Seeking Streams

A landscape framework for urban and ecological revitalization in the upper Ballona Creek watershed

Prepared For
City of Los Angeles
Department of Public Works, Bureau of Sanitation
Watershed Protection Division

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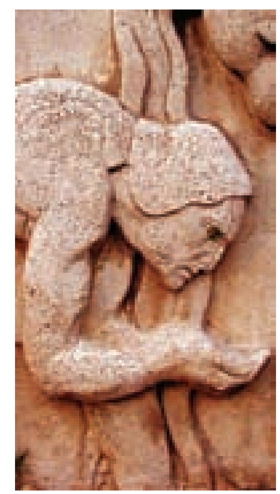

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Introduction

Photo: Wilshire Blvd. and La Brea Ave. In the middle ground can be seen the Arroyo del Jardin de las Flores. A fragment of that stream is preserved in the Wilshire Country Club and through the Brookside Estates neighborhood. The stream in the foreground has no known name. 1922. Courtesy Photo Collection/ Los Angeles Public Library.

Los Angeles has been most often read about, seen metaphorically, and shaped around a theme: arcadian dream, exotic paradise, technological wonder, placeless nowhere (McClung, 2000). The authors of these metaphors, and developers of the city, worked hard to edit out development-impeding geographic features.

These attributes, the historic streams and marshes, supported abundant vegetation and wildlife (Gumprecht, 1999). They are the reason Los Angeles exists where it does, as the city was established along the banks of the Los Angeles River. Early inhabitants were attracted not only to the ocean's edge, but to streambanks as well.

In contemporary Los Angeles these streams have been piped and channelized for development and flood control purposes. Surface runoff that once nourished habitat and was cleansed by waterside vegetation now flows directly into the Santa Monica Bay. It carries with it pollutants common to modern cities, including trash and dissolved heavy metals, that have harmed marine animals and caused beach closures. Reintegrating streams and wetlands into the urban fabric can filter this pollution before it causes problems. Such a strategy, however, can do more than clean stormwater.

Stream corridors can give the city a stronger geographic orientation, create pedestrian links between communities, provide badly needed open space, and connect residents to the wonder of a living stream. Along its route, the stream can infuse a multiplicity of experiences, drawing a person along its course through commercial, industrial, and residential districts. Integration of urban streams can also provide a structure for redevelopment within the city. Development along streams can be built in higher densities because of its proximity to open space. This density can support transit-oriented development that includes a mix of housing and retail establishments. Once again, the development of the city could be centered around the feature that attracted people to Los Angeles in the first place: flowing water.

The overall goal of this project is to provide guidance and inspiration for daylighting streams in the upper Ballona Creek watershed. Ideally, this effort will use ecological processes to address key social and environmental issues.

This project includes three types of plans: long-term framework, stream segment daylighting, and site-specific demonstration.

To ensure a workable structure for daylighting, a long-term framework for redevelopment is needed. Introducing streams back to the city will happen over several decades only as social, economic, and political conditions permit. Stream rights of way must be created, requiring significant land alterations. To provide value for people's daily lives, meaningful connections must be made as part of a larger planning effort. In this way, the city will be able to link streams to community, transit, open space, natural rhythms, and history.

Daylighting efforts will probably happen stream by stream, most likely in small segments. The larger framework will ensure that the smaller segments maximize both community building and environmental benefits, and take advantage of mass transit opportunities. However, guidelines are also needed to ensure smaller projects fit within the long-term effort.

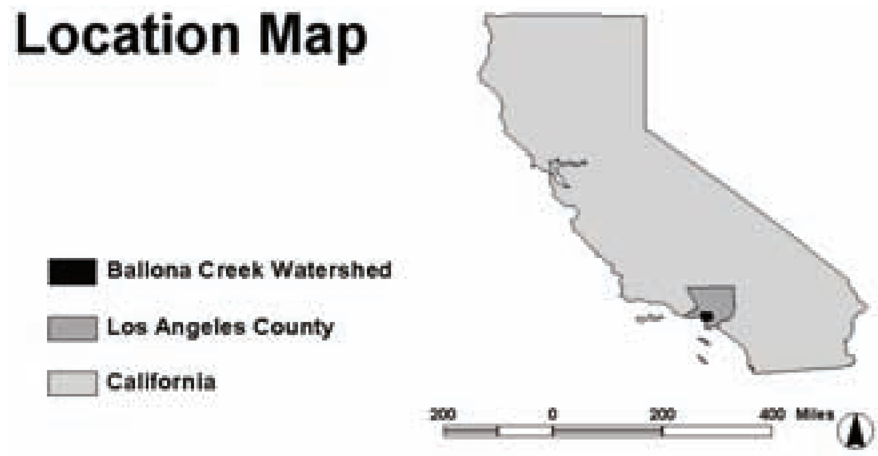
Demonstration projects are crucial for building community support in the short-term. These projects show the value of streams to a community, which creates momentum for achieving the long-term vision.

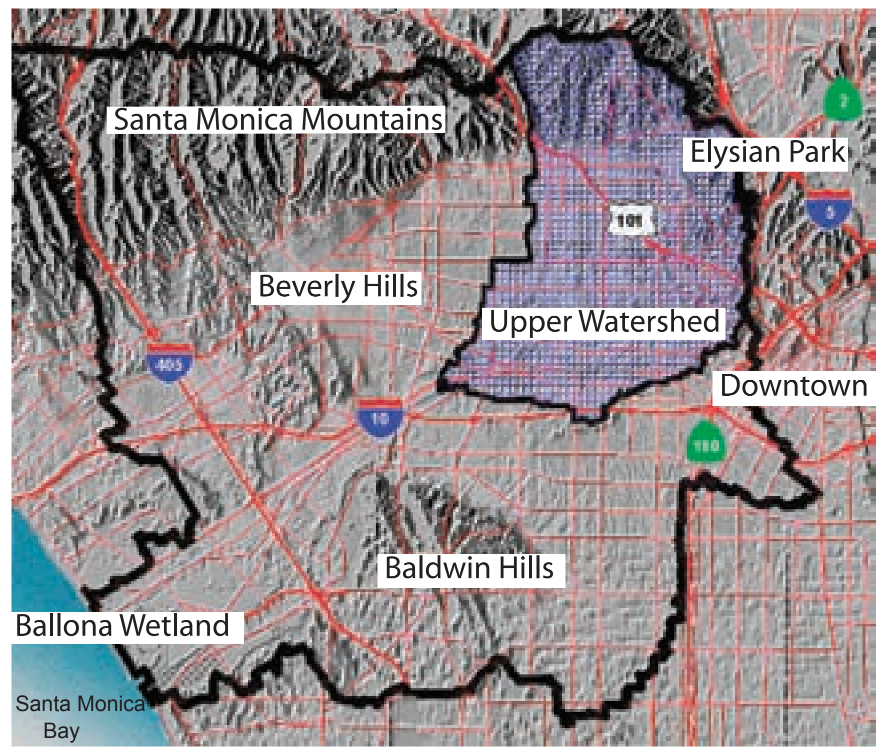
Project Location

The project is located in the Ballona Creek watershed in southern California. This watershed is located in Los Angeles County and encompasses part of the city of Los Angeles as well as several other communities. It extends from the Pacific Ocean to the Elysian Hills, and from the Santa Monica Mountains to the Baldwin Hills. The watershed covers approximately 130 square miles.

Many political jurisdictions share authority in this area, from state and federal agencies like the Santa Monica Mountains Conservancy (SMMC) and the Army Corps of Engineers to the Los Angeles County Department of Public Works and the many cities that occupy the watershed. Forty-six percent—1.6 million people—of the population of the city of Los Angeles live within the Ballona Creek watershed. Its communities are economically and ethnically diverse. This diversity continues to evolve.

The watershed is a focal point of activity within the region. Planning efforts within the watershed typically involve dozens (if not hundreds) of advocates and special interest groups. These efforts require balancing grass-roots citizens' needs and business interests. Efforts to daylight historic streams in the watershed will ultimately require the scrutiny and involvement of many groups.



