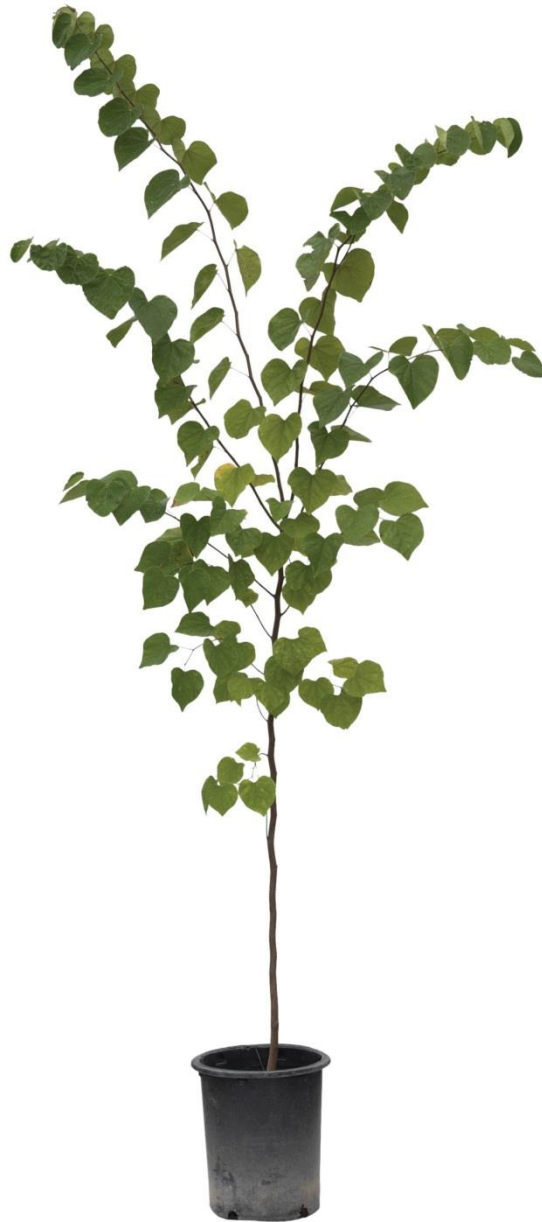


Landscaping Guidance for Improving Air Quality near Roadways

Plant Species and Best Practices for the Sacramento Region



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I - Introduction

Roadside green space and landscaping has served aesthetic and roadway functionality purposes. Vegetation along roadways provides value to wildlife, human mental health and social benefits, storm water interception and retention, carbon sequestration and urban heat island mitigation. Recent scientific studies show that roadside landscaping and barriers can also reduce roadway-generated pollutant exposure for nearby sensitive populations. The air quality benefit occurs when particles are captured by leaf surfaces as air flows past. In July 2016, the United States Environmental Protection Agency (EPA) released [Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality](#) (EPA Recommendations), summarizing the current research findings and best practices.

The Sacramento Metropolitan Air Quality Management District (SMAQMD) has developed this *Landscaping Guidance for Improving Air Quality near Roadways* (Landscaping Guidance), which focuses on the Sacramento region and aims to translate information from the EPA Recommendations for local use. The goals of this landscaping guidance document are to:

- Provide guidelines for evaluating a potential vegetation barrier site;
- Offer vegetation planting recommendations to meet height, thickness and porosity goals;
- Evaluate appropriate vegetation characteristics through a recommended plant species list;
- Address best practices for vegetation planting;
- Offer suggestions for effective long term maintenance; and
- Suggest sample condition of approval language.

Please direct any questions about this document to Rachel DuBose of SMAQMD staff: (916) 874-4876 or rdubose@airquality.org.

II - Evaluating Potential Vegetation Barrier Locations

Consideration of location feasibility is the critical first step in implementing a roadside vegetation barrier that will result in near-road air quality improvements. Not every roadside will have the physical attributes required to establish an effective vegetation barrier. Before advancing to design and plant species selection, the following steps must be undertaken:

Assess Available Space: Ensure that adequate space is available to support the long-term establishment of a permanent vegetation barrier. The barrier should consist of at least 32 feet, 9 inches (10 meters) of an uninterrupted vegetation thickness, and be at least 16 feet, 5 inches (5 meters) tall. Also, adequate access space must be preserved to allow for long term success and maintenance. Please see Section III for more information on design options.

Review Underground and Overhead Utilities: Underground and overhead utilities create a variety of limitations depending upon the type of utility and its operator. Always call 811 before you dig. A complete inventory of on-site utilities and space separation requirements must be undertaken. Useful resources can be found in Appendix B.

Identify Local Fire Safety Codes: Local fire prevention standards may restrict the location and types of vegetation allowed near roadway areas. In addition, defensible space allowances under Public Resources Code may preclude vegetation barrier installations if buildings are nearby. In general, roadside vegetation should remain 10 feet (3.048 meters) from roadside edges and 15 feet (4.572 meters) in vertical clearance from the roadway surface. Useful resources can be found in Appendix B.

Examine Caltrans Vegetation Requirements: Many roadways that are prime locations for roadside vegetation barriers to improve near-road air quality are under Caltrans jurisdiction. For vegetation within the roadway right-of-way, general Caltrans tree and vegetation guidelines are as follows, with more specific information in Appendix B:

- Plant trees at least 30 feet from the edge of the traveled way.
- Overhanging foliage must be 15 feet from the pavement to the overhanging branches.
- Trees must be at least 20 feet from any manholes.
- Shrub setback distance is determined by the height and width of the species.
- Plant all vegetation at least 10 feet from fences, walls, ditches or drainage features. In some circumstances, vegetation can be placed closer to these features with an encroachment permit.
- Vegetation must not interfere with safety features such as shoulders, existing barriers, guardrails or signs, and must not interfere with a driver's ability to see a continuous length of roadway.

- The vegetation cannot add a maintenance burden to Caltrans; it must be managed in perpetuity by the entity responsible for planting.
- Coordination with the appropriate Caltrans District Office is recommended as part of your site evaluation process.

