Impacts of Waste and Heavy Vehicles on Pavement Life

Final Report

NCE Project No. 1004.05.55
Mar 2022

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March 2021

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Executive Summary

The purpose of this study was to estimate the structural and financial impact of waste and heavy construction vehicles on streets in the City of Pacifica. To accomplish this, NCE performed a vehicle impact analysis that combined methods from both the American Association of State Highway and Transportation Official's *Guide for Design of Pavement Structures* and the Caltrans *Highway Design Manual*. The analysis compared the estimated traffic demand associated with waste and heavy construction vehicles to the average remaining structural capacity of streets. The resulting impact was then integrated with a financial analysis.

The results of the study (shown below) indicate that approximately 10.1 percent of a residential street's pavement life is consumed each year by waste vehicles. This damage corresponds to an average cost of $510,906 per year. Similarly, approximately 6.2 percent of an arterial or collector street's pavement life is consumed each year by waste vehicles. This damage corresponds to an average cost of $183,963 per year. The City can use these results to recoup pavement damage costs associated with waste collection by implementing a flat fee, a cost-per-vehicle fee, or other payment structure.

Vehicle Type	Residentials		Arterials/Collectors	
	Avg % Pvmt Life Used/Yr	Avg Damage Cost/Yr	Avg % Pvmt Life Used/Yr	Avg Damage Cost/Yr
Garbage	3.1%	$157,202	2.2%	$65,349
Green Waste	3.1%	$157,202	1.7%	$49,011
Recycling	3.1%	$157,202	2.2%	$65,349
Bulk Waste	0.8%	$39,300	0.1%	$4,084
Total	**10.1%**	**$510,906**	**6.2%**	**$183,793**

A proposed heavy-vehicle impact fee was estimated based on the assumption that the damage caused to pavement structures by heavy construction vehicles is similar to that caused by a typical waste vehicle. The proposed fee (shown below in 2021 dollars) represents the transportation costs associated with the construction of new developments and can be collected as part of a development impact fee for residential and non-residential units. Any implemented waste or heavy vehicle fee structure should include an inflation factor since pavement maintenance costs increase over time.

Option	Residential Unit Fee*	Non-Residential Unit Fee*	Unit
1	$2,126	NA	per unit
2	$1.19	$1.19	per square foot
3	$0.17	NA	per $100 valuation

*Fee in 2021 Dollars

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1 Introduction

Over the past 10 to 15 years, the number of waste-vehicle repetitions has increased on local roads and streets throughout California. Historically, one waste vehicle provided services once a week. More recently, three or four different waste vehicles (e.g., garbage, recycling, organics) provide weekly or biweekly services. In addition to waste vehicles, private development can have a significant impact on pavement condition. When new development construction occurs, heavy equipment and material delivery vehicles cause more rapid deterioration and worse pavement condition. This separation of waste categories, increase in waste collection frequency, as well as new construction due to land development, has caused many local agencies to question:

1. What impact do waste and heavy construction vehicles have on pavement deterioration?
2. What is the corresponding financial impact of waste and heavy construction vehicles on pavement life?

Similar questions have been studied for over 60 years by many state highway agencies, universities, the U.S. Department of Transportation, industry groups, and consulting/research firms. While the research completed and continued by these entities has significantly improved the understanding of pavement deterioration and the impacts of various treatments and loads on pavement performance, the bulk of this research has not focused on local or low-volume roads. Additionally, the impact and quantification of waste and heavy construction vehicles on local roads and streets varies significantly based on site- and agency-specific information. Such variables include pavement condition and structure, vehicle type and frequency, and maintenance costs. Therefore, to really understand the impact of waste vehicles on roads and streets within a particular agency, a custom study and analysis must be performed.

Customized studies estimating the impact of waste and heavy construction vehicles on pavement life and the corresponding costs for a particular agency can be used to develop impact fees. Such fees help agencies recapture costs associated with accelerated pavement deterioration due to frequent waste-vehicle trips and continued land development.

The City of Pacifica (City) wants to identify the vehicle impacts and develop fees to recoup damage sustained on City streets due to waste vehicles and heavy construction vehicles. Consequently, Nichols Consulting Engineers, Chtd. (NCE), performed this study to estimate that impact and to quantify it in financial terms. The following sections describe the technical approach used and present the results of the study.

2 Technical Approach

For this project, NCE employed a sophisticated analysis combining methods from both the California Department of Transportation (Caltrans) *Highway Design Manual* (HDM) (Caltrans 2019) and the American Association of State Highway and Transportation Officials (AASHTO) *Guide for Design of Pavement Structures* (AASHTO 1993). City streets in California are typically designed according to the Caltrans HDM; whereas the AASHTO pavement design guide is widely used throughout the United States. Both methods were employed to more accurately represent traffic demands and incorporate the effect of pavement condition. Ultimately, this analysis compared the estimated traffic demand associated with waste and heavy construction vehicles to the average remaining structural capacity of streets. The resulting impact was then integrated with a financial analysis.

