are generally not available at the more granular state level, and consequently, the relationship between brand revenue nationwide has been assumed to reasonably reflect the extent to which such brands are consumed within the state of Tennessee. These limitations notwithstanding, the analysis does provide additional information that can be useful for understanding what brands are most susceptible to being littered.

Raw Data Processing and Quality Control

The nFront approach to quality control and data management is based upon the philosophy that there is no automated substitute for meticulous checking. nFront utilized a custom Microsoft Access™ database, which has been developed specifically for litter analyses, to input all accumulated litter observations. This database has been designed with certain pre-specified quality control queries that will check the data for the most probable and common data entry errors. The database was adjusted to align with the roadway classifications specified for this project, and was then combined with the 2006 study database to foster downstream comparative analytics (as detailed further below). All of the data was subsequently transferred into a spreadsheet model in order to further validate the outcomes and results derived from the Access database.

In addition to such automated checking, data entry personnel followed a strict physical quality control protocol, and each data sheet was checked in its entirety by a staff member that did not perform the entry. Additional steps taken to ensure proper data transcription included, but are not limited to: (i) review for problematic data points (no specific problematic data points encountered in this Study), and (ii) design of data collection form that minimize handwritten sections in lieu of pre-determined fields and check boxes.

The outputs of all of the raw data and basic study results were them combined with a series of spreadsheets of potential explanatory variables (as described earlier in this Report) in preparation for the econometric analysis. Refer to the Econometric Analysis subsection for a detailed discussion of the implications of the multivariate modeling performed on data gathered during this Study.

BASIC STUDY RESULTS AND FINDINGS

Statewide Litter Prevalence

On an overall basis, Visible Litter and Total Litter have declined over the period 2006 to 2016 by 23% and 53%, respectively. This is consistent with the findings described further below on a roadway classification basis, wherein, with the exception of Interstates, litter per mile across all other roadway classifications has declined. This finding, coupled with the fact that Interstates do not represent a large portion of total roadway miles in the state, results in a statewide litter per mile metric that more closely resembles local roads than Interstates. Figure 2 below summarizes the estimated Visible and Total litter items, in millions of items, for the 2006 and 2016 studies.

As evidenced by Figure 2, Visible Litter has declined from an estimated 44 million items to an estimated 34 million items, and Total Litter has declined from an estimated 212 million items to an estimated 100 million items. ***It is critical to maintain the appropriate perspective regarding these estimates, as they are based on a weighted average derived from the total number of miles of each roadway classification in the state, which as noted above favors local roads. This does not imply that negligent litter on Interstates should not be a top messaging priority, and the Abatement Policy & Tactics subsection of this Report provides a comprehensive discussion across all roadway classifications.***

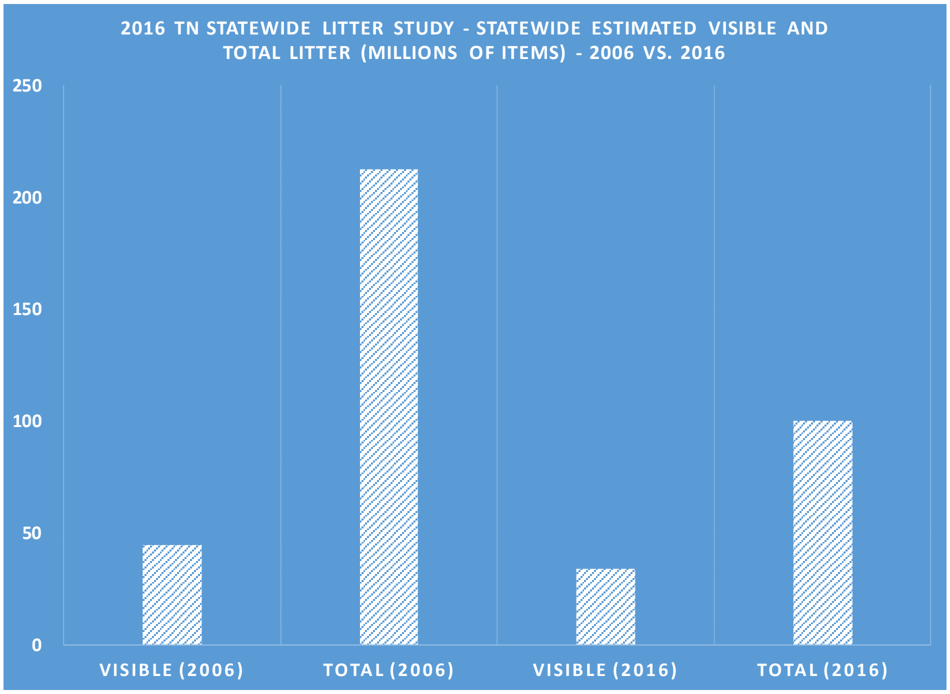

Figure 2 – Statewide Litter Prevalence Results

Litter Per Mile and Cigarette Butt Counts

Figures 3, 4, and 5 provide the results for both 2006 and the Study with respect to litter per mile, the split between negligent and deliberate litter, and the number of cigarette butts found by roadway classification.

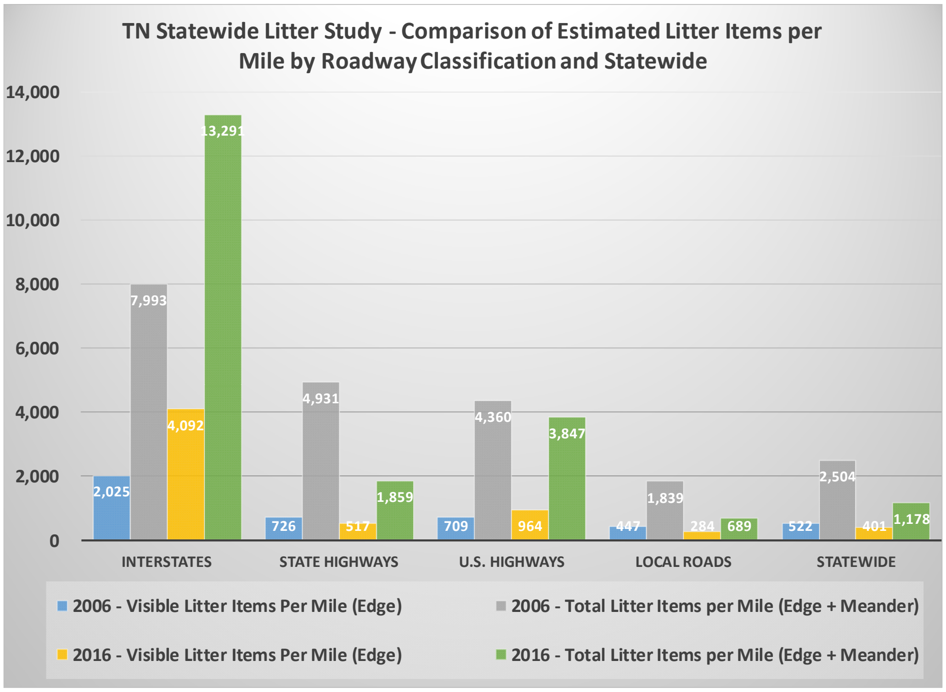

Figure 3 – Litter Per Mile Results

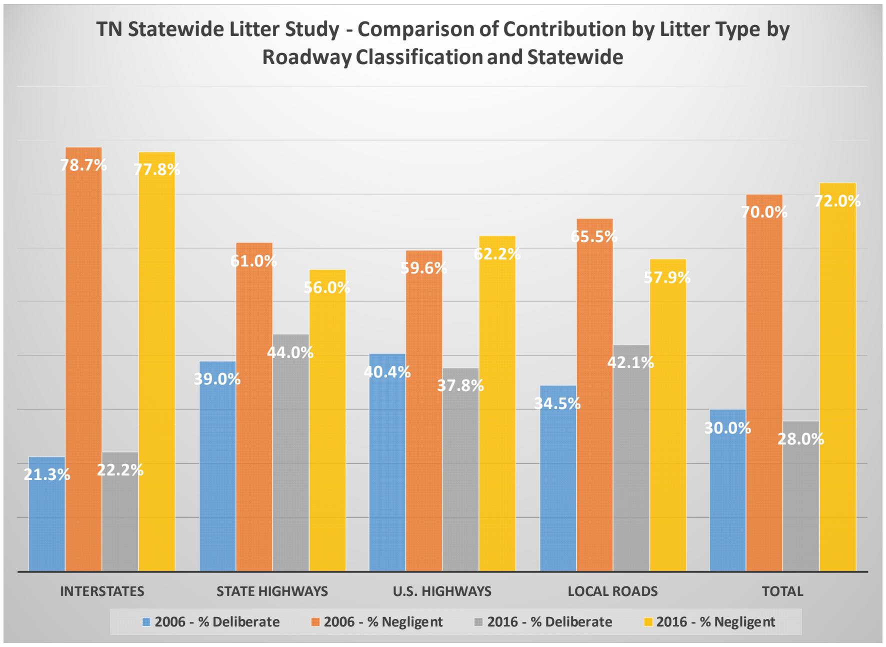

Figure 4 – Negligent vs. Deliberate Litter Results

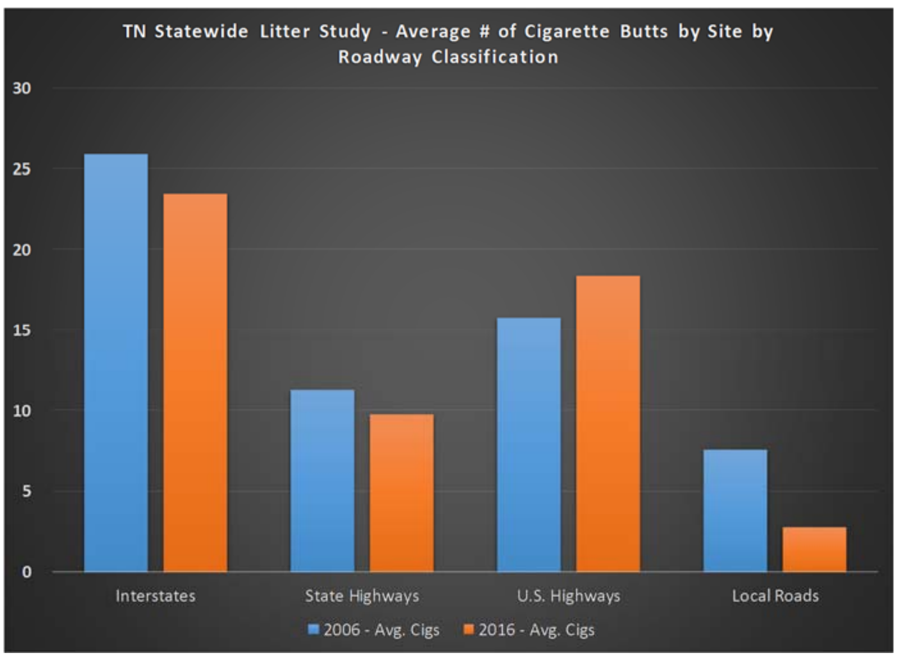

Figure 5 – Cigarette Butt Counts Results

As evidenced by the above figures:

- Litter per mile is dramatically higher for Interstates as compared to other roadway classifications. A compartmentalized approach to analysis and development of abatement tactics and messaging is described further below in this Report under the Abatement Policy & Tactics subsection.

- Litter per mile has declined across all roadway classifications, with the exception of Visible Litter per mile and Total Litter per mile on Interstates.
- There has been no material shift across all samples or with respect to a given roadway classification with respect to the split between negligent and estimated litter. While there is some fluctuation, negligent litter remains the majority component of all roadway classifications across both the 2006 and the 2016 data.
- Cigarette butt counts have fluctuated across roadway types, but are not subject to material long-term shifts in relative terms.

Litter Composition

Figures 6 and 7 below summarize the composition results at a high level (reflective of rolled up categories for illustrative purposes) for all samples and local roads. The *all samples* composition has been weighted based on the litter per mile for Total Litter in order to provide a realistic depiction of composition that takes the amount of litter found for each sample into account.

Notwithstanding the results for "all samples", it is important to note that the individual roadway classification results reflect considerable diversity (albeit the quantity of litter found for samples other than Interstates is considerably smaller), and that on a total roadway mileage basis, local roads represent a far larger proportion of the state than Interstates. The Econometric Analysis subsection details models inclusive of all samples as well as isolated to individual roadway classifications, each of which results in unique insights regarding the drivers of litter in a given context. Appendix B of this Report provides full composition results by roadway classification and across all samples for the 30 Study categories.

