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Preparing for the Storm
Sycamore Alluvial Woodland Pilot Study
Implementation Guidelines

Project #4142-01

Prepared for:

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February 13, 2023

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Section 1.0 Introduction

1.1 Purpose of these Guidelines

This document presents guidelines for implementing, maintaining, and monitoring a study to restore sycamore alluvial woodland (SAW) at two locations in Livermore, California. The study is part of the San Francisco Bay Water Quality Improvement Fund project called *Preparing for the Storm: Riparian Restoration, Sediment Reuse, and Urban Greening to Enhance Stream and Watershed Resilience* (Grant Number W9-99T69401-0) (project), funded by the U.S. Environmental Protection Agency. This study is part of a grant project of the EPA Water Quality Improvement Fund (Grant Number W9-99T69401-0) awarded to Alameda County Flood Control and Water Conservation District (also known as "Zone 7 Water Agency") with support from San Francisco Estuary Institute (SFEI), San Francisco Bay Joint Venture, H. T. Harvey & Associates (H. T. Harvey), Livermore Area Recreation & Park District, Concannon Vineyard, Castlewood Country Club, City of Livermore, City of Dublin, and the City of San Ramon. The purpose of the project is to improve San Francisco Bay water quality and the health and resilience of Alameda Creek watershed by enhancing aquatic and riparian habitat, advancing stormwater planning, and supporting coarse sediment reuse. SAW is a rare open woodland plant community and habitat type that occurs and is particularly adapted to California intermittent rivers and streams, and Mediterranean-climate. SAW is dominated by California sycamore (*Platanus racemosa*), a species of plane tree that is native to California and Baja California. Historically, SAW occurred along intermittent streams and their floodplains; however, changes to natural hydrologic, geomorphic, and ecological processes have reduced SAW's extent and capacity to regenerate throughout its range and made it difficult to restore.

The purpose of these guidelines and pilot implementation project are to help improve the success of SAW restoration projects throughout the Alameda Creek watershed and other watersheds in California where SAW historically occurred. This document builds off SFEI's *Sycamore Alluvial Woodland Enhancement and Restoration Suitability* report (SFEI et al. in prep.), which describes the distribution and health of California sycamores along two streams in the Livermore-Amador Valley (Arroyo Mocho and Arroyo del Valle) within the Alameda Creek watershed, the hydrologic and geomorphic processes that support SAW, and strategies to restore SAW. This document provides sufficient information for a non-profit group to install, maintain, and monitor California sycamore plantings; it is not intended to serve as a biddable document for a landscape contractor.

1.2 Responsible Parties

Zone 7 Water Agency (Zone 7) is the project proponent, grant holder, implementing agency, landowner, and lead coordinator between other land-owning entities, expert scientists, regulators, and community groups for the project. Elke Rank is its representative. Zone 7 and the Living Arroyos program will be responsible for the implementation, maintenance, and monitoring actions described in this document.

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Section 2.0 Pilot Study Description

2.1 California Sycamore and SAW Regeneration Background

A current threat to SAW is a lack of natural recruitment and establishment caused primarily by anthropogenic changes to natural physical and ecological processes and conditions (Beagle et al. 2017). Moreover, the natural regeneration of California sycamores is infrequent and episodic because it depends upon the rare co-occurrence of a relatively large constellation of driving factors. The low frequency of natural sycamore regeneration combined with anthropogenic removal of California sycamore trees and impacts to the drivers of regeneration underlie the need for active restoration of SAW to sustain and increase the distribution of this valuable and rare riparian habitat type. H. T. Harvey (in collaboration with cbec ecoengineering and SFEI) previously developed a conceptual model of California sycamore regeneration for the Santa Clara Valley Habitat Agency's Pacheco Creek Restoration Project which includes substantial SAW restoration (H. T. Harvey et al. 2020). The constellation of drivers that must co-occur to support successful California sycamore regeneration from seed is bulleted here and described below:

- large flood event (e.g., approximately a 10-25 year recurrence interval event) sufficient to yield fresh, bare, coarse alluvial surfaces via deposition or scour on floodplains (Beagle et al. 2017)
- ample California sycamore seed production and dispersal to these fresh alluvial surfaces shortly after that flood event
- sustained surficial soil moisture from rains or base flows during several months after germination to support initial growth of seedling root systems
- absence of scouring flood flows following seedling emergence (for several years while young trees establish)
- slowly declining groundwater table to allow seedlings sufficient time to root down to access late dry season moisture
- dry season groundwater table close enough to the ground surface to sustain establishing and mature sycamores
- dry season groundwater table deep enough to deter establishment of dense stands of competing obligate riparian species such as willow species (*Salix* spp.)
- limited herbivory on seedlings (e.g., from cattle)

The settings required for California sycamore recruitment include freshly deposited alluvial sediment to promote recruitment from seed and adequate flows to sustain soil moisture for seedlings to begin to establish. Fresh soils are typically deposited in high flood years; floods associated with at least 10-25 year recurrence intervals may be needed to deposit fresh soils suitable for meaningful California sycamore recruitment (Beagle

et al. 2017). Additionally, California sycamore seed production varies between years from very few to abundant seeds. For California sycamore seeds to successfully establish, they must be produced and dispersed to suitable fresh alluvial soil in the same year as when they are deposited. Once recruited, conditions must be favorable for approximately five years so that seedling/sapling sycamores can establish roots that reach groundwater throughout the year and become strong enough to withstand future flood events. Moreover, if the summer groundwater table is too high, other faster growing obligate riparian trees such as willows can outcompete sycamore seedlings. Finally, intense herbivory (e.g., from cattle attracted to mesic riparian environments) can result in sycamore seedling mortality. Due to the infrequent co-occurrence of this constellation of drivers, California sycamores typically establish episodically in cohorts (i.e., many California sycamores establish within the same time period when conditions are favorable).

Another factor affecting California sycamores is hybridization with a common nonnative landscaping tree, London planetree (*Platanus ×hispanica*) (Johnson et al. 2016). California sycamore and London planetree pollen is typically transferred via wind and can result in fertile hybrid seed. Hybridization with nonnative trees can dilute native genetics, lead to outbreeding depression, and may threaten the existence of California sycamore as a species (Anttila et. al. 1998, Johnson et al. 2016). While California sycamore–London planetree hybrids are not currently recognized as an invasive plant species which negatively affect ecosystems (Cal-IPC 2022), hybridization between native and nonnative species is a common evolutionary pathway that can lead to invasiveness (Schierenbeck and Ellstrand 2009).

Habitat restoration and mitigation projects have typically used nursery stock grown from wild-collected California sycamore seed, but this practice is now recognized as risky because wild collected seeds may have been fertilized with London planetree pollen and produce hybrid trees. One approach for reducing risk is to propagate vegetative cuttings (e.g., small branches or stump sprouts from which roots may develop) from native California sycamores. However, propagation from cuttings is difficult and typically results in low rates of success (Beagle et al. 2017). Alternatively, California sycamores seedlings can be genetically tested to verify that they are native prior to planting and all hybrids can be culled, but this is expensive and time consuming. While efficient propagation techniques are still in research and development, they are adequate to support initial SAW restoration efforts in California. Additionally, directly planting California sycamore stakes (i.e. large cuttings or poles) into locations with sufficient long-term moisture and related conditions can lead to the establishment of sycamores, although there is not much information on the success of this method with California sycamores (Duncan and Klingshirn 2012, Duncan 2014).

Natural recruitment and establishment of California sycamores has been rare in the recent past, likely due to hydrologic modifications, livestock grazing, and prolonged droughts. Hydrologic modifications, such as dams and water diversions, prevent floods from inundating floodplains, depositing fresh sediment, and recharging groundwater, all of which are conditions that promote California sycamore recruitment and establishment.

Given the extent of anthropogenic impacts to California sycamore regeneration processes, active planting of SAW is a necessary tool for SAW restoration; restoration of physical processes is often not possible and alone

is not likely to be adequate to restore SAW habitats before they are further reduced or become extinct under current conditions. While the conditions for natural California sycamore recruitment and establishment have occurred rarely in the recent past, certain restoration efforts can provide the majority of the requirements for California sycamore and SAW establishment by collecting cuttings, growing native California sycamore nursery stock, and planting and maintaining these trees in locations with suitable geomorphology, hydrology, and biotic conditions for establishing and mature sycamores.

2.2 Study Goals and Approach

The goal of this study is to identify successful site-level revegetation techniques for restoring SAW habitat. SAW is a rare plant community and habitat type consisting of widely-spaced trees—predominantly California sycamore—along broad alluvial streams in California's Coastal Range and southern Sierra Nevada (Holland 1986, Sawyer et al. 2009). The habitat supports many sensitive wildlife species, including riparian birds, western pond turtle (*Actinemys marmorata*), and steelhead trout (*Oncorhynchus mykiss*).