The following subsections describe the assumptions made and the analysis procedure used to estimate and quantify the impact of waste and heavy construction vehicles on pavement life and maintenance costs for the City. Note that the analysis differentiates between two functional class groups: 1) residentials, and 2) arterials and collectors. This differentiation accounts for differences in pavement structures and traffic demands.

2.1 PAVEMENT CONDITION

Pavement condition is typically quantified using the pavement condition index (PCI), which ranges from 0 to 100. Pavements in excellent condition have a PCI above 85, pavements in very good condition have a PCI between 70 and 85, pavements in good condition have a PCI between 50 and 70, pavements in poor condition have a PCI between 25 and 50, and pavements in very poor condition have a PCI below 25. Note that these condition categories are consistent with those presented in the City's Budget Options Report (City of Pacifica 2021) with one modification—the excellent condition category was added to provide an additional data point, and therefore additional accuracy, during the analysis portion of this study.

The City's street network is in poor condition with an average PCI of 39 as of March 2021. Table 1 summarizes the portion of the City's street network in each condition category by functional class. As shown, nearly half the 62.6 centerline miles of residential streets, and a quarter of the 27.6 centerline miles of arterials/collectors, are in failed condition.

Table 1. Pavement Condition Breakdown by Functional Class

Condition Category	PCI Range	Pavement Condition Breakdown (% Area)*	
		Residentials	Arterials/Collectors
Excellent	85-100	1.4	14.5
Very Good	70-85	9.1	11.4
Good	50-70	13.7	22.6
Poor	25-50	28.7	27.8
Very Poor	0-25	47.1	23.7
Total	**-**	**100.0**	**100.0**

*Condition data obtained from StreetSaver® on March 15, 2021

For each condition category, the percent of remaining service life (RSL) was estimated using the StreetSaver® family deterioration curves for asphalt concrete (AC) streets. The AC curves were selected since City streets are predominantly AC pavement (99.4 percent). The deterioration curves, illustrated in Figure 1, are customized (using historical condition surveys) within StreetSaver® to match the typical performance of streets within the City.

A pavement's RSL reaches zero when a pavement falls into failed condition, meaning it has a PCI less than 25. Consequently, residential streets have a total service life of approximately 34 years, while arterials/collectors have a total service life of approximately 29 years. Table 2 shows the estimated percent RSL for each condition category and functional class.

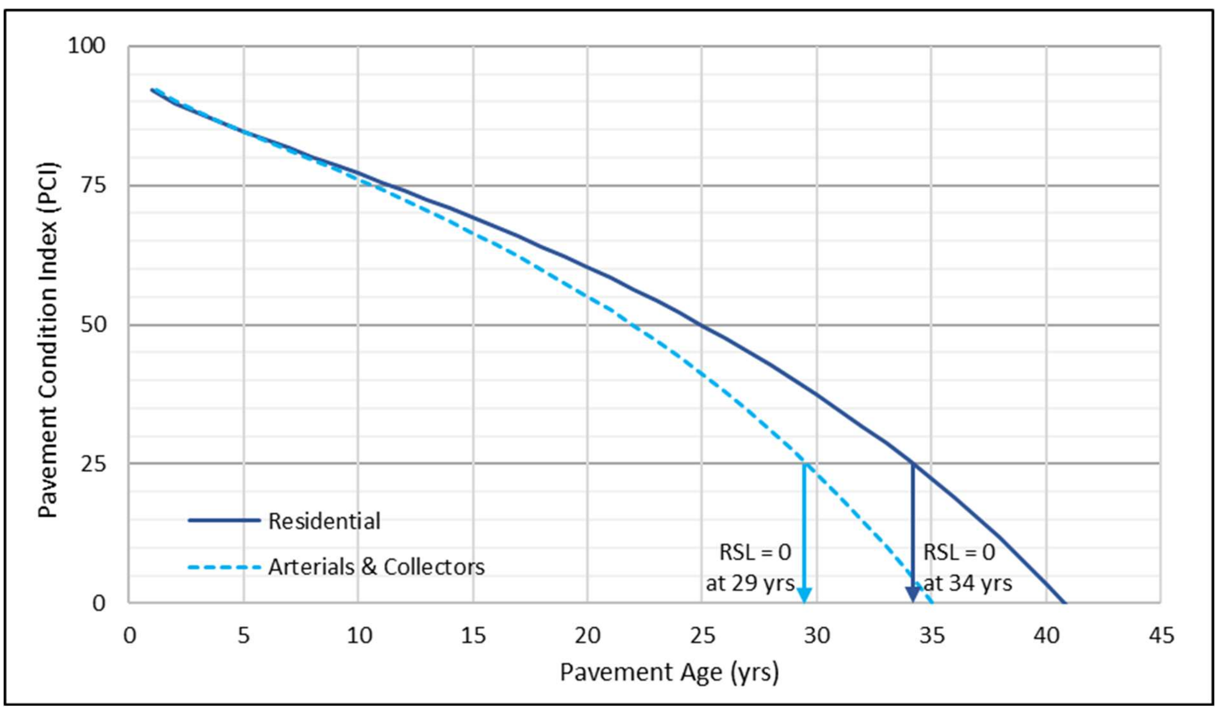

Figure 1. Family Deterioration Curves by Functional Class

Table 2. Remaining Service Life by Functional Class

Condition Category	PCI Range	Remaining Service Life (%)	
		Residentials	Arterials/Collectors
Excellent	85-100	97.1	96.6
Very Good	70-84	70.6	69.0
Good	50-69	41.2	37.9
Poor	25-49	11.8	10.3
Very Poor	0-24	0	0

