CALTECH
LANDSCAPE DESIGN PRINCIPLES

Prepared by

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INTRODUCTION

These Landscape Design Principles provide detailed approaches for the design and management of landscaping on the Caltech campus, based on a) updated analyses of landscape settings as they have evolved over the years, along with projections of future scenarios; b) updates to overall framework and design principles; and c) new initiatives related to universal accessibility, environmental and public health, safety, and security as well as expressions of Caltech's sustainability ethic, culture, and values.

This document updates and supplements the 2006 Landscape Development Plan, 2007 Landscape Initiatives, and 2010 Landscape Programming documents. It is based on site observations and analyses conducted in 2022 and 2023 and includes building and landscape projects implemented since 2007 as well as new initiatives associated with currently proposed building and independent site and landscape projects.

In addition, these observations and analyses incorporate new information associated with current Caltech sustainability policy documents and specific initiatives including: the 2023 Caltech Campus Design Guidelines (V5.4, notably sections 32 00 00, 32 10 00, 32 33 00, 32 80 00, and 32 90 00); the 2021 Campus Tree Inventory database; the 2022 Water Conservation Areas/Non-Functional Turf Areas Irrigation Halt Map; the 2022–23 Flood Prone Areas and Stormwater Retention/Infiltration Maps; the Tree Canopy Increase Opportunity Map; and Stormwater Management investigations conducted by Psomas Associates, Civil Engineering Consultants (2023).

This new information and the incorporation of current Caltech Sustainability policies as fundamental to this effort are the bases of new articulations of Guiding Principles, Campus Landscape Framework, Landscape Initiatives, and Landscape Design and Management Guidelines.

Caltech Institutional Context

As stated on the official institute webpage, "Caltech at a Glance":

Caltech is a world-renowned science and engineering institute that marshals some of the world's brightest minds and most innovative tools to address fundamental scientific questions and pressing societal challenges. Caltech's extraordinary faculty and students are expanding our understanding of the universe and inventing the technologies of the future, with research interests from quantum science and engineering to bioinformatics and the nature of life itself, from human behavior and economics to energy and ***sustainability.***

Caltech is ***small*** *but prizes excellence and ambition.*

The mission of the California Institute of Technology is to expand human knowledge and benefit society through research integrated with education. We investigate the most challenging, fundamental problems in science and technology in ***a singularly collegial, interdisciplinary atmosphere, while educating outstanding students to become creative members of society.***

University President Thomas F. Rosenbaum, Sonja and William Davidow Presidential Chair and Professor of Physics, writes in his 2022–23 Academic Year Welcome:

Both Joliot-Curie and Poincaré speak to the inspiration that is required to elevate the pursuit of knowledge into a meaningful and deeply fulfilling vocation. The freedom to let your imagination roam and the potential to light in unexpected places are rare privileges afforded by the academy. The bricklayers provide context. We — Caltech staff, students, postdocs, faculty, alumni, and friends — are part of a community, each contributing in their own way, that strives together to create something much larger than any one of us could accomplish alone.

The intense and intimate character of the Institute makes possible the focused interactions and serendipitous encounters that round out the pursuit of knowledge. In the wake of the social isolation brought on by the coronavirus, we must be intentional and proactive in forming connections. There remain psychological barriers to full engagement that we must surmount to realize once again the full benefits of our diverse community; to learn from others with different approaches, backgrounds, and perspectives; and to translate our local insights into global discoveries.

These statements speak explicitly of Caltech's core role in:

- Addressing "pressing societal challenges … inventing the technologies of the future" in the context of sustainability;
- Its community's "singularly collegial, interdisciplinary atmosphere … educating outstanding students to become creative members of society"; and
- The "intense and intimate character of the Institute that makes possible the focused interactions and serendipitous encounters that round out the pursuit of knowledge."

Achievement of sustainability and the stewardship of Caltech's ***singularly collegial, interdisciplinary atmosphere*** can and must be framed as complementary outcomes of all efforts in the planning, design, and management of campus landscape.

Sustainability Initiatives

Caltech's sustainability initiatives require a holistic approach to the management of energy, water, materials, land use, and the cycling and recycling of material flows. These initiatives are particularly suited to decision-making related to the design and management of the landscape.

Caltech faces challenges in the coming decades due to climate change effects including increasing periods and intensity of extreme hot weather, decreasing annual rainfall, and increasing storm intensity. These emerging new realities require responses guiding all aspects of planning, design, and operation of the Caltech campus, including the forms and arrangement of all elements in its landscape.

The characterization in earlier expressions of the campus landscape into typologies and zones reflective of historical period and architectural and landscape design materials is not compatible with the current climate reality. Therefore, all future work must sustainably enhance the campus' beauty and integrity.

Ecosystem Based Design
Campus sustainability initiatives and responses to the COVID–19 pandemic offer new perspectives toward the development and management of Caltech's landscape resource.

The living fabric of the campus consists not only of the matrix surrounding and connecting buildings but comprises the settings for the collective life of the campus — large gatherings, ceremonies, celebrations, sports and games, small gatherings, learning, and chance social encounters — and also serves as the settings for the individual's enjoyment, contemplation, and inspiration. Equally, this living fabric has **intrinsic value** in and of itself and provides necessary functions and essential "ecosystems services" to our community.

I. GUIDING PRINCIPLES

The guiding principles for the landscape of the campus represent three complementary imperatives to embody, communicate, and celebrate:

1. The fundamental identity, purpose, values, and mission of Caltech;
2. the Institute's commitment to an ethic of sustainability; and
3. consequent adoption of principles of Eco-Centric Based Design.

Beyond serving as an evocative setting for campus life, these updated principles call for the landscape to not only address and express Caltech's unique identity, history, and values, but to **embody them.** The landscape is acknowledged as an intentionally combined human-natural network whose ethical and aesthetic dimensions are interconnected and interdependent, not only as a setting or backdrop but performing critical functions with intrinsic value.

The design and stewardship of the campus landscape must therefore be founded on the principle that environmental considerations (climate, air, water, habitat, energy production, pollution) and social imperatives (wellness, education, equity, participation,

access) can be explicitly seen and engaged as interconnected and interdependent aspects of a whole "ecosystem" that is greater than the sum of its parts.

These guiding principles will inform the evolution of the campus. For example, initiatives to increase tree canopy, conserve stormwater, and transition non-functional turf to native ground covers will be guided by the provision of expressive settings for campus life, responsible use of resources, and enrichment of habitat for all.

II. SETTING

1. Campus Landscape Context

Site context — the surrounding fabric of the existing and planned landscape and infrastructure of all proposed projects — must be taken into consideration from the earliest stages of any proposed effort. Opportunities to mitigate and improve surrounding conditions must be identified, as well as constraints present. The inherent connectedness of landscape elements must be taken into consideration.

2. History

These updated guiding principles advance and evolve the 2006 Plan's characterization of the campus landscape as a *lush and serene* setting mediating the scale of buildings and *offering outdoor environments for study, reflection, casual interaction, and formal gatherings* and call for the campus landscape to *address and express* Caltech's unique identity, history, and values.

Fundamentally, all future work must aesthetically enhance and extend the historic beauty, integrity, and continuity of the campus. This can be accomplished through designs that are compatible with, but do not replicate, existing forms, patterns, or materials, expressing the ethic of sustainability and celebration of the unique culture and values of Caltech — past, present, and evolving into the future.