To restore SAW habitat and test site-level planting techniques for restoring SAW habitat, Zone 7 and the Living Arroyos community program will establish up to 100 California sycamore container stock plantings and up to 100 cuttings across two sites—Robertson Park and Medeiros Parkway—where SAW habitat was likely historically present. The plantings will be propagated from cuttings, grown as container plants at a native plant nursery, and installed across a variety of geomorphic landforms to test if survival and establishment differ by geomorphic zone. California sycamore stakes (medium to large sized cuttings) will also be directly installed in locations likely to be suitable for establishment, and will test if stakes are a successful alternative restoration method to establish California sycamores. The plantings will be maintained and monitored to promote successful establishment. The techniques that produce the highest survival rates could be used in future projects to help restore SAW habitat throughout its range.

2.3 Pilot Study Site Descriptions

2.3.1 Setting and Locations

Robertson Park is a 110-acre neighborhood park located at 3200 Robertson Park Road in Livermore, California (Figure 1). The park is owned by the City of Livermore and managed by the Livermore Area Recreation & Park District. The park contains an equestrian center, dog park, sports stadium, artificial-turf fields, picnic tables, natural open space, and multi-use trails. Arroyo Mocho is an intermittent stream that runs through the middle of the park. The park is surrounded by residential development to the north, west, and south, and a school and agricultural land to the east. The pilot study site is located along Arroyo Mocho northeast of the equestrian center and north of the dog park and artificial-turf fields. The study site can be accessed from a dirt parking area near the sports stadium.

Medeiros Parkway is a 40-acre natural community park located along a 0.7-mile reach of Arroyo Mocho between Arroyo Road and Holmes Street in Livermore (Figure 1). The land is owned by Zone 7 and the public

roadways and bridges are owned by the City. The parkway is an undeveloped open space with a multi-use trail and a flood detention basin. The paved Arroyo Bike Trail runs along a levee on the north side of Arroyo Mocho and dirt walking paths and maintenance roads weave throughout the park. The parkway is surrounded by residential development. The study site is located along Arroyo Mocho, north of Florence Road approximately 1 mile downstream and west of the Robertson Park study site. The site can be accessed from Florence Road.

2.3.2 Climate, Hydrology, and Geomorphology

Similar to much of California, the pilot study sites (Robertson Park and Medeiros Parkway) experience a Mediterranean climate with hot, dry summers and cool winters with varying periods of rain, fog, and frost. Mean annual precipitation is 15.05 inches, all of which falls as rain with most of the rain occurring in November through April (Figure 2) (PRISM Climate Group 2022). Both sites are located along Arroyo Mocho, which is a 10-mile long and approximately 97 square mile tributary watershed within the Alameda Creek watershed. It originates in the Diablo Mountain Range, flows northward into the Livermore-Amador Valley, enters the city of Livermore east of Robertson Park, and terminates southeast of the Interstate 580-680 interchange where it meets Arroyo de la Laguna. At the pilot study sites, Arroyo Mocho is an intermittent stream (i.e., a stream that has flowing water during certain times of the year—typically winter and spring—when groundwater and rainfall provide water for stream flow). The stream is not dammed; however, its hydrology is modified by summer inflows from the South Bay Aqueduct to recharge groundwater, and channel incision associated with agricultural and urban development. Arroyo Mocho was historically a braided, coarse-grained intermittent stream channel that supported California sycamores and SAW along a broad (approximately 650 to 1,300-feet-wide) floodplain and riparian corridor (SFEI et al. in prep.). Today, Arroyo Mocho consists of a single meandering stream channel (active channel) and narrow riparian corridor (approximately 100 to 550-feet-wide) (SFEI et al. in prep.).

Arroyo Mocho within the Robertson Park and Medeiros Parkway sites, contains four distinctive hydrogeomorphic surfaces: the active channel, side channels, gravel bars, and inner and outer floodplains. The active channel consists of a single, approximately 8–26-feet-wide channel where flow is typically confined. The active channel generally lacks vegetation and contains areas of coarse alluvium (e.g., cobble and gravel). Side channels occur above the active channel and are activated during higher flows. They also generally lack vegetation and contain coarse alluvium along with finer material (e.g., gravel and sand). Gravel bars occur within the active and side channels where moderate to high flows deposit coarse alluvium. The floodplains along Arroyo Mocho are predominantly flat areas above and next to the active and side channels that flood during high flow events. They contain coarse (e.g., sand and gravel) as well as fine (e.g., silt and clay) alluvium , woody (e.g., trees and shrubs) and herbaceous (e.g., grasses and herbs) vegetation, scour pools, and large woody debris. A small side channel at Robertson Park has similar qualities to the floodplain, but is in a depression causing it to flood more frequently than the rest of the floodplain and have closer access to groundwater.

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Figure 1. Vicinity Map
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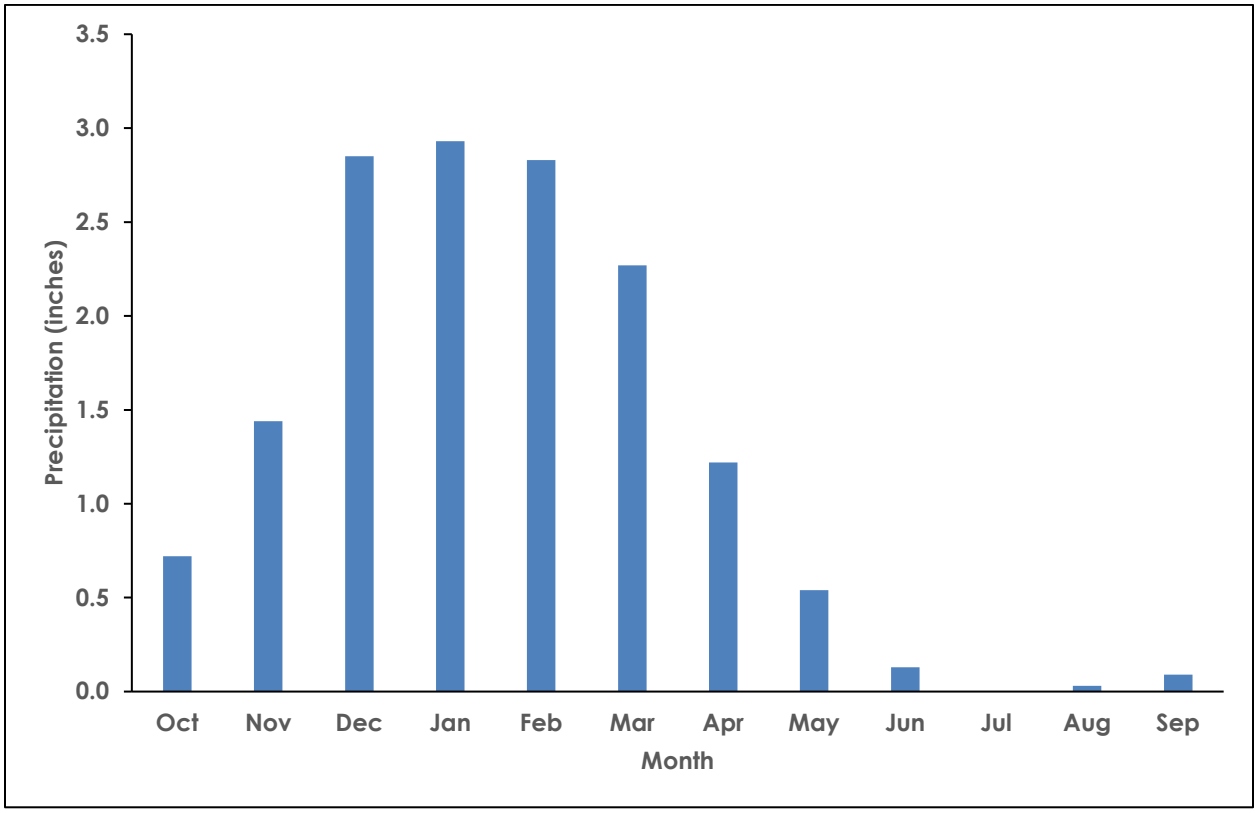

Figure 2. Average Monthly Precipitation for Livermore, California
Source: PRISM Climate Group 2022

2.3.3 Topography and Soils

Topography at the pilot study sites is mostly flat, with elevations approximately 515–536 feet above mean sea level at Robertson Park and 482–487 feet above mean sea level at Medeiros Parkway. The elevations decrease gradually from east to west. The soil at the Robertson Park study site is mapped as Riverwash and the soil at the Medeiros Parkway study site is mapped as Riverwash, with a small portion of the site (approximately 30%) mapped as Livermore soils (NRCS 2022). Riverwash consists of recently deposited gravel, sand, and silt derived from sandstone and shale. Riverwash soil occurs in stream and river channels and is excessively drained. Livermore soils consist of very deep, somewhat excessively drained soils that formed in very gravelly alluvium derived from sedimentary and metasedimentary rocks. They occur on alluvial fans and fluvial terraces (e.g., floodplains) and are composed of very gravelly coarse sandy loam at approximately 0–34 inches and very gravelly loamy coarse sand at approximately 34–60 inches below the soil surface (NRCS 2022).