2.2 STRUCTURAL CAPACITY

A pavement's capacity to carry traffic loads depends on pavement structure and condition. The pavement structure of City streets were assumed to meet the City's typical design traffic index (TI) values of 5 for residential streets and 7 for arterials and collectors. Based on these design TI values and a subgrade R-value of 9, which was observed during the City's 2020-2021 Resurfacing Program, typical pavement structures were calculated following the Caltrans HDM. Consequently, residential streets were assumed to have structure consisting of 4 inches of AC over 8 inches of aggregate base (AB). Similarly, arterials and collectors were assumed to have 6 inches of AC over 10 inches of AB.

The structural impact of a vehicle on a pavement depends on the vehicle's load and axle configuration. An 18,000 lb load on a single axle is commonly used as the standard to which all other axle configurations and loads can be compared. Thus an Equivalent Single Axle Load (ESAL) describes the damage to a pavement caused by an 18,000 lb load on a single axle (Huang 2003). As an axle load increases, the damage caused increases exponentially. Additionally, as pavement condition worsens, the damage caused by a given load also increases. Since damage to a pavement is often quantified in terms of ESALs, it is fitting then to also describe a pavement's structural capacity in terms of ESALs.

The corresponding ESALs for the design TI values were estimated according to the Caltrans HDM. For a TI of 5, the design ESALs are 7,161; for a TI of 7, the design ESALs are 121,021. These design values represent the capacity, in ESALs, that a pavement structure has at the time of construction. The number of ESALs remaining based on condition category were estimated for each functional class by multiplying the design ESALs by the percent RSL (See Table 3).

Table 3. ESALs Remaining by Functional Class

Condition Category	PCI Range	ESALs Remaining	
		Residentials (TI=5)	Arterials/Collectors (TI=7)
Design		7,161	121,021
Excellent	85-100	6,950	116,847
Very Good	70-84	5,054	83,462
Good	50-69	2,948	45,904
Poor	25-49	842	12,519
Very Poor	0-24	0	0

2.3 TRAFFIC DEMAND

After calculating the structural capacity of the pavement network, the traffic demand was estimated for waste vehicles and heavy construction vehicles.

2.3.1 Waste Vehicles

Currently, there are several waste vehicles servicing the City, including weekly garbage, weekly green waste, weekly recycling, and as-needed bulky waste pickup. Based on discussions with the City and the waste collection companies, it was assumed that on a given weekday there are four garbage routes, three green waste routes, four recycling routes, and one bulky waste route. Additionally, it was assumed and that all waste collection routes drop off their loads twice daily.

While all residential streets will be driven by a waste vehicle during collection, the route a driver takes to access a particular residential route depends on driver discretion. Consequently, it was assumed that only 40 percent of arterial and collector streets would be used by waste vehicles to access residential routes and drop-off sites. Table 4 lists the assumed frequency of each waste vehicle for each functional class. These frequencies are expected to remain consistent throughout the analysis period.

Table 4. Waste-Vehicle Collection Frequency

Vehicle Type	Vehicles per Week	
	Residentials	Arterials/Collectors
Garbage	1	40
Green Waste	1	30
Recycling	1	40
Bulky Waste	0.25	2.5
Total	**3.25**	**112.5**

The waste vehicles used in the City are typically single-trailer trucks with a single front axle and a tandem rear axle. The gross vehicle weight is approximately 55,000 lbs, while the tare weight is approximately 37,000 lbs. Figure 2 details the assumed axle loading of both full and empty waste vehicles. As shown, a full vehicle would have a 36,850 lb load on the rear tandem axle and 18,150 lbs on the front single axle. An empty vehicle would have a 24,790 lb load on the rear tandem axle and 12,210 lbs on the front single axle.

Figure 2. Typical Waste-Vehicle Loading

NCE used AASHTO's load equivalency factor (LEF) approach to estimate the traffic demand of the waste vehicles. LEFs describe the equivalent damage caused by various axle loads and configurations while also considering the existing condition of the pavement. LEFs are a function of axle load and configuration, structural number (SN), and terminal serviceability. The sum of all LEFs for a given vehicle is the ESAL value for that vehicle.

A SN expresses the existing structural strength of a pavement and depends on pavement layer types and thicknesses, drainage, and condition. SN values range from 1 to 7, where 7 represents the greatest structural capacity. The SN values for the residential and arterial/collector pavement structures were calculated per the AASHTO pavement design guide according to Equation 1.

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3 + \cdots + a_n D_n m_n \quad \text{(Eq. 1)}$$

where:

a_n: nth layer coefficient
D_n: nth layer thickness
m_n: nth layer drainage coefficient

Representative layer coefficients were selected based on pavement condition from AASHTO Tables 2.4 and 5.2 (AASHTO 1993) and a drainage coefficient of 1 was assumed. Table 5 summarizes the calculated SNs based on condition category and functional class.