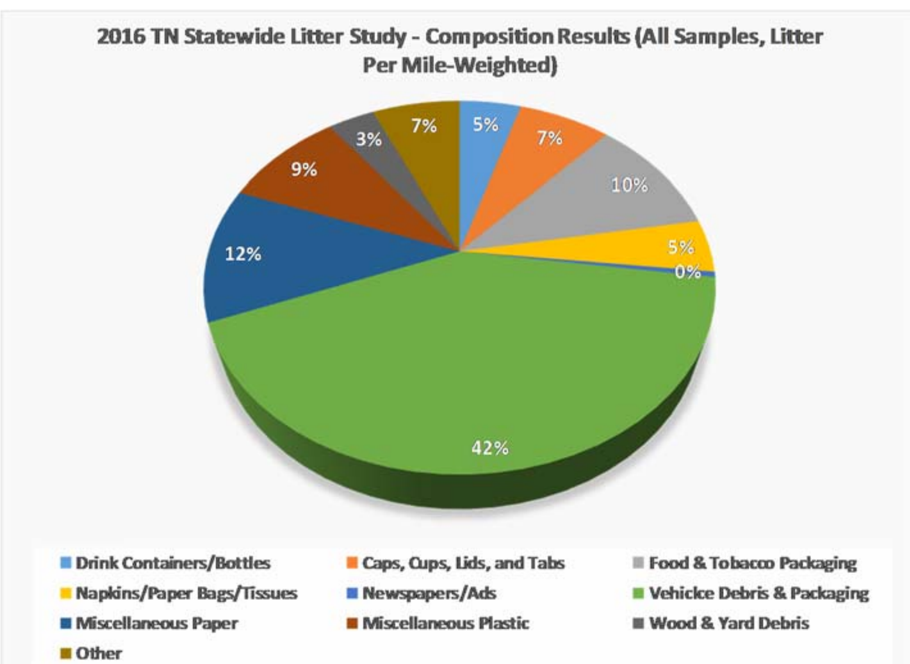

Figure 6 – Litter per Mile-Weighted Composition Results

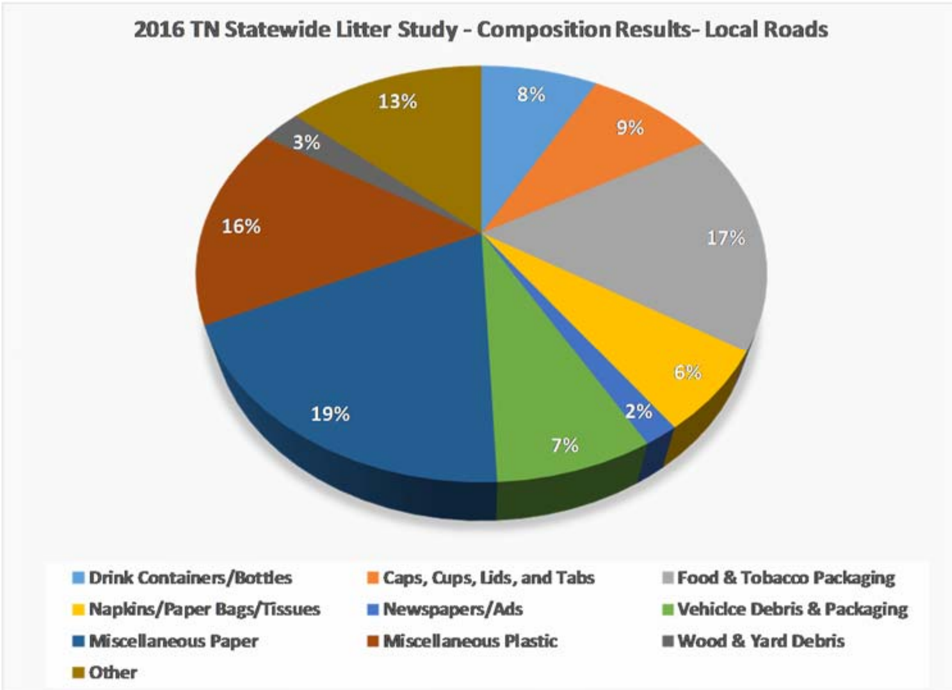

Figure 7 – Composition Results – Local Roads

Brand Name Analysis

Figures 8 through 13 below summarize the top ranked brand names found across the Study, and the results of the revenue adjusted frequency analysis by brand universe.