Consider Other Location Factors: Proximity to sensitive populations (human populations such as educational facilities, or endangered plant populations) may indicate special consideration during plant selection. Examples include avoiding poisonous plants in areas where children may come into contact with them, or avoiding planting native plants near similar unique or endangered native populations¹. Consideration of micro-site characteristics such as localized wind flow patterns, unique or challenging soil types, past history of landscape use by transients, and wildlife attractiveness may inform plant selection and maintenance activities to ensure long term project success.

¹ For example, *Fremontedendron californica* near *Fremontedendron decumbens*, an endangered plant found in El Dorado County.

III – Vegetation Barrier Design Considerations

Best Practices

- Use at least two types of vegetation (i.e. trees and shrubs) to ensure that the foliage covers from ground level to top of canopy. Avoiding monocultures will reduce the risk of project failure due to an infestation of pests that target a certain species.
- Stagger spacing and plant low vegetation in between trees to maximize growth space and ensure uniform coverage.
- Fill the available space, both horizontally and vertically, with vegetation. (Note that the species listed in Appendix C will ensure space coverage for the first 7 to 10 years.) Once mature, foliage should be a minimum of 10 meters thick (32 feet, 9.7 inches), 5 meters high (16 feet, 5 inches) and 1 meter (3 feet, 3.37 inches) higher than associated noise barriers.
- Barriers should extend 50 meters (164 feet) or more beyond the area to be protected, or can wrap around and extend perpendicularly away from the roadway.
- Expect tighter plant spacing when compared to landscape designs that are for solely aesthetic uses.

Space Requirements: Space availability can pose a significant challenge when designing a vegetation barrier to improve near-road air quality. This is especially true where roadway setbacks are inflexible. While the EPA guidelines recommend a thickness of at least 10 meters (32 feet, 9.7 inches) or more, the modeling also suggests that **any** type of barrier (solid, vegetation, or combination) will limit the distance and amount of air pollution travel from a roadway. Because the Sacramento region has significant opportunities to retrofit existing roadsides, the following scenarios have been developed that meet EPA guidelines. We also provide scenarios for locations that do not meet the EPA’s recommended 10 meter-thickness.

In general, roadside vegetation should remain 10 feet (3.048 meters) from roadway edges and 15 feet (4.572 meters) in vertical clearance from the roadway surface. On a Caltrans facility, trees must be planted at least 30 feet from the edge of the traveled way. Caltrans will not maintain vegetation planted less than 10 feet from fences, walls, ditches or drainage features.

IV – Example Scenarios

Scenario 1 - Vegetation Only

An effective vegetation barrier can only be achieved with a minimum planting thickness of 32 feet, 9.7 inches (10 meters). Layer vegetation to fill all available growing space from ground level to the top of the canopy. The spacing will be very tight. Compared to traditional landscape plantings, vegetation barrier plantings may look overplanted.

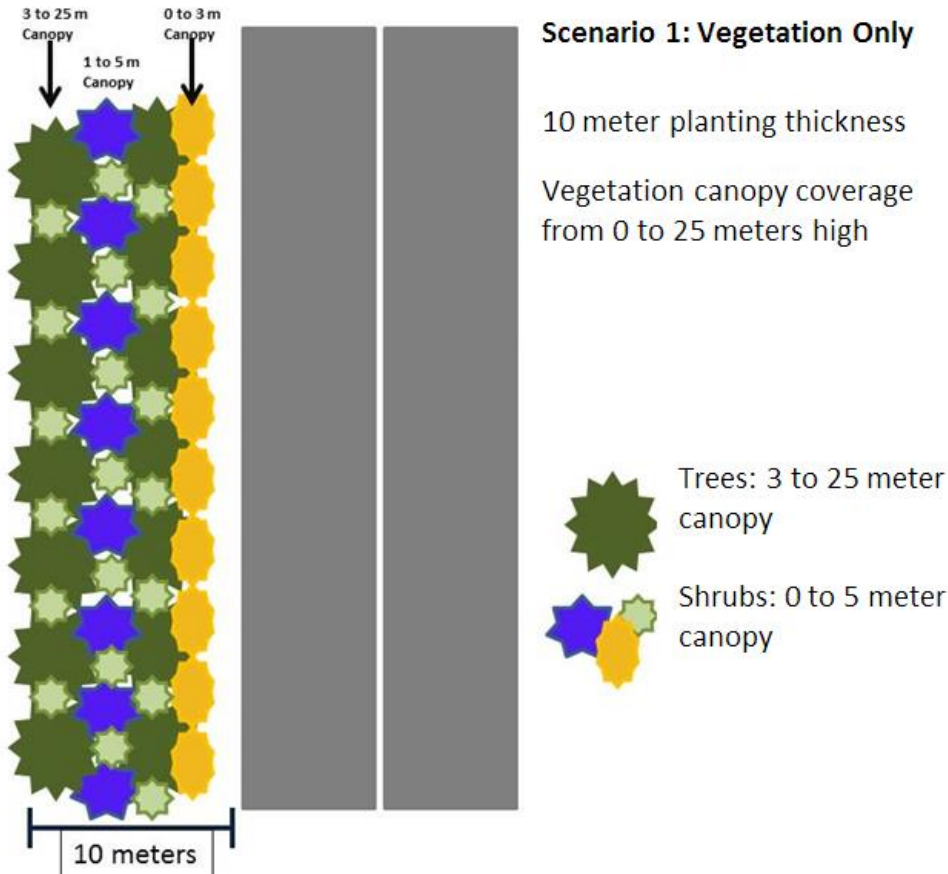


Figure 1: Vegetation Only

Scenario 2 - Vegetation on One Side of Noise Barrier

Solid noise barriers (sound walls) can be effectively paired with vegetation barriers to improve near-road air quality. Vegetation should extend a minimum of 1 meter (3 feet, 3.37 inches) higher than the nearby noise barriers.

