Landscaping Guidance for Improving Air Quality Near Roadways

Plant Species and Best Practices for the Sacramento Region

V 2.1

February 2024

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Introduction

In 2016, the Environmental Protection Agency (EPA) published *Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality* (referred to hereafter as EPA Guidelines), which provides recommendations on using vegetation and sound walls or noise barriers to reduce air pollution exposure to people in homes, schools, and other buildings and uses alongside heavily-traveled roadways to reduce air pollution exposure. The Guidelines summarize modeling data, research findings and best practices in various design scenarios. The summary table is included in the Resource section of this document and the complete *Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality* can be found online at: https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=528612&Lab=NRMRL

In 2017, using the EPA's Guidelines, the Sac Metro Air District developed this Landscaping Guidance for Improving Air Quality near Roadways: Plant Species and Best Practices for the Sacramento Region. It provides recommendations appropriate to the Sacramento region, and is intended for use by land use planners, landscape architects, developers and other interested parties.

The Sac Metro Air District's Vegetation Guidance continues to:

Provide guidelines for evaluating a potential vegetation barrier sites alongside roadways.

- ✓ Offer recommendations appropriate to meet height, thickness and porosity goals.
- ✓ Evaluate vegetation characteristics through a recommended plant species list.
- ✓ Address best practices for designing and planting vegetation alongside roadways.
- ✓ Offer suggestions for effective long-term maintenance.
- ✓ Suggest sample condition of approval language.

Version 2.0 series includes the following major updates:

Emphasis that the selected species must be able to thrive in our projected climate future.

Practical information on choosing and caring for plants to reduce airborne allergens.

New for Version 2.1

Clarifying the tree and shrub tables for BVOC (Biogenic volatile organic compounds)

For questions, comments or suggestions on how to improve this document, please contact Sac Metro District Staff at projectreview@airquality.org.

Special thanks to the Sacramento Tree Foundation for assisting in the development of this document.

Climate Resiliency

Climate resiliency should be one of the foremost considerations when designing, planting, and maintaining a vegetation barrier to reduce air pollution exposure from heavily traveled roadways. A vegetation barrier that is resilient to climate change will be able to thrive and continue to benefit humans, especially the most highly affected populations, in the face of the effects of climate change.

Preventative planning will reduce vegetation barrier degradation and lower economic costs in future maintenance practices. Plan with future human generations in mind.

Proper maintenance to mitigate pest, disease, and fire risks is essential for the long-term viability of the vegetation barrier.

Temperatures in the Sacramento region are expected to be 10F higher by the end of the century, and Sierra snowpack may nearly disappear by 2100.

Source- UC Davis Science and Climate, California's Fourth Climate Change Assessment.

Key planning considerations and solutions include, but are not limited to:

- To improve adaptability to heat, fire and drought stress, *choose native species*.
- To increase resistance to pests and diseases, *plant at least 2 different species*.
- To avoid the unintended consequence of planting high-allergenic vegetation and thereby further burdening a community already particularly susceptible the negative effects of climate change, *select male-gendered plants*.
- To encourage enduring ecosystem services potential, such as carbon sequestration potential and other benefits that humans receive from healthy ecosystems and the natural environment, *choose long-lived species*.

Climate change resiliency must be one of the foremost considerations when designing, planting, and maintaining the vegetation barrier.

Site Evaluation

Available space can be a significant challenge when designing a vegetation barrier to reduce air pollution exposure near heavily traveled roadways. This is especially true in "retrofit" situations when roadway setbacks are inflexible. The EPA Guidelines recommend a thickness of at least 10 meters (32 feet, 9.7 inches) or more. However, the modeling referenced also suggests that any type of barrier (solid, vegetative or combination) will limit the distance and amount of air pollution travel from a roadway. Because our region has significant opportunities to retrofit existing roadsides, these guidelines will address designs options that meet EPA Guidelines as well as those that do not due to space availability less than the EPA recommended 10 meters.

Consideration of location feasibility is a 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.

Complete a full inventory of on-site utilities, existing site conditions, and space separation requirements. Identify any existing right of ways, utilities and easements to help inform vegetation species selection, spacing and placement thereof. 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.

If the vegetation barrier is desired within or adjacent to Caltrans property, contact the local Caltrans district office. See the Caltrans Requirements section of this document for more information.

Local Utilities and Fire Prevention Standards

Utilities and fire prevention standards may restrict the location and types of vegetation allowed near roadway areas. Evaluate potential conflicts with local fire safety codes as step two of your site evaluation process. In addition, defensible space allowances under Public Resources Code may preclude vegetation barrier installations in cases where buildings are nearby.

Always call 811 before you dig. Underground and overhead utilities have a variety of vegetation proximity limitations depending upon the type of utility and its operator.

Caltrans Requirements

Many roadways that are prime locations for roadside vegetation barriers to improve near-road air quality will be under Caltrans jurisdiction. Always coordinate with Caltrans if your project could be within or adjacent to Caltrans property. For vegetation within the roadway right of way, general Caltrans tree and vegetation requirements and guidelines are:

- Vegetation must be planted at least 30 feet from the edge of the traveled way.
- Overhanging foliage must be 15 feet from the pavement to the overhanging branches.
- Vegetation must be at least 20 feet from manholes.
- Plant setback distance is determined by the height and width of the specific species to be planted.

- All plants should be planted at least 10 feet from fences, walls, ditches or drainage features. In some circumstances, vegetation can be placed closer to fencing with an approved encroachment permit.
- Plants must not interfere with the function of safety features such as shoulders, barriers, guardrails or signs and must not interfere with a driver's ability to see a continuous length of highway.
- Plants cannot add a maintenance burden to Caltrans, and thus must be managed in perpetuity by the entity responsible for the vegetation barrier.