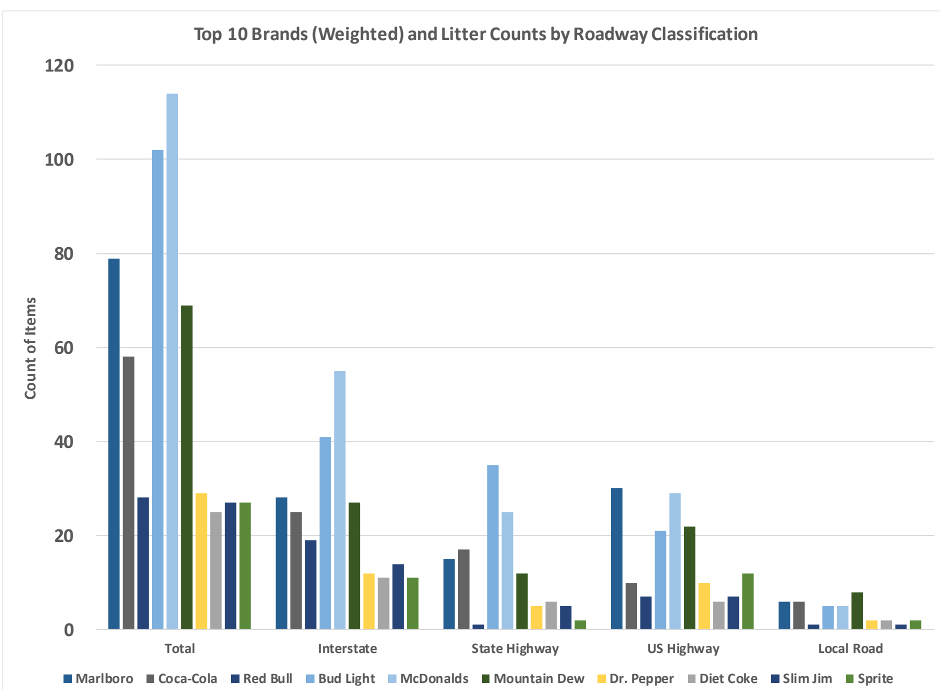

Figure 8 – Top 10 Brands and Litter Counts

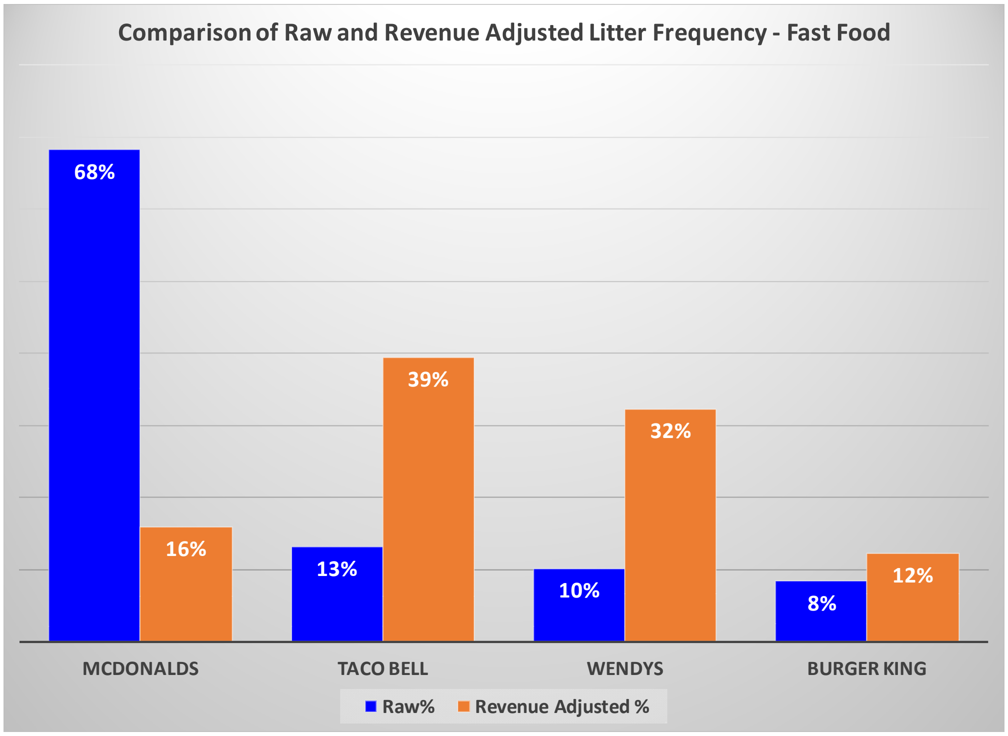

Figure 9 – Brand Name Cross-Walk Results – Fast Food

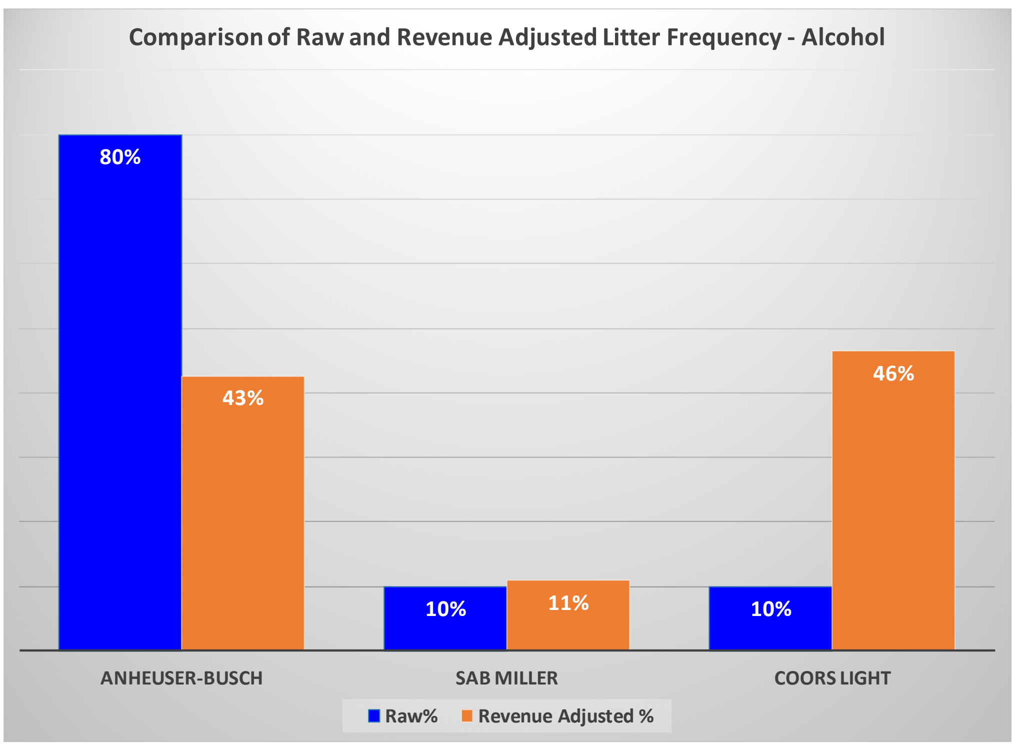

Figure 10 – Brand Name Cross-Walk Results - Alcohol

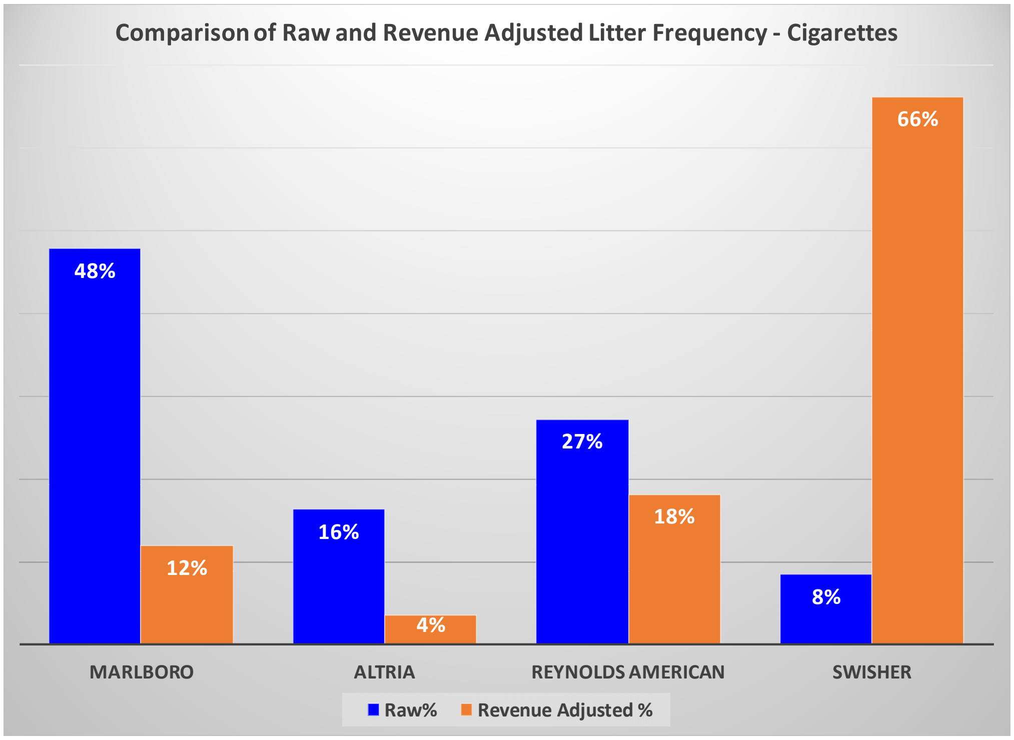

Figure 11 – Brand Name Cross-Walk Results - Cigarettes

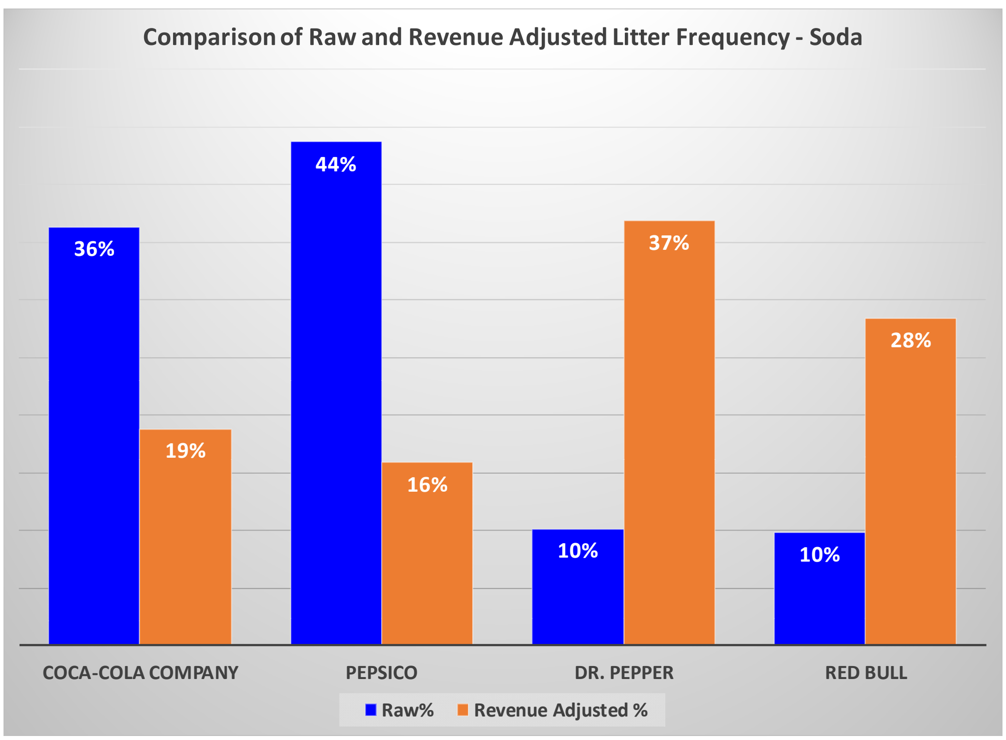

Figure 12 – Brand Name Cross-Walk Results - Soda

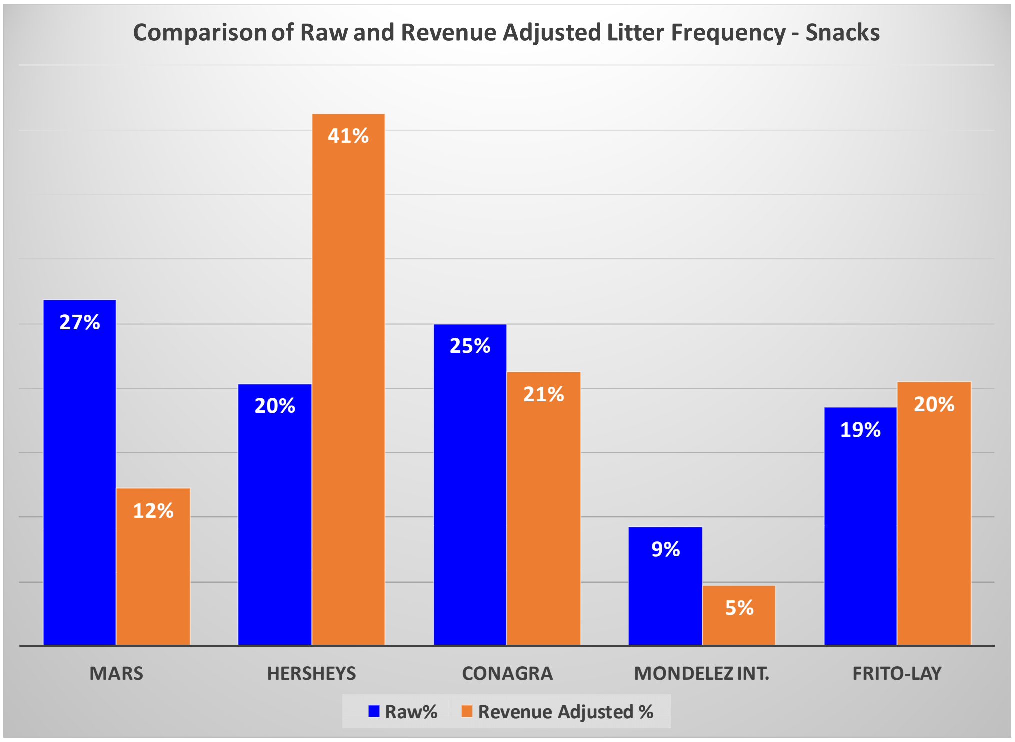

Figure 13 – Brand Name Cross-Walk Results - Snacks

Based on the range of results presented in Figures 8 through 13 above, the brand name analysis suggests the following conclusions.

- The most frequently encountered brands in raw total and weighted form were McDonalds (#1), Bud Lite (#2), and Marlboro (#3).
- If you combine the sub-brands for soda, the Coke brand (reflective of Coke, Diet Coke, and Sprite) eclipses Marlboro and Bud Lite and is only marginally less frequently encountered than McDonalds.
- Mountain Dew (a Pepsi product) was just behind Marlboro in the tally.
- If you include Dr. Pepper in the overarching tally, the most prominent litter items for which brands could be discerned and which were encountered frequently are in the soda domain (note that the less frequently encountered soda brands would also contribute to this total).
- Over 272 unique brand names were encountered in the field. The grouping of brand names into overarching "universes" (as defined above) was partially intended to help determine whether brands that may not have been found as frequently add up to something more material if sub-brands are combined. That being said, some brands were only encountered a few times and the list becomes fairly dispersed after the leaders are collated, which implies that the top brands identified in each universe reflect a significant portion of the brands encountered in total.

- Brands within each universe reflect over-littering or under-littering. Brands such as Coke, Pepsi, McDonalds, and Marlboro were littered less frequently than what would be expected as a function of their revenue contribution to that particular brand universe. Conversely, brands such as Wendy's, Taco Bell, Swisher Sweets, and Coors Light, among others, were littered more frequently than what would be expected as a function of their revenue contribution to that particular brand universe.

ECONOMETRIC ANALYSIS

This section provides an overview of the econometric analysis conducted for the Study, and presents tabularized results associated with each of the econometric models developed. Supportive discussion is also provided associated with interpretation of each model. Refer to the Abatement Policy & Tactics subsection later in this Report for a detailed discussion of the implications of the econometric analysis.

Econometric Modeling Approach

nFront deployed Econometric Views™ ("Eviews") software to develop a series of statistically valid models of litter rates, negligent litter percentages, and cigarette butt counts. This software has been used in the industry for over 30 years, and combines spreadsheet and relational database technology, as well as advanced visualization tools, with the traditional functionality found in statistical software. This program allows nFront to compile, review, and analyze large amounts of data with a transparent and time-tested process. This process involves testing a variety of combinations of potential explanatory variables for their ability to explain variations in litter rates, negligent litter percentages, and cigarette butt counts. Figure 14, below, provides a pictorial representation of the customized econometric modeling process developed for the Study.

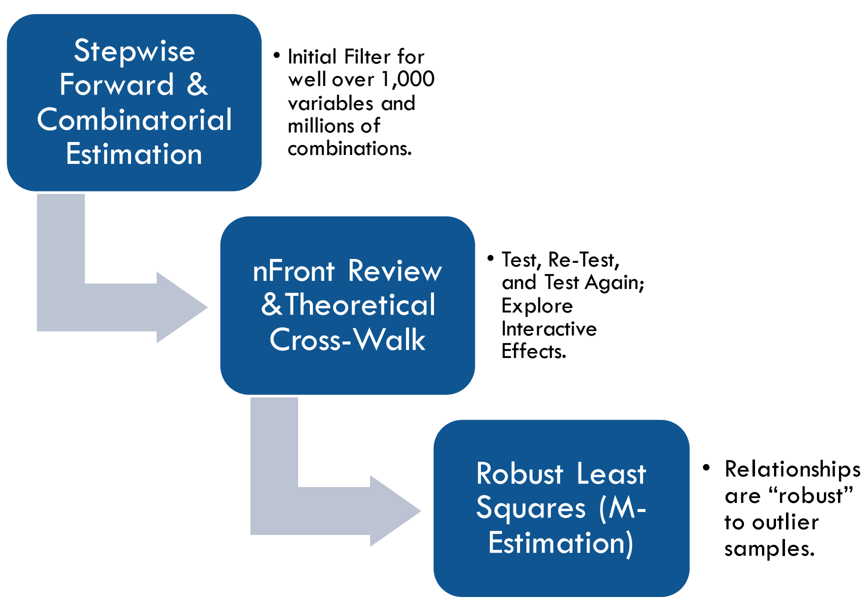

Figure 14 – Overview of Econometric Modeling Process

As indicated by Figure 14, above, the approach to developing each econometric model contained the following key steps.

- A stepwise-forward and combinatorial estimation routine was initiated using Eviews. These routines allow the statistical software to serve as an initial filter, based on technical criteria specified by the analyst, for well over 1,000 individual explanatory factors (both primary and secondary) and millions of combinations of explanatory variables. Each model was initiated using both approaches, resulting in two preliminary candidate equations for each model.
- nFront then engaged in a thorough review and theoretical cross-walk of each equation, wherein the coefficients (or explanatory variable parameters) estimated in each candidate model were tested, re-tested, and compared to theoretical expectations. As the stepwise-forward and combinatorial approaches cannot examine interactive effects (e.g. are local roads that are also residential significant?), and due to the likelihood of inferential errors resulting from overreliance on the stepwise routine, this intermediary phase of analysis was critical to deriving reasonable results. The stepwise and combinatorial model variables were fused and coupled with analyst review to result in a single candidate model across each litter metric.
- The candidate model was then re-estimated using robust least squares, which is an alternative to traditional least squares regression that provides parameter estimates that are more "robust" to the presence of outliers. As evidenced by the Basic Study Results sub-section above, there was a good "spread" (or sufficient variation) across the 120 samples collected, and consequently, the difference between the robust estimation and traditional estimation was bounded. However, the robust estimation provides a more precise set of parameters from which impacts can be quantified.
- As appropriate, additional iterations and estimations were conducted, particularly as it related to certain secondary data (most notably information regarding AAH) that was not immediately available at the onset of the econometric modeling process. These variables were subjected to similar testing procedures to determine whether the models could be improved with their inclusion.

Ultimately, the combination of factors that performed best in explaining the observed variations in each model were retained for development of final conclusions regarding the key drivers of litter, the results of which directly drive our recommended education, enforcement, and eradication strategies. As depicted in Figure 14 above, at various points in this final equation development, the candidate variables are subjected to a multitude of statistical tests, coupled with review of estimated parameters for theoretical sensibility (i.e., the impact of variables in the model are compared to expectations), in an effort to isolate the key drivers of litter rates on TDOT roadways. Additionally, variables that were included in the model were examined to ensure that there was no undue influence on model parameters resulting from strong correlation between one or more variables (an issue referred to as multicollinearity), which can disrupt the statistical estimation routine and prevent the model from producing theoretically sensible results.

