LANDSCAPE PERFORMANCE SERIES

South Grand Boulevard Great Streets Initiative – St. Louis, MO
Methodology for Landscape Performance Benefits

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Environmental

Projected to reduce vehicle emissions by 50% as a result of reducing delays by reconfiguring the street and improving signal timing.

Several studies indicate that effective signal timing and coordination plan can reduce on-road emissions. The Institute of Transportation Engineers (2009) showed that improved traffic signal timing can reduce fuel consumption by 10% and reduce harmful emissions up to 22%.

In the South Grand project, the transportation engineers utilized the program SimTraffic to calculate the current and future emission rates (based on the proposed 3-lane design model). SimTraffic is a microsimulation package that allows the Synchro traffic input data to be animated and then analyzed from a different, microsimulation perspective. The study results show that under similar speed levels, vehicles travelling on the 4-lane configuration produce greater harmful emissions and use more fuel than the 3-lane configuration. This is because the poor signalization timing at traffic signals in the 4-lane configuration causes traffic congestions and longer delays.

The estimated emission rates were determined in the SimTraffic program and presented in Table 1.

Table 1. Estimated emission rates in the current and proposed street models. (Source: Greet Streets Initiative: South Grand Boulevard Mater Plan, 2010, Design Workshop, Inc., p.18)

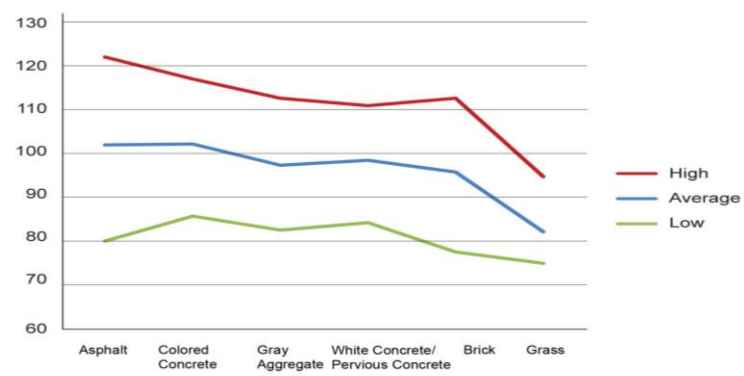
	Current 4-lane emission	Proposed 3-lane emission	Reduction rate
HC (g)	112	35	69%
CO (g)	3050	1369	55%
NOx (g)	364	169	53.5%

Abbreviations: HC, hydrocarbon; CO, carbon monoxide; NOx, nitrogen oxides.

Projected to reduce the peak ground-level temperature by 7.8°F in areas where asphalt was replaced with high-albedo pervious concrete. Large planted areas and tree canopy help to further cool the streetscape.

Surface materials largely affect surface temperatures and thus the surrounding air temperatures. Measurements taken on South Grand in early September are shown in Figure 2, demonstrating that asphalt has the highest peak temperature (122 degree), while grass has the lowest temperature (75 degree). Measurements were taken by Design Workshop project team, using a hand-held infrared thermometer at 12” above the surface. All measurements were taken in the sun on the same day with the same ambient temperature.

Pavement Material	Lowest Temp. in °F	Highest Temp. in °F	Avg. Temp. in °F
Grass	74.9	90	82.45
Brick	77.5	112.6	95.05
Grey Concrete	82.7	112.6	97.65
White Concrete	84.2	110.4	97.3
Painted/Colored Concrete	85.7	116	100.85
Asphalt	88.2	122	105.1



Note: Measurements were taken using a hand held infrared thermometer at 12” above the surface. All measurements were taken in the sun on the same day with the same ambient temperature.

Figure 2. Temperatures of various materials used on site (adapted from Greet Streets Initiative: South Grand Boulevard Mater Plan, 2010, Design Workshop, Inc., p.21).