III. CAMPUS LANDSCAPE FRAMEWORK

The updated Campus Landscape Framework Plan carries forward the principles of respect for the history and character of the campus articulated in earlier plans, reconciling this heritage and simultaneously acknowledging the significant transformational changes brought by major building and policy initiatives and environmental factors in the past two decades.

This updated plan continues the 2006 plan's recognition that *the existing Caltech Landscape provides the unifying bond for the disparate architecture of the campus,* and its observation that *future development should do more to incorporate Southern California's unique native plant palette and provide positive examples of more sustainable water use.*

The updated plan retains the earlier framework's identification of the north-south core circulation spine and Beckman Mall gathering space, along with the campus's major east-west corridors: California Boulevard; Olive/Bechtel Walk; San Pasqual Walk; and Moore Walk. In addition to these through-campus corridors, it recognizes a connective network of secondary north-south and east-west corridors and landscape places, all of which provide opportunities to express the unique identity of the campus as a whole, as well as the particular character of each place.

As noted, the updated Framework Plan (Figure 1) acknowledges the significant transformational changes brought by major building and policy initiatives and environmental factors in the past two decades, which no longer support the earlier stratification of the campus into four north-south zones, each with a separate overall landscape character and distinct primary signature tree species. New building and landscape projects have been and are in progress or are being planned throughout the campus.

The updated framework with its emphasis on strengthening the character of distinct landscape places and connecting corridors addresses the earlier stated goal of reinforcing *the significance of many of Caltech's most cherished and ceremonial outdoor spaces while strengthening the connection between the South Campus and the Campus precincts north of California Boulevard.*

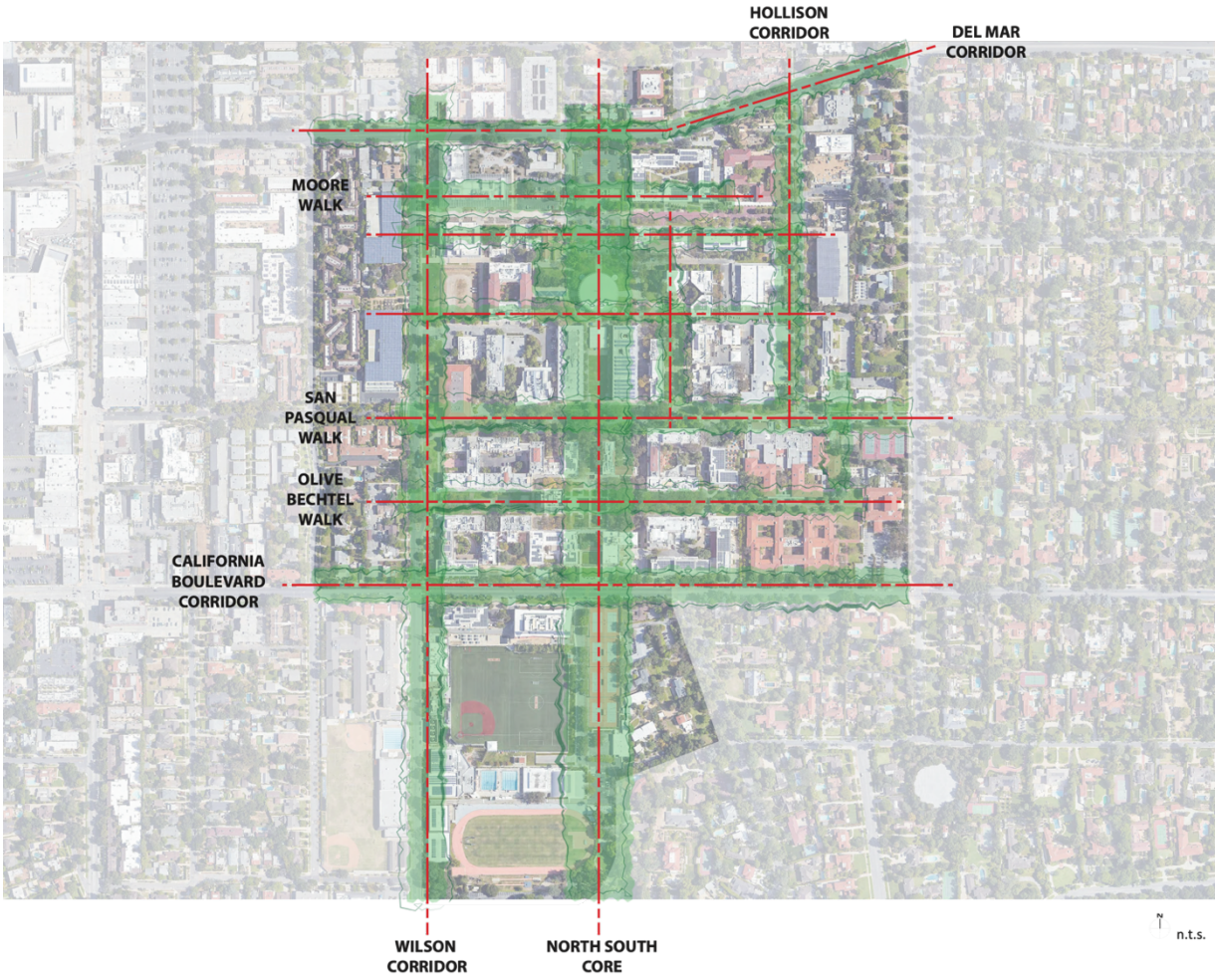

Figure 1.
LANDSCAPE FRAMEWORK
February 12,2024

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The framework builds on earlier imperatives "to create intentional landscape spaces," applying this approach throughout the campus generally and in the context of Caltech's current Campus Landscape Initiatives.

The landscape of the entire campus should embrace the future, incorporating sustainable practices in design and materials throughout. The landscape framework will of course address and complement the forms and character of the significant "original" early 20th century Mediterranean inspired campus, as the ethos and quality of its design is particularly resonant with contemporary awareness of the embrace of context and environmental values. In this context the landscape framework will also address and complement Caltech's significant expressions of the "modern" mid 20th century architecture, as well as subsequent and contemporary expressions.

Planting design should further the identity of specific places as well as the coherence of connecting corridors rather than application of specific signature trees and understory plants,

defining distinct campus zones. Further, generally, while the use of native trees and other plants is associated with distinct advantages and is to be encouraged, this is not the case with all native plants. The encouragement of use of native and other plants should be qualified to those species and selections that have been traditionally associated or are novel but resonant with the built, *cultural* landscapes of Southern California and in particular the rich landscape design heritage of Pasadena and the Caltech campus.

The design of other elements in the landscape should also be informed by this heritage. This is particularly important in the case of water. The traditional pre–20th century expressions of water in the Southern California landscape — present or anticipated — celebrating its animating presence and preciousness in our environment should be recalled and re-visioned in new designs.

Along with water, design should employ and advance the traditional uses of shade and shadow as defining elements of the Caltech landscape. Pergola, trellis, and ramada forms all provide prototypes for the increasingly essential provision of shade on the campus.

IV. CAMPUS LANDSCAPE INITIATIVES

As noted in the 2007 Campus Plan review Landscape Initiatives document: *A key finding of the review is that the character of the Campus is determined as much by its landscape as by its architecture* and *Over the course of the last thirty years the design and maintenance of the landscape has lost some of the original vision.*

This 2007 plan suggested the restoration of significant spaces, the creation of new spaces, and a strategy for more effective planting, identifying thirteen “landscape initiatives,” five of which were linked to building projects, and eight were independent projects. In the ensuing period four of these initiatives have been completed and two are underway. (Figure 2.)