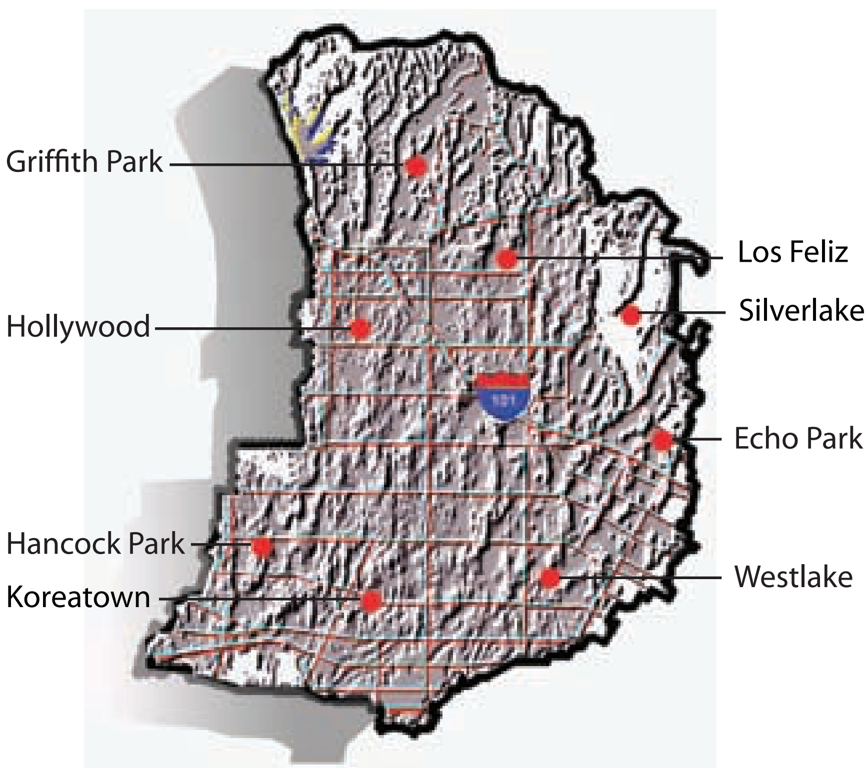


Ballona Creek watershed.

Study Area

The upper Ballona Creek watershed, the project study area, comprises several subwatersheds bordered by Griffith Park in the Santa Monica Mountains to the north and the Elysian Hills and downtown Los Angeles to the east. The area's southern boundary is Washington Blvd. La Brea Ave. marks its western edge. The study area encompasses 22 square miles of densely populated urban communities including Hollywood, Koreatown, Hancock Park, Franklin Hills, and Los Feliz.

The upper watershed was chosen as the study area for several reasons. Because the sponsor for this project was the City of Los Angeles, the study should be within the city limits. There currently are other advocate groups working on restoration and management plans for many areas both within and near the watershed, including the Santa Monica Mountains, the Santa Monica Bay, the Baldwin Hills, the Los Angeles River, Ballona Creek as it runs through Culver City, and the Ballona wetlands near Marina Del Rey. Even with all of this activity, there was a lack of attention to the upper watershed. However, management of water quality must include the upper reaches of a stream in order to reduce downstream pollution. Therefore, solving problems in this area is essential for improving water quality in Santa Monica Bay.



Upper Ballona Creek watershed (study area).

Project Description

Goal

The goal of this project is to provide a framework and vision for daylighting streams within the upper Ballona Creek watershed. This plan will integrate watershed planning and regenerative design principles within an urban context.

…land…is not merely soil; it is a fountain of energy flowing through a circuit of soils, plants, and animals. Food chains are the living channels which conduct energy upward: death and decay return it to the soil. The circuit is not closed; some energy is dissipated in decay, some is added by absorption from the air, some is stored in soils, peats, and long-lived forests; but it is a sustained circuit, like a slowly augmented revolving fund of life. There is always a net loss by downhill wash, but this is normally small and offset by the decay of rocks. It is deposited in the ocean and, in the course of geological time, raised to form new lands…

–Aldo Leopold, *A Sand County Almanac*

Watershed Function

Aldo Leopold's understanding of ecological systems seems particularly relevant in today's planning environment. He understood land as a system governed by natural constraints and boundaries. A watershed represents such a natural boundary because of its interdependent systems. As a result, many agencies are starting to use watershed boundaries instead of political boundaries for planning purposes.

When addressing the goal of integrating watershed planning and regenerative design principles within an urban context, it is necessary to understand the principles behind these concepts. A watershed is an area of land that drains water, sediment and dissolved materials to a common receiving body or outlet. The term is not restricted to surface water runoff and includes interactions with subsurface water. Watersheds vary from the largest river basins to just acres or less in size (EPA, 2000).

The goal of watershed planning is to achieve or emulate overall watershed function. Watershed function refers to the structure, role, diversity and dynamics of a natural ecosystem (Riley, 1998). Ecosystems are essential processes such as the flows and cycles of energy, water, soil, wind and species—including humans (Woodward, 1999). Key functions in a healthy watershed include transport and storage of water, cycling and transformation of nutrients and energy, and ecological succession.

Within the watershed, various forms of matter, including water, are in constant cyclic flow. This flow creates a nonliving base of air, water, and soil. If this base is healthy, life will flourish upon it. The interaction of nonliving and living elements comprise watershed's ecosystem, or structure. However, this structure is affected by varying combinations of climatic, geomorphic, and hydrologic processes (EPA, 2000).

Life's necessities ultimately come from the landscape and its ecosystems. Regenerative design is concerned with providing the necessities of daily life—energy, shelter, water, and food—through self-maintaining systems. Integral to this approach is working within the capacity of natural systems, and promoting their ability to recycle energy. Thus, natural and social processes must be integrated to promote overall ecological health (Lyle, 1994).

Integrating regenerative design concepts into urban watershed planning will improve the ecological health of a city and its surroundings. Residents will be the ultimate beneficiaries.

Planning Objectives

Objectives include supporting the process of stream reach and land parcel prioritization as well as the design and management of those parcels for planned vitality.

- To prioritize stream reaches for daylighting based on relevant criteria including: available land; zoning; plan correlations; property values; deficiency of open space; need for neighborhood and transit links; stormwater issues; and historical, natural, and cultural significance of the land.

- To express the region's natural and cultural past and present through stream design, native plantings, and use of local art.

- To rehabilitate watershed function to improve stormwater management using best management practices and/or mimicking natural processes.

- To increase public open space and use it to provide linkages to nodes within the community.

- To establish safe alternative transportation routes with links to transit stops.

- To provide management strategies and key considerations for daylighting streams.

Project Issues

In order to create an effective plan for daylighting streams, several factors must be considered. There are challenges that will face the city of Los Angeles—and many other urban areas—over the coming years. However, in order to prepare for the future, one must understand current issues.

Many of these issues resulted from efforts to maximize space for private development by claiming space occupied by natural systems. In the past cities have considered these systems foes that impede progress. However, in recent years they have been found to be a necessary, integral component of a city for both ecological and civic health. Specifically, the issues affecting the study site are as follows:

- *Point and Nonpoint Source Pollution*: Everyday activities of residents produce a variety of pollutants absorbed by stormwater and taken to Santa Monica Bay, where they cause beach closures and health risks to swimmers.

- *Runoff*: Roofs, roads, parking lots, and other paved surfaces prevent water from soaking into the ground. This causes increased flooding and prevents pollutants from being removed from stormwater by plants and micro-organisms.

- *Utilities*: Systems that provide basic services to city residents are typically located above stormdrains, requiring relocation for stream restoration.

- *Demographics/Open Space*: The upper Ballona Creek watershed has a large number of low-income residents living in dense conditions. Typically, there is little open space for recreation.

- *Spatial Analysis*: Paths, districts, and nodes within the study area are primarily automobile-oriented, resulting in challenges for lower-income residents who don't own cars. Also, the area's many busy roads result in barriers and injury zones for pedestrians. Landmarks are mostly architectural, preventing a clear understanding of the city's topography, hydrology, range of ecosystems, and relationship to the larger environment.

- *Housing Shortage*: An existing housing shortage could either fuel or inhibit redevelopment efforts, depending on zoning priorities.

- *Street Design, Control Messages and Disjointed Urban Space*: Access and use of public space is limited by motor vehicle-oriented urban design standards and an excess of fencing and restriction signs

These topics are described in more detail in the Current Issues section on page 63.

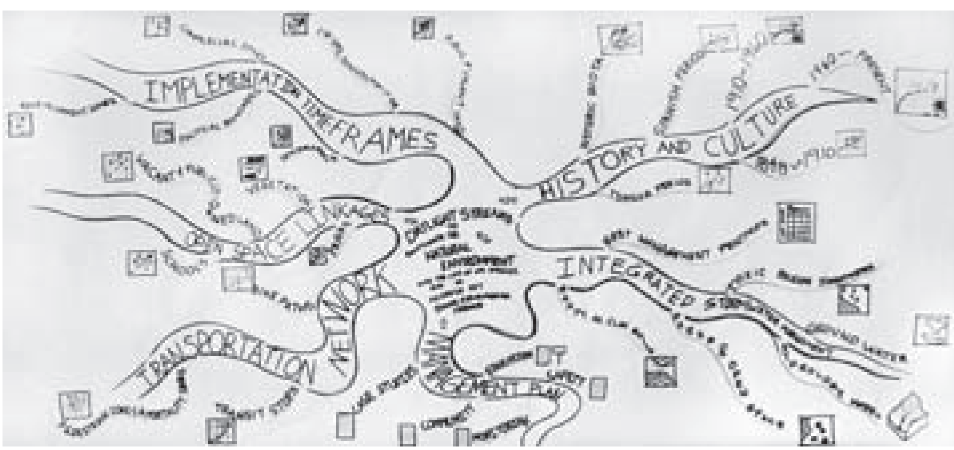
Design Process

The 606 Studio organizes design projects into three stages based on the method described by John Lyle in *Design for Human Ecosystems (1999)*. These stages are based on Alfred North Whitehead's theory of learning and are referred to as Romance, Precision, and Generalization. This method encourages cycling back and forth between the stages, creating a feedback loop. It also emphasizes synthesis of intuitive and analytical thinking. The result is a more thorough exploration of design than a linear process generates.