These aspects of analyst review and judgement represent a critical component of sound econometric modeling – theories must "confront" the available data, and all estimations must reflect plausible theoretical relationships. Models that posit untenable theoretical relationships, irrespective of the ostensible statistical significance of a given factor or other measures of fit (or equation diagnostics) may reflect spurious relationships and should not arbitrarily be used to inform policy. The econometric approach represents a significant enhancement to the quality, defensibility, and usefulness of results. In prior litter analyses, key areas or potential causes of litter have been either qualitatively identified or been subjected to binary analysis (or analysis of a single causal factor in isolation). For example, where a conclusion in a prior study may have been "sites that were participants in an Adopt-a-Highway program have lower litter rates than other roadways," the econometric analysis affords the analyst the ability to answer more in-depth questions, such as:

- Is the difference between Adopt-a-Highway sites and other sites statistically significant, and how many observations were conducted in order to reach this conclusion?
- Does the type of roadway in question matter when examining the impact of this conclusion, or is it valid across all roadway types?
- Is this factor statistically significant when other potential factors are considered (e.g., perhaps Adopt-a-Highway sites tend to reflect other important characteristics)?
- Should this factor be a priority from a policy, education, and eradication perspective as compared to other drivers of litter rates, and if so, is this conclusion consistent with expectations/theory?

An econometric model allows the analyst to answer these questions because it allows for the evaluation of multiple factors concurrently. As a result, the outcome of the models can directly drive recommendations to TDOT regarding education, enforcement, and eradication policies that will be most effective in reducing litter rates in the short term and sustaining this reduction in the long-term. Furthermore, the Study design was predicated upon the ability to derive models using all samples as well as models isolated to specific roadway classifications in order to ensure that differentiators within a roadway classification could successfully be identified.

Econometric Modeling Results

Econometric models were developed for the following litter metrics, consistent with the definitions of each metric in the Basic Study Results section above.

- Visible Litter per mile (all Samples and 4 Roadway Classifications)
- Total Litter per mile (all Samples and 4 Roadway Classifications)
- Percent Negligent Litter (Supplemental Model, all Samples only)
- Cigarette Counts (Supplemental Model, all Samples only) [3]

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[3] Limited data adjustments were required to render the cigarette butt data suitable for the econometric process outlined above. Such adjustments have a negligible impact on inferences made from the supplemental cigarette butt model.

Tables 5 through 16, below, summarize, in tabular format, the results of each econometric model. In order to aid in interpretation of each model, the list below describes the fields included in each table.

- **Variable Name** – Each line of each table contains a detailed description of each variable, including distinguishing whether a variable was binary, delineating distance based metrics that may apply (e.g. within 3 miles of the site), the granularity of the variable (if applicable, such as whether the variable was measured at the Census tract level or at the county level), and other key descriptors. These variables represent the results of the model in each "universe" (120 samples for "all samples" and 30 samples for each of the four roadway classifications).
- **% Impact of 1-Unit Change in Variable** – This field can be interpreted as, all else equal, a change of one unit (or for binary variables, the existence of a given condition) was found to reflect X% higher/lower [insert litter metric]; this coefficient reflects the relative impact in the context of each multivariate model, and the model tables have been sorted in descending order (with the variables found to have the largest positive (upward) impact shown in red at the top of the table, and the variables found to have the largest negative (downward) impact shown in green at the bottom of each table[4].
- **Statistical Significance Level (%)** – This field is a measure of how confident the analyst/model is that the variable in question has a statistically significant impact on litter; while this measure is typically 90% or higher, there is nothing magical about 90% confidence. Data sets measuring human behavior call for loosened standards, within reason, for variables that posit a sound theoretical relationship or that otherwise are valuable to quantify (which in some cases can help falsify preconceived notions regarding the importance of a given factor). Each table below contains variables with high levels of statistical significance, but the modeling process was flexible and inclusive for variables with less significance as deemed appropriate by nFront.

[4] Certain econometric variables deployed, most notably business establishments per 1,000 people in a county, reflect a very small number. Consequently, a one-unit change reflects a significant increase, which results in a very high percent impact estimate for that variable. Such variables should be interpreted accordingly.

Table 5 – Econometric Results – Visible Litter (All Samples)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Proximity to Rest Stop (Binary,3 miles, Sample)	187%	90%
Professional, Scientific, & Technical services Est. per 1,000 ppl. (County)	93%	95%
Federally Designated Truck Route (Binary, Sample)	81%	95%
Distance of Buildings/Structures from Road (<50 ft. to >100 ft., Sample)	12%	71%
# of Convenience Stores Nearby (GPS, 1 mile, Sample)	7%	95%
Selected Monthly Owner Costs - No Mortgage - <$100 (Tract)	6%	90%
% Transportation, Warehousing & Utilities Employment (Tract)	5%	95%
Roadway Speed Limit (MPH, Sample)	2%	95%
Teen births / Females Ages 15-19 * 1,000 (County)	2%	95%
# of Registered Refuse Trucks (County)	1%	90%
# of Open Bed Vehicles (Count, Sample)	0%	95%
Male Population Ages 25 - 34 (Tract)	0%	90%
% Government Employees (Tract)	-3%	95%
# of Convenience/Drop-Off Centers (County)	-3%	90%
% of Householders who Moved in during 1990s (Tract)	-5%	95%
Finance and Insurance Employment (Thousands, County)	-9%	95%
Local Road AND Residential Area (Sample)	-22%	70%
Agriculture, Forestry & Fishing Est. per 1,000 ppl. (County)	-100%	95%

Table 6 – Econometric Results – Total Litter (All Samples)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Graffiti (Binary, Sample)	279%	95%
Damaged Buildings (Binary, Sample)	68%	95%
Professional, Scientific, & Technical services Est. per 1,000 ppl. (County)	55%	95%
Transportation & Warehousing Est. per 1,000 ppl. (County)	50%	84%
Proximity to an On-Ramp/Exit-Ramp (Binary, Sample)	46%	95%
Federally Designated Truck Route (Binary, Sample)	43%	90%
Paved Road (Binary, Sample)	37%	95%
# of Lanes (Sample)	12%	95%
# of Utilities Est. (County)	5%	89%
% Adults Obese (County)	4%	95%
Roadway Speed Limit (MPH, Sample)	3%	95%
# of Manufacturing Est. (County)	0%	89%
# of Registered Motor Homes (County)	0%	83%
State Tax Receipts per Capita ($M, County)	0%	95%
% Government Employees (Tract)	-1%	80%
# of Agriculture, Forestry & Fishing Est. (County)	-11%	95%
Local Road AND Residential Area (Binary, Sample)	-32%	90%
Welcome Sign (Binary, Sample)	-42%	90%
# of Public Transportation Hubs Nearby (1,000 ft., Sample)	-45%	95%

Table 7 – Econometric Results – Visible Litter (Interstates)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Finance and Insurance Est. per 1,000 ppl. (County)	287%	95%
Road Expansion (Binary, Sample)	185%	95%
Proximity to Rest Stop (3 miles, Sample)	183%	95%
Traffic Backup (Binary, Sample)	91%	95%
Proximity to an On-Ramp/Exit-Ramp (Binary, Sample)	32%	95%
Health Care and Social Assistance Est. per 1,000 ppl. (County)	22%	95%
# of Hardware Stores Nearby (GPS, 1 mile, Sample)	4%	95%
# of Fast Food Est. Nearby (GPS, 1 mile, Sample)	2%	95%
AADT (Sample)	0%	95%
AAH Program (Binary, County)	-20%	95%
Curbside MSW Collection (Binary, County)	-20%	95%
Overpass Intersecting Site (Binary, Sample)	-37%	95%
Admin/Support/Waste Management/Remediation Est. per 1,000 ppl. (County)	-78%	95%

Table 8 – Econometric Results – Total Litter (Interstates)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
AAH Program (Binary, County)	67%	95%
Road Expansion (Binary, Sample)	61%	90%
Traffic Backup (Binary, Sample)	52%	89%
Distance of Buildings/Structures from Road (<50 ft. to >100 ft., Sample)	46%	95%
Roadway Speed Limit (MPH, Sample)	8%	95%
# of Open Bed Vehicles (Count, Sample)	0%	95%
Older Concrete (Binary, Sample)	-36%	95%
Near Major Construction Zone (Binary,3 miles, Sample)	-38%	95%

Table 9 – Econometric Results – Visible Litter (State Highways)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Grass Height > 6 Inches (Binary, Sample)	321%	95%
# of Visible Convenience Stores (1 mile, Sample)	128%	95%
# of Convenience/Drop-Off Centers (County)	8%	95%
# of HHs with PY $20K - $29K (Thousands, County)	8%	95%
AADT (Sample)	0%	89%
Manufacturing Employment (Thousands, County)	-6%	95%
AAH Program (Binary, County)	-19%	86%
# of Stop Signs (1,000 ft., Sample)	-31%	95%
# of Bale Facilities (County)	-62%	95%

Table 10 – Econometric Results – Total Litter (State Highways)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Persons Per HH (County)	368%	89%
Grass Height > 6 Inches (Binary, Sample)	130%	95%
Proximity to Park(s) (Binary, Sample)	79%	89%
# of Traffic Lights (Sample)	71%	84%
Manufacturing Est. per 1,000 ppl. (County)	69%	85%
Damaged Buildings (Binary, Sample)	63%	89%
Paved Road (Binary, Sample)	50%	90%
Tree-Lined Roads (Binary, Sample)	-30%	87%
Forestry/Fishing Employment (Thousands, County)	-79%	79%

Table 11 – Econometric Results – Visible Litter (US Highways)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Anti-Littering Signage (Binary, Sample)	343%	95%
Maintained Shoulder - Gravel (Binary, Sample)	103%	95%
Visible Fast Food Est. (1 miles, Sample)	73%	95%
Distance of Buildings/Structures from Road (<50 ft. to >100 ft., Sample)	72%	95%
Federally Designated Truck Route (Binary, Sample)	27%	90%
# of Stop Signs (1,000 ft., Sample)	25%	95%
# of Lanes (Sample)	17%	95%
Population Ages 15-17 (Thousands, County)	5%	78%
Roadway Speed Limit (MPH, Sample)	4%	95%
Population Ages 85 or Over (Thousands, County)	-6%	60%
Curbside MSW Collection (Binary, County)	-16%	85%
Grass Height > 6 Inches (Binary, Sample)	-46%	95%
Tree-Lined Roads (Binary, Sample)	-60%	95%

Table 12 – Econometric Results – Total Litter (US Highways)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Management of Companies Est. per 1,000 ppl. (County)	699%	90%
Murals/Fancy Landscape (Binary, Sample)	160%	95%
Distance of Buildings/Structures from Road (<50 ft. to >100 ft., Sample)	44%	95%
Proximity to an On-Ramp/Exit-Ramp (Binary, Sample)	27%	61%
# of Fast Food Est. Nearby (GPS, 1 mile, Sample)	7%	95%
Percent Self-Employed (Tract)	5%	90%
Percent Construction Employment (Tract)	5%	90%
Roadway Speed Limit (MPH, Sample)	2%	90%

Table 13 – Econometric Results – Visible Litter (Local Roads)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Mining/Oil & Gas Extraction Est. per 1,000 ppl. (County)	2578%	83%
Empty Commercial Buildings (Binary, Sample)	165%	95%
Low Income Housing Tax Credit Qualified (Binary, Tract)	85%	95%
# of Multi- Occupant Vehicles (Count, Sample)	49%	90%
# of Trash Cans (1,000 ft., Sample)	19%	95%
Average Home List Price ($, County)	0%	90%
# of Single Occupant Vehicles (Count, Sample)	-6%	90%
Grass Height 3 to 6 Inches (Binary, Sample)	-48%	95%
Older Concrete (Binary, Sample)	-51%	95%
Murals/Fancy Landscape (Binary, Sample)	-51%	95%
New Building/Work Zone (Binary, Sample)	-66%	95%

Table 14 – Econometric Results – Total Litter (Local Roads)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Mining/Oil & Gas Extraction Est. per 1,000 ppl. (County)	14239%	90%
Fresh Concrete (Binary, Sample)	194%	95%
Graffiti (Binary, Sample)	194%	95%
Damaged Buildings (Binary, Sample)	105%	95%
# of Visible Hardware Stores/Self-Storage (1 mile, Sample)	98%	89%
Low Income Housing Tax Credit Qualified (Binary, Tract)	71%	95%
Distance of Buildings/Structures from Road (<50 ft. to >100 ft., Sample)	22%	87%
# of Convenience Stores Nearby (GPS, 1 mile, Sample)	6%	82%
Murals/Fancy Landscape (Binary, Sample)	-49%	95%