Figure 2.
LANDSCAPE INITIATIVES
Draft March 15, 2023

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The updated Landscape Framework Plan incorporates these thirteen original initiatives, acknowledging their importance to the identity and coherence of the campus.

These include:

Landscapes Associated with Building Projects:

1. Moore Walk and Annenberg Center for Information Sciences and Technology – (Completed)
2. Schlinger Laboratory for Chemistry and Chemical Engineering – (Completed)
3. Campus Center – (Started but Not Completed)
4. North Undergraduate Houses – (Not Started)
5. Cahill Center for Astronomy and Astrophysics – (Completed)

Independent Landscape Projects

1. Beckman Lawn – (Ongoing, Part of Resnick Project)
2. Watson Bookman Grove – (Not Started)
3. Heart of Campus – (Not Started)
4. Sculpture Garden – (Part of Resnick Project)
5. Red Door Café Dining Green-Hameetman – (Completed)
6. Throop Garden – (Not Done)
7. Olive Walk – (Not Started)
8. South Campus – (Not Started)

Additional Potential Landscape Initiatives

This update also identifies opportunities for additional potential initiatives, related to specific site conditions including stormwater infiltration, tree canopy enhancement, and turf area conversion, supporting strengthening and articulating places and corridors within the landscape framework of the campus. (See Appendices B and C) These include:

1. Wilson Corridor
2. Moore Walk Adjacent Areas
3. Campus Entry at Olive/Bechtel Walk
4. Beckman Lawn
5. San Pasqual Corridor
6. Red Door Café Dining Green
7. California Boulevard Corridor
8. California Blvd. South Campus Gate area

V. LANDSCAPE DESIGN AND MANAGEMENT GUIDELINES

As noted above, these updated landscape design and management guidelines are based on new articulations of guiding principles informed by site observations and analyses conducted in 2022 and 2023 of current conditions on the Caltech campus including building and landscape projects implemented since 2007 as well as new sustainability initiatives associated with currently proposed building and independent site and landscape projects.

In addition to the incorporation of post–2007 projects and initiatives, the observations and analyses include surveys of current site conditions related to stormwater and

vegetation management. This information has allowed the identification of opportunities to reinforce the identity, coherence, and functional efficiency of the Caltech campus pedestrian environment movement corridors and gathering places.

This information has also identified opportunities to advance interrelated imperatives supporting the campus community's health, well-being, and safety as well as sustainability initiatives. These include increase of desirable shade producing and atmospheric cooling tree canopy, turf reduction, and introduction of climate appropriate landscape planting and pervious paved surfaces where feasible. These measures also offer benefits of reducing water consumption, incident solar radiation, and heat gain on buildings and outdoor places. Additionally, these measures offer benefits including mitigation of flood-prone areas through retention and infiltration of stormwater, as well as mitigation of life safety hazards associated with fire-prone and brittle tree and plant species. (Figure 3.)

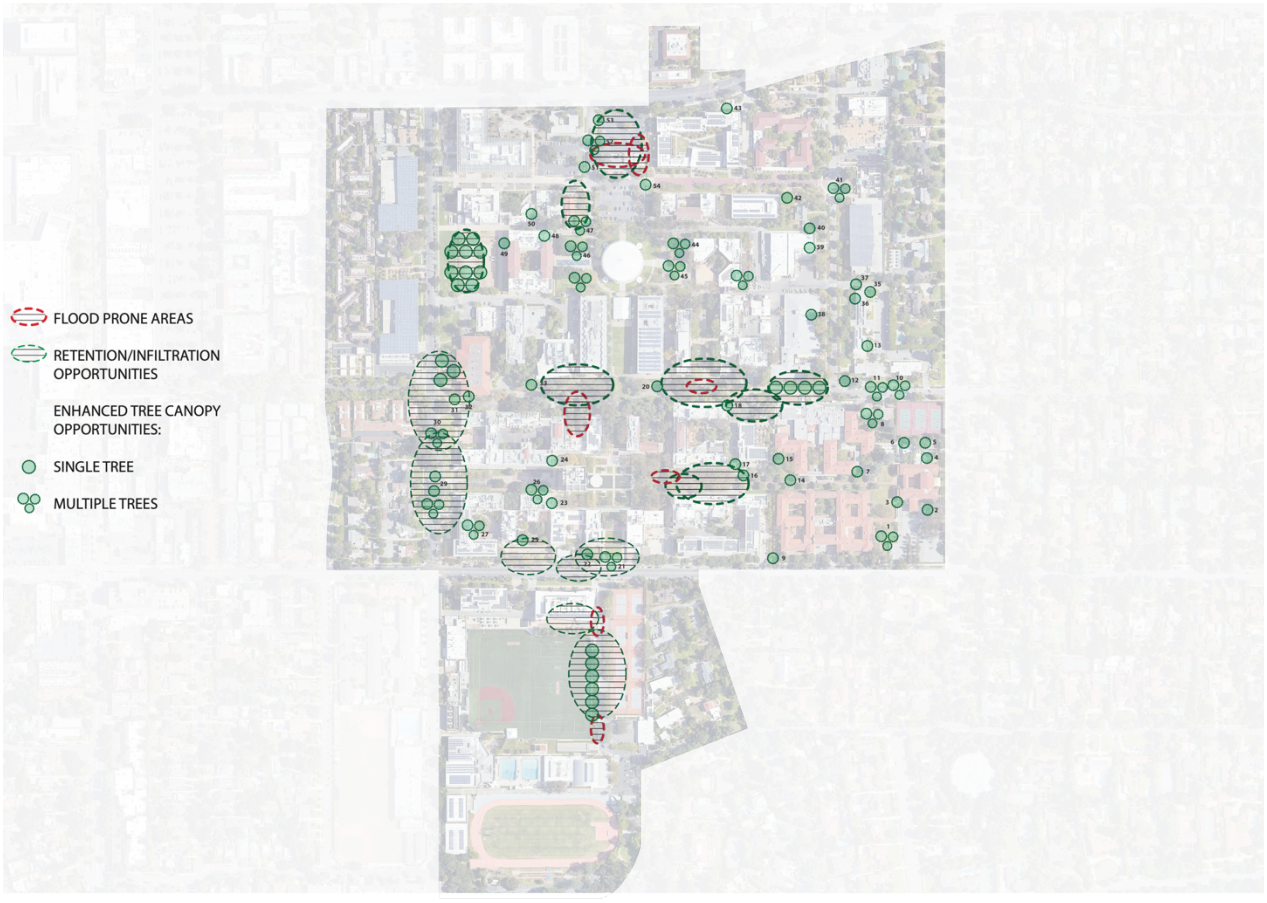

Figure 3.
LANDSCAPE ANALYSIS
FLOOD PRONE AREAS/ STORM WATER INFILTRATION & RETENTION OPPORTUNITIES/
TREE CANOPY INCREASE OPPORTUNITIES
Draft February 12,2024

LANDSCAPE SYSTEMS AND COMPONENTS

Pre-Design Assessment and Planning

The consultant team recommends that Caltech formulate and adopt specific pre-design assessment and planning procedures for all projects and project components concerning the campus landscape and related infrastructure components noted herein. These include initiatives of Buildings and Grounds, Capital, and Ad-Hoc Projects. Participants would include representation of the Sustainability Office, Planning, Design and Construction, Buildings and Grounds, and consultant campus landscape architect and civil engineer.