During the Stage of Romance, the design team became familiar with the project. It was a time to let impressions sink in, for listening to people, for asking questions, for dabbling and generally messing about within shadows that only slowly take form (Lyle, 1999). This time was stimulating, intriguing, confusing, and challenging. Many basic assumptions about the site changed as a result of this stage.

In the Stage of Precision, the team used the ideas that arose during Romance to provide direction for further research. It became immediately apparent that a solid understanding of the site required an analysis that began with physical characteristics of the Los Angeles region, such as water, geology and soils, historic habitat and vegetation, and historic settlement patterns. Additionally, it required an analysis of the current environment of the city, its socio-political organization, and its impact on surrounding ecosystems. This base of information is key to planning and design decisions.

Finally, in the Stage of Generalization, the wealth of knowledge compiled during Precision was used to test possibilities that arose throughout the process. Ultimately, design alternatives emerged in this stage because it is the most fertile ground for insights, ideas, even visions (Lyle, 1999).



Issues identified early in the project provided insight and direction for data gathering and synthesis activities.

Study Process

To assure a thorough study, this project was executed in six steps:

1. Inventory the environmental, economic, demographic, cultural, and historic resources in the study area.
2. Evaluate the following areas:
    - Stormwater management opportunities.
    - Expected water flows during storm events.
    - Alternative transportation linkages.
    - Historic and cultural sites.
    - Linkages of existing with proposed open spaces.
    - Economic pressures and opportunities for daylighting.
    - Existing zonings and densities.
3. Produce criteria and priorities for daylighting streams in the study area.
4. Identify a long-term framework for stream daylighting, including zoning changes and redevelopment priorities for a selected stream within the study area.
5. Produce guidelines for and visualizations of redevelopment options for typical landscapes within the city: schoolyard, commercial zone, residential neighborhood, and street.
6. Create conceptual plans for demonstrating stream daylighting and watershed concepts on a specific site.

About the 606 Studio

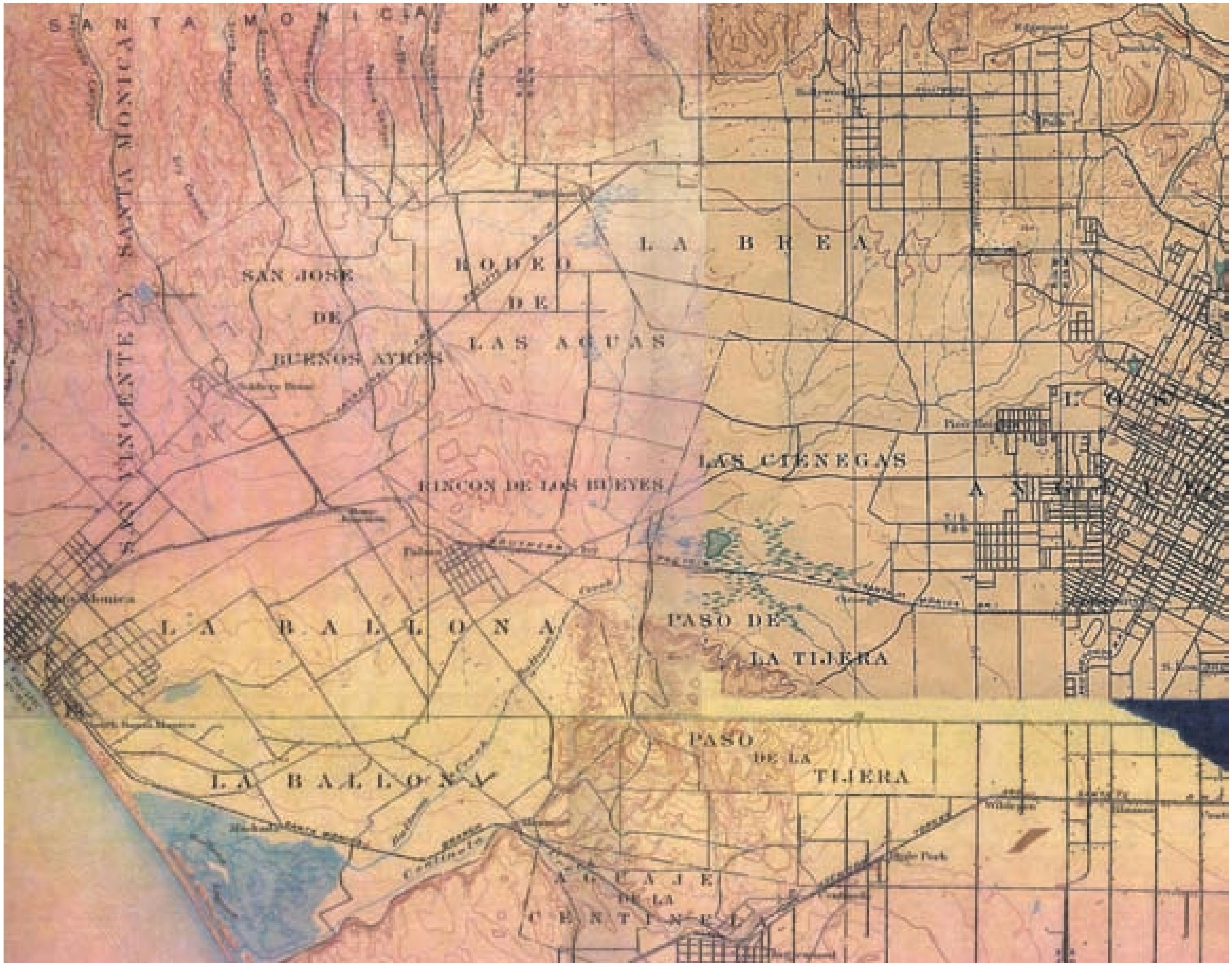
The 606 Studio is part of a capstone project for graduate students of Landscape Architecture at California Polytechnic University at Pomona (Cal Poly). The studio is composed of third-year Landscape Architecture graduate students, supervised by faculty, working to produce a landscape planning and design document, typically a master plan, land use framework plan, conceptual or schematic plan, or land management strategies. Studio teams, usually of three to five students, resolve contemporary problems relating to the management, preservation, restoration, or rehabilitation of ecological systems. Six of the Studio's previous projects have won professional Merit or Honor Awards from the American Society of Landscape Architects.

Searching for Streams

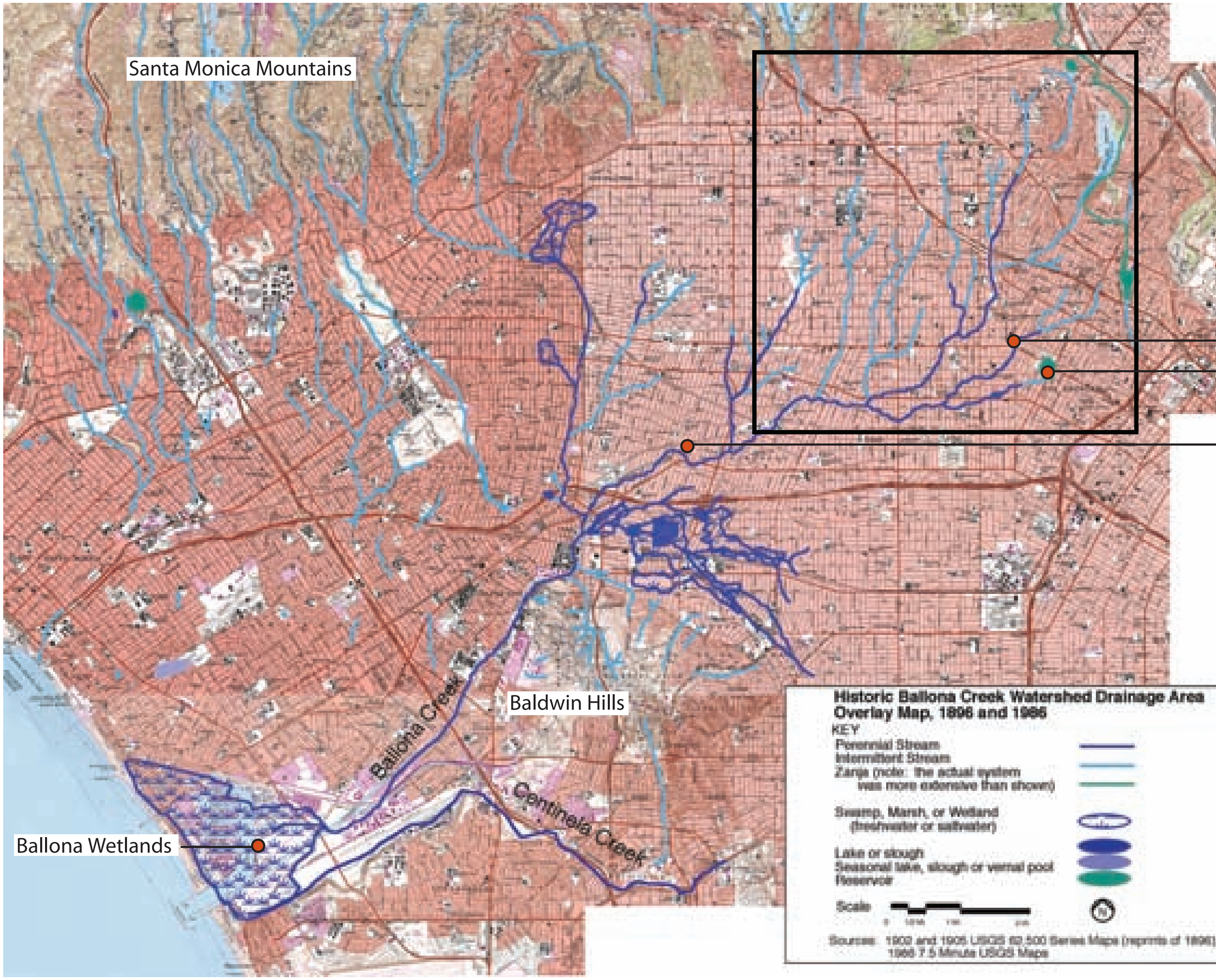
Stream seekers looking for traces of an intermittent stream.