Table 15 – Econometric Results – Percent Negligent Litter (All Samples)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Paving/Lane Closure (Binary, Sample)	179%	95%
Graffiti (Binary, Sample)	124%	95%
STRAHNET TDOT Designation (Binary, Sample)	51%	95%
AAH (Binary, Sample)	28%	90%
Empty Commercial Buildings (Binary, Sample)	27%	95%
Street Lights (Binary, Sample)	15%	95%
Transportation & Warehousing Est. per 1,000 ppl. (County)	15%	80%
# Of Recycling Vehicles (Count, Sample)	5%	81%
% of Total Housing Units Built in 1970s (Tract)	-1%	95%
# of Storm water Runoff Basins (Sample)	-7%	95%
Curbside Recycling (Binary, County)	-8%	86%
# of Visible Fast Food Est. (1 mile, Sample)	-8%	95%
Local Road (Binary, Sample)	-18%	95%
Construction Est. per 1,000 ppl. (County)	-20%	95%
TN Scenic Highway (Binary, Sample)	-42%	95%
New Building/Work Zone (Binary, Sample)	-58%	95%
No Grass (Binary, Sample)	-58%	95%
Murals/Fancy Landscape (Binary, Sample)	-58%	95%

Table 16 – Econometric Results – Cigarette Butt Count (All Samples)

Variable Name	% Impact of 1-Unit Change	Statistical Significance Level
Paved Road (Binary, Sample)	125%	95%
# of Visible Hardware Stores/Self-Storage (1 mile, Sample)	69%	95%
Empty Commercial Buildings (Binary, Sample)	69%	95%
TN Bicycle Route (Binary, Sample)	49%	90%
% Excessive Drinking (County)	21%	95%
% Families with PY $25K - $35K (Tract)	4%	95%
Roadway Speed Limit (MPH, Sample)	1%	90%
# of Open Bed Vehicles (Count, Sample)	1%	95%
Unemployment % (Tract)	1%	89%
High-Rent as % of Family PY (>35%, Tract)	-2%	95%
Overpass Intersecting Site (Binary, Sample)	-36%	90%

Refer to the Abatement Policy and Tactics subsection for a detailed discussion of conclusions, suggested messaging and abatement tactics, and prevailing themes that are directly driven from the results shown above.

KEY STUDY ASSUMPTIONS AND LIMITATIONS

The findings resulting from this Study must be interpreted in light of the following key Study assumptions and limitations.

- Data from 3rd party entities or from TDOT that has been provided to nFront for purposes of this Study is assumed to be accurate to the best knowledge of each respective provider. While nFront has undertaken a significant and detailed quality control process as described earlier in this Report to ensure the alignment of the appropriate variables with each of the 120 samples collected, we have not independently verified externally developed data and have assumed all such data is reasonable for the purposes described in this Report.
- Assignation of litter items to “negligent” versus “deliberate” categories is based on the preponderance of assumed sources for a given category. There is no guarantee that any item of litter found in the field is negligent/deliberate.
- The basic study results and econometric findings presented in this Report reflect a cross-sectional analysis, and consequently, the conclusions drawn from such findings are reflective of relationships estimated for the current period in time. Longitudinal studies (which reflect tracking of the impact of enacted policies/messaging over specific intervals in time) should be considered as mechanism to determine which strategies, messaging initiatives, and tactics are most effective over time.
- The basic study results associated with litter per mile at the statewide and roadway classification level reflect extrapolative techniques based on edge distance, as well as assumptions and measurements regarding the existence and length of the median. While the extrapolations reflect a reasonable approach based on the number of samples collected, and the statewide estimates are based on a weighted average that takes the total mileage

available in each roadway classification into account, the results should be interpreted as planning level outcomes that are appropriate for the purposes of this Study, and not as absolute results.

- Policy-oriented econometric models are intended to test hypotheses related to the impact of a given explanatory variable on the variable to be explained. As is the case with any econometric model, there is a small chance that variables that cannot be measured or that were not considered can bias the coefficients derived from a given econometric equation. This is often referred to as omitted variable bias. The impact of this type of bias is assumed to be minor for the purposes of this Study.
- The objective of the econometric analysis and the various equations developed is not to "forecast" litter metrics, and such models should not be interpreted or deployed for this purpose. Adjusted R-squared[5] ranges for the econometric models developed for this Study are well above average for hypothesis testing models (50% to 70% reflects the general range of models developed for this Study). The efficacy of hypothesis testing models is not primarily based on the proportion of variation explained (which even in forecasting models can be arbitrarily increased by adding explanatory variables). The robust estimation procedures deployed for this Study and the vast number of theoretically-based explanatory variables evaluated has resulted in above average explained variation that provides defensible estimates of the impact of a given factor, all else equal.
- Notwithstanding the quality control process associated with litter counts, litter characterization, brand name identification, data entry and associated review, and downstream data management of all pertinent data points, there is always a small possibility that measurement error has occurred (i.e., that a particular condition either in the field or as measured by secondary data has been inaccurately measured). The impact of measurement error is assumed to be negligible for this Study as a function of the representative random sample and the large range of primary and secondary data collected, which when analyzed in a multivariate model greatly reduces the influence of potential measurement error associated with a single data point or observation.

ABATEMENT POLICIES & TACTICS

Leveraging the full extent of basic study results, as well as the detailed econometric modeling results tables presented earlier in this Report, this section provides a series of detailed suggestions for abatement, messaging, and tactics. First, a series of prevailing themes that captures the overarching relationships suggested by the range of analysis are provided. This is followed by a more detailed listing of strategies and tactics that reflect implications across all samples collected, which feeds into specific areas of focus for individual roadway classifications. ***As noted elsewhere in***

[5] Adjusted R-squared is a measure of the proportion of variation of the dependent variable that is explained by the set of explanatory variables in each equation that penalizes models for arbitrarily adding explanatory factors.

this Report, the conclusions and suggested tactics represented herein are directly driven by the analysis conducted over the course of this Study, and do not reflect nor endorse any preconceived notions regarding the efficacy of a given policy. Furthermore, the Econometric Analysis section contains quantification of each individual variable resulting from the various models, which should be cross-referenced to the suggested strategies and tactics below. nFront has focused on "low hanging fruit", top-priority items in this section that represent factors and activities that TDOT is believed to have control over. There may be additional variables or factors represented in the econometric modeling results section that could warrant effort as a function of TDOT's long-term resource constraints.

Prevailing Themes

- **Abatement messaging and policy should take a compartmentalized, prioritized approach.**

  Based on the range of analysis conducted, it is clear that factors that impact litter are different in magnitude and makeup by roadway classification. While litter per mile on Interstates far outpaces the same metrics on other roadways, the same tactics and messaging cannot unilaterally be applied to mitigate long-term litter accumulation on Interstates as on other roads. Additionally, the econometric analysis can be used to prioritize the types of messaging and resource allocations afforded a particular roadway classification.

- **The most prevailing meta-theme is ownership.**

  Across all of the analysis conducted, there is a strong relationship between variables that define a sense of personal ownership (or lack thereof) and the amount of litter found on a given roadway.

- **Socioeconomics matters, but primarily closer to home.**

  The econometric results suggest that as you move down from Interstates to Local Roads, socioeconomic factors are far more influential in determining differences between one sample and another. In contrast, contextual variables that provide an opportunity for litter to accumulate have a significant impact irrespective of socioeconomic or demographic makeup as you move away from localities. This is a critical distinction, in that the analysis conducted in this Study suggests that opportunities for litter to accrue that reflect primary conditions associated with a roadway outweigh economic distinctions surrounding the roadway for the majority of samples evaluated. Demographics, in general, also reflected limited significance, and the impact of younger cohorts was mixed to insignificant.

Policy Implications – All Roadway Types & Samples

- Advertising and messaging should solicit the same sense of respect/ownership for Interstates as the street you live on. Ownership related variables can help solicit a sense of pride in surrounding roadways and a higher overall aesthetic standard. Areas where building distance from roads is smaller, and which are predominantly residential in nature have dramatically less litter, which could serve as the messaging benchmark.

- Interstate litter per mile far outpaces other roadway classifications. Interstate litter should be a top abatement and messaging priority.
- Low-Income and public housing neighborhoods should be targeted for strategies. These areas correspond to the overall theme that limited feelings of ownership are related to higher litter per mile, all else equal.
- The econometric analysis suggests that TDOT and supportive partners can target certain types of businesses in messaging to engage in ways to improve ownership of areas. These businesses may also have specific ideas regarding how to better contain litter that can be gleaned through more direct interaction.
- Proximity to rest stops was found to significantly impact litter per mile (as applicable). Tactics to better address this contextual variable include the following:
  - Littering Signage (littering fine notice, checking truck beds for loose trash, etc.)
  - Adequate and maintained trash/recycling receptacles (among parking lots and not just by restrooms/indoor facilities)
  - Improved overall rest stop maintenance
- Proximity to interstate and highway on-ramps and exit ramps and proximity to traffic lights and stop sign intersections heading into and out of higher density commercial areas were another major contextual variable that related strongly to increased litter prevalence. These situations provide an excellent target for signage, advertising and messaging in terms of location/context.
- General aesthetic variables and conditions were strongly related to litter prevalence, which supports the notion that community condition does beget litter. Improved roadside maintenance, fines for derelict buildings, and providing incentives for re-development of brownfield sites can help reduce the impact of environmental conditions on litter per mile.
- Consistent with the Premise Document, designated truck routes were found to have higher litter per mile, all else equal. There may not be any direct control of such routes as it relates to TDOT activities, but TDOT should investigate ways to target messaging on such routes.
- Proximity to littered material sources, such as fast food restaurants, and their significant impact on litter per mile, suggest the following tactics.
  - Creation and enforcement of rules associated with trash receptacles at fast food/convenience stores (e.g. outdoor receptacles must be available by building egress points and in parking lot and maintained).
  - Targeted campaigns regarding littering in concert with fast food providers (e.g., drive-through packaging with anti-littering messaging).

- The TDOT should consider re-evaluating the efficacy of anti-litter signage. The econometric analysis indicates that anti-litter signage has limited to no impact on litter, and in the case of US Highways, may be serving the converse purpose relative to its intent.

- Negligent vehicle debris and packaging was the single most contributory component of litter per mile across all of the roadway types. The following tactics may help mitigate this class of litter.

  - Improve vehicle cleanups after wrecks in order to reduce negligent litter.
  - Utilize abatement crews to regularly drive the Tennessee Interstate system to pick up vehicle debris on the edge of roadways.
  - Consider a mobile reporting system (e.g. information derived from Waze or a similar application) where drivers can report the location of their wrecks/blowouts, in order to support more comprehensive cleanup of such events.
  - Improve road surface transitions for paving/lane closures.
  - Re-evaluate efficacy of anti-litter signage around work zones, as the signage may in fact be serving the converse purpose relative to its intent.

- Increase policing and partnerships to reduce negligent litter. Negligent litter constitutes 72% of total litter across all of the roadway types (and between 56% and 80% for specific roadway types).

  - Increase secure loads enforcement by state highway patrol.
  - Partner with the waste collection industry to reduce unsecured waste in hauling vehicles.

- Target Adapt a Highway ("AAH") and maintenance efforts to high traffic volume roadway stretches (e.g., inside and heading into/out of high density areas).

  - AAH activity at the county level corresponds with measurements of higher litter per mile, which supports the notion that AAH efforts are being strategically targeted towards areas that are known to be more littered.
  - Investigations of AAH activity suggest that TDOT should look to enforce actual cleanups, as feedback from representatives suggested that certain clean-ups were not being performed.
  - TDOT has indicated that there may be a possibility that AAH activity could be extended to Interstates.

Tactics & Key Issues – Interstates

- Negligence from Open-Bed Vehicles should be one of the top priorities of any litter messaging and abatement campaign focused on Interstates.

- Expansion of AAH to Interstates may help contain further litter accumulation, and TDOT should engage in a thorough examination of accountabilities for AHH activity within counties, as even though there are no AAH activities currently on Interstates, the results of the nFront team's interaction with representatives suggests that some clean-ups on other roadways are not being done.

- Steps should be taken to better manage backups/traffic during road expansion. Examples of tactics in this realm include:
    - Anti-littering ads during rush hour
    - Strategic messaging in known traffic backup areas
- The "usual suspects" (i.e. proximity to fast food & convenience stores) are documented as drivers of litter accumulation in prior studies. This Study has quantified those impacts on a per-store basis over a 3-mile radius. TDOT should partner with these stores to generate new ideas regarding messaging and how best to help these business get involved in the solution.
- No one group is immune from opportunities to litter with respect to Interstates. Consequently, in lieu of focusing on a particular group from a socioeconomic standpoint, efforts should focus on conditions (primary factors for a given site) that provide opportunities to litter on both a negligent and deliberate basis.