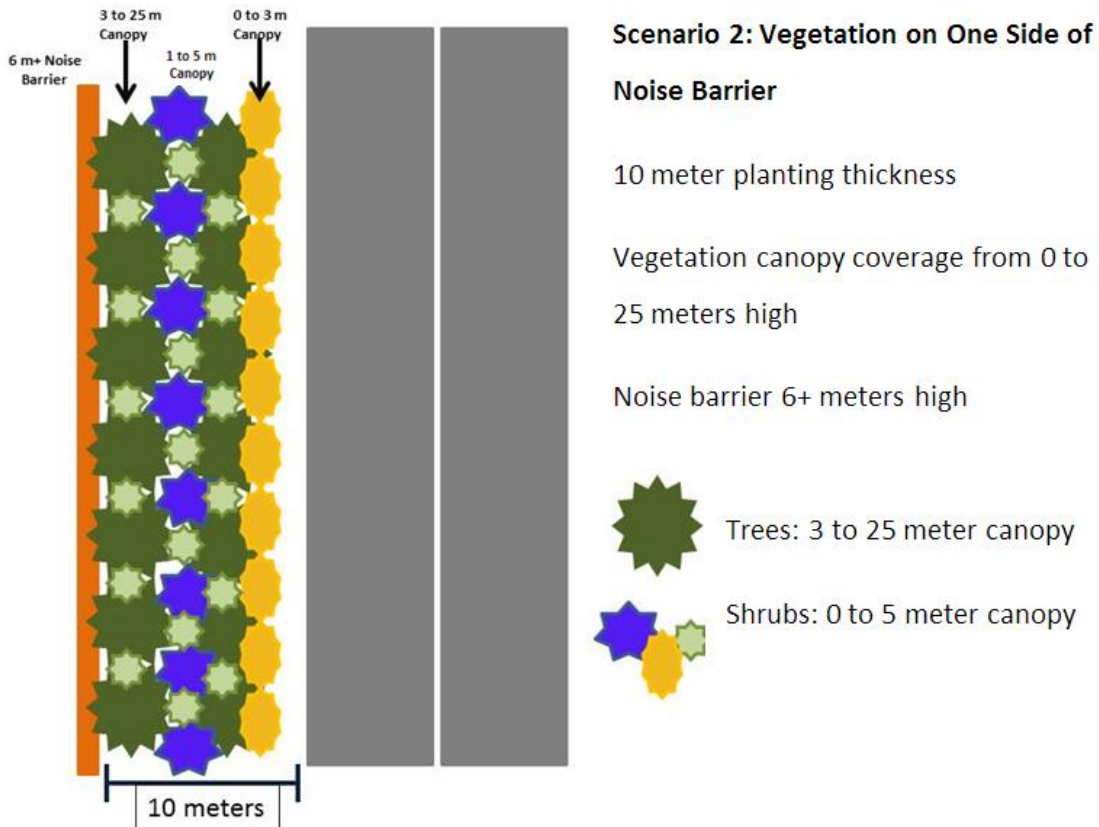


Figure 2: Vegetation on One Side of Noise Barrier

Scenario 3 - Vegetation on Both Sides of Noise Barrier

Vegetation can be planted on both sides of a solid noise barrier. The recommended 10-meter (32 feet, 9.7 inches) vegetation thickness can be achieved through canopied trees or multiple rows of tall vegetation.

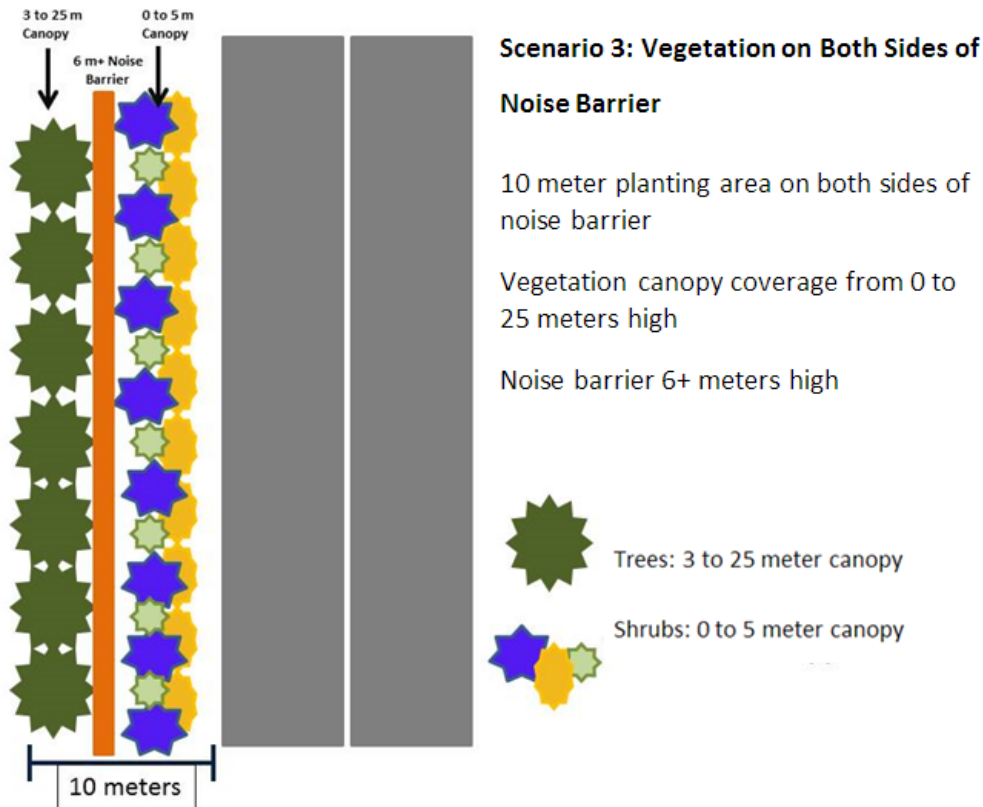


Figure 3: Vegetation on Both Sides of Noise Barrier

Scenario 4 - Narrow Vegetation Strip on One Side of Noise Barrier

While this design does not meet the EPA Recommendations, modeling suggests that, when compared to a scenario lacking any sort of barrier, this design will reduce near-road air quality and pollutant dispersal.