2.3.4 Vegetation

The Robertson Park study site is vegetated with nonnative California annual grassland species on gravel bars floodplains, and side channels, including ripgut brome (*Bromus diandrus*), wild oat (*Avena* sp.), and red brome (*Bromus rubens*) (Photo 1). Native shrubs and trees, including California sagebrush (*Artemisia californica*), mule fat (*Baccharis salicifolia*), sandbar willow (*Salix exigua*), and red willow (*Salix laevigata*), occur on gravel bars, secondary

and tertiary side channels, and floodplains. The floodplains also contain northern California black walnut (*Juglans hindsii*) and large woody debris, likely from previously existing California sycamores and California black walnut trees. Invasive plant species growing within and around the study site include black mustard (*Brassica nigra*), short podded mustard (*Hirschfeldia incana*), perennial pepperweed (*Lepidium latifolium*), tree tobacco (*Nicotiana glauca*), and Himalayan blackberry (*Rubus armeniacus*).

Photo 1. Inner Floodplain and Coarse Woody Debris at Robertson Park (February 25, 2021)

The Medeiros Parkway study site is more densely vegetated than Robertson Park (Photo 2). Largely nonnative California annual grassland species occur on gravel bars and floodplains, including ripgut brome, red brome, wild oat, red stemmed filaree (*Erodium cicutarium*), California poppy (*Eschscholzia californica*), and chick lupine (*Lupinus microcarpus*). Native tree and shrub species occur on gravel bars and floodplains, including willows (*Salix* spp.), Fremont cottonwood (*Populus fremontii*), California sagebrush, California mugwort (*Artemisia douglasiana*), California buckeye (*Aesculus californica*), California black walnut, and California sycamore. Additional, dense stands of mule fat, planted by Zone 7 as cuttings, occur on the southwestern gravel bar at Medeiros Parkway. The gravel bars and floodplains also contain large woody debris. Invasive species within and around the study site include tree-of-heaven (*Ailanthus altissima*), black mustard, Bermuda grass (*Cynodon dactylon*), sweet fennel (*Foeniculum vulgare*), perennial pepperweed, and wild radish (*Raphanus sativus*).

Photo 2. Looking at Downstream along Arroyo Mocho and an Adjacent Floodplain at Medeiros Parkway

2.4 Basis of Revegetation Design

As noted above, the goal of this pilot study is to identify successful site-level revegetation techniques for restoring SAW habitat. Both Robertson Park and Medeiros Parkway contain geomorphic and hydrologic conditions that are expected to support California sycamores and SAW habitat despite hydrologic and geomorphic modifications. However, which geomorphic zones have the highest success for California sycamore planting and establishment is not known. Arroyo Mocho historically supported SAW habitat, and both sites have coarse alluvial soils and intermittent stream flows typical of SAW habitats (Stanford et al. 2013). The hypothesis that site conditions are adequate for SAW is also supported by the occurrence of mature California sycamore in the vicinity of the pilot study sites. Therefore, the low abundance of California sycamore in the vicinity of the pilot sites is likely due to the naturally low frequency of regeneration events combined with biotic limiting factors also described above. H. T. Harvey's restoration ecologists conducted field visits to select the planting areas (i.e. specific areas for California sycamore planting) at the Medeiros Parkway and Robertson Park sites. The planting areas are shown on the conceptual design plan view with hydrogeomorphic zones and elevations for Robertson Park and Medeiros Parkway in Figures 3 and 4, respectively. Conceptual cross sections showing the hydrogeomorphic zones, site features, and conceptual planting locations at Robertson Park and

Medeiros Parkway are shown in Figures 5 and 6, respectively. We selected the planting areas based on the following selection criteria:

- Contained multiple geomorphic zones suitable for California sycamore establishment
- Contained microsites that could improve California sycamore establishment including scour pools and woody debris
- Had low percent cover of woody species which might compete with California sycamore seedlings and saplings
- Had low percent cover of invasive plant species
- Had a relatively short distance to the active channel

SAW is composed of many different species of woody trees and shrubs. However, we are focusing on establishing and testing the effectiveness of restoring California sycamores because other woody native species are already present and regenerating at and near the site, revegetation methods for other native woody species are well established, and California sycamores are the dominant species within SAW that are currently not reestablishing to the extent historically present and are thus at risk.

California sycamores will be installed both as nursery stock grown from cuttings at a native plant nursery (i.e. seedlings) as well as directly as stakes. Both the cuttings for container plants and stakes will be collected from large California sycamore trees that are highly unlikely to be hybrids with London plane trees. Propagating cuttings in a native plant nursery requires at least a year to grow the cuttings into container plants that can be planted and the success of cuttings successfully transitioning to container plants has historically been low. We are not aware of anyone installing California sycamores directly as stakes. However, other sycamore species have successfully established using this method (Duncan and Klingshirn 2012, Duncan 2014). Installing California sycamores as stakes would reduce the time and cost required for propagation in a native plant nursery and could increase the overall success or restoring SAW, if successful.

California sycamore planting areas are located across the range of geomorphic features within the pilot study sites. However, California sycamores will not be installed in the active channel since the plantings are likely to be damaged or washed-out during high flows in that hydrogeomorphic position (or zone). Planting the California sycamore seedlings on a variety of geomorphic features and elevations will allow for assessing where California sycamores establish most effectively and will reduce the likelihood of the loss of all planted California sycamores due to scour or inability to access groundwater during the establishment phase (typically 3–5 years). We anticipate that this pilot study may reveal a relationship between California sycamore seedling survival and hydrogeomorphic zone which could then inform planting location selection for future SAW revegetation efforts on Arroyo Mocho and elsewhere. California sycamore stakes will be located in geomorphic zones with the lowest elevations, such as on the edge of the inner floodplain and in side channels, so that they have the

greatest chance of reaching the groundwater that they will need to survive. The success of container plants and stakes in these locations will also be compared to assess which method is more effective.

During project implementation, the specific seedling and stake planting locations within each planting area will be selected by the project's restoration ecologist in the field at the time of plant installation. The specific planting locations will be selected to have suitable soil, lack of woody vegetation, and suitable hydrogeomorphic microsites (i.e., in the inner floodplain, side channels, or gravel bars). Additionally, any nonnative invasive plant species will be removed from throughout the planting areas to limit their competition with the plantings. During planting, relatively large planting holes will be excavated and prepared in a manner that decompacts the soil and allows roots to establish and spread beyond the planting hole. Additionally, the top 1 foot of the planting hole will be amended with composted organic matter to improve the water retention capability and nutrient availability for the plantings. Cuttings will be installed in narrow pilot holes created with a digging bar or auger. Once installed, an irrigation basin will be created around each installed nursery plant and stake to contain applied water during irrigation allowing it to infiltrate deep into the soil and promote establishment of the California sycamore seedlings. Metal plant protection cages will be installed around the outside of the irrigation basins to protect the plantings from deer browse as well as during goat grazing events used by the City for weed management in the broader park areas.

Following plant installation, temporary vegetation maintenance will be necessary to foster establishment of self-sustainable California sycamore trees. Following installation, the planting areas will be maintained during a 10-year plant establishment period. Site maintenance focused on controlling factors that could limit sycamore seedling establishment including removal of nonnative and invasive plants, irrigation of installed California sycamores, and maintenance of plant/browse protection cages.