Tactics & Key Issues – State and U.S. Highways

- High persons per household areas may support locational messaging. The Woods and Poole and Census data provided to TDOT can serve as a platform for isolating these areas.
- As is the case with Interstates, convenience stores/fast food establishments provide context/opportunities to litter on State and US Highways, which should be the focus of both messaging and enforcement. Specific examples of tactics include:
    - Teaming with stores on anti-litter messaging such as messaging on take-out packaging
    - Providing a volunteer litter prevention plan (e.g. City of Laredo, TX) template for convenience stores/commercial establishments; The City of Laredo, TX requires commercial establishment operators to have two 55 gallon trash receptacles per 5,000 ft. of parking lot area, and an additional receptacle for every additional 2,500 feet of parking lot area; one highly visible anti-littering sign (in English and Spanish); and submittal of a litter prevention plan with site layouts and other information to certify that the plan will be followed (including location of receptacles and frequency of trash collection). This represents a publically available example of how to approach such requirements.
- Improve roadside maintenance (e.g. mow the grass), notably in lower-tier income areas.
- Control blight (or mitigate negative externalities associated with poor site aesthetics).
- Engage manufacturing establishments for ideas on how to better engender a sense of ownership for nearby roadways.

Tactics & Key Issues – Local Roads

- Local road initiatives should be prioritized in relative terms as a function of current litter prevalence. This is not to suggest that TDOT should "forget" about local roads, but that TDOT should recognize the imbalance of the abatement problem in light of the basic and detailed results presented herein.
- Low income & public housing areas, as identified by HUD at the tract level, should be a high-priority target within the local road universe. These tracts are clearly distinct from other areas, but the results of the econometrics are consistent with the ownership differential theme. Tract-level information can help optimize resources as TDOT contemplates policy initiatives.
- Recognize the much broader issue of poverty and blight and the teaming that is required with other community organizations to achieve community improvement. In particular, damaged buildings and/or graffiti should be mitigated as part of targeted blight removal efforts. Examples of tactics in this realm include:
    - Offer competitive funding for beautification projects (e.g., Governor's Community Achievement Awards in Texas, which provides $2,000,000 in grants for highway landscaping initiatives); TDOT should consider outreach to Keep Texas Beautiful for template and grant program development support.
    - Promote competitive grants as part of AAH reengineering.

Tactics & Key Issues – Cigarette Butts

- Cigarette butt prevalence was found to be associated with lower levels of income and lifestyle characteristics (excessive drinking). These findings provide contextual opportunities for strategic ads/messaging.
- Blight and proximity to hardware stores/self-storage facilities were also significant drivers of cigarette butt prevalence. Similar tactics to those suggested above should be carried out to address the disproportionate number of cigarette butts found for samples with such characteristics. Prioritizing anti-cigarette butt litter messaging near hardware stores/self-storage facilities should be considered.
- Behavior of open-bed vehicle drivers should be subjected to additional monitoring and enforcement. Additionally, targeted ads should be developed in a manner that doesn't profile open bed vehicles, but still relays some distinction and defines the problem in the context of specific behaviors.
- As noted in the basic results section of this Report, Marlboro is the third highest brand found as litter on Tennessee roadways. Additionally, Swisher Sweets (flavored cigars) represent a significant portion of cigarette litter on a revenue adjusted basis. These findings suggest the following tactics:

- Prioritize anti-litter messaging on the Swisher and Marlboro demographics.
- Based on high-level research conducted by nFront in an effort to better understand the revenue-adjusted results for the Swisher brand, Swisher Sweets are individually packaged or come in packs of two as opposed to a pack of cigarettes, resulting in more litter opportunities. The tobacco wrap around a Swisher Sweet may also be used for other consumptive purposes, leaving the plastic tip to be discarded before use. These related activities may be a good opportunity for contextual ads.

As previously noted, the prevailing themes, global policy suggestions, and roadway specific tactics presented herein reflect a prioritized and compartmentalized approach that is directly informed by the results of the econometric modeling performed for the Study. TDOT should carefully review all available intelligence gathered during the Study, as well as the results of the parallel focus groups and attitudinal survey, to determine if additional or alternative approaches may be warranted in due consideration of TDOT's long term resource constraints.

APPENDIX A

Litter Survey Field Log

Site#	FID	Roadway Class	Weather	Walk: Direction Facing	Street Name	Edge Count			Latitude	Longitude	Median		Vehicle & Pedestrian Count										County	Roadway	KAB	CIG BUTTS
						Distance (ft.)	Bottles & Cans	Other			Divider (Y/N)	Width	Start Time	Stop Time	1 Occ	2 Occ	3+ Occ	OBV	SHB	RCY	MOV	# of Peds	City/Parish/Town	AAH, etc.	Index #	10 x 3 Area
1																										
2																										
3																										
4																										
5																										
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7																										
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Day of Week:	
Date:	
Start Time:	
End Time:	
Traffic Count:	
RES/VIU/COM/PUB: Count traffic in both directions.	
RFT/UFT/RLR/OSR: Count traffic one way only.	

Note:

Key:

Weather	Roadway Class	Median	Vehicles
R = Rain	**LR** = Local Road	**KM1**: No median or less than 5' median width	**OBV** = Open Bed Vehicle
S = Sunny	**LRR** = Local Road is Residential	**KM2**: Between 5' to 10' median width	**SHB** = Self-Haul Business
C = Cloudy	**I** = Interstate	**KM3**: Greater than 10' median width	**RCY** = Recycling/Refuse Trucks
PC = Partially Cloudy	**SH** = State Highway		**MOV** = Multi-Occupant Vehicles
	UH = U.S. Highway		

TDOT Litter Study - Meander Count Form

FID #: _________________

Date Surveyed: _______________

Notes: ____

	Category	Not Available	Brand #1	Brand #2	Brand #3	Brand #4
DELIBERATE	Juice & Soft Drink Containers					
	Beer, Wine, & Liquor Containers					
	Water Bottles					
	Bottle Caps & Seals					
	Pull Tabs					
	Beverage Containers & Cartons (Milk)					
	Cups, Lids, Straws					
	Snack Food Packaging (Candy, Gum, etc.)					
	Take-out Food Packaging					
	Cigarette Packs, Lighters, Matches					
	Napkins, Bags (Paper Only), Tissues					
	Plastic Bags					
	Toiletries, Toys, Drugs					
NEGLIGENT	Newspapers, Magazines, Books					
	Advertising Signs & Cards					
	Home Food Packaging (TV Dinners, etc.)					
	Vehicle Debris & Packaging					
	Tires					
	Construction & Demolition Debris					
	Miscellaneous Paper					
	Miscellaneous Plastic					
	Gas Tanks					
	Miscellaneous Metal & Foil					
	Miscellaneous Glass & Ceramics					
	Wood & Yard Debris					
	Mattresses					
	White Goods					
	Entire 32-gallon trash bags					
	Tie-downs for trucks					
	Other (Carpet, Fabric)					

FID #: ________________

Date Surveyed: _______________

	Category	Brand #5	Brand #6	Brand #7	Brand #8	Brand #9
DELIBERATE	Juice & Soft Drink Containers					
	Beer, Wine, & Liquor Containers					
	Water Bottles					
	Bottle Caps & Seals					
	Pull Tabs					
	Beverage Containers & Cartons (Milk)					
	Cups, Lids, Straws					
	Snack Food Packaging (Candy, Gum, etc.)					
	Take-out Food Packaging					
	Cigarette Packs, Lighters, Matches					
	Napkins, Bags (Paper Only), Tissues					
	Plastic Bags					
	Toiletries, Toys, Drugs					
NEGLIGENT	Newspapers, Magazines, Books					
	Advertising Signs & Cards					
	Home Food Packaging (TV Dinners, etc.)					
	Vehicle Debris & Packaging					
	Tires					
	Construction & Demolition Debris					
	Miscellaneous Paper					
	Miscellaneous Plastic					
	Gas Tanks					
	Miscellaneous Metal & Foil					
	Miscellaneous Glass & Ceramics					
	Wood & Yard Debris					
	Mattresses					
	White Goods					
	Entire 32-gallon trash bags					
	Tie-downs for trucks					
	Other (Carpet, Fabric)					

TDOT 2016 LITTER ASSESSMENT FIELD SURVEY FORM

Surveyor ______________________ Date ______________________

FID # ______________________ Location ______________________

GENERAL

No. of Public Transport Hubs (1,000 ft) ________

No. of Storm Water Runoff Basins (Frontage) ________

	Yes	No
Overhead Street Lights (Frontage)	☐	☐
Roadway Has Curb	☐	☐

STOPPAGE OPPORTUNITY COUNTS

No. Within Sampled Frontage ________

No. of Stop Signs (1,000 ft) ________

No. of Traffic Signals (1,000 ft) ________

TRAFFIC METRIC COUNTS

	Yes	No
Toll Road	☐	☐
Sidewalks	☐	☐
Bike Lanes	☐	☐

Speed Limit ________

# of Lanes ________

CONSTRUCTION

	Yes	No
Road Expansion	☐	☐
New Building/Work Zone	☐	☐
Overpass Intersecting Site	☐	☐
Daytime Construction	☐	☐

LANE CLOSURES

	Yes	No
Paving/Lane Closure	☐	☐
Workers/Police Present	☐	☐
Backed Up Traffic	☐	☐

ROADWAY PAVING

	Yes	No
Dirt Road	☐	☐
Concrete (Fresh)	☐	☐
Concrete (Older)	☐	☐
Cobblestone/Brick	☐	☐
Maintained Shoulder (Gravel)	☐	☐
Maintained Shoulder (Paved)	☐	☐

PROXIMITY TO LITTER GENERATING SOURCES

No. of Fast Food Establishments (1 mi) ____ Vis. ____ GPS

No. of Convenience Stores (1 mi) ____ Vis. ____ GPS

Hardware Store/Self Storage (1 mi) ____ Vis. ____ GPS

	Yes	No
Near Day-Worker Pickup Area	☐	☐
Near Rest Stop (Rest Area) (3 mi)	☐	☐
Near Major Construction Zone (3 mi)	☐	☐

GRASS HEIGHT

	Yes	No
No Grass (Concrete/Paved)	☐	☐
< 3 inches	☐	☐
3 to 6 inches	☐	☐
> 6 inches	☐	☐

BUILDINGS AND STRUCTURES

	<50	50-100	>100
Distance of Buildings/Structures from Road	☐	☐	☐

TRASH RECEPTACLES

Quantity (1,000 ft) ________

	Poor	Avg	Good
Maintenance	☐	☐	☐

TDOT 2016 LITTER ASSESSMENT FIELD SURVEY FORM

Surveyor ______________________ Date ______________________

Sample No. ______________________ Location ______________________

COLLECTION STATUS (RESIDENTIAL ONLY)

Refuse Collection ☐ Vis. ☐ Coll. ☐ None

Recycling Collection ☐ Vis. ☐ Coll. ☐ None

Ramps and Major Cross Streets

Nearby Ramps and Major Cross Streets ☐ On-Ramp ☐ Exit Ramp ☐ Cross Street

SITE AESTHETIC

	Yes	No	
Graffiti	☐	☐	
Damaged Buildings/Windows	☐	☐	
Empty Comm. Buildings	☐	☐	
Anti-Littering Message/Ads	☐	☐	
Murals/Fancy Landscape	☐	☐	
Billboards	☐	☐	
Tree Lined Roads	☐	☐	
Community “Welcome” Sign	☐	☐	
General Aesthetics	☐ Poor	☐ Avg	☐ Good

Notes

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APPENDIX B

Weighted Litter Composition Results - Interstates

Weighting Basis - Total Items per Mile (Edge + Meander) by Roadway Classification

Material Group		Material	Percent of Litter
Deliberate			22.1%
	1	Juice & Soft Drink Containers	1.5%
	2	Beer, Wine, & Liquor Containers	0.9%
	3	Water Bottles	0.8%
	4	Bottle Caps & Seals	1.3%
	5	Pull Tabs	0.1%
	6	Beverage Containers & Cartons (Milk)	0.3%
	7	Cups, Lids, Straws	4.5%
	8	Snack Food Packaging (Candy, Gum, etc.)	4.6%
	9	Take-out Food Packaging	2.5%
	10	Cigarette Packs, Lighters, Matches	1.0%
	11	Napkins, Bags (Paper Only), Tissues	3.6%
	12	Plastic Bags	0.8%
	13	Toiletries, Toys, Drugs	0.2%
Negligent			77.9%
	14	Newspapers, Magazines, Books	0.2%
	15	Advertising Signs & Cards	0.1%
	16	Home Food Packaging (TV Dinners, etc.)	0.1%
	17	Vehicle Debris & Packaging	52.0%
	18	Tires	0.1%
	19	Construction & Demolition Debris	0.5%
	20	Miscellaneous Paper	9.8%
	21	Miscellaneous Plastic	7.6%
	22	Gas Tanks	0.2%
	23	Miscellaneous Metal & Foil	1.7%
	24	Miscellaneous Glass & Ceramics	0.1%
	25	Wood & Yard Debris	4.0%
	26	Mattresses	0.0%
	27	White Goods	0.0%
	28	Entire 32-gallon trash bags	0.1%
	29	Tie-downs for trucks	0.1%
	30	Other (Carpet, Fabric)	1.2%
Grand Total			100.0%