The project increases vegetative cover and uses high-albedo (reflective) surface materials to reduce the impacts of the urban heat island (UHI) effect. White concrete porous paving is used on site to minimize heat storage and absorption. The average air temperature in the street is projected to be reduced by 7.8 degrees Fahrenheit as a result of replacing asphalt with high-albedo pervious concrete. Moreover, increasing planted areas and tree canopy coverage also contribute to the UHI effect reduction.

$$105.1\ °F - 97.3\ °F = 7.8\ °F$$

Typically, electric demand of U.S. cities increases about 1-2% per Fahrenheit degree (3-4% per Celsius degree) increase in temperature (McPherson and Rowntree, 1993). Therefore, the project is estimated to save 7.8% to 15.6% electric consumption in cooling.

Social

Expected to reduce average traffic speed by 17 mph, which is projected to result in a 85% drop in accidents, saving $3 million in estimated costs and damages. This also reduces the probability of pedestrian fatality upon vehicular impact from 40% to 5%.

South Grand Boulevard exists as one of St. Louis’ primary north-south arterials. The high vehicular speed averages 42 mph which fosters an unsafe environment for pedestrians who wish to cross the street and for cyclists who wish to travel alongside vehicles. According to the Alderman of the City, more than 110 traffic accidents were recorded within the study site in 2009 (Design Workshop, 2010, p. 24). Reducing vehicular speed through lane reduction, traffic-calming techniques, and increasing walkability of sidewalks are the major foci of this project.

Speed is an aggravating factor in the severity of all crashes. On average, each 1 mph reduction in speed may reduce accident frequency by 5% (Taylor, 2000). The relationship between speed and the outcome of a crash is directly related to the kinetic energy that is released during a collision ($E=1/2mv^2$). The more kinetic energy absorbed in a collision, the greater the potential for injury to vehicle occupants and pedestrians hit by the vehicle.

In this project, Design Workshop worked with traffic engineers on retrofitting the current 4-lane configuration into a 3-lane configuration with Intersection bulb-outs in order to reduce traffic volume and speed. The objective of this project is to reduce the average traffic speed from 42 mph (68 km/h) to the speed limit 25 mph (40 km/h) and therefore reduce the injury rate. Preliminary traffic data and project analysis showed that in one of the high traffic volume intersections (south of Arsenal), traffic volume can drop significantly from 28,643 to 19,209 vehicles/day (Chellman, 2009).

Therefore,

- the reduction in accidents would be: (42 mph – 25 mph) × 5%/1mph = 85%
- 40% decrease in speed can result in a 65% reduction in the kinetic energy of a vehicle. Calculations are shown below:
  - 25 mph ÷ 42 mph = 0.6 (60%)
  - $$E_2/E_1 = \frac{1/2\, mv_2^2}{1/2\, mv_1^2} = \frac{v_2^2}{v_1^2} = \frac{25^2}{42^2} = 0.35\ (35\%)$$

Walz et al. (1983) analyzed the relationship between the impact speed and the potential pedestrian injury severity. The probability for survival for a given Injury Severity Score (ISS) was estimated from 952 cases (Interdisciplinary Working Group for Accident Mechanics, 1986). The data were combined to relate the probability of death to impact speed (Figure. 1)