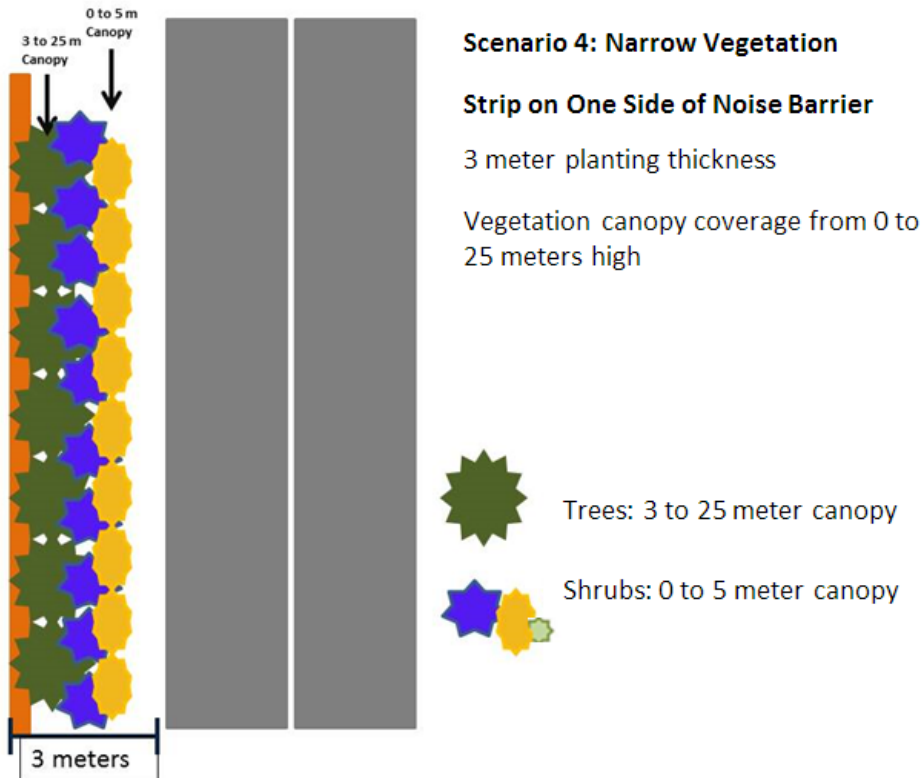


Figure 4: Narrow Vegetation Strip on One Side of Noise Barrier

V - Vegetation Characteristics

The roadside air quality benefit occurs when air pollution particles are captured by leaf surfaces. Low-porosity plants are those that exhibit very dense foliage and do not allow significant air flow through the interior of the plant canopy. High-porosity plants are those that have a less dense canopy and allow significantly more air flow through. For vegetation roadside barriers, planting lower-porosity plants closer to the roadway and higher-density plants at the furthest edge of the planting should have the most benefit to near-road air quality. Local professionals have evaluated the plant species recommended in Appendix C of this Landscaping Guidance, and rated them as Low, Medium or High for porosity.

Each plant in Appendix C meets the EPA Recommendations for minimal seasonal and climatic variability. In addition, they are either native or drought-tolerant and will thrive with limited specialized care beyond the 3 to 5 year establishment period. They are generally available within the local nursery trade or can be easily acquired. The list includes additional criteria such as desirable leaf surface characteristics (waxy, hairy and with high leaf surface area), capacity to produce BVOC (biogenic volatile organic compound) emissions under certain conditions that contribute to ground level ozone levels (1 to 3 star comparative rating scale; 1 is good, 2 is better, and 3 is best for air quality), flowering/fruitletting and estimated plant porosity rating (high, medium, low). Invasive plants are not included. This list is not comprehensive and other species may meet the criteria outlined in the EPA Recommendations.

The plants recommended in this guidance have crown widths to ensure space coverage over the first 7 to 10 years. Long-term maintenance of vegetation barriers is needed in order to manage natural processes and replace failed or damaged plant materials.

VI - Vegetation Acquisition and Planting Recommendations

Because the preferred plants may not be readily available in the appropriate quantity or plant size, the landscape plans should include several alternatives that can to fill the same space and functionality. Give nurseries or contract growers advance notice so they can have the materials you need in stock. Smaller pot sizes may be more readily available than larger ones.

Fall and winter are the best seasons to plant trees and shrubs. The individual planting sites may need to be pre-irrigated if it has not rained at least 2 inches within the prior 30 days. Smaller-sized plants (#5 pots or smaller) will encourage healthy root establishment and future drought tolerance. In most cases, smaller-sized materials "catch up" to larger plant materials in 2 to 4 years and greatly outperform them year 5 and on. Planting appropriately-sized materials is also the most cost-effective method when establishing a new landscape.

Inspect plant materials before planting and after they are in the ground. See Appendix D for more resources on proper planting.

Long-Term Maintenance

Vegetation must be adequately maintained to meet both short and long term plant growth and establishment goals.

The establishment period covers the first 3 to 5 seasons after planting. An effective maintenance plan will address irrigation, plant protection, weed management and plant replacement. Healthy establishment of native and drought-tolerant plants will require supplemental irrigation during the dry season (May-November) for the first three dry seasons². Temporary irrigation systems or other methods may be appropriate. Irrigate in accordance with individual plant species needs and in response to soil and climatic conditions, which will vary with planting location. Use stakes, planting tubes or other protective materials to avoid damage from weather, animals and weed abatement activities, where appropriate. Remove stakes and other protective materials after the roots are established sufficiently to survive a wind event (typically 3 years). Materials left behind can damage growing plants when used improperly. Abatement of invasive species will support the healthy establishment of vegetation barrier plants and will reduce fire hazards. Mulch application, mowing and herbicide application may be appropriate for weed management depending on the location and types of weeds to be controlled. Replacement of damaged plants during the establishment period is necessary to

² Supplemental irrigation rates are dependent on a variety of factors, including amount of rainfall in current and recent seasons, soil type, slope and aspect. In all cases, deep, infrequent watering will result in greater establishment of native and drought tolerant vegetation.

ensure a consistent and fully vegetated barrier. Pruning, with the exception of targeted structural pruning of trees, should be avoided during the establishment phase.