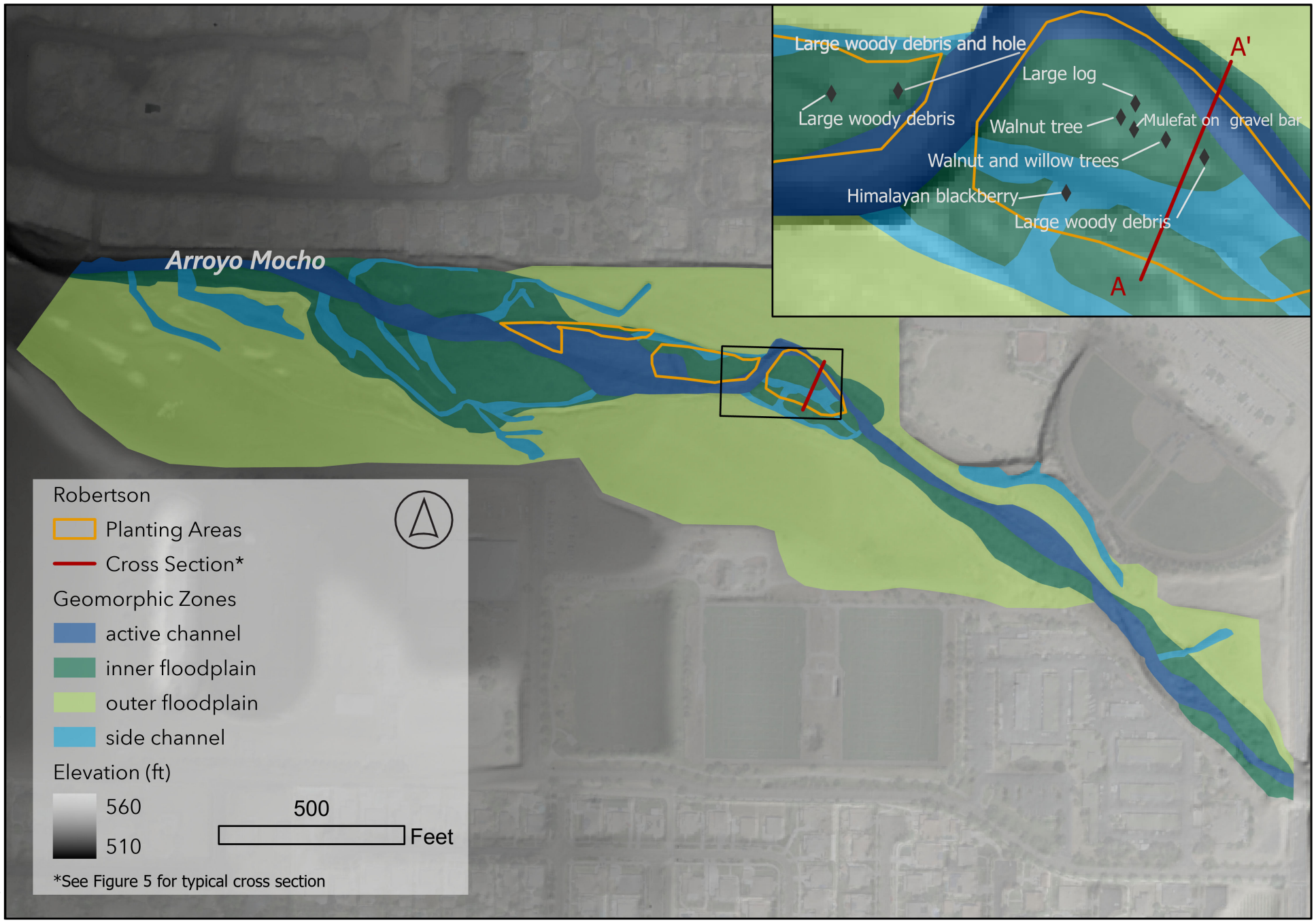

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Figure 3. Conceptual Restoration Design Plan View—Robertson Park

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Figure 4. Conceptual Restoration Design Plan View—Medeiros Parkway

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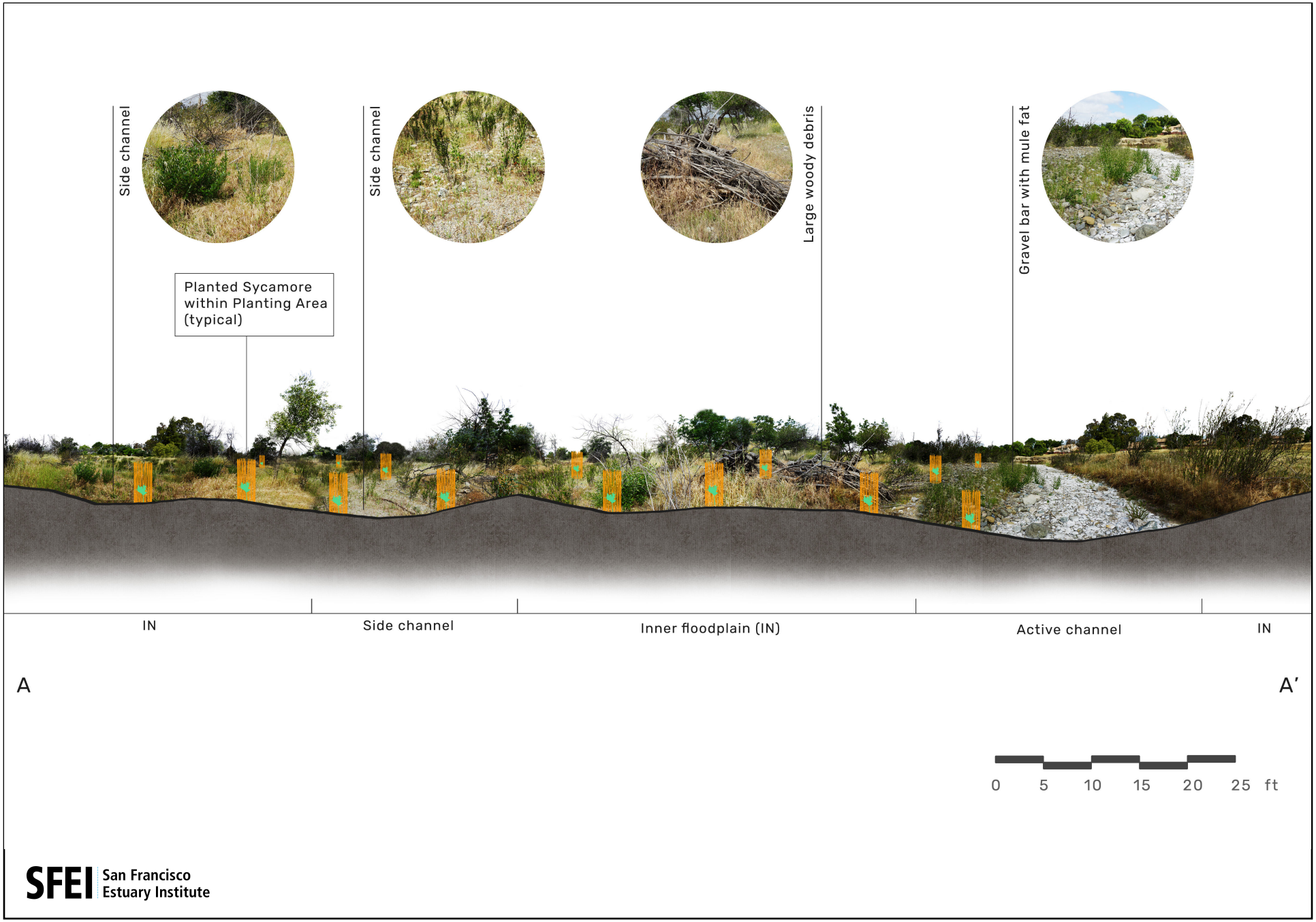

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Figure 5. Conceptual Restoration Design Cross-Section—Robertson Park