Alcoholic	0.9%
Non-Alcoholic	2.5%

Weighted Litter Composition Results - State Highways

Weighting Basis - Total Items per Mile (Edge + Meander) by Roadway Classification

Material Group		Material	Percent of Litter
Deliberate			44.0%
	1	Juice & Soft Drink Containers	2.5%
	2	Beer, Wine, & Liquor Containers	2.1%
	3	Water Bottles	1.2%
	4	Bottle Caps & Seals	3.3%
	5	Pull Tabs	0.2%
	6	Beverage Containers & Cartons (Milk)	0.2%
	7	Cups, Lids, Straws	7.1%
	8	Snack Food Packaging (Candy, Gum, etc.)	9.5%
	9	Take-out Food Packaging	5.0%
	10	Cigarette Packs, Lighters, Matches	2.8%
	11	Napkins, Bags (Paper Only), Tissues	8.4%
	12	Plastic Bags	1.1%
	13	Toiletries, Toys, Drugs	0.4%
Negligent			56.0%
	14	Newspapers, Magazines, Books	0.2%
	15	Advertising Signs & Cards	0.3%
	16	Home Food Packaging (TV Dinners, etc.)	0.2%
	17	Vehicle Debris & Packaging	12.7%
	18	Tires	0.0%
	19	Construction & Demolition Debris	0.6%
	20	Miscellaneous Paper	17.2%
	21	Miscellaneous Plastic	14.4%
	22	Gas Tanks	0.0%
	23	Miscellaneous Metal & Foil	6.4%
	24	Miscellaneous Glass & Ceramics	0.9%
	25	Wood & Yard Debris	1.6%
	26	Mattresses	0.0%
	27	White Goods	0.0%
	28	Entire 32-gallon trash bags	0.0%
	29	Tie-downs for trucks	0.1%
	30	Other (Carpet, Fabric)	1.7%
Grand Total			100.0%

Alcoholic	2.1%
Non-Alcoholic	3.9%

Weighted Litter Composition Results - U.S. Highways			
Weighting Basis - Total Items per Mile (Edge + Meander) by Roadway Classification			
Material Group		Material	Percent of Litter
Deliberate			37.8%
	1	Juice & Soft Drink Containers	4.0%
	2	Beer, Wine, & Liquor Containers	2.1%
	3	Water Bottles	1.4%
	4	Bottle Caps & Seals	2.8%
	5	Pull Tabs	0.1%
	6	Beverage Containers & Cartons (Milk)	0.4%
	7	Cups, Lids, Straws	5.7%
	8	Snack Food Packaging (Candy, Gum, etc.)	7.7%
	9	Take-out Food Packaging	3.5%
	10	Cigarette Packs, Lighters, Matches	2.9%
	11	Napkins, Bags (Paper Only), Tissues	5.7%
	12	Plastic Bags	1.3%
	13	Toiletries, Toys, Drugs	0.1%
Negligent			62.2%
	14	Newspapers, Magazines, Books	0.4%
	15	Advertising Signs & Cards	0.3%
	16	Home Food Packaging (TV Dinners, etc.)	0.2%
	17	Vehicle Debris & Packaging	26.7%
	18	Tires	0.1%
	19	Construction & Demolition Debris	0.5%
	20	Miscellaneous Paper	14.1%
	21	Miscellaneous Plastic	10.4%
	22	Gas Tanks	0.0%
	23	Miscellaneous Metal & Foil	4.7%
	24	Miscellaneous Glass & Ceramics	0.1%
	25	Wood & Yard Debris	3.1%
	26	Mattresses	0.0%
	27	White Goods	0.0%
	28	Entire 32-gallon trash bags	0.1%
	29	Tie-downs for trucks	0.1%
	30	Other (Carpet, Fabric)	1.6%
Grand Total			100.0%
Alcoholic			2.1%
Non-Alcoholic			5.8%

Weighted Litter Composition Results - Local Roads

Weighting Basis - Total Items per Mile (Edge + Meander) by Roadway Classification

Material Group		Material	Percent of Litter
Deliberate			42.1%
	1	Juice & Soft Drink Containers	3.5%
	2	Beer, Wine, & Liquor Containers	2.6%
	3	Water Bottles	1.8%
	4	Bottle Caps & Seals	2.6%
	5	Pull Tabs	0.4%
	6	Beverage Containers & Cartons (Milk)	0.1%
	7	Cups, Lids, Straws	5.8%
	8	Snack Food Packaging (Candy, Gum, etc.)	11.2%
	9	Take-out Food Packaging	4.0%
	10	Cigarette Packs, Lighters, Matches	2.0%
	11	Napkins, Bags (Paper Only), Tissues	6.3%
	12	Plastic Bags	0.6%
	13	Toiletries, Toys, Drugs	1.3%
Negligent			57.9%
	14	Newspapers, Magazines, Books	1.4%
	15	Advertising Signs & Cards	0.3%
	16	Home Food Packaging (TV Dinners, etc.)	0.4%
	17	Vehicle Debris & Packaging	7.4%
	18	Tires	0.2%
	19	Construction & Demolition Debris	1.2%
	20	Miscellaneous Paper	18.8%
	21	Miscellaneous Plastic	15.8%
	22	Gas Tanks	0.0%
	23	Miscellaneous Metal & Foil	5.2%
	24	Miscellaneous Glass & Ceramics	0.6%
	25	Wood & Yard Debris	2.7%
	26	Mattresses	0.0%
	27	White Goods	0.0%
	28	Entire 32-gallon trash bags	0.2%
	29	Tie-downs for trucks	0.0%
	30	Other (Carpet, Fabric)	3.7%
Grand Total			100.0%

Alcoholic	2.6%
Non-Alcoholic	5.4%

Weighted Litter Composition Results (Entire Study)

Weighting Basis: Total Litter Items per Mile (Edge + Meander)

Material Group		Material	Percent of Litter
Deliberate			28.0%
	1	Juice & Soft Drink Containers	2.1%
	2	Beer, Wine, & Liquor Containers	1.3%
	3	Water Bottles	1.0%
	4	Bottle Caps & Seals	1.9%
	5	Pull Tabs	0.1%
	6	Beverage Containers & Cartons (Milk)	0.3%
	7	Cups, Lids, Straws	5.0%
	8	Snack Food Packaging (Candy, Gum, etc.)	5.9%
	9	Take-out Food Packaging	3.0%
	10	Cigarette Packs, Lighters, Matches	1.6%
	11	Napkins, Bags (Paper Only), Tissues	4.6%
	12	Plastic Bags	0.9%
	13	Toiletries, Toys, Drugs	0.3%
Negligent			72.0%
	14	Newspapers, Magazines, Books	0.3%
	15	Advertising Signs & Cards	0.2%
	16	Home Food Packaging (TV Dinners, etc.)	0.2%
	17	Vehicle Debris & Packaging	41.8%
	18	Tires	0.1%
	19	Construction & Demolition Debris	0.5%
	20	Miscellaneous Paper	11.7%
	21	Miscellaneous Plastic	9.1%
	22	Gas Tanks	0.2%
	23	Miscellaneous Metal & Foil	2.8%
	24	Miscellaneous Glass & Ceramics	0.2%
	25	Wood & Yard Debris	3.5%
	26	Mattresses	0.0%
	27	White Goods	0.0%
	28	Entire 32-gallon trash bags	0.1%
	29	Tie-downs for trucks	0.1%
	30	Other (Carpet, Fabric)	1.4%
Grand Total			100.0%

Alcoholic	1.3%
Non-Alcoholic	3.4%

APPENDIX C

TN 2016 Statewide Litter Assessment
Summary of Potential Study Variables and Premises

	Variable	Source	Expected Relationship	Premise
	General Roadway Characteristics			
1.	Roadway Group – Interstates	Sample Selection	**(+)/(-)**	Higher traffic volumes and less maintained ROW lead to more accumulated deliberate and negligent litter, but Interstates are "Limited Access" highways with no pedestrians or bicycles.
2.	Roadway Group – State Highways	Sample Selection	**(+)/(-)**	State highway locations outside of urban areas (i.e., less densely populated areas) may be less littered, but may also be subject to large traffic volume.
3.	Roadway Group – Local Roadways	Sample Selection	**(+)/(-)**	Local roadways are subject to lower traffic volumes, but are potentially less maintained and may be subject to illegal dumping.
4.	Roadway Group – US Highways	Sample Selection	**(+)/(-)**	Higher traffic volumes result in more accumulated negligent litter, although US Highways are typically better maintained.
5.	Scenic Roadways	GIS Data	**(-)**	Scenic roadways are likely subjected to more frequent maintenance/pick-ups.
6.	# of lanes for a given Roadway	GIS Data	**(+)/(-)**	A greater number of lanes is generally correlated with higher traffic volumes, but may provide fewer stoppage opportunities and be associated with interstates or state highways.
7.	Number of Stoppage Opportunities within Sampled Roadway Frontage	Field Survey	**(+)**	Stoppage opportunities are opportunities to deliberately litter.
8.	Number of Stoppage Opportunities – Stop Signs (1,000 ft)	Field Survey	**(+)**	Any stoppage opportunity is an opportunity to deliberately litter.
9.	Number of Stoppage Opportunities – Traffic Signals (1,000 ft)	Field Survey	**(+)**	Any stoppage opportunity is an opportunity to deliberately litter.
10.	Number of Public Transportation Hubs (bus stop, park & ride, etc.); (1,000 ft)	Field Survey	**(+)**	Physical stoppage opportunities for users of public transportation increases likelihood of deliberate litter during wait and decreases accountability for littering behavior.

TN 2016 Statewide Litter Assessment
Summary of Potential Study Variables and Premises

	Variable	Source	Expected Relationship	Premise
11.	Overhead Street Light(s) present within sampled site (Yes/No)	Field Survey	(-)	The presence of street lights may decrease crime, and nighttime darkness may invite more accumulated litter.
12.	Number of Storm-Water Runoff Basins within site boundaries	Field Survey	(+)	Basins can accumulate litter from the roadway collected and concentrated by run-off.
13.	Adopt-A-Highway Road (Yes/No)	Field Survey/ Client Data	(+)/(-)	Regular maintenance may decrease accumulated litter; however, the need for a roadway to be a part of this program may imply an above average amount of accumulated litter.
14.	Toll Road (Yes/No)	Field Survey	(-)	Toll road users are more likely to be affluent, single passengers, and be in transit to work or some major commitment.
15.	Construction – Paving/Lane Closure	Field Survey	(+)	Lane closure and associated activity decreases accountability for littering behavior.
16.	Construction – Day or Night	Field Survey	(+)/(-)	Time and nature of construction may impact accountability for littering.
17.	Lane Closure – Workers/Police Present (Yes/No)	Field Survey	(-)	People may be less likely to intentionally litter in front of law enforcement or other government crew.
18.	Lane Closure – Traffic Backed Up (Yes/No)	Field Survey	(+)	Backed up traffic increases likelihood of certain types of litter, particularly cigarette butts.
19.	Construction – New Building/Work Zone	Field Survey	(+)	Construction debris and deliveries to and from work zones increase accumulated negligent litter (trucks, self hauls, etc.).
20.	Construction – Road Expansion	Field Survey	(+)	Road expansion increases construction-related negligent litter and decreases accountability for littering behavior.