Table 5. Structural Number by Functional Class

Condition Category	PCI Range	Structural Number	
		Residentials	Arterials/Collectors
Excellent	85-100	3.0	4.1
Very Good	70-84	2.2	3.0
Good	50-69	2.0	2.7
Poor	25-49	1.4	1.8
Very Poor	0-24	1.0	1.3

For each waste-vehicle axle configuration (single or tandem) and loading (empty or full) an LEF was estimated using the SNs and an assumed terminal serviceability of 2.5. The LEFs for each waste-vehicle axle loading were then summed to estimate the total ESALs for an empty and a full waste vehicle.

A full waste vehicle was estimated to have an ESAL value ranging from 2.532 to 2.555 based on condition and functional class. An empty waste vehicle was estimated to have an ESAL value of 0.520 to 0.597 also based on condition and functional class. Note that in general, a waste vehicle will do a little more damage to a pavement in worse condition than to a pavement in better condition. Similarly, a waste vehicle will typically do more damage to a residential street than to an arterial or collector street.

The empty and full waste-vehicle ESAL values were combined in a weighted average according to Equation 2. This weighting was performed to account for variability in loading throughout a route. The weighted average ESALs ranged from 1.871 to 1.889.

$$Waste\ Vehicle\ Weighted\ Average\ ESAL = \frac{2}{3} * ESAL_{Full} + \frac{1}{3} * ESAL_{Empty} \qquad \text{(Eq. 2)}$$

The weighted average ESALs values were then multiplied by the vehicle frequencies (previously provided in Table 4) to estimate the ESAL demand per year based on pavement condition and functional class. Table 6 lists the estimated waste-vehicle traffic demands.

Table 6. Traffic Demand on City Streets by Condition Category

Func. Class	Condition Category	ESALs/Yr			
		Garbage Truck	Green Waste	Recycling	Bulky Waste
Residential	Excellent	98.2	98.2	98.2	24.6
	Very Good	97.7	97.7	97.7	24.4
	Good	97.6	97.6	97.6	24.4
	Poor	97.6	97.6	97.6	24.4
	Very Poor	97.6	97.6	97.6	24.4
Arterial/ Collector	Excellent	3,891	2,918	3,891	243
	Very Good	3,929	2,947	3,929	246
	Good	3,924	2,943	3,924	245
	Poor	3,903	2,927	3,903	244
	Very Poor	3,903	2,927	3,903	244

2.3.2 Heavy Construction Vehicles

Other heavy vehicles, such as construction vehicles, also provide services within the City, and also have impacts on pavement life. After consultations with City staff, the following assumptions were made to estimate their impact:

- Heavy construction vehicles cause approximately the same amount of damage, in ESALs, as typical waste vehicles.
- The construction of residential/non-residential units require 20 heavy construction vehicles traveling 2.5 miles round trip to the project site (half the mileage on residential streets, half on arterial or collector streets).
- The average size of a residential unit in the City is 1,800 square feet (sf).

To arrive at the assumption that construction of a new unit would produce approximately 20 heavy vehicle trips, the City of Pacifica Engineering Department estimated construction equipment, building material, and home appliance vehicle trips needed. If the given lot is undeveloped, and therefore requires grading and placement of a concrete slab, the large construction equipment traveling to the site would include an excavator, mini excavator, and skid steer/forklift totaling 3 truck roundtrips. Material delivery was estimated at 27 truck roundtrips including, off haul/infill material, foundation concrete pouring, lumber deliveries, drywall delivery, plumbing fixtures, HVAC fixtures and venting, roofing materials, landscaping materials, flooring materials, windows, counters, doors, street utility materials, driveway installation (concrete/asphalt truck or paver delivery), conditioned street improvement materials (asphalt and concrete), and general home appliances. As construction varies and to be conservative, the 30 trips were rounded down by 33% to 20 heavy vehicle trips.

2.4 FINANCIAL ANALYSIS

As previously mentioned, the City's street network is currently in poor condition with an average network PCI of 39. This is a result of minimal maintenance historically, coupled with years of increased frequencies of waste and heavy construction vehicles. Consequently, the City's goals are to, over the next 15 years, improve the residential street network from a PCI of 33 to 60. Similarly, the City intends to improve the arterial and collector street network from a PCI of 50 to 70. These goals will bring the overall network into fair condition.

To estimate the financial commitment required to accomplish these goals, a budget analyses was performed in StreetSaver® using the City's existing decision tree with an inflation rate of 3 percent and an analysis period of 15 years. The 15-year total funding needed to accomplish these goals is $120.7 million, which is an average of $8.05 million per year. Figures 3 and 4 illustrate the resulting pavement condition breakdown for residential and arterial/collector streets, respectively, for each year in the analysis period.