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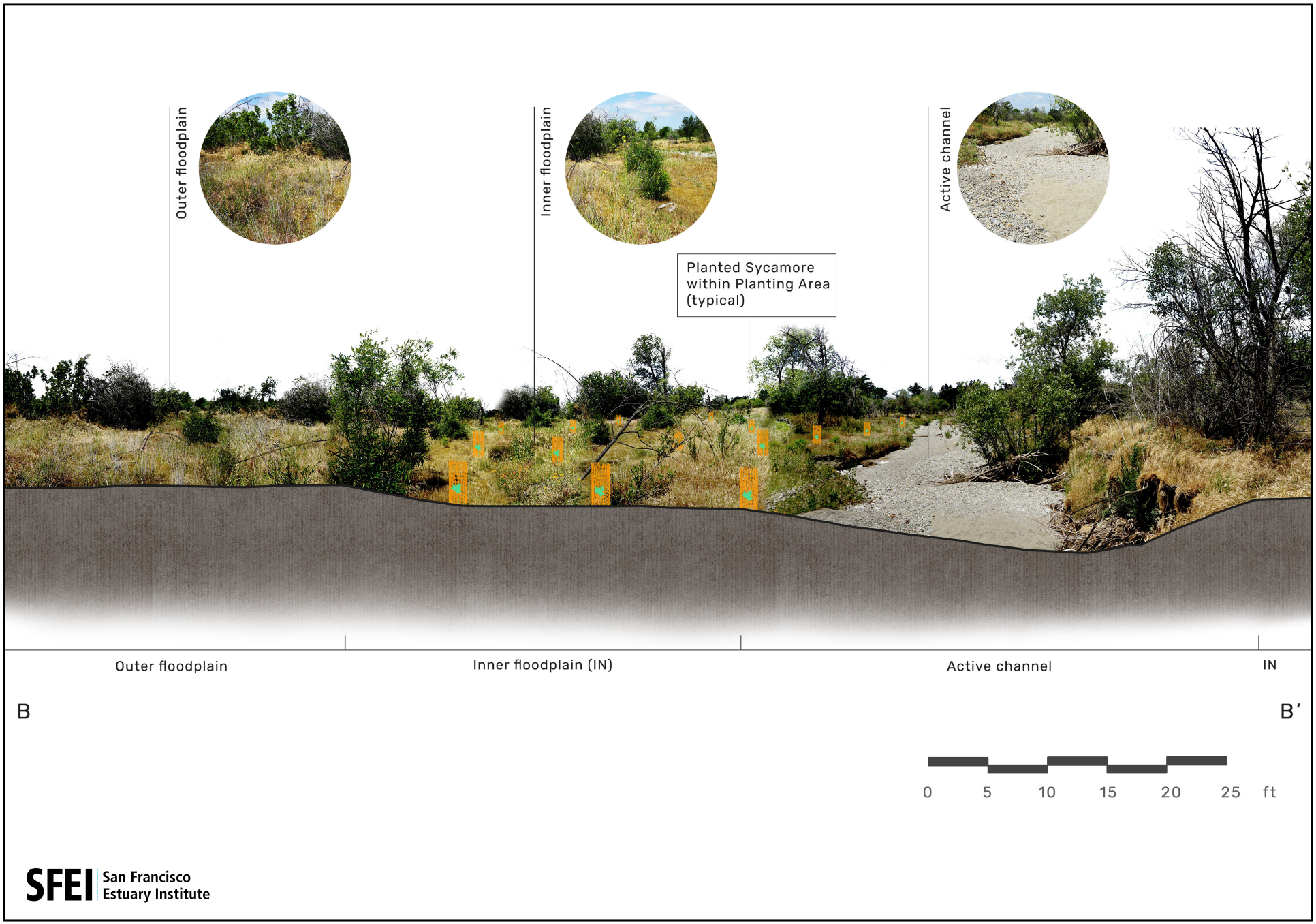

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Figure 6. Conceptual Restoration Design Cross-Section—Medeiros Parkway

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Section 3.0 Implementation Guidelines

The following describes the measures and steps that will be taken to implement the pilot study.

3.1 Avoidance and Minimization Measures

Zone 7 and its partners will implement the following measures during the implementation of this study to avoid and minimize environmental impacts.

- No heavy machinery will be utilized because the pilot project does not include earthwork and is limited to the manual or light mechanical labor needed for revegetation installation and maintenance.
- All vehicles used to transport materials and personnel for revegetation construction and maintenance will use only the existing roads to provide access outside of the low-flow channel. Vehicles will not access the bed or side channels of Arroyo Mocho.
- All temporary staging areas will be located in upland areas or on existing developed areas.
- Equipment and tools used for all project activities will be cleaned prior to use in an effort to prevent the unintentional introduction and spread of invasive plant seeds or propagules and *Phytophthora*. Washing will occur outside the project site, in locations where invasive plants are unlikely to become established (e.g., equipment storage areas, paved or gravel-covered surfaces, etc.).

3.2 Installation Crew and Ecological Construction Monitoring Support

Living Arroyos will be responsible for all of the California sycamore planting and stake preparation and installation work. An H. T. Harvey restoration ecologist will monitor the preparation and installation in accordance with these guidelines.

3.3 Site Preparation

The current site conditions are sufficient to be directly planted with no earthwork required. During habitat restoration implementation, care will be taken to avoid impacts to any existing woody vegetation within and next to the project sites. Plants will not be installed within the dripline of pre-existing trees or shrubs. Invasive plants will be removed throughout the planting areas shown in Figures 3 and 4 via manual or mechanical methods (e.g. hand pulling, shovel removal of tap roots, string-trimming). Specific techniques will be selected based on their expected effectiveness in controlling the target species, which include black mustard, short podded mustard, perennial pepperweed, and other species identified by the restoration ecologist as having the potential to negatively affect the success of the study.

3.4 Planting Plan

This section describes California sycamore cutting procurement and propagation, container planting layout and spacing, plant installation, irrigation, and plant protection. The planting will be implemented during the rainy season in January-February 2023 and October 2023 – January 2024. At this time the nursery stock are expected to be dormant or just breaking dormancy, soils are expected to be moist from wet season rains, and groundwater levels are expected to be high to allow easy water access for the planted trees; these factors tend to limit transplant shock and increase seedling survival rates in the site's Mediterranean climate.

3.4.1 Container Plant Procurement and Propagation

H. T. Harvey will supply all of the California sycamore container plants via a contract with a qualified plant nursery. To maintain local genetic diversity and integrity, all California sycamore cuttings will be collected from Sycamore Grove Park, in Livermore, that has similar soils, climate, and natural hydrology to the pilot study sites. All cuttings will be sourced from trees that are highly unlikely to be London planetree hybrids that likely established before London planetrees were introduced to the Bay Area in the mid- to late-1800s, and have a minimum trunk diameter of 3.3 feet (Johnson et al. 2016). To reduce the risk of introducing plant pathogens to the nursery while minimizing damage to the cuttings, approximately half of the cuttings for nursery propagation will be soaked in a hot water bath for 30 minutes to kill any plant pathogens within the cuttings prior to striking. However, this water bath has killed many of the cuttings in the past, so half will not be soaked in the hot water bath. The container stock will be grown in accordance with established *Phytophthora* prevention best management practices to prevent the introduction of infested plant material and soil at the pilot study sites. The California Oak Mortality Task Force provides a set of applicable guidelines to minimize *Phytophthora* pathogens in restoration nurseries (Working Group for *Phytophthoras* in Native Habitats 2016a, 2016b). A qualified restoration ecologist will inspect the plants upon delivery to ensure that they are of sufficient quality. In January 2022, California sycamore cuttings were collected for propagation. However, propagation of these sycamores was generally unsuccessful for unknown reasons and only 10 container plants were successfully produced for installation in winter 2022/2023. Additional cuttings have been collected in winter 2022/2023 to be installed in winter 2023/2024.

3.4.2 Stake Procurement

California sycamore stakes will be harvested from Sycamore Grove Park. Similar to the container plant propagation, all cuttings for stake installation will be from trees that are highly unlikely to be hybrid and have a minimum trunk diameter of 3.3 feet (Johnson et al. 2016). No more than 10% of a tree's canopy will be collected to preserve the existing sycamore trees and Sycamore Grove Park. The cuttings will be 3 to 4 feet long with the basal end cut at a 45 degree angle and the top end cut flush (Figure 7). The cuttings may come from both the tree canopy as well as from root crown sprouts. All branches will be cut flush to the main stake. Immediately after collection, the stake will be placed into a tall bucket filled with water to prevent the stake from becoming dehydrated. The stakes will be planted within 24 hours of collection according to Section 3.4.5.