Additional Considerations

Proximity to sensitive populations (human populations such as educational facilities or endangered plant populations) may indicate special consideration during plant selection. For example, avoid poisonous plants in areas where children may encounter them, and avoiding planting native plants near similar unique or endangered native populations (i.e. *Fremontedendron californica* near *Fremontedendron decumbens*, an endangered plant found in El Dorado County).

Consideration of micro-site characteristics such as localized wind flow patterns, unique or challenging soil types, history of landscape use by transients, and wildlife attractiveness may inform plant selection and maintenance activities to ensure climate resiliency of the site.

Key Summary Points: Site Evaluation

- ✓ Identify potential utility conflicts and adjust plant selection accordingly
- ✓ Review local Fire Safety Codes
- ✓ Review and comply with Caltrans vegetation requirements for plant placement and selection for roadside safety
- ✓ Identify and understand nearby sensitive populations (human and wildlife) to allergens and other impacts

Barrier Design

Dimensions

Vegetation should be from medium thick to very thick, but not so thick that the vegetation acts like a solid barrier with air flowing around the vegetation instead of through it.

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.1 See below for a discussion of porosity.

Adequate access space must be preserved to allow for implementation and long-term maintenance.

Use at least two types of vegetation (i.e. one tree and one shrub) to ensure foliage from ground level to top of canopy.

Stagger spacing and plant low vegetation in between plants to maximize growth space and ensure uniform coverage.

Fill the available space, both horizontally and vertically, with vegetation.

Foliage should be a minimum of 10 meters thick (32 feet 9.7 inches), 5 meters high (16 feet 5 inches) and one meter (3 feet 3.37 inches) higher than associated sound wall or noise barrier.

Barriers should extend 50 meters (164 feet) or more past the area to be protected or can wrap around and extend perpendicular away from the roadway.

Expect tighter plant spacing than landscape designs for aesthetic uses.

See the Resources section for a visual representation of four hypothetical scenarios.

Vegetation Characteristics

The Tree and Shrub Information Tables in the Resources section of this document are appropriate for use in the greater Sacramento Region. Each plant meets the EPA Guidelines recommendation for minimal seasonal and climatic variability. Plant species included are either native or projected to be climate resilient with limited specialized care beyond the three to five-year establishment period. Plants that show invasive tendencies, have a high susceptibility to pests and diseases, or pose high allergen risks have not been included. Species on this list are generally available within the local nursery trade or can be easily acquired through the horticultural industry. This list is not comprehensive and other species may meet the criteria outlined in the EPA Guidelines and may be appropriate for use.

Project priorities and scope should be used as the guiding factors in species selection for the optimal climate resiliency.

All species have varying levels of benefits and trade-offs.

[1] This is a significant area for further research and on the ground testing.

In order to ensure a barrier is as solid as possible and does not contain gaps, crown width estimates have been carefully considered to ensure space coverage over the first 7-10 years. Long term maintenance of vegetated barriers will need to occur in order to manage natural processes and replace failed or damaged plant materials.

Porosity

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. Planting lower porosity plants closer to the roadway and higher density plants at the furthest edge of the planting should have the most health benefit.[2]

The EPA Guidelines recommend that vegetation should be from medium thick to very thick, but not so thick that the vegetation acts like a solid barrier with air flowing around the vegetation instead of through it.

The recommended plant species listed in this report have been evaluated by local professionals and rated Low, Medium or High porosity.

[2] This is a significant area for further research and on the ground testing.

Allergen Hazard Reduction

The social impact to sensitive communities to hazardous allergens must be identified and planned for appropriately when creating roadside vegetation barriers. In location and site selection, identify priorities and sensitivities to nearby populations. For example, vegetation barriers without sidewalks might have a lower sensitivity to allergens than sites adjacent to schools or hospitals.

Diversity

Plan for a diverse vegetation selection when sensitive populations are present. Over exposure to a large population of one species can increase a person's sensitivity to that species. Although a species might have a low allergy rating, if planted as a monoculture, it has the potential to pose a health hazard over time. Typically, species related within a plant family, i.e. oak family, will have similar allergen potentials and should be considered in the species selection process.

Cultivars, Varieties, and Pollination

Understand variations within species as some may have higher allergen ratings than other related varieties.

A cultivar is a cultivated variety of a specie (produced by cloning or careful crossing with specific parent plants) that makes a consistent mature plant. A plant that is often naturally occurring with only somewhat consistent mature plants but with a unique attribute to other members in its species, such as different flower color.

Nursery tags will note the variety or cultivar, but will not identify the sex of the cultivar, so understanding the differences within cultivars and varieties is essential. Dioecious species have separate male and female plants, where the females do not produce the pollen associated with allergies. Plants that are dioecious females should be prioritized, as they will pose a minimal to no allergen risk.

Dioecious:

Having the male and female organs in separate and distinct individuals; having separate sexes.

Source: Dictionary.com

Other characteristics to consider when minimizing allergens include plants pollinated by insects versus wind-blown and pollination length of time.

When planning to reduce allergens it should be noted that all plants pose some sort of allergy risk and trade-off. Identifying project priorities and levels of sensitivity in nearby populations will help inform decisions to minimize exposure and impact.

The Tree and Shrub Information Tables in the Resources section of this document include allergy hazard information, where available.

A Note from the Sacramento Tree Foundation

When it comes to olive trees (*Olea europaea)*, the Sacramento Tree Foundation recommends the cultivar Swan Hill (*Olea europaea* 'Swan Hill'). A cultivar is a "cultivated variety", produced by cloning or careful crossing with specific parent plants, to make a consistent mature plant.