Long-term maintenance should be guided by a project-specific adaptive management plan, with a minimum of 2 assessments per year with corresponding interventions depending on observed barrier conditions. For example, plants within the vegetation barrier that are in poor health may be slated for replacement the following fall. Careful implementation and strategic care of vegetation barriers will result in greater effectiveness and lower maintenance costs over the long term. Avoid regular and significant pruning. Landscape management contractors may need to be closely overseen to ensure proper care.

Condition of Approval Language

Condition of approval language is most effective when it is clear and concise. It will need to be tailored to each project, dependent on the specific project design and plant materials used. Sample language is included in Appendix E.

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Appendix A - Summary Table from EPA Recommendations

Barrier Characteristic	Recommendation	Description
<i>Physical Characteristics</i>		
Height	5 meters or higher (or extend 1+ meter above an existing solid barrier)	The higher the vegetative barrier, the greater the pollutant reductions. A minimum of 5 meters should provide enough height to be above typical emission elevations for vehicles on the road. However, heights of 10 meters or more would likely provide additional pollutant reductions.
Thickness	10 meters or more	The thicker the vegetative barrier, the greater the pollutant reductions. A minimum thickness of 10 meters should provide enough of a barrier to remove particulate and enhance dispersion. However, gaps in the barrier should be avoided. Multiple rows of different types of vegetation (e.g. bushes, shrubs, trees) should be considered for maximum coverage and pollutant removal during all stages of the barrier.
Porosity	0.5 to 0.9	Porosity should not be too high to allow pollutants to easily pass through the barrier or cause wind stagnation. As the porosity gets lower, the vegetation barrier will perform similarly to a solid barrier, which may limit the amount of particulate removal since air is forced up and around the plants.
Length	50 meters or more beyond area of concern	Extending the barrier beyond the area of concern protects against pollutant meandering around edges. May also consider constructing the barrier perpendicular from the road depending on land availability.
<i>Vegetation Characteristics</i>		
Seasonal Effects	Vegetation not subject to change by season	Vegetative barrier characteristics must be consistent throughout all seasons and climatic conditions in order to ensure effective pollutant reductions.
Leaf Surface	Complex waxy and/or hairy surfaces with high surface area	Leaf surfaces with complex and large surface areas will capture and contain more particulate pollutants as air passes through the structure.
Air Emissions	Vegetation with low or no air emissions	Vegetation used for roadside barriers should not be sources of air pollution, either at the local or regional scale.
Pollution and Stress Resistant	Resistant to effects of air pollution and other stressors	Vegetation must be able to survive and maintain its integrity under the high pollution levels and stress that can occur near roads in order to provide effective pollution reductions from traffic emissions. In addition to air pollution, other stressors can include salt and sand for winter road conditioning and noise impacts

Barrier Characteristic	Recommendation	Description
<i>Other Considerations</i>		
Maintenance	Plan must be in place to properly maintain vegetative barrier	Proper vegetation maintenance must be provided in order for the barrier to survive and maintain its integrity to provide effective pollution reductions from traffic emissions.
Water Runoff	Contain surface water runoff and improve water quality	Roadside vegetative barriers constructed appropriately can provide an added benefit of controlling and containing surface water runoff from the road, which can also improve local water quality.
Drought Resistant	Choose species resistant to drought and flooding	Many regions face climatic conditions of extended drought followed by localized flooding. Vegetative barrier must maintain its integrity under these conditions in order to provide effective pollution reductions.
Native Species	Choose native species	Native species will be more robust and resistant to climatic conditions in the area of interest; thus, maintaining its integrity under these conditions in order to provide effective pollution reductions.
Non-invasive	Choose non-invasive species	The use of non-invasive species will ensure effective pollutant reductions without potential unintended consequences from invasive species adversely effecting nearby land uses.
Non-poisonous	Choose non-poisonous species if sensitive populations will be nearby	Non-poisonous species are strongly encouraged and should be used if the barrier will be at a location with sensitive populations, such as elementary schools, parks, and recreation fields where small children may be active and in close contact.
Roadway Safety	Maintains safety for drivers on the road; conforms to local safety and permit requirements	Prior to planting, ensure vegetation plan will meet all safety and other local permit requirements (e.g. local highway department, city planning department) to preserve sight-lines and vegetation compatibility while avoiding potential wildlife/auto accidents and obstruction of outdoor advertising.



Appendix B – Resources

The SelecTree website outlines various utility precautions as they relate to vegetation.

<http://selectree.calpoly.edu/>

Local Fire Prevention Standards:

Sacramento Metro Fire Community Wildfire Protection Plan, Weed Abatement Requirements and Inspections

<https://metrofire.ca.gov/index.php/fpb-forms/category/64-initial-study-mnd>

<https://metrofire.ca.gov/index.php/component/phocadownload/category/61-weed-abate-docs?download=93:fps11-weed-abatement>

CalFire Wildland-Urban Interface Codes:

http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_codes

CalTrans district offices:

<http://www.dot.ca.gov/hq/jobs/districtoffices.htm>

CalTrans Roadside Maintenance and Adopt A Highway Information:

<http://www.dot.ca.gov/hq/maint/roadside.htm>

CalTrans Landscape Architecture Program:

<http://www.dot.ca.gov/design/lap/>

Includes links to the Scenic Highway program, which may pertain to your project given specific location.