The few remaining streams that exist in the Ballona Creek watershed represent possibilities for streams that are currently piped through the stormdrain system. A review of historical maps—the 1902 United States Geological Survey and the 1888 State Engineer's Irrigation Map—revealed the original locations of streams, and a starting point for studying today's environment. Through bringing stream vectors into GIS, and then overlaying those streams onto a contemporary map, stream traces could be located through surveying neighborhoods.

El Rio del Jardin de las Flores is a current-day above ground stream found in a three-block section of of Brookside Estates backyards.



1902 USGS map of the Ballona Creek watershed, showing historic streams and wetlands.

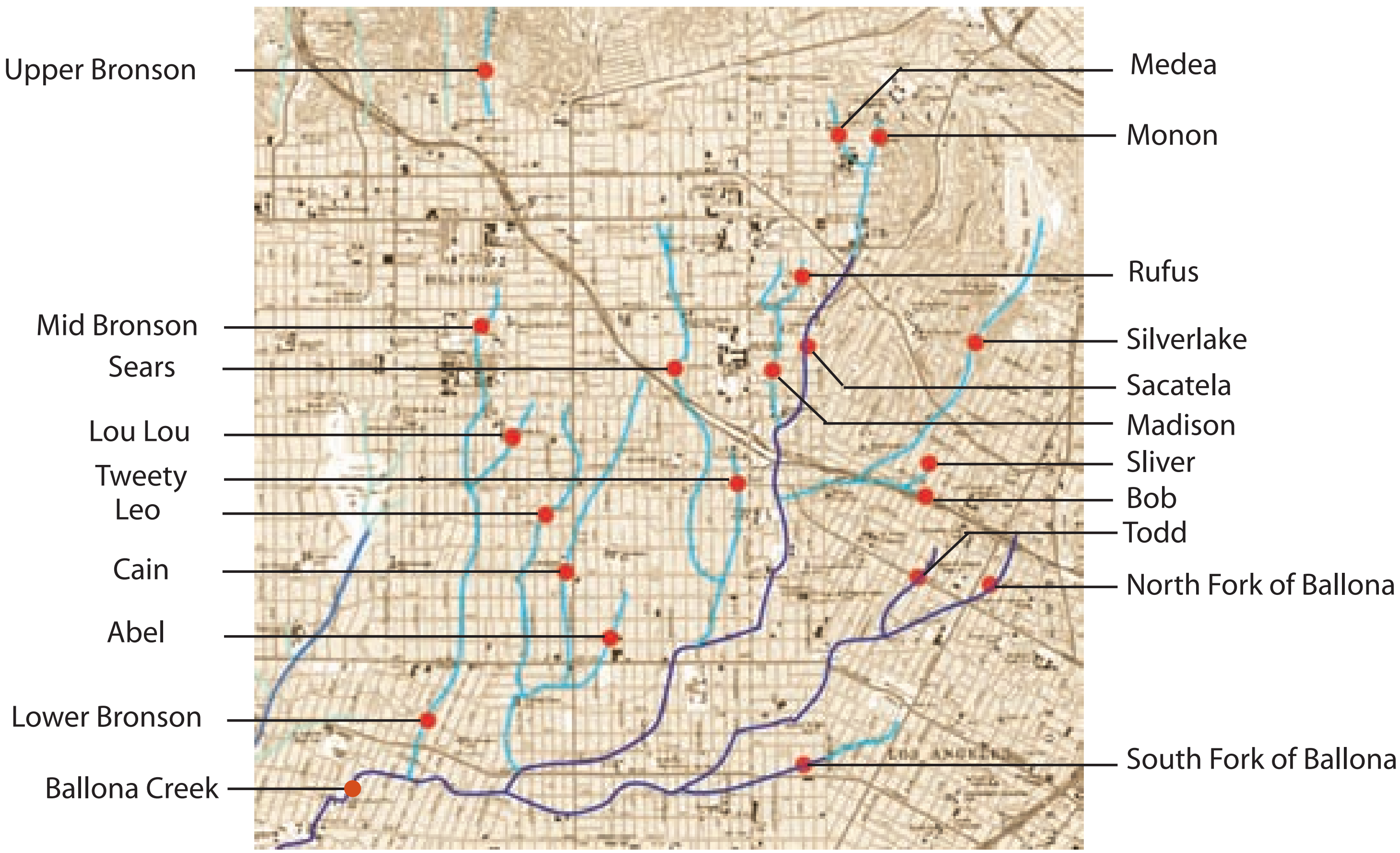


Contemporary USGS map of the Ballona Creek watershed, with overlay of 1902 streams and wetlands.

Context: Names

Stream seeking involved developing an intimate knowledge of the streets and neighborhoods of the study area. Familiarity not only aided the seeking of streams, but helped with developing spatial analyses. While the nature of stream seeking is anecdotal and somewhat subjective, the correlation of landforms and building patterns to the overlay map and historic photographs provided powerful validation of the approach. Anecdotal evidence was gathered through the Friends of the Los Angeles River listserver.

In order to stream seek, a classifying method was required. The majority of these streams had no known names, so working names were given for the purpose of distinguishing them one from another. In no way are these names meant to be construed as recommended names for functioning, daylighted streams. For this reason, the term "creek" was not used in these descriptions.



Working stream names for the upper Ballona Creek watershed study area.

Ballona Creek
Stream seeking began at the point where Ballona Creek daylights, near the intersection of Venice Blvd. and Pickford St. Double layers of fencing created an area where the homeless had assembled.

The piped Ballona Creek crosses Pico Blvd. in a community redevelopment zone. A new shopping center sits over the low point that defines the creek's floodplain.

Further upstream, Ballona Creek runs through the grounds of the Queen Anne School.

Steep drops in otherwise gently rolling areas confirm the presence of the creek.

Country Club Dr. follows the stream path indicated on the 1902 USGS map of Ballona Creek.

The street flooded in the 1950s when a local newspaper article stated "street becomes a lake… fortunately the homes…were on high grounds and not damaged…"

South Fork, Ballona Creek
MacArthur Park
MacArthur Park, once known as Westlake Park, is located at the headwaters of South Fork, an intermittent stream. This area was a swamp in the mid-1800s.

Today the park has a distinctly formal civic aesthetic. A large lake is the park's prominent feature.

North Fork, Ballona Creek
While older buildings generally were raised, some buildings found at low points of terrain suggest a design that anticipated flooding. This utility building was built on stilts.

In the intermittent portions of North Fork, sometimes extreme conditions were observed. Here a steep, utilitarian retaining wall allows an apartment building to perch on the stream channel.

Nearby, in the flood plain of North Fork, the entry levels to small homes were observed to be on the second floor.

Lafayette Park
Lafayette Park's steep hillsides still suggest the banks of a stream.

Created in 1906, the graceful park included a pond which was situated closely to where the 1902 map indicates the stream would have been.

Empty lots south of the park, also still suggest the topography of the stream channel. Natural tar seeps may be preventing the lots from being developed.

Todd
Another retaining wall supports the Universal World Church and a seemingly vacant school along Todd.

Silverlake

The Silverlake reservoir marks the headwaters of an intermittent stream, which runs down Silverlake Blvd.

The gently curving form of Silverlake Blvd. and the steep canyon alongside it hint at the stream. It now flows through a stormdrain under the street.

Silverlake joins Sacatela Creek near the intersection of Temple Ave., Silverlake Blvd., and Beverly Blvd. An anecdote says the basement of the Holiday Inn at this intersection floods periodically.

Sacatela

Sacatela, also called Bimini, seems to have been significant. Records of its name exist. It even has a stormdrain named after it.