Many cultivars are commonly planted in urban areas, and they are specifically chosen to be low-fruit and thus low mess. Sometimes a cultivar will be a male clone, that produces no fruit, but that does produce substantial amounts of pollen.

Olea europaea 'Swan Hill' is a great choice because it is both low mess and low pollen. However, some people might initially avoid a cultivar like Swan Hill, assuming it has a high allergy rating given the low fruit, and select a variety like *Olea europaea* var. *sylvestris*, which wouldn't be an allergy improvement. That's why we suggest being familiar with cultivars if you're making substitutions.

Key Summary Points: Allergens

- ✓ Prioritize dioecious females
- ✓ Choose a diverse plant population
- ✓ Understand the difference between varieties and cultivars

Planting, Establishment and Maintenance

Create a list of substitution species in case there is limited nursery availability. Landscaping plans should specify additional species if the desired plants are not available.

When ordering, give nurseries or contract growers as much lead time as possible to ensure that they will have the items in stock.

Inspect plant materials before planting for damage and pests and after they are in the ground.

The Importance of Pot Size

Planting smaller sized planting materials (#5 pots or smaller) will assist with healthy root establishment, help ensure future drought tolerance, and cost less at the outset and during the long-term than larger sized planting materials. Within two to four years, they are comparable in size to larger plant materials, and typically exceed them within five years.

Establishment Period

Proper establishment of vegetation will increase the barrier's ability to survive excessive heat, drought conditions, and pest and disease susceptibility. Planting should occur in fall or winter, and the establishment period covers the first three to five seasons after planting.

Irrigation

Pre-irrigate individual planting sites if rainfall has not yet occurred for the season.

Native and drought tolerant plants will require supplemental irrigation during the dry season (May-November) for the first three dry seasons after planting. Supplemental irrigation rates are dependent on a variety of factors including amount of rainfall in current and recent seasons, soil type, and ground slope characteristics.

Deep, infrequent watering will result in a healthier establishment of native and drought tolerant vegetation.

Temporary irrigation systems or other methods may be appropriate. Irrigation must be applied in accordance to individual plant species needs and in response to soil and climatic conditions, which will vary due to planting location.

Staking and Pruning

When newly planted, stakes, planting tubes or other protective materials may be used to avoid damage from weather, animals and weed abatement activities. Remove tree stakes by the third year of establishment.

Pruning, except for targeted structural pruning of trees to encourage development of a strong trunk, is not recommended during the establishment phase.

Key Summary Points: Planting and Establishment

- ✓ Create a list of substitution species in case there is limited nursery availability.
- ✓ Irrigate for the first 3 dry-seasons (May-Nov) is needed to establish drought tolerance for all plants
- ✓ Remove nursery stakes at planting.
- ✓ Support stakes must be removed by year 3.
- ✓ Use mulch, planting tubes, mowing, and approved herbicides as needed for weed management.
- ✓ Replace plants as needed to ensure full vegetation barrier
- ✓ Avoid pruning to encourage thickness of vegetation barrier

Maintenance

Adaptive Plans

Develop an adaptive maintenance plan before problems arise. This sort of adaptive management plan should spell out specific condition ratings and triggered actions. A plan will increase chances of plant survival and resilience to global climate change.

An adaptive management plan will support the vegetation barrier's integrity and lower maintenance costs over the long term. For example, the plan could stipulate that plants that are in poor health will be slated for replacement the following fall.

An effective adaptive management plan will include a minimum of two inspections per year to determine health of the vegetation barrier and correct any deficiencies.

Irrigation

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.

Fire Risk Reduction

Remove invasive weeds, leaf litter, and dead plants or branches immediately to support a healthy vegetation barrier and reduce fire hazards. Mulching, mowing and herbicide application are all methods that may be appropriate for weed management. Replace dead plants as soon as is appropriate.

Pruning

As with the establishment phase, regular and significant vegetation pruning should not only be unnecessary but avoided as a thick, solid barrier of vegetation is desired. This sort of plant culture is not common within the landscaping industry and landscape management contractors will need to be trained and closely overseen to ensure proper care is given to ensure vegetation barrier integrity.

Key Summary Point: Planting, Establishment and Maintenance

- ✓ Deep, infrequent watering will result in a healthy vegetation barrier establishment.
- ✓ An effective adaptive management plan will support the vegetation barrier's ability to adapt to extreme climactic variations brought on by global climate change.

Resources

Shrub and Tree Information Tables

The Shrub and Tree Information Tables include shrubs and trees that meet the EPA Guidelines for minimal seasonal and climatic variability (do not shed their leaves) and are appropriate for locations in the greater Sacramento region. These plant species have been evaluated by local professionals.

The plant species are evergreen and either native or projected to be climate resilient with limited specialized care beyond the three to five-year establishment period. They are generally available within the local nursery trade or can be easily acquired through the horticultural industry.

The tables include the following information for each plant:

- Common name
- Scientific name
- Height
- Crown diameter
- Porosity (if available)
- Whether it is a native to California. California natives are ideal.
- Allergy potential (if available). We recommend choosing plants that have lower allergen potentials.
- A BVOC rating (Biogenic Volatile Organic Compounds) (if available). We recommend choosing plants with lower BVOC ratings.
- A special note about each plant (for example, the color of foliage, soil requirements, etc.)

Keep in mind that all species have varying levels of benefits and trade-offs.

Invasive plants, and those that are particularly susceptible to pests and diseases, or those with unacceptably high allergen risks have not been included.

The tables are not comprehensive and other species may meet the criteria outlined in the EPA Guidelines.