CalTrans Encroachment Permits:

<http://www.dot.ca.gov/trafficops/ep/index.html>

Appendix C - Species Matrix

Scientific Name	Common Name	Height	Crown Diameter*	Porosity[®]	CA Native	BVOC[♠]	Type	Notes
<i>Artemisia californica</i>	California sagebrush	3'	3'	L	Yes	Not Rated	Shrub	Green-gray foliage, appropriate for north side of sound wall or noise barrier, limit summer irrigation
<i>Cneoridium dumosum</i>	Coast Spice Bush	3'	3'	M	Yes	Not Rated	Shrub	Fragrant flowers and red fruit, best on north/east side of noise barriers, may cause skin irritation
<i>Trichostema lanatum</i>	Woolly Blue Curls	3'	3'	L	Yes	Not Rated	Shrub	Fuzzy spikes of violet flowers, no water post establishment
<i>Abutilon palmeri</i>	Indian mallow	4'	4'	M	No	Not Rated	Shrub	Apricot flowers, fuzzy leaves
<i>Malacothamnus fasciculatus</i>	Bush mallow	4'	4'	M	Yes	Not Rated	Shrub	Tolerates sand, pink 1" flowers, hairy stems and leaves
<i>Senna nemophila</i>	Desert cassia	4'	4'	H	No	Not Rated	Shrub	Needlelike structure, airy habit, bright yellow flowers. Also known as Cassia nemophila.
<i>Artemisia tridentata</i>	Big sagebrush	5'	5'	L	Yes	Not Rated	Shrub	Yellow-green flowers, twisted trunk
<i>Baccharis pilularis</i>	Coyote Bush/Brush	5'	5'	L	Yes	Not Rated	Shrub	Lots of white-yellow flowers along stems
<i>Berberis aquifolium</i>	Oregon grape	5'	5'	M	Yes	Not Rated	Shrub	Dark green leaves, fragrant yellow flowers. Also known as Mahonia aquifolium.

<i>Scientific Name</i>	<i>Common Name</i>	<i>Height</i>	<i>Crown Diameter*</i>	<i>Porosity</i> [®]	<i>CA Native</i>	<i>BVOC</i> [†]	<i>Type</i>	<i>Notes</i>
<i>Ceanothus cuneatus</i>	Buckbrush	5'	5'	L	Yes	Not Rated	Shrub	Tough fleshy leaves, white flowers, very tough and extremely drought tolerant
<i>Ceanothus</i> 'Blue Jeans'	California Lilac	5'	5'	L	Yes	Not Rated	Shrub	No shade or summer water post-establishment, lavender flowers
<i>Cercocarpus betuloides</i>	Mountain mahogany	5'	5'	M	Yes	Not Rated	Shrub	Birch-like leaves, tail-shaped fruit, small clustered white flowers, tolerates clay and sand
<i>Eriodictyon californicum</i>	Yerba santa	5'	5'	M	Yes	Not Rated	Shrub	Long narrow leaves, bluish bell-shaped flowers
<i>Eriogonum giganteum</i>	Saint Catherine's lace	5'	5'	L	Yes	Not Rated	Shrub	Leathery wooly oval leaves, tiny pinkish white flower
<i>Isomeris arborea</i>	Bladderpod	5'	5'	L	Yes	Not Rated	Shrub	Long, pointed oval shaped leaves; abundant yellow flower clusters
<i>Lavandula x gingsii</i> 'Goodwin Creek Grey'	Goodwin Creek lavender	5'	5'	L	No	Not Rated	Shrub	Silvery leaves, scented, purple flowers
<i>Leucophyllum frutescens</i>	Cenizo	5'	5'	L	No	Not Rated	Shrub	Purple flowers, evergreen, silvery leaves
<i>Leucophyllum langmaniae</i> 'Lynn's Legacy'	Lynn's Legacy lleucophyllum	5'	5'	L	No	Not Rated	Shrub	Fragrant purple bell-shaped flowers, evergreen
<i>Myrsine africana</i>	African boxwood	5'	5'	L	No	Not Rated	Shrub	Very dense foliage, appropriate for a hedge, may be poisonous, occasional irrigation post-establishment

Scientific Name	Common Name	Height	Crown Diameter*	Porosity[®]	CA Native	BVOC[†]	Type	Notes
<i>Peritoma arborea</i> , Syn. <i>Cleome arborea</i>	Bladderpod	5'	5'	M	Yes	Not Rated	Shrub	Lacy gray-green leaves, yellow flowers year round, tolerates alkalinity
<i>Phlomis purpurea</i>	Pink phlomis	5'	5'	M	No	Not Rated	Shrub	Colorful flowers, fuzzy leaves, pleasant aroma, poisonous if ingested
<i>Rosmarinus officinalis</i>	Rosemary	5'	5'	L	No	Not Rated	Shrub	Pleasant scent, long-stemmed shoots, edible, white, purple or blue flowers
<i>Salvia clevelandii</i>	Cleveland sage	5'	5'	L	Yes	Not Rated	Shrub	Wrinkly-leathery leaves, rounded purple flower clusters
<i>Teucrium fruticans</i>	Bush germander	5'	5'	L	No	Not Rated	Shrub	Evergreen, silvery blue leaves, lavender flowers
<i>Rhaphiolepis indica</i>	Indian hawthorn	5'	5'	L	No	Not Rated	Shrub	Thick leathery leaves, white star shaped flowers, blue-black fruits
<i>Rubus ursinus</i>	Blackberry	5'	5'	L	Yes	Not Rated	Shrub	Prickly branches, white flowers, edible fruit
<i>Rhus integrifolia</i>	Lemonade berry	5'	8'	L	Yes	Not Rated	Shrub	Leathery, dark green leaves, small pink flowers, shorter on slopes
<i>Rosa californica</i>	Wild rose	5'	8'	L	Yes	Not Rated	Shrub	Prickly stems, 5-petaled colored leaves, scented
<i>Carpenteria californica</i>	Bush anemone	6'	3'	L	Yes	Not Rated	Shrub	Shiny evergreen foliage, white flowers, native to Fresno County.
<i>Atriplex lentiformis</i>	Salt bush	6'	6'	L	Yes	Not Rated	Shrub	Silver-gray foliage, tolerates alkaline soil and clay