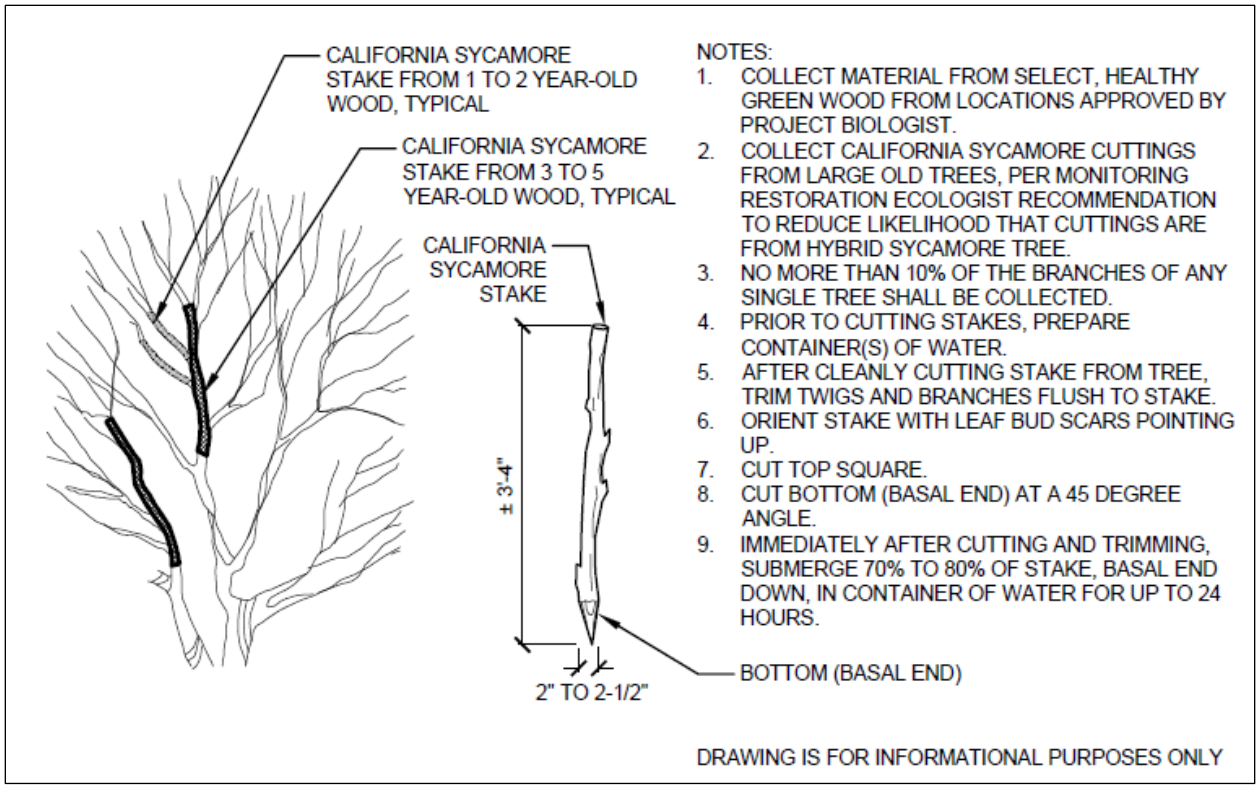

Figure 7. Typical Stake Collection

3.4.3 Planting and Stake Layout

The California sycamore container stock will be installed throughout the planting areas at both pilot study sites (Figures 3 and 4). Up to 50 plantings will be installed at each study site over the course of installation. In winter 2022/2023 the 10 California sycamore container plants will be installed in one planting area at Medeiros Parkway to allow for efficient maintenance of these plants. Within each planting area, the plantings will be installed on a minimum 16–20-foot centers in floodplain depressions, side channels, sediment mounds, and near large woody debris, which provide favorable access to groundwater and protection from scour during high flows (Figures 5 and 6). The plantings will be located at least 6 feet from existing trees and shrubs. The exact planting locations will be selected and marked in the field by an H. T. Harvey restoration ecologist using pin-flags. In addition to the container stock, approximately 50 California sycamore stakes will also be installed at each of the pilot study sites. They will be installed at an elevation where surrounding soil can be expected to be saturated, but not inundated, for the majority of the growing season (i.e. not within the active channel). Stake installation locations will be identified by an H. T. Harvey restoration ecologist during installation.

3.4.4 Container Plant Installation

All herbaceous vegetation within 4 feet of the planting locations will be removed by hand, removing as much root and stem material as possible. Care will be taken to avoid impacts on native plant species. All planting holes will be 2 feet wide and 2 feet deep (Figure 8). Planting holes will be excavated by hand or using hand tools. All rocks greater than 3 inches in diameter will be removed from the excavated soil. The sides and bottom

of each planting hole will be scarified prior to planting to remove smooth or glazed surfaces. Additionally, the upper 1 foot of backfill will be amended with composted organic matter to increase water holding capacity and nutrient levels. Composted organic matter will be thoroughly blended with the backfill soil at a volumetric ratio of 5 parts soil to 1 part compost. The type of proposed compost will be reviewed by an H. T. Harvey restoration ecologist prior to purchase and import to the site.

Each planting hole will be irrigated and allowed to drain before planting and again immediately following planting. The container plants will be installed so that each root crown is 0.25 inch above finish grade after irrigation.

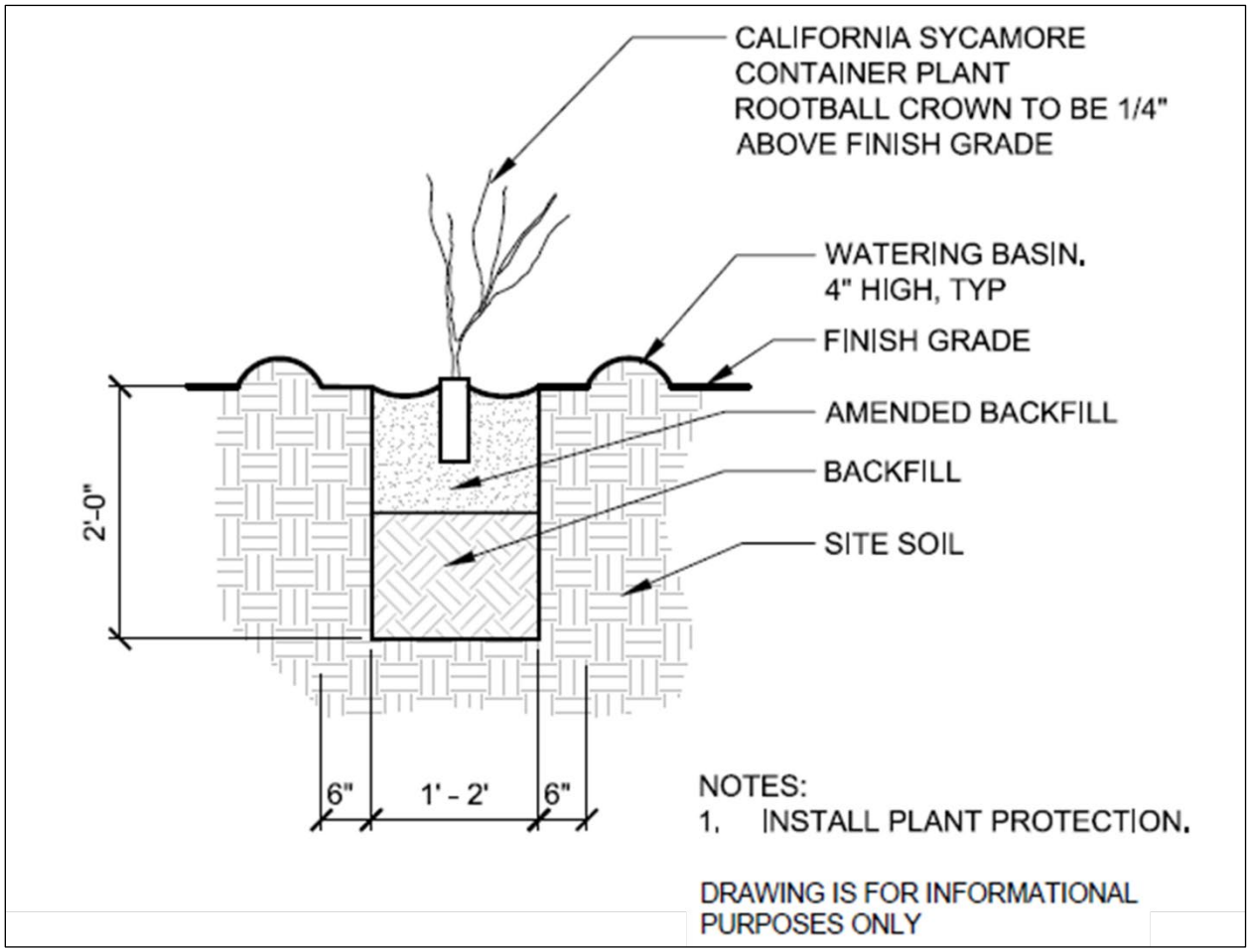

Figure 8. Typical Plant Installation

3.4.5 Stake Installation

California sycamore stakes will be installed so that the upper quarter of each cutting is exposed aboveground; the stake should be 70% to 80% below ground once installed. To facilitate cutting installation, narrow pilot holes only slightly wider than the cutting will be created (e.g., using a digging bar) or drilled (e.g., using an auger), and the soil will be compacted firmly around each cutting to eliminate voids between the soil and the cutting (Figure 9). Stakes will not be driven into the ground using a hammer or mallet.