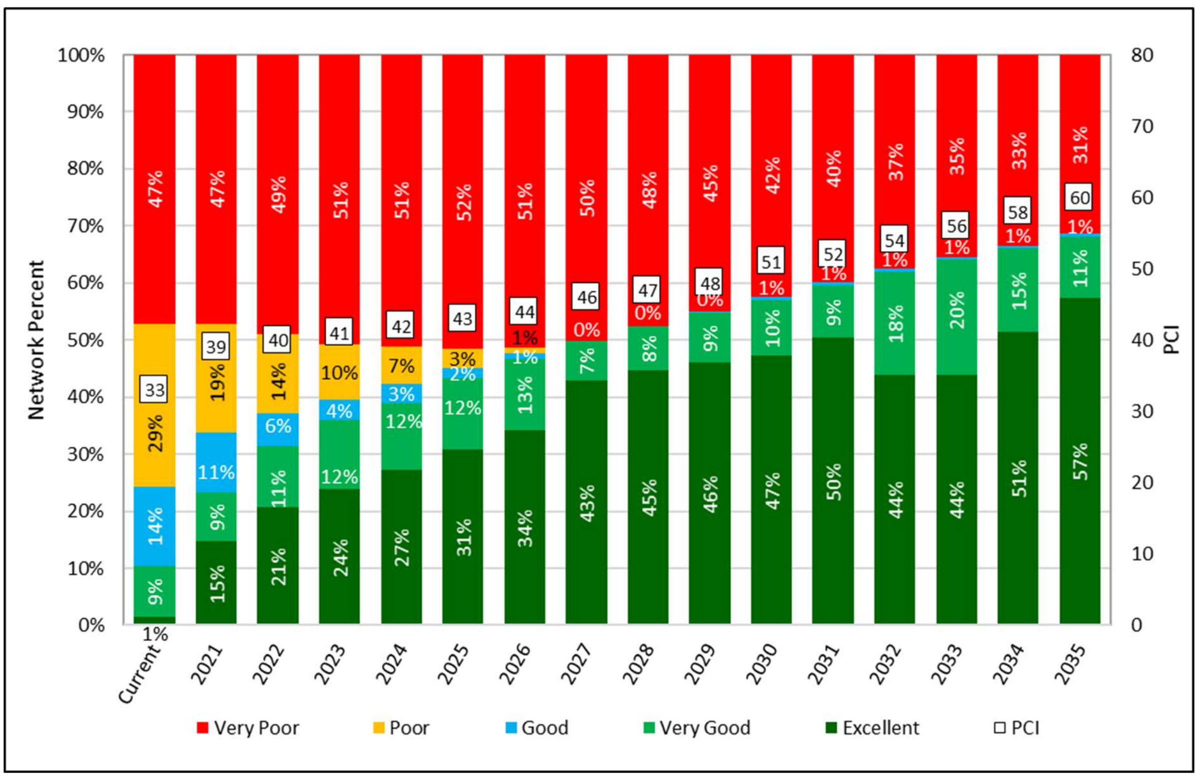

Figure 3. Annual Pavement Condition Breakdown for Residential Streets

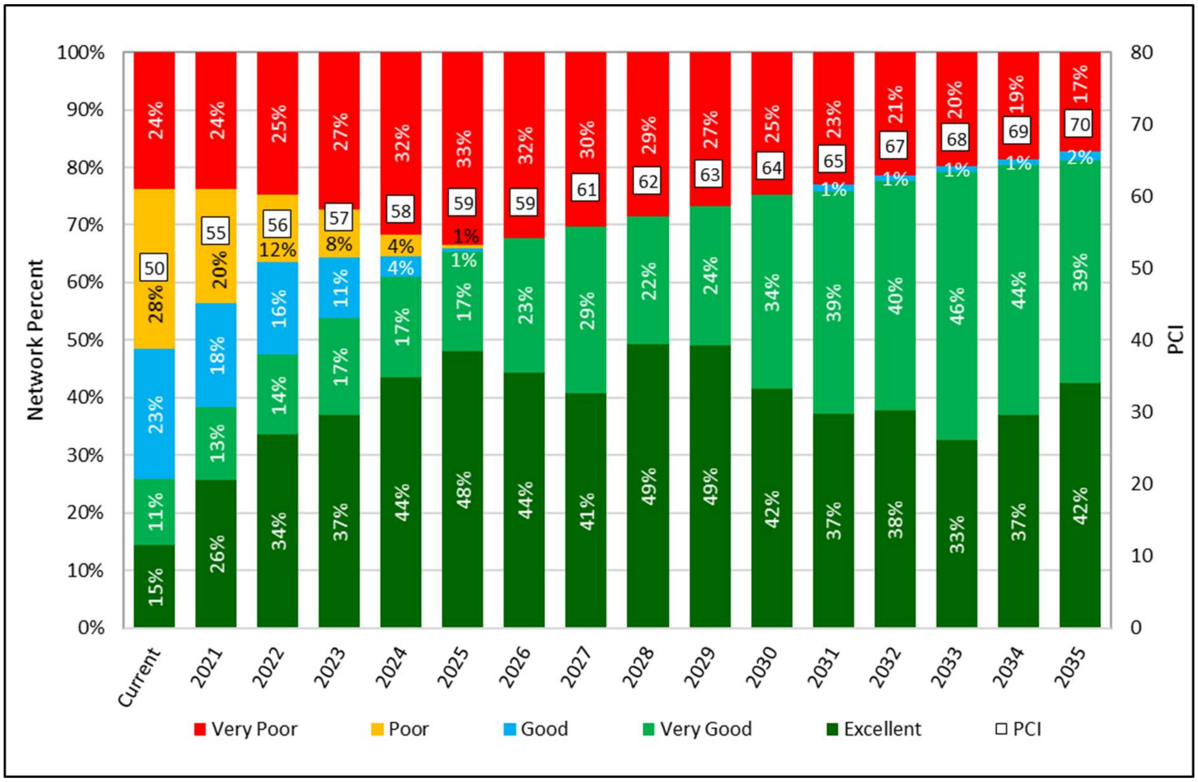

Figure 4. Annual Pavement Condition Breakdown for Arterial/Collector Streets

2.5 VEHICLE IMPACT ANALYSIS

The following sections describe the vehicle impact analysis performed for waste vehicles and heavy construction vehicles.

2.5.1 Waste Vehicles

The process to determine the impact of waste-vehicle damage to City streets is described by the following steps:

1. Calculate the weighted average structural capacity, in ESALs, remaining per year. This was performed by multiplying the ESALs remaining in a given condition category (Table 3) by the pavement condition breakdown for each year resulting from the StreetSaver® analysis (Figures 3 and 4) and summing the resulting products. This value represents the average annual structural capacity, in ESALs, remaining on any given street in the City.
2. Calculate the weighted average traffic demand, in ESALs, per year for each waste-vehicle type. This was performed by multiplying the traffic demand for each waste vehicle type (Table 6) by the pavement condition breakdown for each year resulting from the StreetSaver® analysis (Figures 3 and 4) and summing the resulting products. These values represent the average annual waste-vehicle traffic demand on any given street in the City.

3. Calculate the percent of life used each year by each waste vehicle type. This was performed by dividing the annual demand for a given waste vehicle (from Step 2) by the weighted average structural capacity remaining per year (from Step 1).
4. Calculate the associated damage cost each year for each waste vehicle type. This was done by multiplying the percent of life used per year for each waste vehicle type (Step 3) by the financial commitment per year ($8.05 million).
5. Calculate the average percent of life used per year by each waste vehicle type (average of Step 3).
6. Calculate the average damage cost per year for each waste vehicle type (average of Step 4).

2.5.2 Heavy Construction Vehicles