Scientific Name	Common Name	Height	Crown Diameter*	Porosity[®]	CA Native	BVOC[†]	Type	Notes
<i>Xylosma congestum</i>	Shiny xylosma	6'	6'	L	No	Not Rated	Shrub	Shiny light green leaves, occasional irrigation post-establishment
<i>Acacia vestita</i>	Hairy wattle	8'	6'	M	No	Not Rated	Shrub	Hairy foliage, yellow flowers
<i>Baccharis salicifolia</i>	Mulefat	10'	5'	H	Yes	Not Rated	Shrub	White, fuzzy pink flowers, long pointed leaves
<i>Myrtus communis</i>	True myrtle	10'	5'	L	No	Not Rated	Shrub	Glossy green leaves and white fragrant flowers
<i>Philadelphus lewisii</i>	Mock orange	10'	5'	L	Yes	Not Rated	Shrub	Light green leaves, pale yellow, scented blossoms, occasional irrigation post-establishment
<i>Adenostoma fasciculatum</i>	Chamise	10'	6'	M	Yes	Not Rated	Shrub	White flowers, possibly not compatible with fire resistant landscaping
<i>Callistemon citrinus</i>	Crimson bottlebrush	10'	6'	M	No	Not Rated	Shrub	Red bottle shaped flowers, citrus smell, hummingbirds love it
<i>Frangula californica</i> , syn. <i>Rhamnus californica</i>	Coffeeberry	10'	10'	L	Yes	Not Rated	Shrub	Dark red branches, coffee-like berries
<i>Garrya fremontii</i>	Bearbrush	10'	10'	L	Yes	Not Rated	Shrub	Smooth green oval-shaped leaves, edible purple berries
<i>Heteromeles arbutifolia</i>	Toyon	10'	10'	L	Yes	Not Rated	Shrub	Dense small white flowers, evergreen, sharply toothed leaves
<i>Juniperus californica</i>	California juniper	10'	10'	L	Yes	Not Rated	Shrub	Alkali tolerant, edible berries, very dense foliage
<i>Quercus berberidifolia</i>	California scrub oak	10'	10'	M	Yes	Not Rated	Shrub	Dull green, oval or toothed leaves, rounded acorns

Scientific Name	Common Name	Height	Crown Diameter*	Porosity[®]	CA Native	BVOC[†]	Type	Notes
<i>Acacia boormanii</i>	Snowy river wattle	15'	10'	M	No	Not Rated	Shrub	Golden ball-shaped flowers, frost tolerant
<i>Arctostaphylos manzanita</i>	Manzanita	15'	10'	H	Yes	Not Rated	Shrub	Bright shiny leaves, smooth red bark
<i>Fremontodendron californicum</i>	Flannel bush	15'	15'	L	Yes	Not Rated	Shrub	Fuzzy leaves, large yellow blossoms
<i>Osmanthus x fortunei</i>	Hybrid tea olive	15'	15'	L	No	Not Rated	Shrub	Small white flowers, dark green dense leaves, gray bark
<i>Pittosporum tobira</i>	Japanese pittosporum	15'	15'	L	No	Not Rated	Shrub	Evergreen, fragrant white flower clusters, leathery green leaves
<i>Allocasuarina verticillata</i>	Drooping she-oak	20'	15'	H	No	Not Rated	Tree	Needles, can have sparse foliage
<i>Cupressus arizonica</i>	Arizona cypress	20'	15'	L	No	Not Rated	Tree	Gray-green, conical, dense foliage, needs well drained soil, tolerates alkaline soils
<i>Geijera parviflora</i>	Australian willow	20'	15'	L	No	2 Stars	Tree	White flowers, older trees take on weeping form
<i>Prunus illicifolia</i> ssp. <i>lyonii</i>	Catalina cherry	20'	15'	M	Yes	Not Rated	Tree	Upright form, white flowers and edible, large-seeded fruit
<i>Eriobotrya japonica</i>	Loquat	20'	20'	M	No	3 Stars	Tree	White flowers and edible fruit
<i>Arbutus unedo</i>	Strawberry tree	25'	20'	M	No	1 Star	Tree	Flowers and fruit, red bark
<i>Laurus nobilis</i>	Sweet bay	30'	30'	L	No	3 Stars	Tree	Yellow flowers and berries
<i>Ceratonia siliqua</i>	Carob tree	35'	30'	M	No	1 Star	Tree	Large; seeded pods; dark green leathery leaves; deep, infrequent irrigation required
<i>Olea europaea</i> 'Swan Hill'	Swan Hill olive	35'	30'	M	No	3 Stars	Tree	Fruitless, low pollen
<i>Brachychiton</i>	Bottle tree	40'	30'	M	No	3 Stars	Tree	Unusual, wide

<i>Scientific Name</i>	<i>Common Name</i>	<i>Height</i>	<i>Crown Diameter*</i>	<i>Porosity</i> [Ⓞ]	<i>CA Native</i>	<i>BVOC</i> [♠]	<i>Type</i>	<i>Notes</i>
<i>populneus</i>								trunk
<i>Pinus eldarica</i>	Afghan pine	45'	25'	M	No	1 Star	Tree	Needles, dense canopy, tall form, tolerates poor soils
<i>Pinus nigra</i>	Austrian black pine	45'	25'	M	No	2 Stars	Tree	Dense canopy with dark green needles
<i>Umbellularia californica</i>	California bay laurel	45'	30'	M	Yes	2 Stars	Tree	Fragrant leaves, small flowers and fruit
<i>Pinus halepensis</i>	Allepo pine	45'	40'	M	No	3 Stars	Tree	Needles, cones persist on tree
<i>Cinnamomum camphora</i>	Camphor	50'	65'	M	No	3 Stars	Tree	Fragrant leaves, dark berries
<i>Quercus wislizenii</i>	Interior live oak	55'	55'	M	Yes	1 Star	Tree	Dark green glossy leaves, distinct and more appropriate than Coast live oak
<i>Abies pinsapo</i>	Spanish fir	60'	20'	L	No	Not Rated	Tree	Needles, conical tree
<i>Podocarpus gracilior</i>	Fern pine	60'	30'	L	No	3 Stars	Tree	Can be frost sensitive
<i>Quercus ilex</i>	Holly oak	60'	55'	L	No	1 Star	Tree	Dark green leaves, acorns, dense canopy
<i>Quercus suber</i>	Cork oak	60'	60'	M	No	3 Stars	Tree	Cork-like bark, acorns
<i>Pinus canariensis</i>	Canary Island pine	65'	30'	H	No	2 Stars	Tree	Dark reddish bark, needles
<i>Cedrus deodara</i>	Deodar cedar	65'	45'	H	No	3 stars	Tree	Silver-gray needles, airy canopy when fully mature
<i>Magnolia grandiflora</i>	Southern magnolia	65'	45'	H	No	2 Stars	Tree	Leathery leaves, fragrant white flowers
<i>Calocedrus decurrens</i>	California incense cedar	70'	20'	H	Yes	2 Stars	Tree	Fragrant needles, lifted canopy when fully mature
<i>Pinus ponderosa</i>	Ponderosa pine	100'	30'	H	Yes	Not Rated	Tree	Needles, conical tree, appropriate for north side of a sound wall or noise barrier