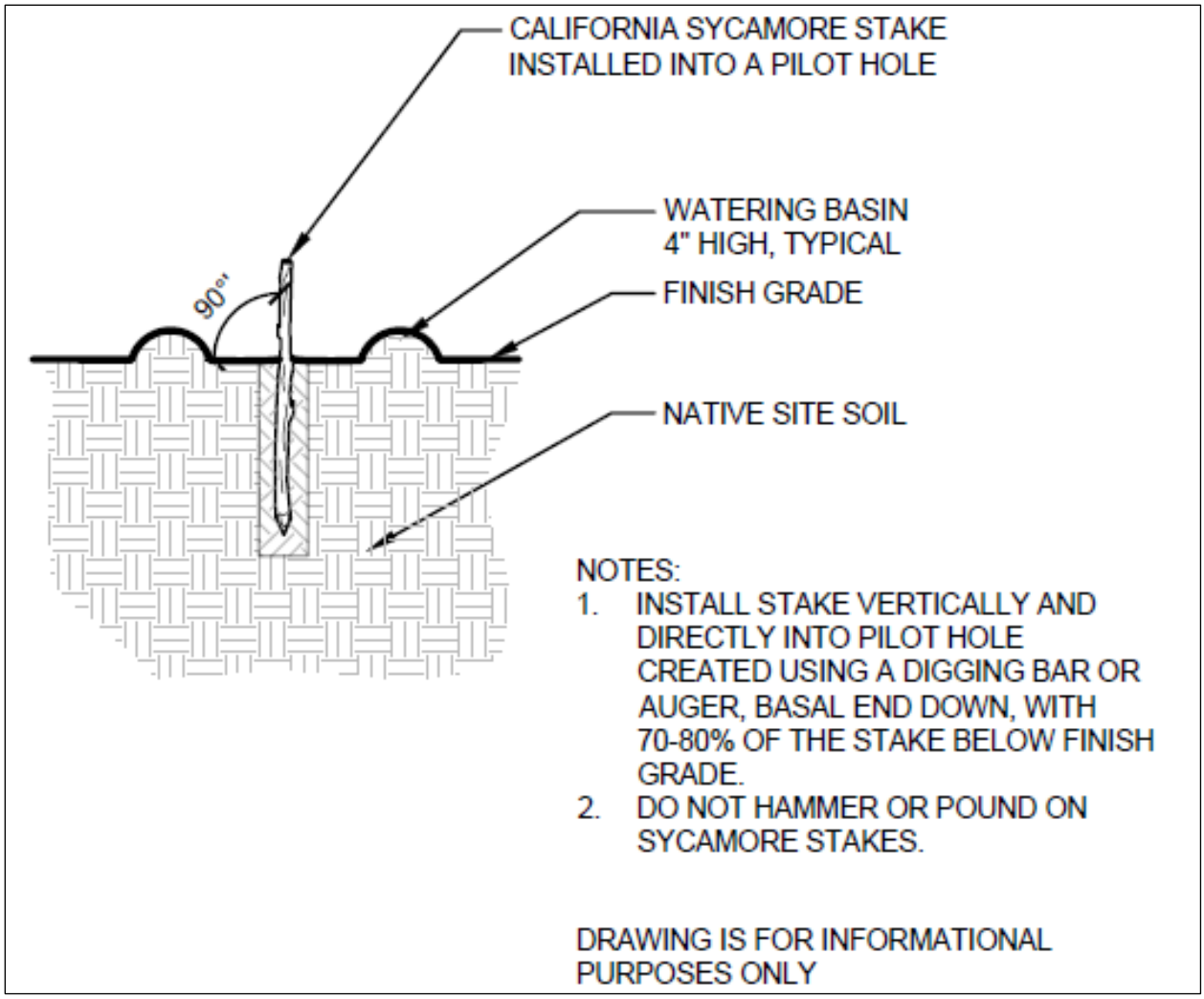

Figure 9. Typical Stake Installation

3.4.6 Irrigation Basin

Earthen irrigation basins will be constructed around each container plant and stake to contain irrigation water (Figures 8 and 9). Each basin will be approximately 3-feet-wide with a 4-inch-tall earthen berm.

3.4.7 Irrigation

All container plants and stakes will be irrigated thoroughly immediately after installation with 7–10 gallons per tree. The irrigation water should be applied slowly so that the water percolates into the ground to saturate the root ball and provide deep soil moisture without causing erosion. Following irrigation, if any plantings have settled such that the root crown is below adjacent grades, these plants will be reinstalled such that the root crowns are at or slightly above grade.

3.4.8 Plant Protection

Plant protection will be installed to protect the installed container plants from deer and goat browse; goats are often used by the City to manage vegetation and control weeds at both pilot study sites. The cylindrical cages will be 3 feet in diameter and 5 feet tall. They will be constructed of welded wire mesh or woven, non-galvanized metal mesh and secured with three metal T-posts per cage.

3.5 Post-Planting Cleanup

All nursery plant containers, tools, trash, and other inorganic debris will be removed from the plantings areas immediately following plant installation. The nursery plant containers will be returned to the providing nursery to be reused.

Section 4.0 Maintenance Plan

The planting areas will be regularly maintained for at least 10 years to ensure successful establishment of the California sycamores. Maintenance needs may include dead plant replacement, irrigation, placement of rice straw mulch, invasive plant and weed control, and plant protection cage repair.

4.1 Dead Plant Replacement

All dead California sycamore plantings will be replaced at the end of the first growing season following plant installation to increase the likelihood of rapid SAW habitat establishment. All dead California sycamores will be marked in summer or fall 2023, prior to going dormant. When replanting occurs, the planting methods described in Section 3.4 will be followed.

4.2 Irrigation

The installed California sycamores will require supplemental irrigation for up to 5 years following installation. All irrigation water will be from non-recycled water sources to reduce the potential for salt accumulation and toxicity. Irrigation application rates will be based on weather conditions and observed plant health and vigor, which will be qualitatively assessed during each irrigation event, with special attention paid to areas where plant performance is substandard. The application rates will generally mimic typical precipitation patterns, with the majority of irrigation being applied in the fall, winter, and spring. The irrigation frequency will be gradually reduced to facilitate plant acclimation to the sites' natural moisture regimes.

In Year 1, the plantings will be irrigated with enough regularity (approximately three to four times per month from March through October) to keep the soil within the plant-rooting zone consistently moist throughout the summer and fall. Each irrigation event will provide enough water to encourage deep root development (approximately 10 gallons per plant per irrigation event). The irrigation water should be applied slowly so that the water does not escape the irrigation basins and percolates into the ground to provide deep soil moisture. In subsequent maintenance years the irrigation frequency will be gradually reduced, while the irrigation volume per event remains constant (approximately 10 gallons per event) to soak the rooting zone of each plant yet gradually reduce the plants' dependence on irrigation. The frequency and duration of irrigation events in Year 2 and beyond, including the decision to cease irrigation altogether, will be based on observed plant health, vigor, and the expected soil moisture requirements of each plant and following the recommendations of a qualified restoration ecologist. However, as a general guideline, it is anticipated that no irrigation will be required beginning the fourth growing season following initial plant installation.

4.3 Irrigation Basins

As long as irrigation occurs, all irrigation basins will be maintained to have an approximately 3-foot diameter and be encircled by a 4-inch high earthen berm to contain irrigation water. As described below, irrigation basins will be maintained to be weed free via hand removal.

4.4 Rice Straw Mulch

Rice straw will be placed into each irrigation basin in the spring/early summer to help reduce soil moisture loss and nonnative weed growth within the irrigation basins. The timing of placement of rice straw mulch should be timed to match receding water level such that rice straw is not likely to be washed away, and so that the rice straw mulch will benefit the sycamores by reducing the amount of soil moisture being lost via evaporation as the groundwater depth recedes. The rice straw will be 6-8 inches high and will be crimped with a shovel to reduce the chance that it is blown or washed away. The rice straw mulch will be replaced annually in the spring or early summer for at least the first 5 years after planting.

4.5 Invasive Plant and Weed Control

Invasive plants could significantly impair the successful establishment of the project, and, therefore, invasive plant monitoring and management will be conducted throughout the 10 years after planting throughout the footprint of all planting areas. For the purpose of this management plan, plant species that are rated "high" by the California Invasive Plant Council (Cal-IPC 2022) are recommended for management; however, additional plant species should be controlled if the restoration ecologist determines that those species have the potential to threaten the success of the study.

The irrigation basins around the container plants will be kept free of invasive plant species and weeds by manually removing the weeds that become established. Invasive plant removal elsewhere throughout the planting areas will focus on control methods with the least potential for adverse environmental effects. Manual removal by hand-pulling will be the preferred weed removal method, but mechanical methods (e.g., string-trimming and mowing) may also be considered on a situational basis. Additionally, the City's Livermore Area Recreation and Park District implements periodic goat grazing at both pilot study sites during spring and summer to control weeds and reduce fire risk. Care will be taken during all invasive plant control activities to avoid existing, planted, and naturally recruited native plant species.

4.6 Plant Protection

Plant protection cages will be maintained in good working order (upright and secure). If plant protection cages substantially impede plant growth, the cages will be adjusted or expanded to prevent foliage from becoming entangled. Protective cages will remain around each tree at least until the vertical stem at the top of the trunk (leader) is above deer browse level (minimum 5 feet) and are robust enough to withstand goat and deer herbivory and rub (expected to occur in approximately Year 5).

4.7 Natural Native Plant Recruitment

During maintenance work, care will be taken to avoid damage to any naturally recruited native plants within the pilot study sites. Naturally recruited native plants will be marked with pin-flags to alert maintenance contractors or volunteers of native plants so that accidental damage/removal during scheduled maintenance activities is avoided.