The financial impact of heavy construction vehicles is based on the assumption that they cause approximately an equal amount of damage as typical waste vehicles. However, heavy construction vehicles do not traverse streets in the same manner as waste vehicles (i.e., a weekly route through all neighborhoods). Therefore, the damage cost for heavy construction vehicles was estimated according to the following steps:

1. Calculate the average damage cost per waste vehicle per year (Section 2.5.1 Step 6) and convert to a cost per vehicle-mile traveled.
2. Calculate the damage cost associated with the construction of residential and non-residential units based on the estimated conservative number of vehicle trips and miles traveled (Section 2.3.2).
3. Convert the damage cost to the following units for comparison with neighboring agencies:
    - Per unit - residential
    - Per square foot of construction - residential/non-residential
    - Per $100 valuation – residential (assumed average residential unit value is $1.25 million (Zillow 2021).

3 Results

The following sections present the results of the vehicle impact analysis performed for waste vehicles and heavy construction vehicles.

3.1 Waste Vehicles

Figure 5 illustrates the average percent of pavement life consumed each year by each waste vehicle type and functional class. On average, garbage, green waste, and recycling waste vehicles each consume 3.1 percent of a residential pavement's capacity, or life each year. Combined with the occasional bulky waste pickup, approximately 10.1 percent of a residential pavement's life is consumed each year by waste vehicles.

The average damage done to arterial and collector streets is lower because the thicker pavement structure and better network condition result in increased structural capacity. On average, garbage, green waste, and recycling waste vehicles each consume 2.2, 1.7, and 2.2 percent, respectively of an arterial or collector pavement's life. Combined with the bulky waste pickup, approximately 6.2 percent of an arterial or collector pavement's life is consumed each year by waste vehicles.