Shrubs

Scientific Name	Common Name/Species	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Abutilon palmeri	Palmer's Indian Mallow	4'	4'	Medium	No	Low	---	Apricot-colored flowers and fuzzy leaves.
Acacia boormanii	Snowy River Wattle	15'	10'	Medium	No	High	---	Golden ball-shaped flowers. Frost tolerant.
Acacia vestita	Hairy Wattle	8'	6'	Medium	No	High	---	Hairy foliage and yellow flowers.
Adenostoma fasciculatum	Chamise	10'	6'	Medium	Yes	---	---	White flowers. May note be fire-resistant.
Arctostaphylos manzanita	Manzanita	15'	10'	High	Yes	Low	---	Bright shiny leaves and smooth red bark.
Artemisia californica	California Sagebrush	3'	3'	Low	Yes	High	---	Green-gray foliage. Appropriate for north side of sound wall or barrier. Limit summer irrigation.
Artemisia tridentata	Big Sagebrush	5'	5'	Low	Yes	High	---	Yellow-green flowers and twisted trunk.
Atriplex lentiformis	Big Saltbush	6'	6'	Low	Yes	High	---	Silver-gray foliage. Tolerates alkaline soil and clay.
Baccharis pilularis	Coyote Brush	5'	5'	Low	Yes	High	---	Many white/yellow flowers along stems.
Baccharis salicifolia	Mule Fat	10'	5'	High	Yes	High	---	White fuzzy pink flowers and long pointed leaves.
Berberis aquifolium	Oregon Grape	5'	5'	Medium	Yes	Low	---	Dark-green leaves and fragrant yellow flowers.

*****Porosity: Low porosity plants exhibit very dense foliage and do not allow significant air flow through the interior of the plant canopy. High porosity plants have a less dense canopy and allow significantly more air flow through.
****** Allergy Rating is based on an overall potential to produce allergen health risks and can be highly dependent on plant species, variety, and/or the selection of female sexed plants.
***Biogenic Volatile Organic Compounds (BVOCs): A type of organic compound emitted by plants, through their normal processes, that become precursors to ground level ozone in the atmosphere.
--- Insufficient data to form a rating

Shrubs

Scientific Name	Common Name/Species	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Callistemon citrinus	Crimson Bottlebrush	10'	6'	Medium	No	High	---	Red bottle-shaped flowers and a citrus smell. Attracts hummingbirds .
Carpenteria californica	California Bush Anemone	6'	3'	Low	Yes	Low	---	Shiny foliage and white flowers. Native to Fresno County.
Ceanothus 'Blue Jeans'	'Blue Jeans' Mountain Lilac	5'	5'	Low	Yes	---	---	No shade or summer water after establishment. Lavender flowers.
Ceanothus cuneatus	Buck Brush	5'	5'	Low	Yes	---	---	Tough fleshy leaves and white flowers. Very tough and extremely drought tolerant.
Cercocarpus betuloides	Mountain Mahogany	5'	5'	Medium	Yes	---	---	Birch-like leaves and tail-shaped fruit. Small clustered white flowers. Tolerates clay and sand.
Eriodictyon californicum	Yerba Santa	5'	5'	Medium	Yes	---	---	Long narrow leaves and bluish bell-shaped flowers.
Eriogonum giganteum	Saint Catherine's Lace	5'	5'	Low	Yes	---	---	Leathery woolly oval leaves and tiny pinkish-white flower.
Frangula californica syn. Rhamnus californica	Coffeeberry	10'	10'	Low	Yes	High	---	Dark red branches and coffee-like berries.
Fremontodendron californicum	California Flannel Bush	15'	15'	Low	Yes	---	---	Fuzzy leaves and large yellow blossoms.

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Shrubs

Scientific Name	Common Name/Species	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Garrya fremontii	Bearbrush	10'	10'	Low	Yes	High	---	Smooth green oval-shaped leaves, edible purple berries.
Heteromeles arbutifolia	Toyon	10'	10'	Low	Yes	Low	---	Dense small white flowers, with sharply toothed leaves.
Isomeris arborea	Bladderpod	5'	5'	Low	Yes	---	---	Long pointed oval-shaped leaves and abundant yellow flower clusters.
Juniperus californica	California Juniper	10'	10'	Low	Yes	Low	---	Alkali-tolerant with edible berries and very dense foliage.
Lavandula x gin ginsii 'Goodwin Creek Grey'	'Goodwin Creek' Lavender	5'	5'	Low	No	---	---	Silvery leaves. Scented, purple flowers.
Leucophyllum frutescens	Cenizo	5'	5'	Low	No	Low	---	Purple flowers, silvery leaves.
Leucophyllum langmaniae 'Lynn's Legacy'	'Lynn's Legacy' Leucophyllum	5'	5'	Low	No	Low	---	Fragrant purple bell-shaped flowers.
Malacothamnus fasciculatus	Bush mallow	4'	4'	Medium	Yes	---	---	Tolerates sand. Pink 1" flowers, hairy stems and leaves.
Myrsine africana	African Boxwood	5'	5'	Low	No	---	---	Very dense foliage, appropriate for a hedge. May be poisonous. Occasional irrigation after establishment.
Myrtus communis	True Myrtle	10'	5'	Low	No	Low	---	Glossy green leaves and white fragrant flowers.