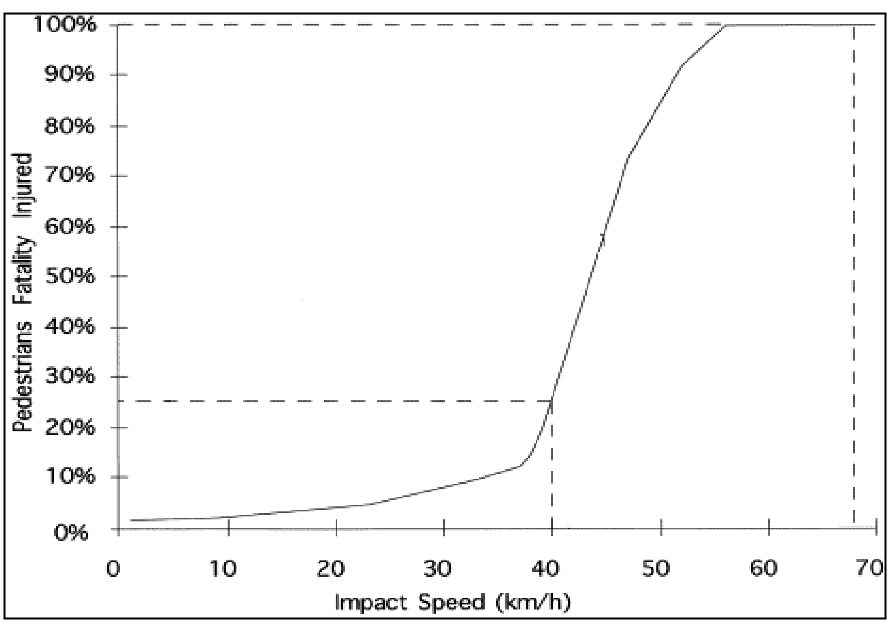


Figure 1. Probability of pedestrian fatality as a result of impact speed. Derived from Walz et al. 1983. (Source: "Vehicle travel speeds and the incidence of fatal pedestrian crashes", by Anderson et al., 1997, Accident Analysis & Prevention, Vol. 29 (5), p.669)

According to the National Highway Traffic Safety Administration (2000) and adjusted to 2010 dollars, the minimum cost of a crash is about $44,000. This includes costs typically absorbed by local governments (police department, emergency services, property damage). The median total cost is about $319,000. This estimate includes quantified economic impact into perspective with the emotional impact that affects the lives of crash victims and their families. On average, 90 accidents occur annually along this section of South Grand Boulevard from 2004 to 2009. Therefore, the average accident cost ranges from $3,960,000 to $28,710,000 per year.

Based on the above analysis, accidents will be reduced by 85% compared to the existing condition. Taking 90 crashes per year and multiplying by 85% yields 76 fewer crashes. This would generate a savings of between $3 million to $24 million per year.

- $44,000 × (90 × 85%) = $3,300,000
- $319,000 × (90 × 85%) = $24,400,000

Projected to reduce the noise level from an average of 68dB to below 60dB by reducing traffic speeds. This falls within the range that allows a comfortable conversation, improving the environment for pedestrians and outdoor dining.

The study site is at the hub of St. Louis International Community. Seven restaurants are located along South Grand in this six-block section. Through widening the sidewalks, more room was made for outdoor dining. It is important to create a comfortable and quiet environment that allows people to communicate easily. The goal of this project is to recreate an attractive pedestrian and outdoor dining environment which in turn will lead to increased revenue for the business owners. Therefore reducing the noise level to an acceptable range will not only enhance human comfort, but also stimulate economic outcomes.

Before this design, the noise level in South Grand was about 68 dB, measured by Design Workshop. The noise level will be further increased to over 77 db because of trucks and buses. This project is designed to reduce traffic speed from 42 mph to 25 mph. This results in a reduction of noise level from 68 dB to below 60 dB in normal traffic conditions (see Figure 3). From a study conducted by Purdue University (Table 2), 60 dB provides a quiet and comfortable environment for conversation.