Monon is one of the upper reaches of Sacatela. A curving road in a cozy canyon clearly delineates a stream path. The Shakespeare Bridge, along Franklin Ave., crosses over the deep ravine.

To the south, the view of its stream flow is obscured by a high bermed area, covered by school buildings. Old stormdrain plans indicate this was a trash dump. The creek then flows through ABC studios and down Myra St. to Thomas Starr King Junior High School.

Continuing down Myra St., Sacatela runs under Sunset Blvd. and crosses Hoover St. just south of Santa Monica Blvd. Below Dayton Heights Elementary School Sacatela's waters are joined by those of Madison, an intermittent stream.

This aerial photograph shows Sacatela between Beverly Blvd. and 4th St. in 1930. This area was in the process of being piped and filled in.

A 1930 Los Angeles Times article stated:

> *Forty-five acres of ground, now a waste...will be reclaimed for use—when this slough..is filled in. The live stream of this creek now flows through the Sacatela No. 3 stormdrain, leaving no excuse for the gullies and ravine which now exist.*

According to a resident, the fill included old Pacific Electric Red Cars not needed once the city's trolley system was dismantled.

Once popular, the Bimini Hot Springs were perched above Sacatela Creek. The building is gone, and the springs are believed to be capped. One local resident recalled being told by an old-timer about how they would fish in the creek.

Sacatela flows past this intersection, 6th St. and Mariposa Ave. This 1930 photograph shows a flood possibly made worse by upstream development.

Today the Creekside Cafe, located in the Chapman Building, sits at the intersection of 6th St. and Mariposa St. The restaurant's owners are unaware of the former stream.

This 1906 picture shows Sacatela crossing Wilshire Blvd. The bridge is the only hint of the creek in this austere photo.

The Ambassador Hotel on Wilshire Blvd. is located immediately east of Sacatela. Sacatela is seen in the foreground.

This building sits over Sacatela on Wilshire Blvd. The large catchbasin is the only clue of its presence.

Madison

The area surrounding Madison has been converted to a low-rise residential street. A slight dip hints at Madison's streambed.

Madison bisects this block, providing opportunity for a comfortable pedestrian link between streamway and neighborhood.

The upper reaches of Madison are deep and incised, representing an intermittent stream geomorphology.

Sears

Low-rise residential dwellings occupy much of Sears' subwatershed.

Sears' path flows under the 101 Freeway. There is vacant, fenced-off land surrounding the freeway.

Sears follows present-day Kenmore St. for much of its length. Here it runs along a low point in the backyards of some houses.

Fern Dell
This stream contained in a finger of Griffith Park provides direction for design in present-day Los Angeles. Built in 1914, the dell has become a valued landmark and place. Design details, such as gutters and pools, are instructive for managing urban runoff. Its multi-tiered path system allows the park to be accessible during the rainy season.

Upper Bronson
The stream at Bronson Canyon appears on the 1902 USGS map as intermittent.

According to the 1902 USGS map, Bronson disappears at the base of the Hollywood Hills. This 1904 photo shows Bronson extending further south than indicated, crossing here at Franklin.

Middle Bronson
Bronson reappearss at the site of today's Hollywood Cemetery. The cemetery, in addition to having water features, also has significant drainage problems.

The location of the Douglas Fairbanks Memorial correlates to the 1902 USGS map's stream location. Its current design mimics a linear stream, but without an outlet. As a result water must now be pumped following storms.

A cemetery worker indicated that an old coworker recalled a stream running through the cemetery. The same worker also said that the concrete structure shown here used to be a bridge.

Conclusion

Seeking streams was not merely an interesting and entertaining method of identifying the current condition of Ballona Creek and its tributaries. The information gathered resulted in a fundamental understanding of the study site, its issues and opportunities.

Onsite analysis is an important activity for designers and planners to undertake (Lyle, 1999). Although Angelenos have worked hard to displace streams for flood control and development, memories and physical traces of the streams remain. Analysis of these traces (i.e. stream seeking) evoked visualizations of possibilities and provided direction to daylighting opportunities.

Natural History

Photo: Panorama of the Santa Monica Mountains. Indentations in the grass indicates small intermittent streams. The low point in the mountains could be the Cahuenga Pass. No Date. Courtesy Photo Collection/Los Angeles Public Library.

A watershed's natural history is comprised of interrelationships of ecology, zoology, botany, biogeography, climatology, paleontology and geology (Schoenherr, 1992). This system of relationships needs to be understood in order to rehabilitate and mimic the natural processes in an urbanized context.

Climate

The Ballona Creek watershed's temperate climate derives from the Pacific Ocean, its western neighbor, and its position in the semiarid southwestern United States. This climate is characterized by warm summers, cool winters, and markedly seasonal rainfall. The average annual rainfall in Los Angeles is 15 inches. Nearly all rain falls from late autumn to early spring, and there is virtually no precipitation during the summer months. Potential evapotranspiration in the coastal plain exceeds precipitation on an annual basis. Under natural conditions, the lower reaches of rivers that drain the basin are dry in summer. Temperatures (in degrees Fahrenheit) range on average from lows in the mid-50s to highs in the mid-70s (Rairdan, 1998; Schoenherr, 1992).

Microclimates

Topography and distance from the ocean result in three microclimates within the Ballona Creek watershed ranging from the cool moist marine border to the warm dry mountains (Rairdan, 1998; Brenzel, 1995).

Marine

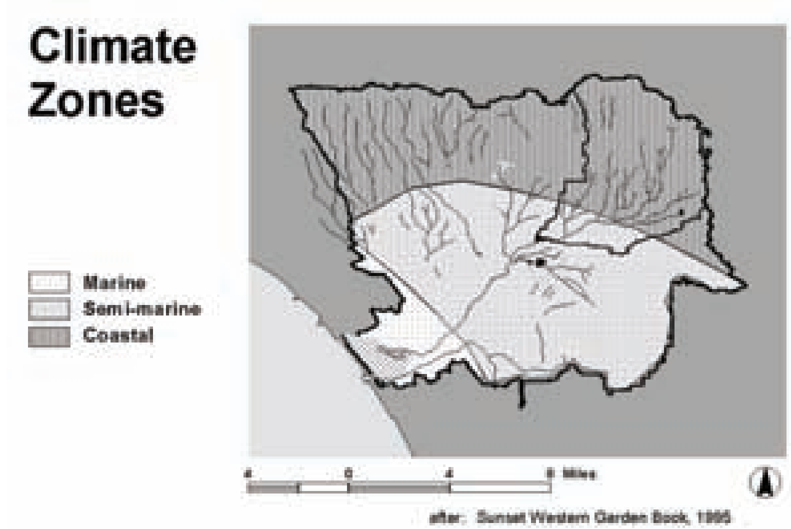
The marine zone occurs along the coast and extends inland until it meets a cliff or gradual slope. The winters are mild and the summers are cool as the nearby ocean moderates temperatures. The air is seldom dry and summer days are often overcast by thick fog.

Semimarine

While generally behind the fog belt, this zone is still under marine influence. Ocean breezes moderate summer temperatures and winter frosts are rare. Spring days may be cloudy due to the presence of high fog, and humidity is lower than along the coast.

Coastal Range

Comprising coastal mountains and foothills, this zone is warmer and drier than the semimarine areas. Winter temperatures are moderate due to the dominating weather of the Pacific Ocean. Year-round, cold air drains down mountain slopes and creates cooling breezes.



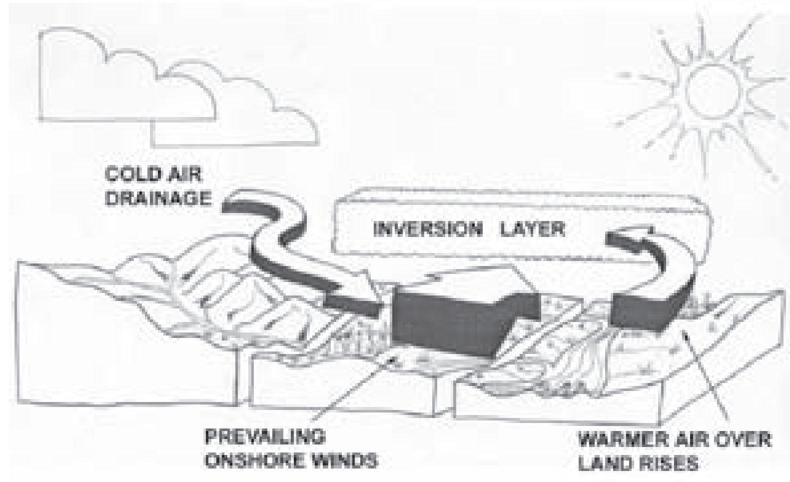
Climate zones in the Ballona Creek watershed.

Air Flow

During the daytime, as air heats and rises over land, a low-pressure cell is created. Air flows toward low-pressure cells, creating a prevailing daytime flow onshore. During the evening, however, the winds reverse direction. This results in a daily cycle of exchanges of air masses over the region (Schoenherr, 1992).