Site Design Requirements and Guidelines

> *DUE TO CLIMATE CHANGE, Californians are experiencing higher average temperatures and should expect more frequent and severe heat waves in coming decades. A now well-established body of research demonstrates that heat exposure has diverse and damaging impacts. Our physical and mental health suffers in a myriad of acute and chronic ways. Students learn less. Workers experience more accidents.* — Adapting to Extreme Heat in California – UCLA Luskin Center publication 2020.

The form, structure, and character of the Caltech campus landscape — its morphology and performance — will be derived from attention to the Guiding Principles, the Framework Plan,
and the specific requirements of design guidelines for each interrelated and interdependent component.

These components include Landscape Form and Structure; Air and Climate; Water and Surface Hydrology; Urban Forest, Soils, Tree Canopy, and Understory Vegetation; and Safety/Security/Support Systems.

Landscape Form and Structure

1. Design of landscape form and structure must address both the aesthetic, programmatic, and performance requirements of each particular project location as well as its relationships with the campus landscape framework as a whole.
2. Landscape form and structure should express their interwoven relationships with the presence and processes of the surrounding environment.

Air and Climate

1. Design of all landscape components must address and mitigate impacts on health and safety related to ambient outdoor air temperature environment conditions in the context of increasing incidence of extreme heat (90º–95º F) events on the campus.
2. Design responses must comprehensively reduce heat gain from incident and reflected solar radiation affecting both landscape and building components with the

introduction of trees and other elements providing shade and increased air circulation and cooling.

3. Design teams should advance landscape and building projects in the context of urban and campus heat action planning generally, including thermally comfortable pedestrian environment initiatives. (See Appendix A)

Water and Surface Hydrology

1. Water management in the campus landscape must respond to changing regional and local climate and weather conditions, including extended periods of drought and increased intensity of rainfall events. These conditions require on-site development of increased capacity for retention and infiltration of stormwater (See Figure 4, *Flood-Prone Areas*) and conservation of water for landscape irrigation.

Figure 4.
LANDSCAPE ANALYSIS
FLOOD PRONE AREAS
Draft March 15, 2023

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2. Design teams must fully integrate stormwater best management practices into all projects, including the provision of ground plane surfaces and structures for

retention and infiltration of stormwater. Ongoing Stormwater Management investigations by Psomas Associates identify opportunities throughout the Caltech campus, including areas related to major east-west corridors:
Moore Walk; San Pasqual; Olive; and California Boulevard in addition to opportunities adjacent to the north-south corridors represented by the Wilson Avenue corridor along the west perimeter of the campus and the central Beckman Mall spine. (See Figure 5, *Stormwater Infiltration & Retention Opportunities*, and Appendix B)

Figure 5.
LANDSCAPE ANALYSIS
STORM WATER INFILTRATION & RETENTION OPPORTUNITIES
Draft March 15, 2023

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3. Design in the landscape for water conservation must employ low water use, climate and drought adapted plant species and species associations, and compatible soil

surface and soil structural design and management practices along with specified high efficiency irrigation control and delivery systems. (See Appendix C)

4. Design expressions of water should contribute to ambience of selected places on the Caltech campus and emphasize its central cultural, historic, and present importance to the region. The preciousness and unique qualities of water should be emphasized, celebrating its presence through all of the senses through the use of effects such as "zero-depth" moving films, fogs, and mists.

Existing campus water features and fountains will be evaluated for the feasibility of potential modifications including displacement of fountain standing water areas with "stone mulch" or other inert materials, or appropriate plantings. Additionally, the use of condensate water from HVAC systems will be evaluated.

Urban Forest, Soils, Tree Canopy, and Understory Vegetation

Urban Forest

A distinguishing feature of Caltech is its "urban forest" of over 3,300 trees extending throughout its over–265-acre campus. These include an array of mature shade trees that can reduce air temperature as much as 45 degrees Fahrenheit beneath their canopies.[1]

Design and management of Caltech's urban forest must emphasize the importance of its role in providing essential environmental health and safety benefits to the campus community as well as its contribution to the campus identity and aesthetic values.

Soils

The establishment and maintenance of soil conditions necessary for the long-term viability of plants must be incorporated into design and management for all new and existing landscapes.
These include provision of adequate soil aeration and drainage, control of evaporation through surface treatment (mulching) and shading, nutrients, and soil micro-organisms. (See Appendix C)

Tree Canopy

1. Designs in the landscape must provide for the augmentation of the campus tree canopy with appropriate tree species. Such trees must be installed at a size to provide an effective canopy over at least 60% of the area of activity spaces and movement corridors within a period of three years of their introduction. Potential locations for enhancement of the existing tree canopy are identified on the *Tree*

[1] *1. EPA, "Using Trees and Vegetation to Reduce Heat Islands," accessed March 27, 2019, https://www.epa. gov/heat-islands/using-trees-and-vegetation-reduce – heat-islands#1.*

Canopy Increase Opportunities diagram (Figure 6.)