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Shrubs

Scientific Name	Common Name/Species	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Osmanthus x for tunei	Hybrid Tea Olive	15'	15'	Low	No	---	---	Small white flowers. Dark green dense leaves and gray bark.
Peritoma arborea syn. Cleome arborea	Bladderpod	5'	5'	Medium	Yes	---	---	Lacy gray-green leaves and yellow flowers year-round. Tolerates alkalinity.
Phlomis purpurea	Purple Phlomis	5'	5'	Medium	No	Low	---	Colorful flowers, fuzzy leaves, and a pleasant aroma. Poisonous if ingested.
Pittosporum tobira	Japanese Pittosporum	15'	15'	Low	No	---	---	Fragrant white flower clusters and leathery green leaves.
Quercus berberidifolia	California Scrub Oak	10'	10'	Medium	Yes	High	---	Dull-green oval or toothed leaves, rounded acorns.
Rhaphiolepis indica	Indian Hawthorne	5'	5'	Low	No	---	---	Thick leathery leaves, white star-shaped flowers and blue-black fruits.
Rhus integrifolia	Lemonade Sumac	5'	8'	Low	Yes	High	---	Leathery, dark green leaves and small pink flowers. Grows shorter on slopes.
Rosa californica	California Wildrose	5'	8'	Low	Yes	---	---	Prickly stems, 5-petaled and colored leaves. Scented.
Rosmarinus officinalis	Rosemary	5'	5'	Low	No	---	---	Pleasant scent with long-stemmed shoots. Edible with white, purple or blue flowers.
Salvia clevelandii	Cleveland Sage	5'	5'	Low	Yes	Low	---	Wrinkled leathery leaves and rounded purple flower clusters.

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Shrubs

Scientific Name	Common Name/Species	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Senna nemophila	Desert Cassia	4'	4'	High	No	---	---	Needlelike structure with an airy habit and bright yellow flowers.
Teucrium fruticans	Bush Germander	5'	5'	Low	No	Low	---	Slivery blue leaves and lavender flowers.
Trichostema lanatum	Wooly Blue Curls	3'	3'	Low	Yes	Low	---	Fuzzy spikes of violet flowers. Needs no water after establishment.
Xylosma congestum	Shiny Xylosma	6'	6'	Low	No	Low	---	Shiny light green leave. Needs occasional irrigation after establishment.

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***Biogenic Volatile Organic Compounds (BVOCs): A type of organic compound emitted by plants, through their normal processes, that become precursors to ground level ozone in the atmosphere.
--- Insufficient data to form a rating

Trees

Scientific Name	Common Name	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Abies pinsapo	Spanish Fir	60'	20'	Low	No	Low	---	Needles. Conical form.
Acacia aneura	Mulga	15'	15'	High	No	High	---	Needle-like silver foliage and yellow blossoms in spring and fall.
Allocasuarina verticillata	Drooping She-Oak	20'	15'	High	No	High	---	Needles. Can have sparse foliage.
Arbutus unedo	Strawberry Tree	25'	20'	Medium	No	---	Good	Flowers and fruit. Red bark.
Brachychiton populneus	Bottle Tree	40'	30'	Medium	No	---	Best	Unusually wide trunk.
Calocedrus decurrens	California Incense Cedar	70'	20'	High	Yes	High	Better	Fragrant needles, lower branches absent when mature.
Cedrus deodara	Deodar Cedar	65'	45'	High	No	High	Best	Silver-gray needles, airy canopy when fully mature.
Ceratonia siliqua	Carob Tree	35'	30'	Medium	No	---	Good	Large, seeded pods and dark green leathery leaves. Deep, infrequent irrigation required. Male flowers may give distasteful odor.
Cinnamomum camphora	Camphor	50'	65'	Medium	No	---	Best	Fragrant leaves and dark berries.
Crinodendron patagua	Lilly of the Valley	15'	10'	Medium	No	---	---	Glossy, dark green leaves and fragrant white bell-shaped flowers.
Cupressus arizonica	Arizona Cypress	20’	15’	Low	No	Low	---	Gray-green, conical, dense foliage. Needs well-drained soil. Tolerates alkaline soils.

*****Porosity: Low porosity plants exhibit very dense foliage and do not allow significant air flow through the interior of the plant canopy. High porosity plants have a less dense canopy and allow significantly more air flow through.
****** Allergy Rating is based on an overall potential to produce allergen health risks and can be highly dependent on plant species, variety, and/or the selection of female sexed plants.
***Biogenic Volatile Organic Compounds (BVOCs): A type of organic compound emitted by plants, through their normal processes, that become precursors to ground level ozone in the atmosphere. Better and Best ratings are preferred.
--- Insufficient data to form a rating

Trees

Scientific Name	Common Name	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Eriobotrya deflexa	Bronze Loquat	15'	15'	Low	No	Low	Best	Fragrant white flowers. Sensitive to frost.
Eriobotrya japonica	Loquat	20'	20'	Medium	No	---	Best	White flowers and edible fruit.
Feijoa sellowiana	Pineapple Guava	10'	10'	Low	No	Low	---	Pink flowers and egg-shaped edible fruit.
Geijera parviflora	Australian Willow	20'	15'	Low	No	Low	Better	White flowers. Older trees take on weeping form.
Juniperus chinensis ‘Spartan’	‘Spartan’ Chinese Juniper	15’	3’	Low	No	Low	---	Thick, compact columnar juniper. Needs well drained soil. Tolerates alkaline soils.
Juniperus scopulorum 'Skyrocket'	‘Skyrocket’ Juniper	15'	2'	Low	No	Low	---	Columnar juniper with blue-green foliage. Needs occasional water when established.
Laurus nobilis	Sweet Bay	30'	30'	Low	No	Low	Best	Yellow flowers and berries.
Magnolia grandiflora	Southern Magnolia	65'	45'	High	No	High	Better	Leathery leaves and fragrant white flowers.
Olea europaea 'Swan Hill'	‘Swan Hill’ Olive	35'	30'	Medium	No	Low	Best	Fruitless and low pollen.
Pinus canariensis	Canary Island Pine	65'	30'	High	No	High	Better	Dark reddish bark and needles.