Inversion Layer

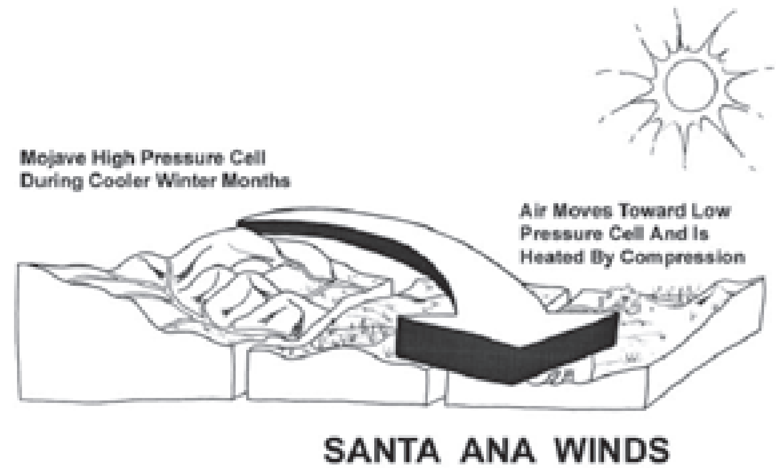
In the Los Angeles basin, cool air flowing downhill from the mountains is called cold air drainage. Cool marine air flows onshore and joins the cold air drainage. This combined cool air is trapped by the surrounding mountain ranges creating what is known as an inversion layer, where cool air is held in the basin and warm air is found above this layer. A serious consequence of an inversion layer is that exhaust gases and other pollutants rise until the inversion layer traps them. Sunlight effects a chemical change in these pollutants, causing photochemical smog, a mixture of haze and oxidized chemical vapors (Schoenherr, 1992). The result—at its worst during summer months—is a yellowish brown mass of air trapped in the basin until either rain occurs or prevailing air flows offshore rather than onshore.



Inversion layer process in the Los Angeles basin.

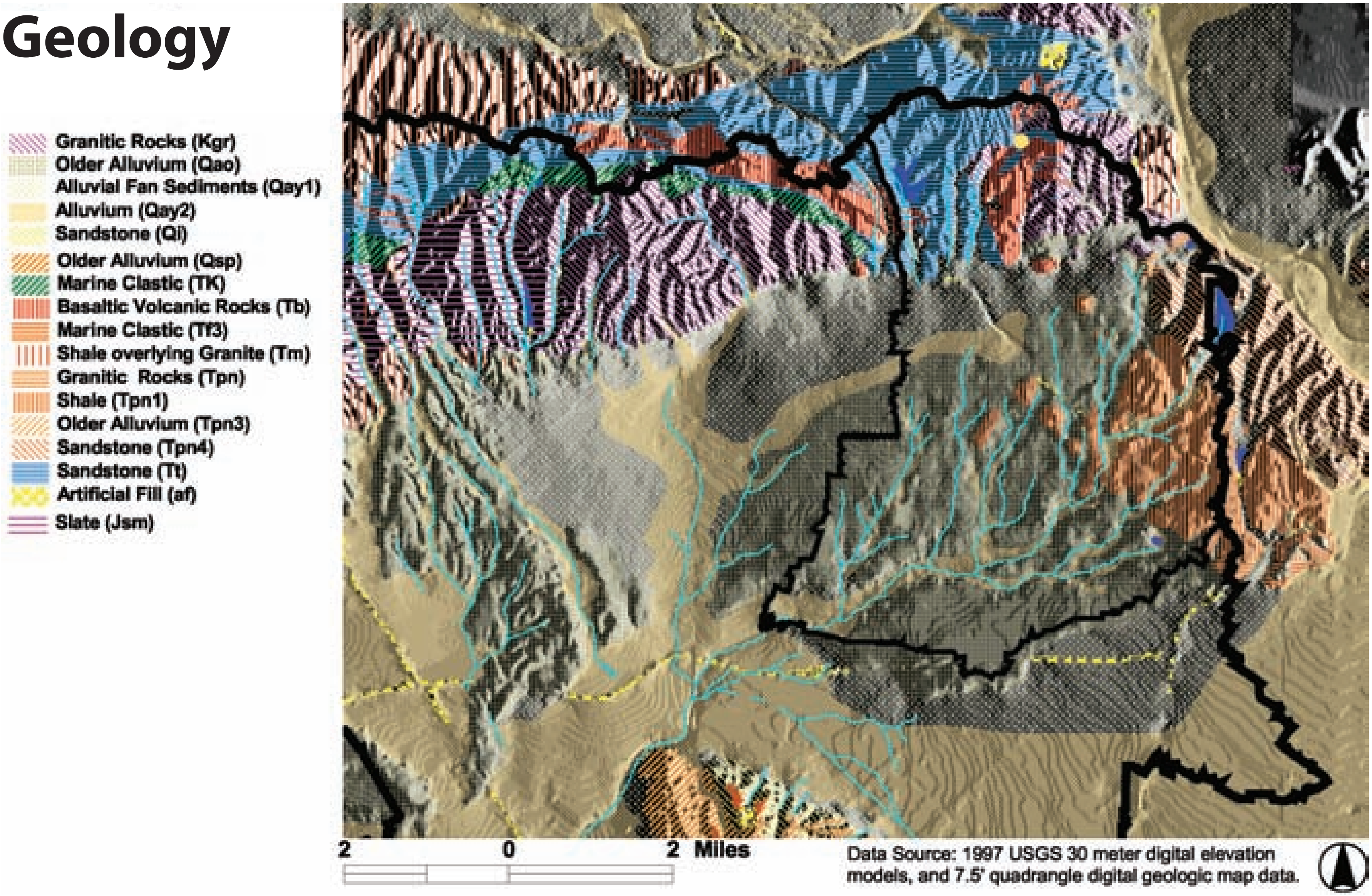
Santa Ana Winds

Occasionally, when air becomes cooler or denser to the northeast of the mountain range in the Mojave Desert, a high-pressure cell forms. Air flows away from high pressure, so it moves toward the coast through mountain passes. This usually occurs during the fall and winter months when air in the desert is cooler than air in the basin. These winds, heated by compression as they flow downhill, are known as the Santa Ana winds, named after their primary course of flow along the Santa Ana River. Although these winds can be forceful and destructive, they remove the inversion layer and smog, allowing for majestic views of the basin's surrounding mountain ranges (Schoenherr, 1992).



Santa Ana winds affect much of the Los Angeles Basin.

Geology



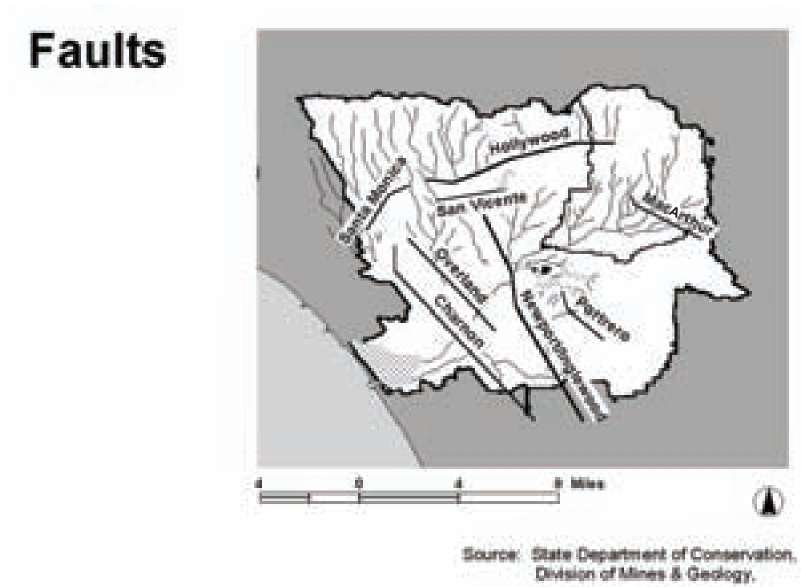
Geology of the upper Ballona Creek watershed.

Geology

The geology of the Ballona Creek watershed is unique. Two continental plates are the primary influence on its landform. The north-moving Pacific Plate's contact with the west-moving North American Plate created the Santa Monica Mountains. Due to the rotation of these major plates, the mountain range has an east-west axis known as a transverse range. Consolidated rocks of igneous (cooled and solidified molten rock), metamorphic (altered from heat and compression), and sedimentary (consolidated particles transported from another source) origin underlie the mountains. A plateau of consolidated old alluvium (parent material weathered and eroded down canyons onto the plains) marks the eastern ridge of the watershed. This plateau contains alternating layers of marine sediments deposited during periodic encroachment of the sea and young alluvial deposits. These deposits have filled the basin with a thick sequence of alluvium, hundreds of feet deep in many places. Rising to 1600 feet in parts of its headwaters in the Santa Monica Mountains, this basin transitions to rolling hills and becomes relatively flat as it reaches sea level (Schoenherr, 1992).