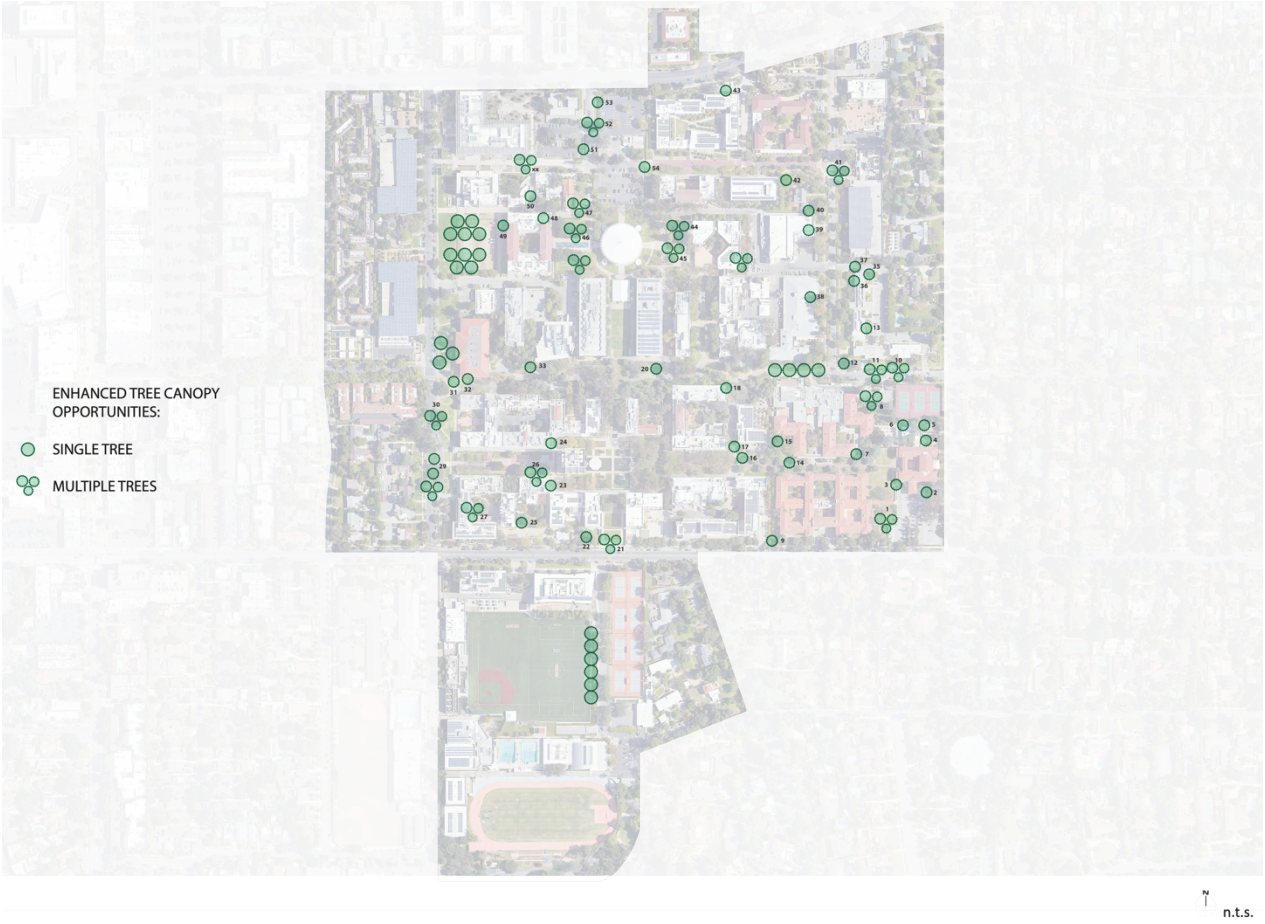

Figure 6.
LANDSCAPE ANALYSIS
TREE CANOPY INCREASE OPPORTUNITIES
February 12,2024

CALTECH LANDSCAPE DESIGN PRINCIPLES
Caltech Buildings and Grounds/ Campbell & Campbell

Suggested canopy and accent tree species selected for their performance, climate adaptability, long-term viability, and habitat value are noted in the recommended plant list, which includes conditional listings in the case of species currently over-represented on the campus. (See Appendix C)

2. On-site evaluations of the health and long-term viability and safety of existing canopy and landmark trees should be made to supplement the existing campus tree inventory database in connection with all projects, allowing determination to be made regarding their retention, required pruning and other management practices, or replacement.

Understory Vegetation

1. The understory vegetation of the campus landscape along with the tree canopy must also address heat mitigation, providing moderation of temperature and relative

humidity, and cooling of ground surfaces, irrigation water conservation, and facilitation of stormwater management.

2. Suggested understory trees, shrubs, groundcovers, and vines selected for their performance, climate adaptability, long-term viability, and habitat value are noted in the recommended plant list, which includes conditional listings in the case of species currently over-represented on the campus. (See Appendix C)
3. See Appendix C for detailed planting guidelines related to growth habits, orientation, wind, irrigation, seasonal color, etc.
4. The use of turf in the landscape should not be continued, except in selected areas related to ceremonial gatherings, historic settings, and sports activities. Turf areas where irrigation has been halted are shown on the *2022 Water Conservation Areas* diagram (Figure 7.)
5. As continuous pruning and clipping of understory vegetation is extremely labor intensive and associated with increased irrigation water consumption and decline in plant health and habitat value, understory plants should be selected for their natural forms and used in massed arrays, requiring little or no pruning.

Figure 7.
LANDSCAPE ANALYSIS
2022 WATER CONSERVATION AREAS
Draft March 15, 2023

Paving, Site Furnishings, and Other Amenities

1. Current Caltech Campus Design Guidelines (See V5.4, Exterior Improvements Sections 32 10 00 and 32 33 00) provide detailed guidelines and standards for Paving and Site Furnishings on the Caltech campus. These include ADA Universal Access requirements.
2. These standards and guidelines provide baselines for design. As noted therein, every project should consult with the Caltech project manager and Caltech Grounds Maintenance prior to selections, as priorities for specific projects may include expressions of historic or other contexts calling for alternative solutions.

Safety/Security/Support Systems

Design in the campus landscape from earliest programmatic and conceptual phases through construction must accommodate and organically incorporate all Caltech environmental health and safety, campus security, and infrastructural and operational support requirements into all projects.

APPENDIX A

Climate/Weather/ Solar Radiation/Air Quality
Public and private entities, including institutional and governmental bodies in the United States, are developing policies and action plans to fight the growing hazard of urban heat. These focus on both heat response (helping people cope with hot weather) and heat mitigation (cooling the environment and making it more comfortable).

References:
Adapting to Extreme Heat in California — UCLA Luskin Center publication 2020.

C40 CITIES ORGANIZATION
https://www.c40.org/about-c40/, https://www.c40knowledgehub.org

CITY OF PHOENIX, AZ
City of Phoenix, AZ, office of Heat Response and Mitigation,
https://www.phoenix.gov/heat

APPENDIX B

Water and Surface Hydrology
See Table 2.1 (Stormwater Management Opportunities)

Recommended Best Management Practices

References:
SITES V2 RATING SYSTEM for Sustainable Land Design and Development – Sustainable Sites Initiative, Green Business Certification, Inc., June 2015

Flood Prone Areas and Stormwater Retention/infiltration Opportunity/Mitigation areas
Initial identification of site stormwater retention opportunities and flood prone areas and mitigations include the following to date (see also Landscape Analysis Figure 4, *Flood Prone Areas,* and Figure 5, *Retention & Infiltration Opportunities*):

I. North side of California Boulevard

1. San Pasqual Walk — south of Keck Lab (Building 78). This location, receiving stormwater flows from the north and from the east (Bldg. 78, 79, 81, and 95), contains paved walkways, mounded turf areas to which irrigation has been halted, massed shrub plantings, and numerous signature skyline trees. Existing conditions limit infiltration and retention opportunities, and leaf litter from trees has been observed to block drain grates, resulting in localized flooding.

2. Throop Memorial Garden — northeast edge south and west of Dabney Hall and Gates-Thomas Lab (Bldgs. 40 and 44). Walkways from the north and east appear to receive principal stormwater flows to this area. As noted for San Pasqual Walk, existing conditions limit infiltration and retention opportunities, and leaf litter from the trees has been observed to block drain grates, resulting in localized flooding.
3. Wilson Corridor East Side — Campus Entries at Olive/Bechtel Walk and Beckman Lawn.
4. Hameetman Center / Red Door Café North
5. Moore Walk

Mitigation opportunities in these areas could involve a combination of interventions, including land-form reconfiguration, access path realignments and reconstruction to provide stormwater flow diversion, subsurface landscape soil profile and drainage structures, and replacement of turf areas with appropriate groundcovers.

II. South side of California Boulevard

1. East side parkways adjacent to the tennis courts
2. Planted area south of Cahill Center (Bldg. 17), and at the west side sloped parkway between the sidewalk and Parking Structure 3 (Bldg. 126)

Exhibit 1.0 Stormwater Mitigation Diagrams

Table 2.1 Stormwater Management Opportunities

Name/Location	Existing Condition	Opportunity	Constraints and Impedences
Parking Lot 10	Construction staging area. The southern portion of Parking Lot 10 was reconstructed as part of the Moore Walk project. Drainage facilities for Moore Walk were designed to accommodate stormwater treatment requirements. The project included collection and infiltration of stormwater from the extended Moore Walk and affected portions of Michigan Avenue, Lot 11, and Lot 10. A hydrology was performed for the project that included Lot 10. Flooding in Lot 10 appears to be caused by an undersized catch basin which was replaced with a larger one and connected to the new infiltration system.	N/A	N/A
Keck Center Lawn	Keck Center Lawn is adjacent to the Moore Walk project and contributes a small amount of stormwater to the new infiltration system.	The Keck Center Lawn could serve to mitigate or assist in potential overflow from the new Moore Walk storm drain due to acute elevated rainfall intensity. This would include design for surface infiltration.	N/A
Resnick Construction Zone	This area is completely obstructed for construction staging severely limiting observation opportunities. Civil and landscape plans should be provided by Caltech for review. It is assumed those plans include LID provisions for the current construction project.	unknown	Utility Tunnel C is shown on the Topo Map going through this area limiting subsurface conveyance and infiltration opportunities.