*****Porosity: Low porosity plants exhibit very dense foliage and do not allow significant air flow through the interior of the plant canopy. High porosity plants have a less dense canopy and allow significantly more air flow through.
****** Allergy Rating is based on an overall potential to produce allergen health risks and can be highly dependent on plant species, variety, and/or the selection of female sexed plants.
***Biogenic Volatile Organic Compounds (BVOCs): A type of organic compound emitted by plants, through their normal processes, that become precursors to ground level ozone in the atmosphere. Better or Best ratings are preferred.
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Trees

Scientific Name	Common Name	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Pinus eldarica	Afghan Pine	45'	25'	Medium	No	---	Good	Needles, dense canopy, and tall form. Tolerates poor soils.
Pinus halepensis	Allepo Pine	45'	40'	Medium	No	---	Best	Needles. Cones remain on tree for many years.
Pinus jeffreyi	Jeffrey Pine	10'	20'	High	Yes	High	Good	Needles and cones. Bark smells like vanilla or butterscotch.
Pinus nigra	Austrian Black Pine	45'	25'	Medium	No	---	Better	Dense canopy with dark-green needles.
Pinus ponderosa	Ponderosa Pine	100’	30’	High	Yes	High	---	Needles, conical tree, appropriate for North side of a sound wall or barrier.
Podocarpus gracilior	Fern Pine	60'	30'	Low	No	Low	Best	Can be frost-sensitive.
Prunus ilicifolia ssp. lyonii	Catalina Cherry	20’	15’	Medium	Yes	---	---	Upright form and white flowers. Edible, large seeded fruit.
Quercus ilex	Holly Oak	60'	55'	Low	No	Low	Good	Dark-green leaves, acorns, and a dense canopy.
Quercus suber	Cork Oak	60'	60'	Medium	No	Low	Best	Cork-like bark. Acorns.
Quercus wislizeni	Interior Live Oak	55'	55'	Medium	Yes	---	Good	Dark-green glossy leaves and distinct form. More appropriate for the Sacramento region than similar Coast Live Oak.

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****** Allergy Rating is based on an overall potential to produce allergen health risks and can be highly dependent on plant species, variety, and/or the selection of female sexed plants.
***Biogenic Volatile Organic Compounds (BVOCs): A type of organic compound emitted by plants, through their normal processes, that become precursors to ground level ozone in the atmosphere. Better or Best ratings are preferred.
--- Insufficient data to form a rating

Trees

Scientific Name	Common Name	Height	Crown Diameter	Porosity* (Low, Medium, High)	CA Native	Allergy Rating** (Low or High)	BVOC*** (Good, Better, Best)	Notes
Umbellularia californica	California Bay Laurel	45'	30'	Medium	Yes	---	Better	Fragrant leaves, small flowers, and fruit.

*****Porosity: Low porosity plants exhibit very dense foliage and do not allow significant air flow through the interior of the plant canopy. High porosity plants have a less dense canopy and allow significantly more air flow through.
****** Allergy Rating is based on an overall potential to produce allergen health risks and can be highly dependent on plant species, variety, and/or the selection of female sexed plants.
***Biogenic Volatile Organic Compounds (BVOCs): A type of organic compound emitted by plants, through their normal processes, that become precursors to ground level ozone in the atmosphere. Better or Best ratings are preferred.
--- Insufficient data to form a rating

Hypothetical Scenario Illustrations

The Scenario Illustrations are four drawings showing hypothetical design scenarios.

Scenario 1 - Vegetation Barrier Without Noise Barrier/Sound Wall

Scenario 2 - Vegetation Barrier on One Side of a Noise Barrier/Sound Wall

Scenario 3 – Vegetation Barrier on Both Sides of a Noise Barrier/Sound Wall

Scenario 4 - Limited Space Scenario: Narrow Vegetation Barrier on One Side of a Noise Barrier/Sound Wall

Scenarios 1 through 3 adhere to the EPA Guideline's vegetation thickness recommendation of at least 10 meters (32 feet, 9.7 inches).

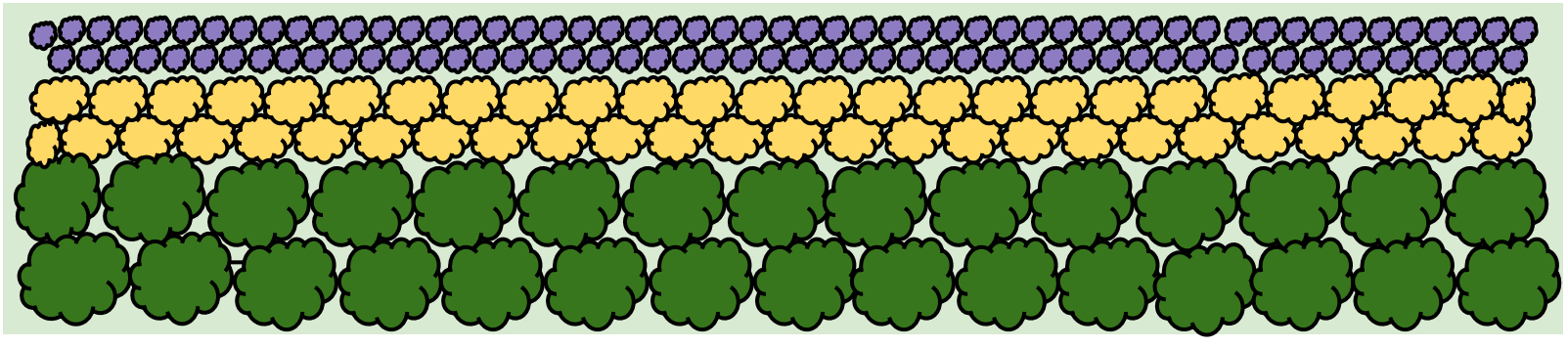
Scenario 4 recognizes that many roadside situations will not have enough space to meet the EPA Guideline's thickness recommendation. We developed this scenario because modeling suggests that any type of barrier (solid, vegetative or combination) will limit the distance and amount of air pollution travel from a roadway.