Faults

Because of the plate action associated with the mountains, the Ballona Creek watershed has several faults. The most active is the Newport/Inglewood Fault. The Santa Monica Fault and the Hollywood Fault both run at the base of the Santa Monica Mountains. Mountain streams have historically disappeared along the Santa Monica and Hollywood faults, as the faults seem to block or redirect the water's flow. Upwarping along the Newport/Inglewood Fault has formed hills that rise in places as much as four hundred feet above the surrounding coastal plain (State of California, 1961).

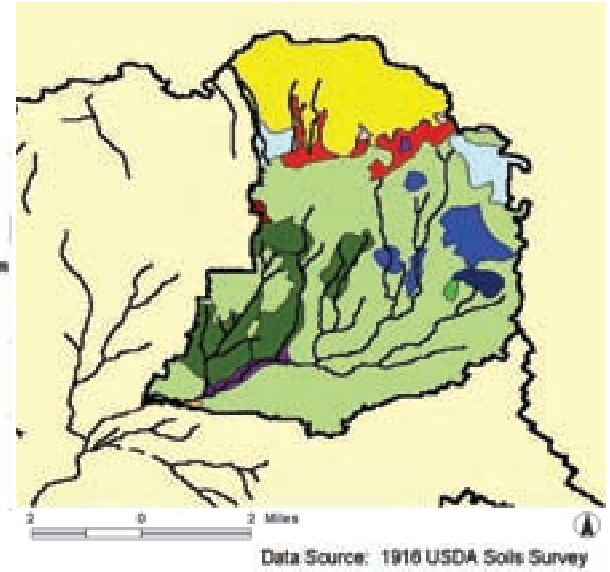


Faults in the Ballona Creek watershed.

Soils

Soils in the watershed are classified as Residual, Coastal Plain, and Recent Alluvium (see Appendix E). Residual soils are from the weathering in place of consolidated rocks, usually in hilly positions. They are well drained and are eroded or deeply furrowed in most places. The Altamont and Diablo series are examples of Residual soils. Coastal Plain soils originate from older alluvium and marine deposits, often with uncertain geological origin. Their subsoils are not well aerated and tend to be less permeable. The Ramona, Madera, and Montezuma series are found in Coastal Plain soils. Recent Alluvium soils have permeable subsoils and are derived from a variety of granites, schists, shales, and sandstones. A high water table exists in much of the lower plains portion of this soil type. Soil types in Recent Alluvium include the Hanford, Chino, Yolo, and Dublin series.

Historical Soils



Historical Soils in the upper Ballona Creek watershed.

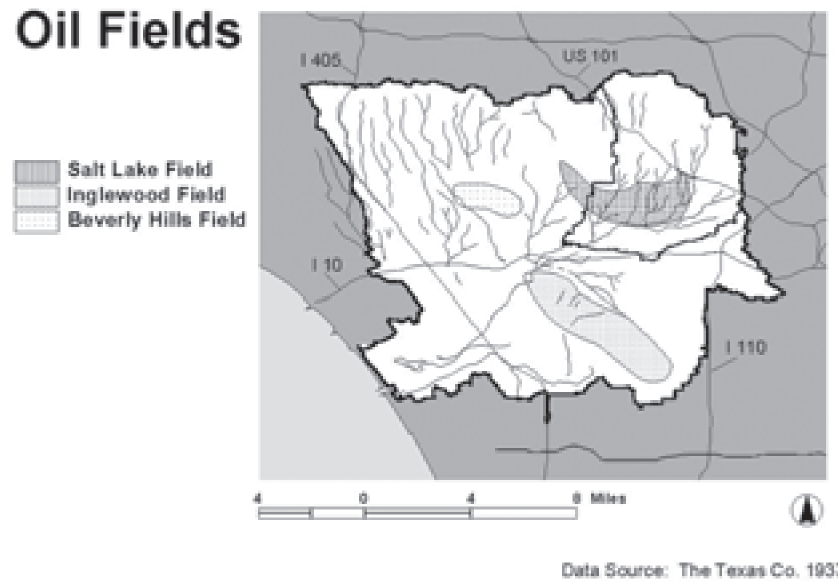
Soil Permeability

Soil Permeability in the upper Ballona Creek watershed.

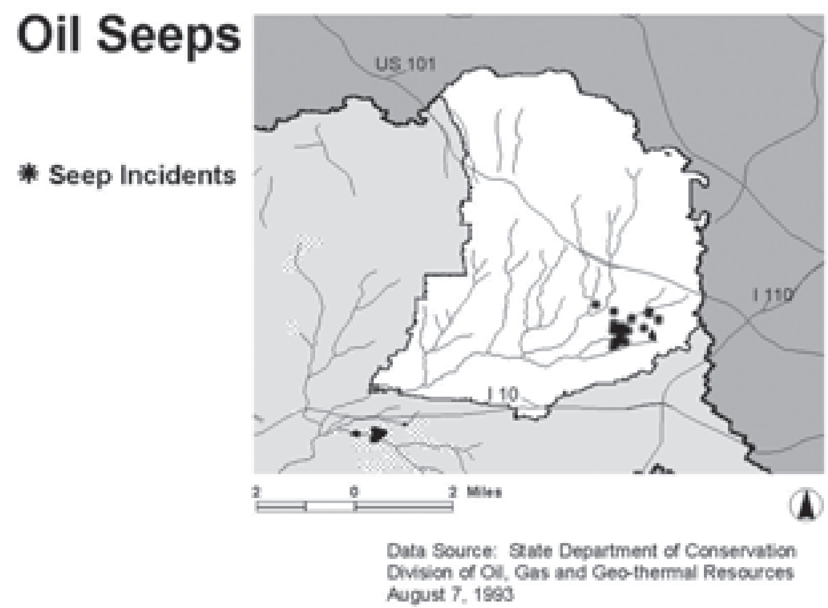
Oil

Oil fields are a significant part of the landscape in the Ballona Creek watershed. Since 1876, oil has been extracted from the basin. The Salt Lake field (see map) is located within the study area and was discovered because of its seeps.

Oil seeps appear where oil emerges at the surface from a subsurface source. Most seeps are formed by the slow escape of oil from fairly large accumulations brought close to the surface and into a fracture zone by erosion, or from accumulations that have been tapped by faults and fractures. Migration to the surface is controlled by hydrostatic pressure, differential compaction, and heat. Seeps appear and disappear through the years, and may become more active when the groundwater table increases or after an earthquake (Hodgson, 1987). Perhaps one of the most celebrated oil seeps can be found at the La Brea Tar Pits near the study area. Smaller seeps continue to emerge near Lafayette and MacArthur parks. Because oil seeps are a natural water contaminant, they must be closely monitored to ensure water quality.