Name/Location	Existing Condition	Opportunity	Constraints and Impedences
Braun/Church/ Kerckoff Lawn	Lawns on the west edge of the campus are generally graded gently to the back of sidewalk. The areas consist of fairly vast and open grass areas with limited flatwork and trees. Tunnel C runs parallel to the west edge of the campus in this area.	These areas can be modified to collect and treat or infiltrate stormwater. Since there is no project or land disturbance triggering LID requirements, Caltech may consider a landscape/ streetscape project to beautify the campus that voluntarily treats stormwater prior to discharge. This type of project will also attenuate stormwater runoff which will assist with flood mitigation. Biofiltration and/or detention can be used to achieve this.	Utility Tunnel C is shown on the Topo Map going through this area limiting subsurface conveyance and infiltration opportunities. The watershed associated with these lawns appears to be quite limited based on the topography. There are utility lines (water, sewer, etc.) that would need to be better identified and mapped.
Wilson Avenue Median	The median is a large planted area in the center of Wilson Avenue, which is public right of way.	Not a significant opportunity for stormwater treatment.	The median is in the crowned portion of the road, thus elevated above the adjacent flatwork. A drainage system designed to capture and impound water at this location could be very expensive. Mature trees in the median will impede construction and maintenance of a storm drain system and may not thrive in a median repurposed for stormwater capture. This area is City of Pasadena right of way. Permitting requirements will certainly be arduous, and the city will likely require Caltech to maintain the facility.

Name/Location	Existing Condition	Opportunity	Constraints and Impedences
Arms Circle	Arms Circle consists of flatwork that experiences vehicle traffic bordered by lush planted areas with low planting and some trees. The area slopes gently to the south toward California Blvd. and there is a trench drain at the back of the public sidewalk that is intended to prevent stormwater from surface flowing offsite. It is assumed that the trench drain discharges directly to the storm drain system. There are utilities in the area as evidenced by surface indications that are not well documented on the utility map and survey provided.	Given the topography and function of the area, Arms Circle presents an excellent opportunity to voluntarily enhance stormwater quality and attenuate and diminish discharge to the storm drain system. Planters and storm drain inlets can be modified to collect, treat, and detain stormwater prior to discharging or infiltrating. Only similar or slightly enhanced maintenance would be required. Such a project could also beautify this publicly high profile area of campus.	The disposition of the utilities does not appear to be well documented. Landscape architect will need to confirm disposition of existing trees for modified planters.
Bridge, Linde Hall	The lawns at Bridge and Linde Hall are flat, expansive areas with very minimal slope to the south toward California Blvd. Portions of these areas are framed with planters containing shrubs. The flat lawns are at different elevations or tiers.	Stormwater can be efficiently captured and directed to the lawn areas that could be partially or completely replaced with drought tolerant vegetation. The tiered nature of the lawns presents an opportunity to interconnect stormwater conveyance in these vegetated areas. These areas can be used to treat and discharge or infiltrate while attenuating flow.	The watershed for this area consists mostly of the existing lawns, so there is not a very significant amount of concentrated stormwater to capture from the surounding flatwork. Stormwater from adjacent building roofs could be evaluated for flow rate to this area. However, roof drainage does not present the same treatment value as it typically does not contain silt, trash, leaves, chemicals, etc., but it can be attenuated effectively. Demonstrating sustainability by replacing the lawns may convey a great message, but that would need to be weighed against the lawn's very "collegiate" aesthetic for this important gateway to the campus.

Name/Location	Existing Condition	Opportunity	Constraints and Impedences
Cahill Rear Lawn	The lawn on the south side of the Cahill building includes fairly dense tree planting. The area is fenced off and appears to be elevated from the surrounding areas.	Area may be considered for evaluation in an integrated solution for the flooding in South Campus Drive.	Opprtunities are limited due to the elevated topography, isolation of the area, dense trees, and lack of surface stormwater.
South Campus Drive	South Campus Drive is designed similar to a public roadway with curb, gutter, and sidewalk. There is a large steeply sloped planted area between the street and the parking structure. Drainage improvements in this area are not adequate, which makes it prone to flooding.	The sloped planter may be suitable for stormwater capture, but the intended function with respect to this aspect is not certain as it is currently constructed. South Campus Drive should be surveyed and analyzed in detail to develop an integrated solution for the flooding and stormwater treatment.	
Throop/Olive Walk	Olive Walk is "mall" area consisting of planted areas (trees and grass) and hardscape that runs east/west with the west terminus at the Throop Memorial Garden. Olive Walk slopes very slightly from west to east. There is a flood prone area at the Throop Olive Walk intersection, which is due to marginally adequate drainage that is somewhat difficult to maintain. The planter ground surface at Olive Walk is generally elevated above the surrounding flatwork.	Olive Walk presents a great opportunity to create stormwater capture in the planter areas, which could help to alleviate the drainage issue at Throop. This would work well as a sustainability demonstration project.	The planter mounds would need to be removed creating soil export and expense. Lawn space currently available for congregation would be diminished; however, staff says students do not take advantage of this area at all. The landscape architect must confirm the disposition of the mature trees if this area is to be repurposed as such.

Name/Location	Existing Condition	Opportunity	Constraints and Impedences
San Pasqual Walk	This portion of San Pasqual Walk is just south of Keck Engineering Lab and is identified as a flood prone area. This is a local low point of the topography creating a sump condition. There is a drain inlet at the low point; however, the inlet is prone to clogging and difficult to maintain. The planted areas here are mounded. There is a county storm drain and other utilities at this location.	There are several solutions that can be employed to remediate the flooding such as installing a dry well, elevating the grade of San Pasqual Walk, installing larger or additional inlets, sump pumps, or a combination of these. The planter may be excavated for stormwater collection and storage.	A constructed solution to decouple the sump condition with an integrated walking path will be costly. No solution will be very economical. There is a county storm drain that may be integral to the solution, but is an impedance as well.
San Pasqual			
San Pasqual West	San Pasqual Walk is at the entrance of Beckman Lab and is identified as a flood prone area.	The specific cause of the localized flooding is unknown. The provided topographic survey does not show enough detail to be conclusive. The problem should be evaluated via an engineering evaluation starting with a detailed topographic survey. There is a planted area just north of the service yard that appears to be suitable for stormwater collection from this area.	The problem simply requires engineering evaluation which involves some cost.

APPENDIX C

Urban Forest, Soils, Tree Canopy, Understory Vegetation, and Irrigation

Soils
(to be developed)

Tree Canopy Increase Opportunity Areas
Initial identification of potential tree canopy increase is shown in the "*Tree Canopy Increase Opportunities*" diagram.