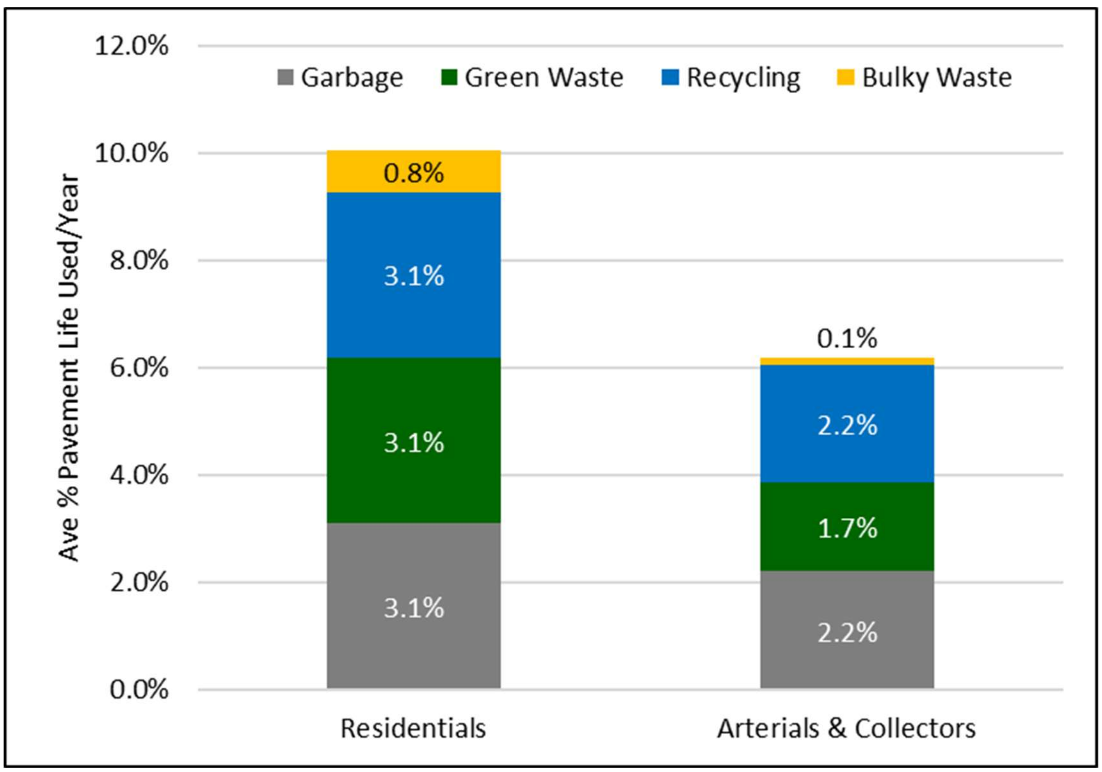

Figure 5. Average Percent of Life Consumed per Year by Waste Vehicle Type

Figure 6 shows the average cost of damage per year due to each waste vehicle type on residential streets as well as on arterial and collector streets. On average, garbage, green waste, recycling, and bulky waste together cause $510,906 worth of damage to residential streets each year. The average damage value caused by waste vehicles each year on arterial and collector streets is $183,793.

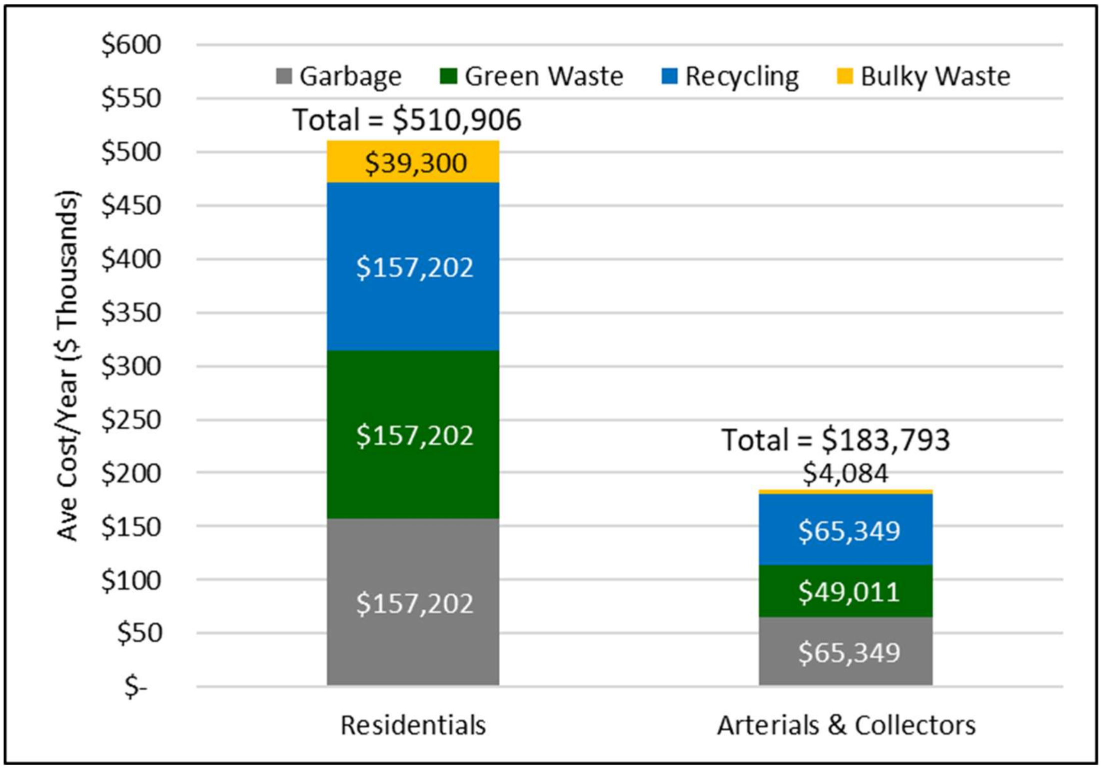

Figure 6. Average Cost per Year Due to Waste Vehicle Damage

Since the impact of waste vehicles on local roads and streets is dependent on site- and agency-specific information (pavement network condition and mileage, pavement structure, vehicle type and frequency, maintenance costs, network goals, etc.), it is difficult to compare waste vehicle impact fees between agencies. Consequently, comparison impact fees are not provided in this report.