*Crown Diameter: Space plants at crown diameter distance for a continuous barrier. For example, space California sagebrush every 3 feet.

ⓄPorosity: Thickness of Plant: High, Medium, Low.

◆Biogenic Volatile Organic Compounds. 1 to 3 star comparative rating scale; 1 is good, 2 is better, and 3 is best for air quality.

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Appendix D - Planting Guidelines and Resources

Sacramento Tree Foundation- How to plant trees and woody vegetation.

<http://www.sactree.com/plantvideo>

<http://www.sactree.com/pages/60>

California Center for Urban Horticulture- Information on planting, irrigation and comprehensive California based plant lists.

<http://ccuh.ucdavis.edu/Resources>

Water Use Classification of Landscape Species

<http://ucanr.edu/sites/WUCOLS/>

Calscape: Interactive Native Plant Database

<http://calscape.org/>

UC Davis Arboretum All-Stars

http://arboretum.ucdavis.edu/arboretum_all_stars.aspx

Appendix E - Sample Condition of Approval Language

Planning-

- A landscape plan shall include a vegetation barrier consistent with the Sacramento Metropolitan Air Quality Management District's *Landscaping Guidance for Improving Air Quality near Roadways*. The landscape plan shall include individual plant locations, species, approved alternate species for substitutions, plant material size and plant material source. Landscape plans shall be approved by _____ prior to site preparation and installation activities.

Installation-

- All vegetation shall be inspected prior to planting by a certified arborist or similarly qualified woody plant expert. Vegetation showing poor rooting structure, disease, insect infestation, low vigor or other indicators of poor quality shall not be planted. Pre-installation reports shall be submitted to _____ within 15 days of the inspection.
- Planting holes shall be dug a minimum of four times the size of the container to be planted and at least as deep as the container is tall.
- Root crowns shall be level with the surrounding soil or less than 2" above.
- All vegetation shall receive five gallons of water applied directly to the planting hole and root ball within 24 hours of planting. Rainfall of 2" or greater during this time will override the need for immediate post-planting supplemental irrigation.
- 6 inches of organic mulch shall be applied within a 4 foot radius of each plant. Mulch must not be in direct contact with plant stems and/or trunks.
- Nursery stakes shall be removed from all plant materials at time of planting. New staking will be installed only if indicated by conditions and/or plant materials.
- All vegetation shall be inspected post-planting by a certified arborist or similarly qualified woody plant expert and improperly planted or damaged plant materials will be corrected or replaced. Post-installation reports shall be submitted to _____ within 15 days of the inspection.

Maintenance-

- During the first dry season after planting, each plant shall receive a minimum of ten gallons of water each week applied in a single event to ensure deep saturation of soil in the rooting area.
- During the second dry season after planting, each plant shall receive a minimum of ten gallons of water twice a month applied in a single event to ensure deep saturation of soil in the rooting area.
- During the third dry season after planting, each plant shall receive a minimum of ten gallons of water once a month applied in a single event to ensure deep saturation of soil in the rooting area.

- Landscape shall be inspected by a certified arborist or similarly qualified woody plant establishment expert in March and September of each year. The following conditions and their recommended corrective actions shall be noted:
 - Damaged/diseased/dying/dead plants: Treat or replace.
 - Hazardous growth or damaged plants: Perform corrective pruning.
 - Irrigation system operability: Repair or replace.
 - Weedy or invasive undergrowth: Perform maintenance, which may include mowing, herbicide application, mulch application or groundcover planting and establishment.
 - Overall site condition including vandalism, refuse accumulation, improper site use (i.e. camping, dumping): Remediate and maintain to avoid inappropriate site conditions.

All landscape inspection reports including the above-suggested corrective actions shall be submitted to _____ within 30 days of the inspection.

- All plant support stakes shall be inspected annually and removed as soon as vegetation can support itself and is properly rooted.
- All pruning, cutting or limb removal from vegetation barrier plants shall be performed under direct supervision of a certified arborist or similarly qualified woody plant expert.

Funding and Reporting-

- For each vegetation roadside barrier project, a _____ (non-revocable funding mechanism) shall be established to provide perpetual funding for ongoing maintenance and monitoring.
- Copies of landscape plans, maintenance plans and all reporting shall be submitted to the _____ (City arborist, Department of Transportation, Planning Department, Community Development Department, etc.)

Appendix F - Additional References, Resources and Acknowledgments

Tong, Z.; Baldauf RW, Isakov V, Deshmukh P, Zhang KM. 2016. Roadside vegetation barrier designs to mitigate near- road air pollution impacts. Science of the Total Environment. Vol 541, pp. 920-927.

Shady Eighty Tree Guide. Sacramento Tree Foundation. <http://www.sactree.com/shady80>

Special thanks to the Sacramento Tree Foundation Technical Advisory Committee for recommending and reviewing the plant lists contained in this report.

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