In addition, preliminary supplementary tree species candidates for review for potential priority areas identified to date include:

1. South Campus Drive west side at Parking Structure 3 — TBD
2. Wilson Avenue: at "Old West Gate" entry frontage (a completed and approved planting plan can be supplemented with additional trees), Braun Labs frontage, and Beckman Lawn frontage — Quercus Engelmanni
3. East San Pasqual Walk: at Red Door Cafe frontage and Facilities (Bldg. 83) frontage — TBD
4. California Blvd. South Campus Gate area — TBD

Initial identification of potential areas for evaluation included:

I. North side of California Boulevard

1. Wilson Avenue Corridor – east side, fronting Bldgs. 18, 96, 74, 75, 29, 27, 23 21, 19 (RSI)
2. East San Pasqual Walk – north side, fronting Bldgs. 51, 52, 83
3. Courtyard – fronted by Bldgs. 43, 41, 44
4. California Boulevard Corridor – fronting Bldgs. 24, 25, 33W, 34, 33E, 37

II. South side of California Boulevard

1. Areas south of Bldgs. 6, 17
2. Area east of Bldg. 126 (parking structure 3) (See item 7. Below)

In addition to these areas, numerous other areas identified by the Campus Arborist are included in the updated Landscape Analysis "Tree Canopy Increase Opportunities" Plan, attached. For many of these locations, a photo record has been made, with the

numbers adjacent to the tree symbols keyed to the photo. When complete, this photo library will be added to the documents. While the full extent of these areas has not been determined, it is estimated that opportunities for additional tree canopy totals over 200,000 square feet (approximately 5 acres).

As part of the tree canopy evaluation, the selective management for preservation and phased transition of campus redwoods to other species has been evaluated.

Preliminary observations of redwood trees in the central areas of the campus have been completed and have identified trees for consideration of potential near- and medium-term removal and replacement west of Watson Labs (Bldg. 95). Replacement candidate trees being considered include *Libocedrus decurrens* (Incense Cedar). Additionally, high fire risk trees have been identified in accordance with the Los Angeles County and California State Wildfire Risk evaluations**.**

Plant Palette

Recommended plants are selected to thrive on Caltech's Pasadena campus into a future that will see increasing aridity in the region's "coastal desert" environment.

Species selected to provide ecosystem services to the campus are low maintenance, resource conserving (especially water), and provide habitat for beneficial fauna especially birds and insects. Additionally, they are proven over the long-term in similar settings with institutional maintenance. Aesthetically they enhance and extend the historic beauty, integrity, and continuity of the campus. Wherever appropriate they contribute to the reinvigoration of significant existing plantings while reducing irrigation and maintenance requirements.

The recommended plant list is general, designating genus and species. Some genera and species contain one or two cultivars, others many. These can vary greatly in size, bloom, vegetation, etc. Since cultivar development is ongoing, the list does not include the full range for each species except for those particularly recommended.

Detailed planting plans for specific projects must carefully designate and site plants according to adjacencies, horticultural affinities, and cultural needs of orientation, sun/shade and prevailing wind patterns, irrigation or not, seasonal vegetation and bloom color and cycle, growth habits, etc. Mindful of installation and mature sizes, these designs must also specify appropriate spacing from walks, walls, structures, lighting, and each other.

Plants are listed by botanical name, common name, and WUCOL irrigation designation for Caltech as M (Moderate), L (Low) and Very Low (VL) water use. In our decades of experience designing large-scale landscapes in Southern California, WUCOL designations are broad therefore do not necessarily reflect specific conditions that contribute to long-term drought adaption and should serve only as a guide. Many of

the plants listed as requiring moderate irrigation for example, can thrive on low quantities of added moisture.

TREES

Small

1. Aesculus californica – California Buckeye, L
2. Agonis flexuosa – Peppermint Tree, L
3. Bauhinia x blakeana – Hong Kong Orchid Tree, M
4. Callistemon citrinus – Lemon Bottlebrush, L
5. Callistemon viminalis – Bottlebrush, L
6. Cassia leptophylla – Golden Rain Tree, M
7. Cercis occidentalis – Western Redbud, L
8. Chioanthus retusus – Chinese Fringe Tree, M
9. Cupressus sempervirens – Italian Cypress
10. Dracaena draco – Dragon's Blood Tree, L
11. Lagerstroemia indica hybrids and cvs. – Crape Myrtle, M *
12. Laurus nobilis – Grecian Laurel, M
13. Laurus 'Saratoga' – Saratoga Laurel, M
14. Stenocarpus sinuatus – Firewheel Tree.M
15. Metrosideros excelsa – New Zealand Christmas Tree

Provisional (under review):

X Chitalpa tashkantensis – Chitalpa
Chilopsis Llinearis – Desert Willow
Melaleuca nesophila – Pink Melaleuca
Hesperocyparis forbesii – Tecate Cypress
Cotinus coggygria – Smoke Tree
Prosopis pubescens – Screwbean Mesquite
Adenostoma sparsifolium – Red Shanks
Aesculus californica – California Buckeye

Medium

1. Arbutus unedo – Strawberry Tree, L
2. Bauhinia fortificata – White Butterfly Tree, M
3. Geijera parviflora – Australian Willow, M
4. Hymenosporum flavum – Sweetshade, M
5. Magnolia grandiflora cultivars – Southern Magnolia, M
6. Michelia doltsopa – Sweet Michelia, M
7. Olea europa cultivars – Olive L
8. Lyonothamnus floribundus ssp. asplenifolius – Santa Cruz Island Ironwood, L
9. Podocarpus henkelii – Long Leafed Yellow-wood, M *
10. Tristania conferta (Lophostemon confertus) – Brisbane Box, M
11. Umbellularia californica – California Bay, M

Provisional (under review):

Yew Pine – Podocarpus Macrophyllus
Gleditsia triacanthos var. inermis – Thornless Honey Locust
Corymbia ficifolia – Red Flowering Gum
Melaleuca linarifolia – Flaxleaf Paperbark
Schinus terebinthifolia – Brazilian Pepper

Large

1. Aftrocarpus falcatus (Podocarpus falcatus) – African Fern Pine.M
2. Afrocarpus elongatus cultivars (Podocarpus gracillor) – Fern Pine, M
3. Brachychiton discolor – Queensland Lacebark, L
4. Brachychiton populneus – Bottle Tree L
5. Castanospermum australe – Moreton Bay Chestnut, M
6. Cedrus deodara – Deodar Cedar, M
7. Cedrus libani – Lebanese Cedar, M
8. Ceiba speciosa – Floss Silk Tree, cultivars, L
9. Cinnamomum camphora – Camphor Tree, M
10. Corymbia citriodora (Eucalyptus) – Lemon-scented Gum *
11. Dombeya caccuminum – Strawberry Snowball Tree, M
12. Eucalyptus sideroxylon var. rosea – Red Ironbark, L
13. Ficus rubiginosa cultivars – Rusty-leaf Fig, M
14. Ginkgo biloba selections and cultivars – Ginkgo, M
15. Jacaranda mimosifolia – Jacaranda, M *
16. Koelreuteria bipinnatta – Chinese Flame Tree, M
17. Pistachia chinensis – Chinese Pistache Tree, L
18. Pinus canariensis – Canary Island Pine, M
19. ~~Pinus halepensis – Aleppo Pine, L~~ (Identified High Fire Risk)
19. **Pinus brutia ssp. Eldarica, L**
20. Pinus pinea – Italian Stone Pine, L
21. Platanus racemosa – California Sycamore, M *
22. Quercus agrifolia – California Live Oak, L
23. Quercus engelmannii – Engelmann Oak, L
24. Quercus tomentella – Island Oak, L
25. Ulmus parvifolia cvr. – Chinese Elm, L