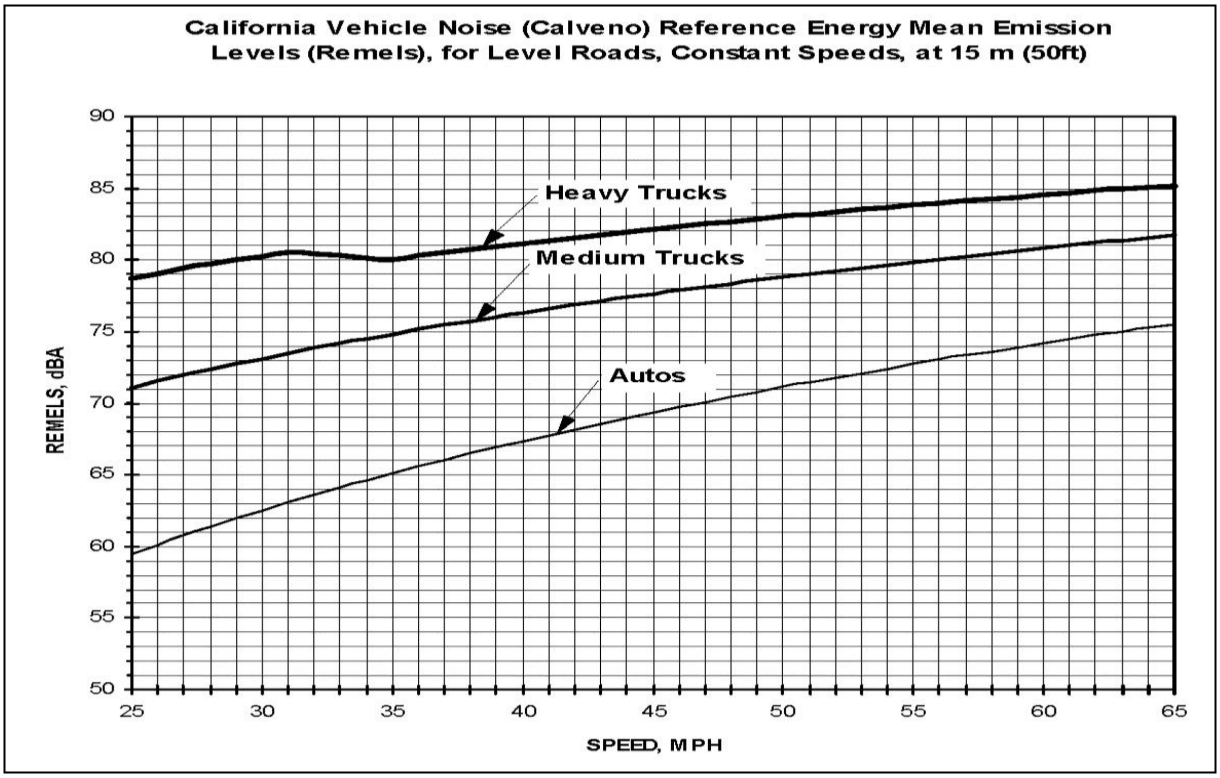


Figure 3: Relationship between vehicle speed and noise emissions. (Source: Ruby Hendrinks, 1995, Use of California Vehicle Noise Reference Energy Mean Emission Level (Calveno REMELS) in STAMINA2.0 FHWA Highway Traffic Noise Prediction Program, Technical Advisory, Noise, TAN 95-03, p.3)

Table 2: Noise sources and their effects. (Source: Purdue University Department of Chemistry, www.chem.purdue.edu/chemsafety/)

Noise Source	Decibel Level	Comment
Garbage disposal, dishwasher, average factory, freight train (at 15 meters). Car wash at 20 ft (89 dB); propeller plane flyover at 1000 ft (88 dB); diesel truck 40 mph at 50 ft (84 dB); diesel train at 45 mph at 100 ft (83 dB). Food blender (88 dB); milling machine (85 dB); garbage disposal (80 dB).	80	2 times as loud as 70 dB. Possible damage in 8 h exposure.
Passenger car at 65 mph at 25 ft (77 dB); freeway at 50 ft from pavement edge 10 a.m. (76 dB). Living room music (76 dB); radio or TV-audio, vacuum cleaner (70 dB).	70	Arbitrary base of comparison. Upper 70s are annoyingly loud to some people.
Conversation in restaurant, office, background music, air conditioning unit at 100 ft	60	Half as loud as 70 dB. Fairly quiet
Quiet suburb, conversation at home. Large electrical transformers at 100 ft	50	One-fourth as loud as 70 dB.

Expected to increase satisfaction with the street aesthetics. 81% of survey respondents felt that the proposed design would have a good or very good appearance. Only 22% said this about the former streetscape.

The project integrates art into the designed elements of the streetscape. To ensure the aesthetic quality, the project dedicates 1% of the construction budget to promote art. From the public survey results, more than 80% of the people surveyed like the new appearance of the proposed South Grand. This is a 268% increase compared to people's reflection on the existing South Grand.