3.2 HEAVY CONSTRUCTION VEHICLES

Table 7 Below shows the resulting proposed heavy construction vehicle impact fee options for the City of Pacifica.

Table 7. Proposed Heavy Vehicle Impact Fees for Pacifica

Option	Residential Unit Fee*	Non-Residential Unit Fee*	Unit
1	$2,126	NA	per unit
2	$1.18	$1.18	per square foot
3	$0.17	NA	per $100 valuation

*Fee in 2021 Dollars

For comparison, Table 8 summarizes heavy vehicle impact fees for several cities throughout California. These fees typically represent transportation costs associated with construction of new developments and are collected by agencies as part of a development impact fee. As shown, many of the agencies have different fees based on the type of construction (residential vs. non-residential). The residential fees are predominantly a flat fee, but some are also based on square footage, vehicle mileage, or building value. The non-residential fees are based on the square footage of the building being constructed.

Table 8. Summary of Other Agencies' Heavy Construction Vehicle Impact Fees

Agency	Criteria	Fee	Reference
Anaheim	Single Family Unit	$2,029 per unit	City of Anaheim 2020
	Multi-Family	$1,297 per unit	
	Commercial/Industrial	-	
Citrus Heights	Single Family Unit	$1,434.12 per unit	City of Citrus Heights 2021
	Multi-Family	$1,312.74 per unit	
	Commercial/Industrial	$4.45 per sf	
San Bruno	Single Family Unit	$4,615 per unit	Economic & Planning Systems, Inc., 2019
	Multi-Family	$2610 per unit	
	Commercial/Industrial	$6.95 per sf	
San Francisco	Single Family Unit	-	City of San Francisco 2021
	Multi-Family	$9.95 per sf	
	Commercial/Industrial	$19.48 per sf	
San Mateo	Single Family Unit	$5003.76 per unit	City of San Mateo 2021
	Multi-Family	$3,071.42 per unit	
	Commercial/Industrial	$5.40 per sf	
Santa Cruz County	Single Family Unit	$697 per mile	NCE 2015
	Multi-Family		
	Commercial/Industrial	-	
Saratoga	Single Family Unit	$0.77 per $100 valuation	CSG Consultants 2007
	Multi-Family		
	Commercial/Industrial	-	

The estimated per-unit fee for residential construction in Pacifica is in the same ballpark as many of the other agencies listed in Table 7. However, in terms of square footage and per $100 valuation, the proposed impact fees are lower than most of the other agencies.

Since the proposed fees were derived based on construction trips for an average size, single-family unit, NCE recommends application of the fee in dollars per square foot to allow for a scaling to multi-family units as well. For example, smaller or larger multi-family units may require less or more heavy construction vehicle trips per unit, respectively, than the average single-family unit. This would allow multi-family unit fees to be adjusted proportionally based on size.

4 Summary

The City of Pacifica is interested in implementing vehicle impact fees to recoup damage to City streets caused by waste-collection and heavy construction vehicles. Currently, the City has several waste vehicles servicing residential streets, including a weekly garbage pickup, weekly green waste pickup, weekly recycling pickup, and an as-needed bulky waste pickup. In addition, construction vehicles provide ongoing but less predictable services. The purpose of this study was to estimate the structural and financial impacts of waste and heavy construction vehicles on City streets in Pacifica.

The damage a particular vehicle imposes on a pavement depends on the load and axle configuration, the pavement structure, and the pavement condition. In general, the damage to a pavement structure increases exponentially as the load increases. Additionally, the damage caused by a given load is less for a thicker pavement structure than it is for a thinner pavement structure. And finally, as pavement condition worsens, the damage caused by a given load increases. With these factors in mind, NCE performed an analysis based on City-specific data, which combined analysis methods from both the AASHTO and Caltrans design standards. Overall, this analysis compared the estimated traffic demand associated with waste and heavy construction vehicles to the average remaining structural capacity of streets. The resulting impact was then integrated with a financial analysis.

The results of this study indicate that under existing traffic conditions, approximately 10.1 percent of a residential pavement's life is consumed each year by waste vehicles. This corresponds to an average damage cost of $510,906 per year. Similarly, approximately 6.2 percent of an arterial or collector pavement's life is consumed each year by waste vehicles. This corresponds to an average damage cost of $183,963 per year. The City can use this information to recoup pavement damage costs associated with waste collection by implementing a flat fee, a cost-per-vehicle fee, or other payment structure.

Assuming heavy construction vehicles cause damage similar to typical waste vehicles, a proposed heavy vehicle impact fee was estimated for the City and converted into several units for comparison with other California agencies.

The estimated per-unit fee for residential construction is similar to other California agencies. However, in terms of square footage and per $100 valuation, the estimated impact fees are lower than most of the comparison agencies. These proposed fees represent the transportation costs associated with the construction of new developments and can be collected as part of a development impact fee.

Any implemented waste or heavy vehicle fee structure should include an inflation factor since pavement maintenance costs increase over time.

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