Provisional (under review):

Juglans californica – Southern California Black Walnut
Liriodendron tulipifera – Tulip Tree
Erythrina Caffra – Coral Tree
X Hesperotropsis leylandii – Leyland Cyrpress
Quercus Suber – Cork oak
Albizia Julibrissin – Silk Tree
Grevillea robusta – Silk Oak
Pinus ponderosa – Ponderosa pine

Taxodium mucronatum – Montezuma Cypress

**Tree use in proposed setting is conditional as tree is currently considered overused on Caltech campus*

Palms and Cycads:

1. Archontophoenix cunninghamiana – King Palm, M
2. Brahea armata – Blue Hesper Palm, L
3. Brahea brandegeei – San Jose Hesper Palm, L
4. Brahea edulis – Guadalupe Island Palm, L
5. Butia capitata – Pindo Palm, L
6. Cycas revoluta – Sago Palm, M
7. Chamaerops humilis – Mediterranean Fan Palm, L
8. Jubaea chilensis – Chilean Wine Palm, M
9. Livistona chinensis – Chinese Fan Palm, M
10. Phoenix dactilifera cvr. – Date Palm, L
11. Phoenix reclinata – Senegal Date Palm, M
12. Phoenix roebelenni – Pigmy Date Palm, M
13. Trachycarpus fortunei – Windmill Palm, L
14. Washingtonia filifera – California Fan Palm, L
15. Washingtonia robusta – Mexican Fan Palm, L *
16. Zamia furfuracea – Cardboard Palm, M

Shrubs:

1. Abelia hybrids and cultivars – Glossy Abelia, M
2. Berberis nevinii – Nevin Mahonia, L
3. Berberis olwakensis – Chinese Holly, M
4. Bougainvillea cultivars (shrub) L
5. Calliandra tweedii – Trinidad Flame Bush, L
6. Callistemon cultivars – Bottlebrush, L
7. Camellia japonica hybrids and cultivars – Camellia, M
8. Camellia sasanqua hybrids and cultivars – Sasanqua Camellia, M
9. Carpenteria californica ‘Elizabeth’ – Elizabeth Bush Anemone, L
10. Ceanothus species, hybrids, and cultivars, (tend to be short lived), L.
11. Chamelaucium uncinatum species and cultivars – Geraldton Waxflower, L
12. Cocculous laurifolius – Cocculous, M
13. Cuphea ‘David Verity’ – Large Firecracker Plant, L
14. Feijoa sellowiana – Pineapple Guava, M
15. Grevillea species and cultivars – Grevillea, L
16. Grewia occidentalis – Lavender Star Flower, M
17. Heteromoles arbutifolia – Toyon, M
18. Ilex species, hybrids, and cultivars – Holly, varies M, L
19. Justicia brandegeeana – Shrimp Plant, L
20. Lantana and cultivars – Lantana L

21. Ligustrum japonicum texanum – Japanese Privet, M
22. Malvaviscus arboreus – Turk's Cap, M
23. Myrica californica – Pacific Wax Myrtle, M
24. Myrtus communis – True Myrtle, M
25. Osmanthus fragrans – Sweet Olive, M
26. Pittosporum tobira species and cultivars– Mock Orange, M
27. Plumbago auriculata cultivars – Cape Plumbago
28. Rhapiolepis indica selections and cultivars – Indian Hawthorne.M
29. Rhapiolepis umbellulata and cultivars – Yeddo Hawthorne, M
30. Rosmarinus selections and cultivars – Rosemary, L
31. Westringia and cultivars – Coast Rosemary, L
32. Xylosma congesta – Shiny Xylosma, M

Vines:

1. Bauhinia fortificata – Red Orchid Bush, M
2. Clytostoma callistegoides – Lavender Trumpet Vine, M
3. Distictis buccinatoria – Blood-red Trumpet Vine, M
4. Macfadyena unguis-cati – Cat's Claw Vine, M
5. Parthenocissus species and cultivars – Parthenocissus, M
6. Pyrostegia venusta – Flame Vine. M
7. Rosa banksiae – Lady Banks Rose, M
8. Solandra maxima – Cup of Gold Vine, M
9. Vitus 'Rogers Red' – Rogers Red Grape Vine, M
10. Wisteria species and selections – Wisteria, M

Long-Lived Perennials, etc.:

1. Adiantum capillius-veneris 'Banksianum' – Maidenhair Fern, M
2. Agapanthus selections and cultivars, M
3. Clivia species, hybrids, and cultivars – Clivia, M
4. Hemerocallis cultivars – Daylily, M
5. Iris 'Nada' – Butterfly Iris, M
6. Kniphofia species, hybrids, and cultivars – Hot Poker, L
7. Microlepia strigosa – Lace Fern, M
8. Phormium selections, hybrids, and cultivars – New Zealand Flax, M
9. Polystichum munitum – Claifornia Sword Fern, M
10. Strelitzia reginae – Bird of Paradise, M
11. Woodwardia fimbriata – Giant Chain Fern, M

Provisional (under review):

Indian Mallow
Bush monkey Flower
Brittlebush
California Fushia
Island Snapdragon

Pitcher Sage
Sage sp – White/Cleveland/Hummingbird/etc
Apricot Mallow
Big Berry Manzanita
Artemisia
California Buckwheat
Narrowleaf Milkweed
Turpentine Bush
Elderberry
Ceanothus sp.
Flannel Bush

Groundcovers:

1. Berberis aquifolium var. repens – Creeping Barberry, L
2. Cotoneaster dammeri hybrids and cultivars – Bearberry Cotoneaster, M
3. Lantana montevidensis selections and cultivars – Lantana, M
4. Rosemarinus officinalis cultivars especially 'Huntington Carpet' – Trailing Rosemary
5. Ruscus hypoglossum – Butcher's Broom, L
6. Tracelospermum jasminoides – Star Jasmine

Cacti, Succulents, and relatives:

1. Aeonimium – species, hybrids, and cultivars – Aeonimium, L
2. Agave species, hybrids, and cultivars (only unarmed) – Agave, L
3. Aloe species, hybrids, and cultivars – Aloe, L
4. Bilbergia nutans – Queen's Tears. L
5. Cistanthe grandiflora 'Jazz Time' – Rock Purslane, L
6. Doryanthus palmeri – Giant Spear Lily, L
7. Dudleya species and cultivars – Live Forever, L
8. Euphorbia species and cultivars – Euphorbia, L
9. Furcraea species and selections – Furcraea, L
10. Mangave cultivars and hybrids (unarmed only) – Mangave, L
11. Yucca species and selections – Yucca, L

Irrigation Delivery Systems

In concert with design for heat gain mitigation, surface hydrology and soil remediation, and climate appropriate planting design, the provision of high efficiency irrigation delivery systems is required for all landscape projects. Current Caltech Campus Design Guidelines (See V5.4
Exterior Improvements Section 32 80 00) provide detailed guidelines and standards for irrigation components. These guidelines and standards have been established to maintain consistency and compatibility with the current campus-wide and delivery control system and its ongoing management.

References:

Water Use Classification of Landscape Species (WUCOLS) Project.
(For the more information on the WUCOLS project, visit ucanr.edu/sites/WUCOLS/.)