(81% – 22%) ÷ 22% = 268%

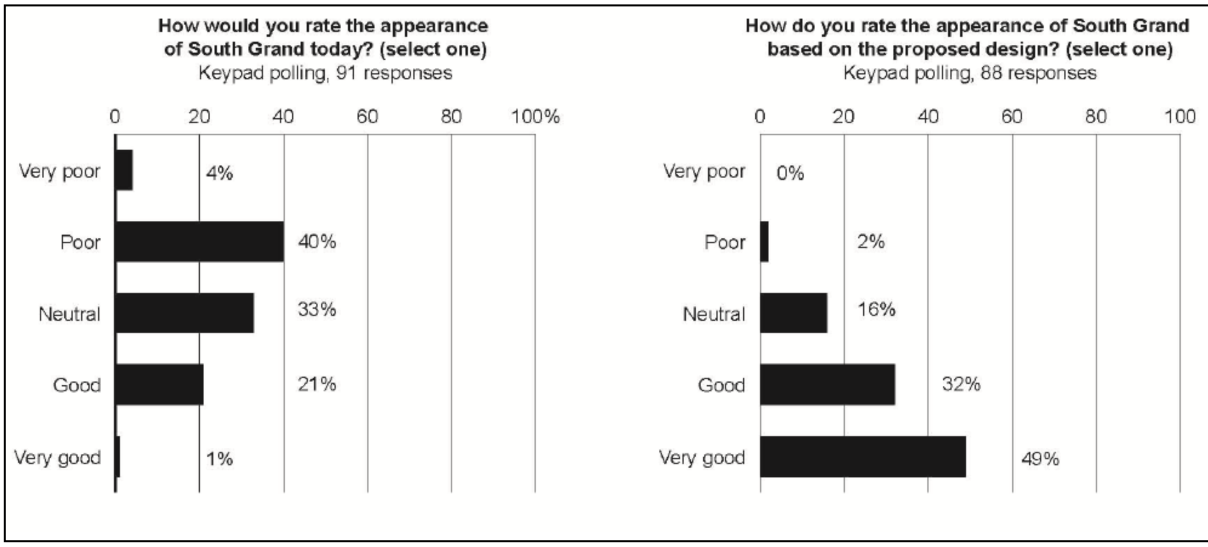


Figure 4. People's perceptions of the South Grand. Results from 2009 keypad polling (Source: Design Workshop, South Grand Master Plan Book. p.33).

Economic

Increased annual sales tax revenue by 14% in the first year after redevelopment. The project was initially projected to increase revenue by 19% over a 10-year period.

The Community Improvement District tracked the sales tax revenues and indicated that there is a 14% increase in tax revenues in the first year after project construction. This rate is even 2% higher than the original projection by Design Workshop**.** The analysis is conducted by Design Workshop (Table 3).

Table 3. Estimated annual revenue increase over a 10-year period in South Grand (Source: Design Workshop, Inc.)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Annual Revenue (Million dollars)	204.0	207.8	211.6	215.4	219.2	223.0	226.8	230.6	234.4	238.2
Annual Revenue Increase (%)	1.9%	3.8%	5.7%	7.6%	9.5%	11.4%	13.3%	15.2%	17.1%	19.0%

Cost Comparison

The project is predicted to achieve a total annual tree benefit of approximately $8,911 compared to the current tree benefit of $3,921 by switching from the existing Honey Locust to Homestead Elm and Sycamore.

According to the City of St. Louis, MO, Street Tree Resource Analysis (completed in March, 2009 by Davey Resource Group), the total annual benefits of the existing Honey Locust trees were about $55 per tree. The proposed Homestead Elm and Sycamore trees at mature sizes will provide an annual benefit of about $105 and $79 per tree, respectively (National Tree Benefit Online Calculation).

Measured from the CAD map, there are 71 Honey Locust trees on site. These Honey Locust trees were replaced by 48 Homestead Elm and 49 Sycamore. The total benefits were calculated as follows.

- Annual benefits from the existing trees: $55.22 × 71 = $3920.62
- Annual benefits from the tree replacements: $105× 48 + $79 × 49 = $8911

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