4.8 Schedule

The planting areas will be maintained regularly throughout the 5-year maintenance period. During this time, maintenance events will occur 2–4 times per month during the growing season (March to October) and approximately once per month from November to February. The timing of maintenance events will depend on factors such as precipitation patterns and the rate of weed growth and spread. Additional events may be added, as needed.

Section 5.0 Monitoring Plan

This section presents H. T. Harvey's recommended post-construction ecological monitoring plan. The purpose of this plan is to adequately monitor the site so that maintenance actions (e.g. irrigation, invasive species removal) can be adaptively implemented to best support the installed California sycamore plantings and stakes. Additionally, information from monitoring will assist in evaluating patterns and lessons learned from the study. Monitoring will include implementation monitoring, maintenance monitoring, and sycamore establishment monitoring.

5.1 Implementation Monitoring

In accordance with the current contract, an H. T. Harvey restoration ecologist will monitor all restoration implementation activities to assist with the restoration design and implementation plan. The restoration ecologist will note changes to the proposed planting layout and plant quantities and document these changes in a restoration as-built report. The ecologist will establish permanent on-the-ground photo documentation points and conduct photo documentation from those points during implementation monitoring. The permanent photo documentation points will be established with the intent that locations will be utilized during the post-implementation monitoring period to enable temporal comparisons between monitoring years. Additionally, SFEI will capture aerial imagery of the as-built conditions using an unmanned aircraft system (UAS, or drone).

5.2 Maintenance Monitoring

A qualified restoration ecologist will conduct site visits starting immediately following plant installation to identify maintenance issues that may hinder the establishment of the installed California sycamores. The establishment period for this project is defined as the 5 years post implementation and the maintenance and maintenance monitoring during this period will be frequent enough to ensure that the California sycamores have the highest probability to establish. Specifically, we recommend that a qualified restoration ecologist visit the site every 2 months for the first 3 years of establishment, then every 3 months for years 4 and 5 after implementation. Additional visits may be warranted during the plant establishment period, particularly if drought conditions persist or if major floods occur. After the establishment period, maintenance monitoring will be conducted 1-2 times a year and may be coupled with plant establishment monitoring described in Section 5.3. Representative photographs will be captured during each site visit from fixed photo documentation points established during preparation of the as-built report (see above section). The restoration ecologist will qualitatively assess the following factors during site visits:

- plant health and vigor, with special attention paid to areas where sycamore performance is poor;
- mortality of plantings;

- irrigation and maintenance needs of the plantings (e.g., need for irrigation, irrigation basins, plant protection);
- invasion of nonnative weeds and invasive plant species;
- natural recruitment of native plant species;
- disturbance (e.g., flooding, grazing, vandalism, and fire); and
- the accumulation of trash and unnatural debris

Based on observations made during these visits, the restoration ecologist will recommend specific management actions to Zone 7, as needed to address issues that may pose a risk to the success of the project.

Additionally, Living Arroyos will take notes regarding the status of the installed California sycamores and the planting areas during each maintenance event. These observations will be recorded in maintenance logs as described in Section 5.6.2 and will be shared with Zone 7 and the monitoring restoration ecologist.

5.3 Plant Establishment Monitoring

Data on California sycamore establishment will be collected by a qualified restoration ecologist for up to 10 years to evaluate the performance and success of the pilot study. Information from this monitoring will provide feedback to direct maintenance as well as assess lessons learned regarding planting and maintenance techniques for use in future California sycamore planting efforts. Monitoring will assess plant survival and plant health and vigor by pilot study site, planting type (i.e. container plant vs stake), and geomorphic zone. Each planting cage will be marked with an aluminum tag noting which geomorphic zone the plant is within to avoid confusion during future monitoring years, or if the existing geomorphic conditions evolve.

5.3.1 Plant Survival

Plant survival will be monitored to assess the establishment of the California sycamore plantings in Years 1-5, 7, and 10. The survivorship of plantings will be determined by field counts. Percent survival will be calculated by study site using the following equation:

> Percent Survival of all Plantings = (Total Number of Individuals Alive at Monitoring / Total Number of Individuals Initially Planted) * 100%.

Additionally, survival will be calculated by propagule type (i.e. seedlings vs stake) and geomorphic zone within each study site using the following equations:

> Percent Survival of Plantings in Zone X = (Total Number of Individuals Alive at Monitoring within Zone X / Total Number of Individuals Initially Planted in Zone X) * 100%

Percent Survival of Propagule A Plantings = (Total Number of Propagule A Individuals Alive at Monitoring/ Total Number of Propagule A Individuals Initially Planted) * 100%

Furthermore, the interaction between propagule type and geomorphic position will be compared graphically to assess if a propagule type does especially well in a geomorphic position(s). The percent survival of plantings at each site will inform dead plant replacement at the end of Year 1 as well as assess differences in survival between the propagule types and geomorphic zones throughout the 10 year monitoring period.

5.3.2 Plant Health and Vigor

Health and vigor will be assessed by considering factors such as plant color, bud development, new growth, herbivory, drought stress, fungal/insect infestation, and physical damage. Health and vigor will be rated as high, medium, low, or dead according to the percentage of healthy foliage, stems, and root crowns, and using the rating system shown in Table 1. Plant health and vigor will be averaged by study site as well as by geomorphic zone within each study site. Health and vigor will be used to adjust maintenance needs and to evaluate the success of planting between the pilot study sites and geomorphic zones.

Table 1. Plant Health and Vigor Ratings

Qualitative Rating	Numerical Values	Observations
High health and vigor	3	67–100% healthy foliage, stem, and root crown
Medium health and vigor	2	34–66% healthy foliage, stem, and root crown
Low health and vigor	1	1–33% healthy foliage, stem, and root crown
Dead	0	No healthy foliage; cambium, when examined, is brown and appears dead; no signs of photosynthetic activity during normal periods of active growth

5.4 Photo Documentation

Photo documentation of the pilot study sites will be conducted during each monitoring year from fixed locations selected during implementation monitoring (Section 5.1). Each photo point will be recorded with a GPS unit. The photos will be taken to document and assess plant performance and establishment as well as site conditions. Photographs will also be taken to document any events that may significantly affect the success of the study, such as severe flooding, channel movement, scour, deposition, fire, or vandalism. Photo documentation will be timed to occur during the peak growing season (i.e., spring to early summer).

5.5 Monitoring Schedule

A schedule of monitoring and reporting activities is presented in Table 2.

Table 2. Monitoring Schedule

	Year 0*	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Biological as-built monitoring	X										
Maintenance monitoring		X	X	X	X	X	X	X	X	X	X
Plant survival		X	X	X	X	X		X			X
Plant health and vigor		X	X	X	X	X		X			X
Photo documentation	X	X	X	X	X	X		X			X
Biological as-built report	X										
Annual monitoring report		X	X	X	X	X		X			X

*(within 2 weeks after installation)

5.6 Reporting

Formal reporting to regulatory agencies is not required for this project. However, reporting is an important part of this study. Reporting will allow Zone 7 and others to assess the effectiveness of the California sycamore installation, maintenance, and monitoring methods as well as which techniques and locations performed best and can be replicated in future SAW restoration activities. As presented above, the report findings will include an assessment of whether there is a relationship between plant establishment and hydrogeomorphic planting zone. The recommended reporting is outlined below.

5.6.1 As-Built Report

H. T. Harvey will prepare a biological as-built report at the conclusion of plant installation. The report will note all significant deviations from these implementation guidelines, such as changes to the planting area configuration, plant installation methods, and plant quantities. In documenting as-built conditions, the restoration ecologist will establish permanent photo documentation points throughout the pilot study sites. Future photo documentation will be conducted from these same points to visually depict changes in the project over time. Future analysis and monitoring of the pilot study will be compared to baseline conditions documented in the as-built report.

5.6.2 Maintenance Logs

Maintenance logs will be prepared by the maintenance crew leader following each maintenance event to document all maintenance actions completed at the pilot study sites. The logs will include observations and recommendations for improving plant establishment such as changes to the irrigation regime, invasive plant control, or adding mulch. The logs will be submitted within one week of the site visit to Zone 7 and to the monitoring restoration ecologist so that any management recommendations can be formulated by the monitoring team and quickly implemented, as needed.

5.6.3 Annual Monitoring Reports

Annual monitoring reports will be prepared in Years 1–5, 7, and 10 to document the results of plant establishment monitoring (Section 5.3). The reports will document survival and health and vigor by pilot study site and geomorphic zone as well as describe the reasoning behind any observed patterns. Maps showing the locations of the planting areas and photo documentation points will be included in each report. Photo documentation will be presented in an appendix. Reports will be prepared in the following format:

1. Introduction
2. Methods
3. Results and Discussion
4. Management Recommendations
5. References
6. Appendices

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