Scenario 1 - Vegetation Barrier Without a Noise Barrier/Soundwall

Aerial View, Not to Scale

Roadway

Allow space for overhead and underground utilities



Vegetation barrier should be at least 33 feet wide

Extend vegetation and sound wall/noise barrier at least 165 feet beyond the site on both sides, or wrap around site

Location of sensitive human population

Legend

- Small shrub: foliage fills vertical space from ground level to 10 feet tall
- Larger shrub: foliage fills the vertical space from 3 feet off the ground to 17 feet tall
- Trees: foliage fills the vertical space from 10 feet off the ground to 82 feet tall
- Potential overhead and underground utilities area
- Heavily-traveled roadway
- Noise Barrier/Soundwall

Always check jurisdiction requirements- including utility providers- before drawing up the landscaping plan

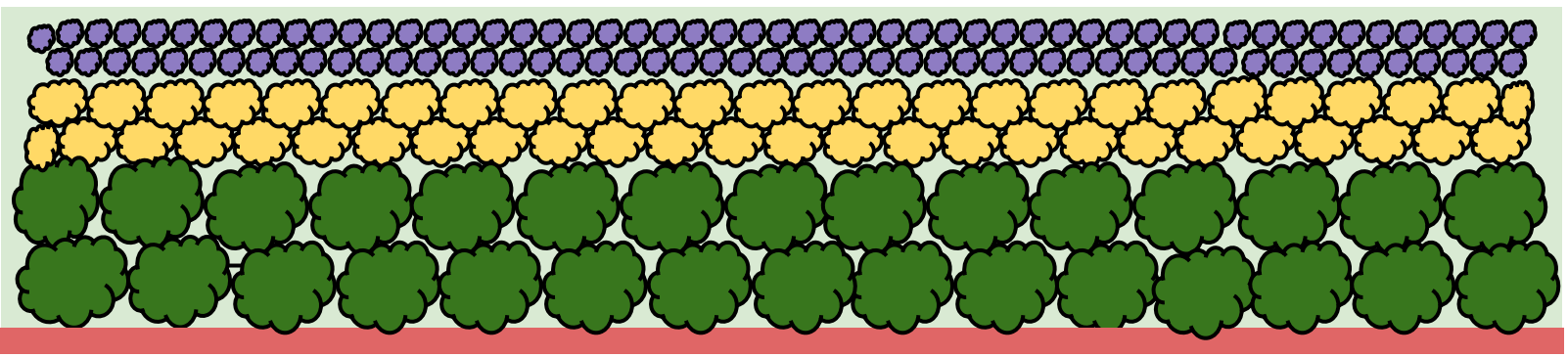
image best viewed in color

Scenario 2 - Vegetation Barrier on One Side of a Noise Barrier/Soundwall

Aerial View, Not to Scale

Roadway

Allow space for overhead and underground utilities



Vegetation barrier should be at least 33 feet wide

Extend vegetation and sound wall/noise barrier at least 164 feet beyond the site on both sides, or wrap around site

Location of sensitive human population

Legend

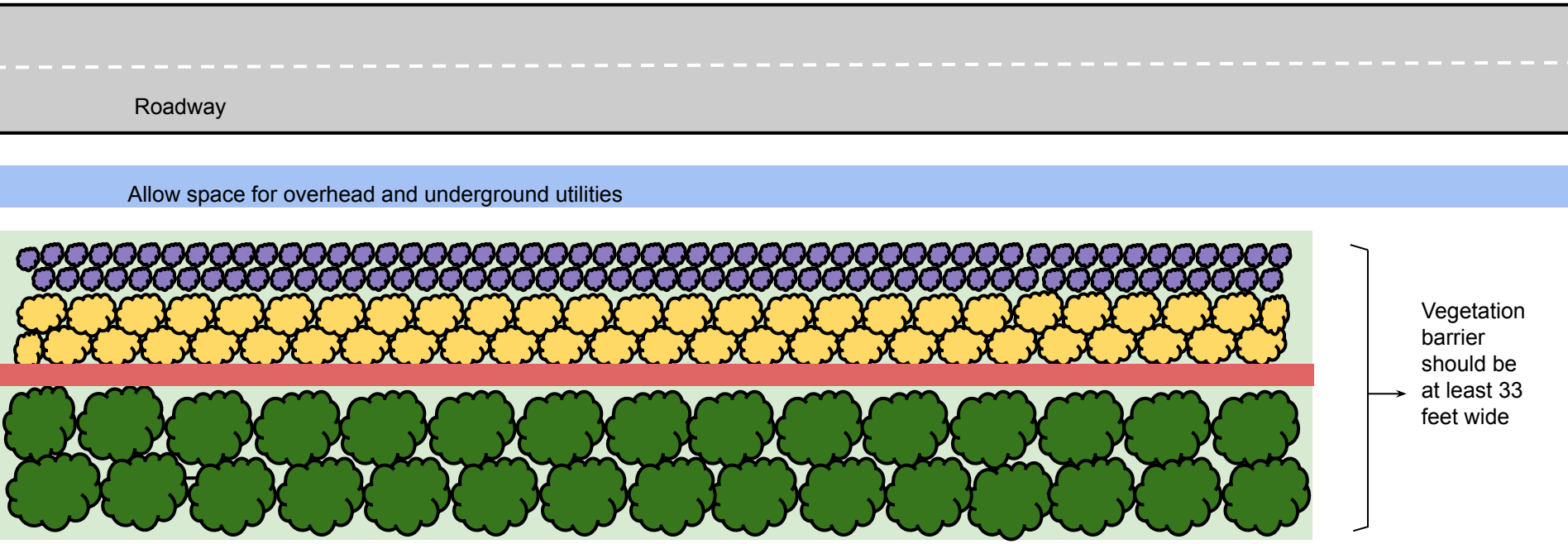
- Small shrub: foliage fills vertical space from ground level to 10 feet tall
- Larger shrub: foliage fills the vertical space from 3 feet off the ground to 17 feet tall
- Trees: foliage fills the vertical space from 10 feet off the ground to 82 feet tall
- Potential overhead and underground utilities area
- Heavily-traveled roadway
- Noise Barrier/Soundwall