	Variable	Source	Expected Relationship	Premise
21.	Roadway has a curb (Yes/No)	Field Survey	**(-)**	Roadways with curbs are less likely to accumulate litter and more likely to be maintained.
22.	Roadway has a maintained roadway shoulder - Gravel	Field Survey	**(+)**	A gravel shoulder may invite more littering behavior as compared to a paved shoulder.
23.	Roadway has a maintained roadway shoulder - Paved	Field Survey	**(-)**	A paved shoulder is likely to have less accumulated litter relative to gravel/poorly maintained shoulders.
24.	Roadway Overpass Directly Intersecting Site	Field Survey	**(+)**	Accumulated litter gathers around overpass portion of roads due to poor overpass lighting and tendency to view such stretches as “garbage cans”.
	Traffic Metrics			
25.	Vehicular Traffic – Open Bed Trucks	Field Survey	**(+)**	Open bed trucks increase likelihood of uncovered spillage from truck beds.
26.	Vehicular Traffic – Self Haul Business	Field Survey	**(+)**	Self-haul business trucks are more likely to engage in improper securing of loads.
27.	Vehicular Traffic – Refuse/Recycling Trucks	Field Survey	**(+)**	Increased traffic volume of waste management trucks increases likelihood of uncovered/poorly tarped vehicles.
28.	Vehicular Traffic – Multi-Occupant Vehicles	Field Survey	**(+)**	Vans, buses, and larger transport vehicles imply a lower degree of personal accountability for littering behavior.
29.	Roadway Traffic – Pedestrians	Field Survey	**(+)**	More pedestrians = more opportunities to litter.
30.	Sidewalks (Yes/No)	Field Survey	**(+)**	Pedestrian traffic on sidewalks increases accumulated deliberate litter.
31.	Bike Lanes (Yes/No)	Field Survey	**(+)/(-)**	Bike lanes may be associated with wealthier and perhaps more progressive communities but also imply more littering opportunities for cyclists.
32.	Roadway is popular alternative/traffic avoidance route (or “back-road”)	Client Data	**(+)**	“Back-roads” may be subject to greater than expected traffic levels due to the desire by residents to avoid more

	Variable	Source	Expected Relationship	Premise
				congested major highways.
33.	Roadway Speed Limit	Field Survey/DOT	**(+)/(-)**	Lower speed limits are likely to be correlated with more stoppage opportunities, but higher speed limits imply more trucking/highway traffic and may cause more road debris (tires, etc.).
	Proximity to Potential Litter Generation Sources			
34.	Proximity to Landfill(s)	Sample Selection/Google Earth	**(+)**	Landfill operations and associated traffic increases likelihood of uncovered/poorly tarped vehicles.
35.	Proximity to Transfer Station(s)	Sample Selection/ Google Earth	**(+)**	Transfer station operations and associated traffic increases likelihood of uncovered/poorly tarped vehicles.
36.	Proximity to Recycling Center(s)	Sample Selection/ Google Earth	**(+)**	Recycling center operations and associated traffic increases likelihood of uncovered/poorly tarped vehicles.
37.	Proximity to Parks/Community Centers	Sample Selection/ GIS Data	**(+)/(-)**	Parks/community centers and nearby roadways may be more likely to be regularly cleaned and maintained, but may also be more littered due to the frequency of traversal of these areas by pedestrians and motorized traffic.
38.	Proximity to Public/Private Universities	Sample Selection/ GIS Data	**(+)/(-)**	Factor may suggest more pedestrian traffic, but may also suggest more regular maintenance.
39.	Proximity to Schools, Elementary	Sample Selection/ Client Data	**(+)/(-)**	Factor may suggest more pedestrian traffic, but may also suggest more regular maintenance.
40.	Proximity to Schools, Secondary (HS)	Sample Selection/ Client Data	**(+)/(-)**	Factor may suggest more pedestrian traffic, but may also suggest more regular maintenance.

	Variable	Source	Expected Relationship	Premise
41.	Proximity to Major Construction Zone	Sample Selection/GIS Data	(+)	Deliveries to and from construction zones increases likelihood of uncovered/poorly tarped vehicles and traffic from self-haul subcontractors.
42.	Proximity to Rest Stop (Rest Area)	Sample Selection/GIS Data	(+)	Rest areas are more likely to generate disposable food/fast food packaging, that may turn into litter when traffic re-enters the roadway.
43.	Proximity to day worker pickup location (e.g., employment agency) – 1000 ft	Field Survey	(+)	Gathering locations with potentially inadequate infrastructure increase incidence of deliberate litter.
44.	Roadway Leads to Major Tourist Attraction/Area (Yes/No)	Sample Selection/ Client Data	(+)/(-)	Roadways near historic regions or tourist hubs are more likely to be subject to regular litter pickup and maintenance, but tourists may be more likely to litter.
45.	Number of Fast Food Establishments within 1 mile (3 miles)	Field Survey/Google Earth	(+)	Fast food packaging volume increases littering opportunities.
46.	Number of Convenience Stores within 1 mile (3 miles)	Field Survey/Google Earth	(+)	Convenience store food/drink packaging volume increases littering opportunities.
47.	Number of Hardware Stores/Self-Storages within 1 mile (3 miles)	Field Survey/Google Earth	(+)	Same premise as convenience stores and fast food establishments.
48.	Major thoroughfare to and from landfill (3 miles) (Yes/No)	Field Survey/ Google Earth	(+)	Frequent passage of waste hauling trucks increases likelihood of negligent litter.
49.	Major thoroughfare to and from transfer station (3 miles) (Yes/No)	Field Survey/ Google Earth	(+)	Frequent passage of waste hauling trucks increases likelihood of negligent litter.
50.	Major thoroughfare to and from MRF (3 miles) (Yes/No)	Field Survey/ Google Earth	(+)	Frequent passage of recycling hauling trucks increases likelihood of negligent litter.

	Variable	Source	Expected Relationship	Premise
	Site Aesthetics			
51.	Approximate Distance of Buildings/Structures from the road edge	Field Survey	(+)	Greater distance reduces accountability for deliberate litter, both in terms of the behavior of the littering individual, and in terms of the ownership stake taken in the roadway by the building owners.
52.	Roadway Paving – Dirt Road	Field Survey	(+)/(-)	Dirt roads are likely to be subject to lower traffic volume but may be less maintained, which decreases accountability for littering behavior.
53.	Roadway Paving – Concrete (Fresh)	Field Survey	(-)	Newer, better maintained roads are likely to be more regularly maintained.
54.	Roadway Paving – Concrete (Older)	Field Survey	(+)	Potholes, uneven lanes, etc. may be conducive to negligent litter from open truck beds.
55.	Roadway Paving – Cobblestone/Fancy	Field Survey	(-)	Road type is associated with affluent areas or downtown shopping strips.
56.	Grass Height – 3 inches or less	Field Survey	(-)	Accumulated litter will increase as grass height increases.
57.	Grass Height – 3 to 6 inches	Field Survey	(+)	Accumulated litter will increase as grass height increases.
58.	Grass Height – greater than 6 inches	Field Survey	(+)	Accumulated litter will increase as grass height increases.
59.	Grass Height – No Grass (Concrete/Paved)	Field Survey	(+)/(-)	No grass may imply less maintenance and/or more traffic volume, but may also signal a smaller shoulder, and hence less littering opportunities.
60.	Street Trash Receptacles – Quantity (1,000 ft)	Field Survey	(-)	Availability of street trash receptacles decreases likelihood of improper disposal.
61.	Street Trash Receptacles – Maintenance (1,000 ft)	Field Survey	(-)	Regular cleanup and pick-up of waste implies proper waste capacity available (important for pedestrians).

	Variable	Source	Expected Relationship	Premise
62.	Site Aesthetic – Graffiti	Field Survey	(+)	Graffiti implies poor maintenance and less accountability.
63.	Site Aesthetic – Broken Windows/Damaged Buildings	Field Survey	(+)	Community damage implies less accountability for littering behavior.
64.	Site Aesthetic – Empty Commercial Buildings	Field Survey	(+)	Abandoned buildings may serve as illegal dumping hubs.
65.	Site Aesthetic – General Aesthetic	Field Survey	(+)	Unsightly roads imply less maintenance and sense of ownership and may increase deliberate litter.
66.	Site Aesthetic – Anti-Littering Messaging/Ads	Field Survey	(-)	Strategic messaging sends direct/indirect signal regarding existing ordinances and potential for consequences to littering.
67.	Site Aesthetic – Wildflower plantings/Fancy landscaping	Field Survey	(-)	Fancy medians and shoulder landscaping may indicate a high-income, closely monitored area, which may be a deterrent to littering.
68.	Site Aesthetic – Billboards within sampled site	Field Survey	(+)	There is a positive correlation between the presence of billboards and accumulated litter, perhaps as a result of the proximity of billboards to certain types of businesses.
69.	Site Aesthetic – Tree lined Roads	Field Survey	(-)	The ability to see the entire scope of the road allows for more targeted littering behavior, and as such tree lined roads may serve as a littering deterrent.
	Socioeconomic Data			
70.	Census Tract Income per Capita	Census Bureau	(-)	Higher income is generally associated with lower amounts of accumulated deliberate litter.
71.	Census Tract Population Density	Census Bureau	(+)	More people = more opportunities to litter.
72.	Census Tract Education - College or Greater %	Census Bureau	(-)	Greater education attainment is generally associated with lower amounts of accumulated deliberate litter.

	Variable	Source	Expected Relationship	Premise
73.	Census Tract Age - 18 to 24 %	Census Bureau	(+)/(-)	This age cohort may be more likely to engage in deliberate littering.
74.	Census Tract Ethnic Makeup – White %	Census Bureau	(+)/(-)	Cultural standards may impact litter; any influence will be tested with other characteristics to avoid collinearity issues.
75.	Census Tract Ethnic Makeup – African American %	Census Bureau	(+)/(-)	Cultural standards may impact litter; any influence will be tested with other characteristics to avoid collinearity issues.
76.	Census Tract Ethnic Makeup – Hispanic %	Census Bureau	(+)/(-)	Cultural standards may impact litter; any influence will be tested with other characteristics to avoid collinearity issues.
77.	Census Tract Single Family Homes %	Census Bureau	(-)	Single-family homes may be associated with a sense of community and accountability v. multi-family homes.
78.	Census Tract Owned vs. Renting	Census Bureau	(-)	Property owners are more likely to be conscientious regarding litter and maintenance.
79.	County – Wealth Index	W&P TN Profile	(-)	Wealthier areas are likely to have residents that are more conscientious regarding litter and maintenance.
80.	County – Manufacturing Employment	W&P TN Profile	(+)	Manufacturing-intensive regions are subject to greater amounts of accumulated negligent litter due to more self-hauling and outdoor storage of materials.
81.	County – Housing Starts/Existing Homes	W&P TN Profile	(+)	Significant housing construction implies more construction debris and potential for accumulated negligent litter.
82.	Urban vs. Rural (by Sample)	GIS Data	(+)/(-)	Urban areas have higher population density but may be better maintained.
83.	County – Average Home Value	County Property Appraiser	(-)	As average home value increases, monitoring and enforcement, particularly with HOAs, etc. increases.

	Variable	Source	Expected Relationship	Premise
84.	County – SIC Codes for Certain Types of Businesses	County Business Patterns	(+)	Prevalence of certain types of businesses that produce above average amounts of packaging and other items that could be littered increases littering opportunities.
85.	Distressed, At Risk, Transitional, Competitive, Attainment Comm.	Client Data (if available)	(-)	As the general socioeconomic well-being of a county increases (i.e., towards Attainment), the amount of accumulated litter decreases.
86.	Subsidized Housing in Vicinity (Yes/No)	HUD	(+)	Subsidized housing implies lower income areas and lowered sense of ownership and accountability.
	Miscellaneous Variables			
87.	County – Waste Collection Frequency	Secondary Research	(+)/(-)	More frequent collection may result in more negligent litter from hauling vehicles; but less frequent collection may encourage illegal dumping and overflowing trash.
88.	County – Recycling Program (Yes/No)	Secondary Research	(-)	Recycling programs and associated education increase social awareness and environmental conscientiousness.
89.	Weather – Wind (e.g., 3-day average wind speed)	NOAA	(+)	Wind disperses litter and may cause litter from un-covered truck beds and poorly maintained trash receptacles.
90.	Weather – Rainfall (e.g., 3-day average rainfall)	NOAA	(-)	Regular or above average rainfall decreases deliberate littering opportunities (for pedestrian or vehicle passengers).
91.	Collection in Carts (Yes/No)	Secondary Research	(+)/(-)	Cart collection may reduce litter due to containerized waste requirements on the part of collectors.
92.	Community “Welcome” or “Entrance” sign (Yes/No)	Field Survey	(-)	Existence of this type of signage may point to a greater sense of ownership on the part of the local municipality.

	Variable	Source	Expected Relationship	Premise
93.	City/County under a Keep America Beautiful Program	Client Data	(-)	Proactive efforts towards education and cleanup-volunteer efforts should result in decreased accumulated litter.
94.	Curbside Collection in the County/Municipality (Yes/No)	Secondary Research	(+)/(-)	Areas with higher proportions of curbside collection are less prone to self-hauling of waste, but may have a higher propensity for negligent litter.

<u>Supplemental Abbreviation Key</u>:

DOT = Department of Transportation
GIS = Geographic Information System
HOA = Homeowner's Association
HS = High School
HUD = Department of Housing and Urban Development
MRF = Materials Recovery Facility
NOAA = National Oceanic and Atmospheric Association
ROW = Right of Way
SIC = Standard Industrial Classification
TN = Tennessee
W&P = Woods and Poole Economics, Inc.