Always check jurisdiction requirements- including utility providers- before drawing up the landscaping plan

image best viewed in color

Scenario 3 - Vegetation Barrier on Both Sides of a Noise Barrier/Soundwall

Aerial View, Not to Scale



Legend

- Small shrub: foliage fills vertical space from ground level to 10 feet tall
- Larger shrub: foliage fills the vertical space from 3 feet off the ground to 17 feet tall
- Trees: foliage fills the vertical space from 10 feet off the ground to 82 feet tall
- Potential overhead and underground utilities area
- Heavily-traveled roadway
- Noise Barrier/Soundwall

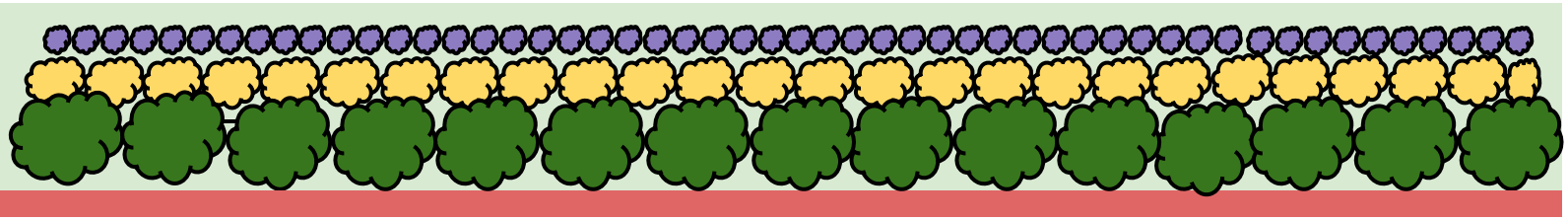
Always check jurisdiction requirements- including utility providers- before drawing up the landscaping plan

image best viewed in color

Scenario 4 - Limited Space Scenario: Narrow Vegetation Barrier on One Side of a Noise Barrier/Soundwall
Aerial View, Not to Scale

Roadway

Allow space for overhead and underground utilities



Vegetation barrier is less than 33 feet due to space limitations

Location of sensitive human population

Extend vegetation and sound wall/noise barrier as far as possible beyond the site on both sides, or wrap around site

Note: While this scenario does not meet the EPA's minimum recommendations, modeling data suggests that any type of barrier (solid, vegetative or combination) will limit the distance and amount of air pollution travel from a roadway.

image best viewed in color

Legend

- Small shrub: foliage fills vertical space from ground level to 10 feet tall
- Larger shrub: foliage fills the vertical space from 3 feet off the ground to 17 feet tall
- Trees: foliage fills the vertical space from 10 feet off the ground to 82 feet tall
- Potential overhead and underground utilities area
- Heavily-traveled roadway
- Noise Barrier/Soundwall

Always check jurisdiction requirements- including utility providers- before drawing up the landscaping plan

EPA Summary Table

Barrier Characteristic	Recommendation	Description
Physical Characteristics		
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.
Vegetation Characteristics		
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
Other Considerations		
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.

Sample Condition of Approval Language

Start with this document in order to ensure a quality roadside vegetation barrier that improves air quality. Modify as necessary to meet the particulars of your project and/or agency.

Planning Phase

Identify project priorities and limitations in line with near roadway pollution reduction and climate resiliency potential. Site location and nearby communities will be determining factors for design and vegetation selection.

A landscape plan shall be prepared including 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.

Funding and Reporting

At the time of xxx

For each vegetated 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.)

Installation

At the time of XXXX

All trees and vegetation shall be inspected prior to planting by a certified arborist or similarly qualified woody plant expert. Plants 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.

Plant 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.

Six inches of organic mulch shall be applied within a four 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.

Landscape Establishment Period

All plant support stakes shall be inspected annually and removed as soon as vegetation can support itself and is properly rooted.

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.

Ongoing Landscape Inspection and Remediation

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 recommended corrective actions shall be noted:

Treat or replace damaged/diseased/dying/dead plants.

Correctively prune hazardous growth or damaged plants.

Repair damaged irrigation systems.

Manage weedy or invasive undergrowth through mowing, herbicide application, mulch application or groundcover planting and establishment, or other actions as warranted.

Remediate and correct for inappropriate site conditions such as vandalism, refuse accumulation, improper site use (i.e. camping, dumping).

All pruning, cutting or limb removal from vegetation barrier plants shall be implemented under direct supervision of a certified arborist or similarly qualified woody plant expert.

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

Useful Links

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.