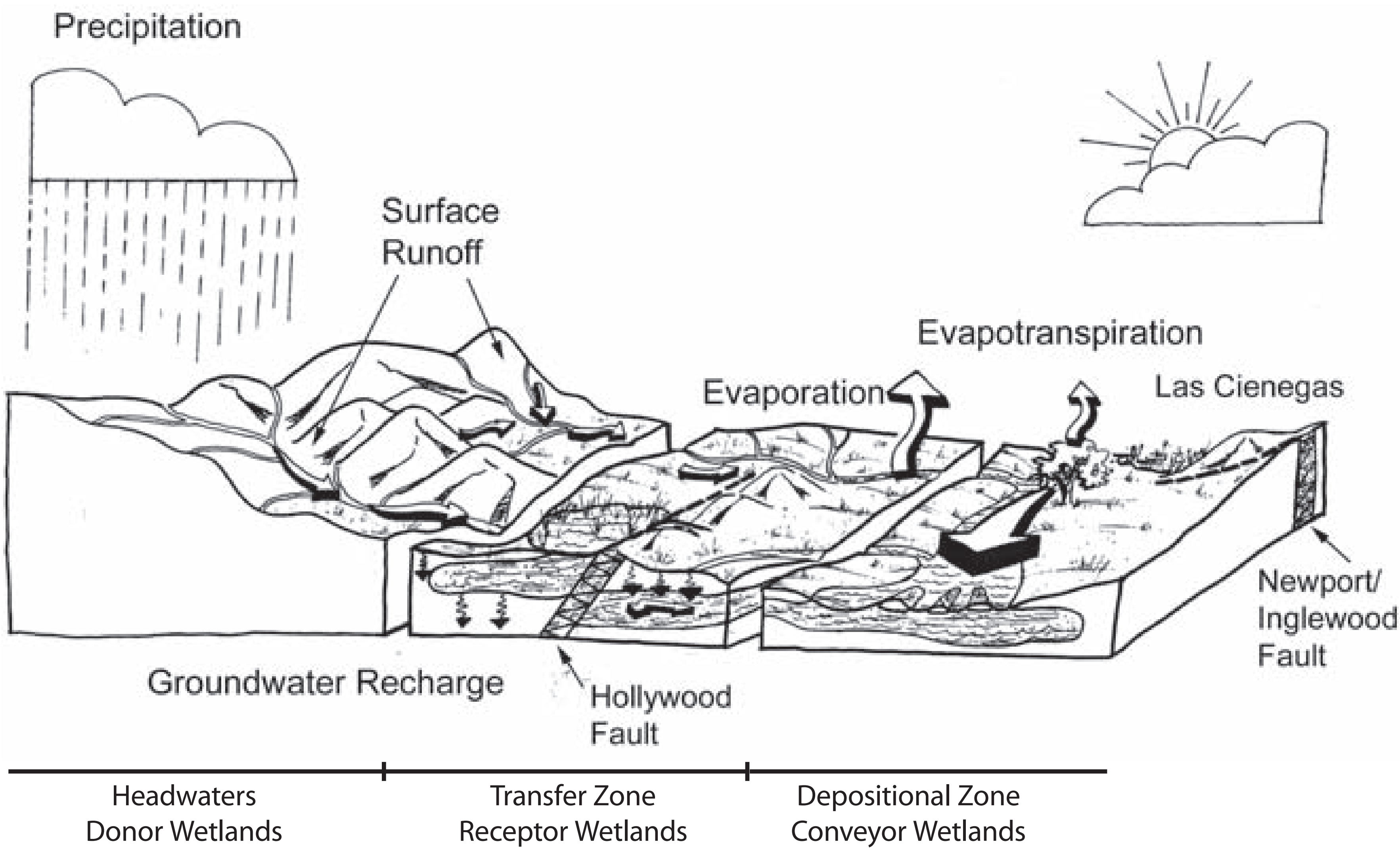


Oil fields within the Ballona Creek watershed.



Reported oil seep incidents in the upper Ballona Creek watershed.


Tar pit on the Hancock Ranch, 1920. Courtesy Photo Collection/Los Angeles Public Library.

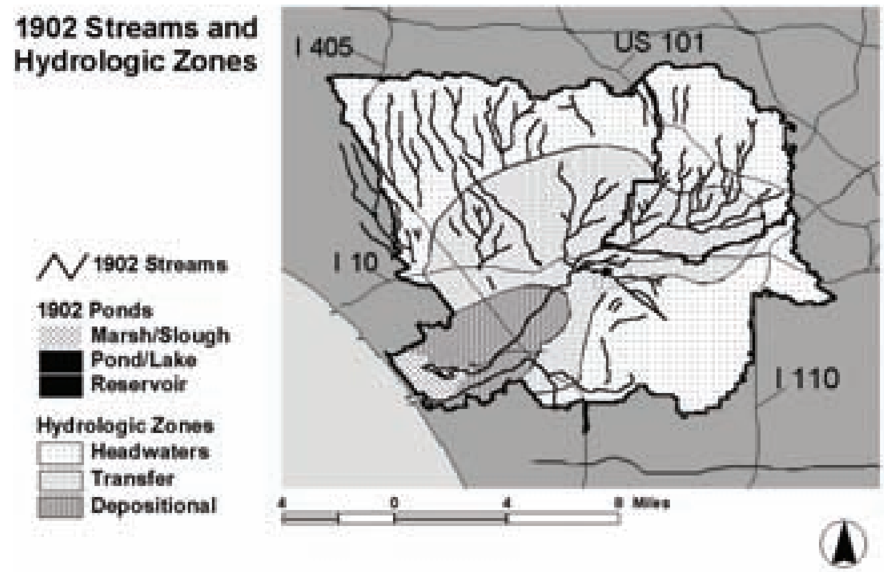


Hydrologic zones of Ballona Creek watershed from mountains to ocean.

Hydrology

The Ballona Creek watershed has three distinct hydrology zones: headwaters, transfer, and depositional (FISRWG, 1998). In the headwaters, precipitation is the primary influence flowing swiftly down steep slopes cutting v-shaped valleys. The headwaters, located in the Hollywood Hills and the Santa Monica Mountains, are sometimes referred to as donor wetlands as they export diluted nutrients and contribute groundwater to downstream systems. They contain sweetwater, or fresh rainwater that has the least amount of contamination of any zone. The transfer zone, where present-day Hollywood, Koreatown and the La Brea and Fairfax districts are found, is known as a receptor wetland due to its reliance on upstream infiltration to recharge the aquifer, commonly referred to as groundwater. After the rainy season, aquifer recharge sustains the base flows. Shallower groundwater tables are typical of the transfer zone. Lower elevation streams of the transfer zone merge and flow down gentler slopes in broader valleys.

Water flows primarily on the surface in the depositional zone, also known as a conveyor wetland. This zone includes riverine and estuarine systems that experience irregular and infrequent flooding. In the Ballona Creek watershed this zone includes Culver City, West Los Angeles, Mar Vista and Marina Del Rey. Riverine systems are typically freshwater and include rivers, creeks, and streams. Estuarine systems are typical where freshwater meets the tidal influence of the ocean. The depositional zone experiences the highest level of productivity of any hydrology zone due to its conveyance and abundance of nutrients. Streams in the depositional zone wander and meander —sometimes resulting in a braiding effect—and may divide into many separate channels as they flow across a delta of river-deposited sediments.



Hydrologic zones with historical streams of the Ballona Creek watershed.

Unique to this watershed is the series of faults that can create a barrier to groundwater movement. Historically these faults have forced groundwater to surface and pool (Treiman, 2001), creating freshwater marshes known locally as “cienegas,” derived from the Spanish word for swamp.

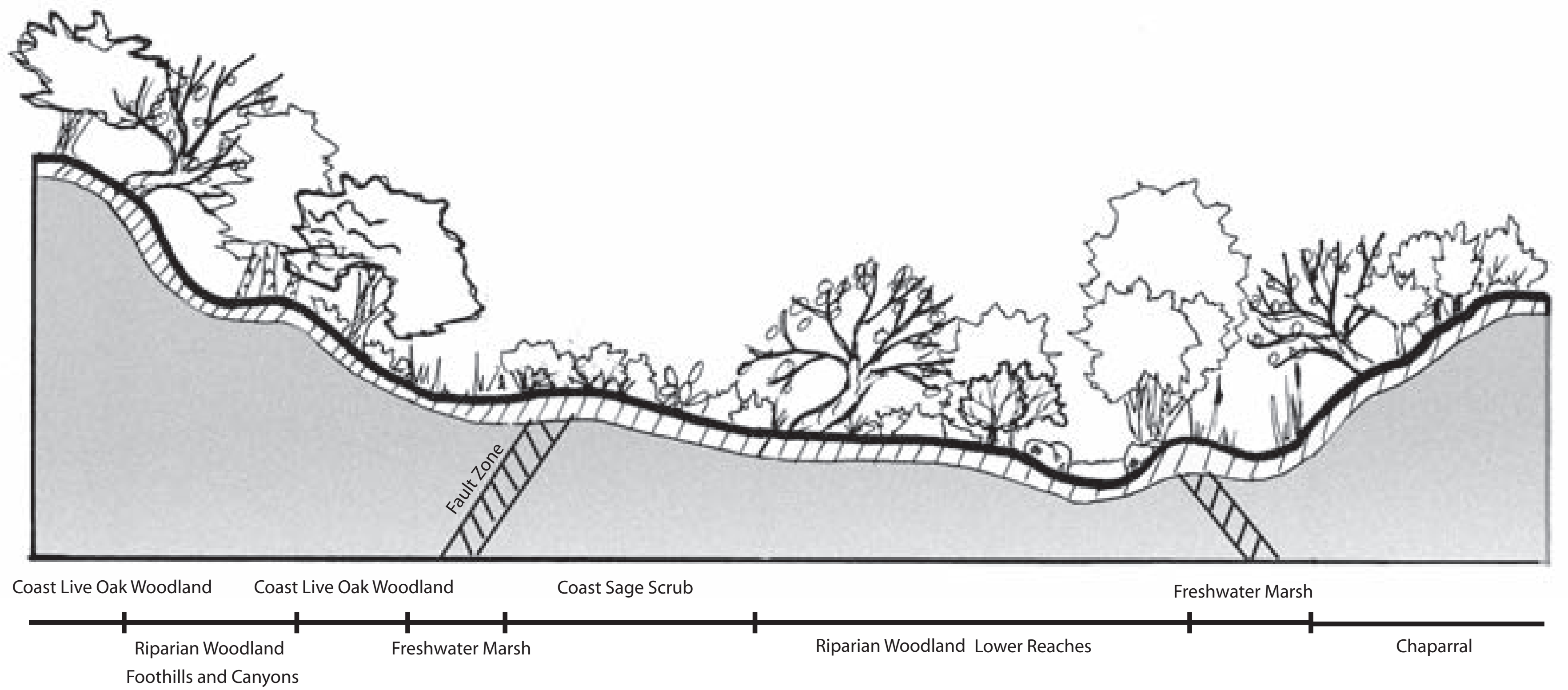
Flora and Fauna

Historical Plant Communities

In order to understand the history of the landscape, one must understand the native plant communities. The watershed's native plant communities developed in response to its terrain and soil types, climate, and availability of water. Native plants within the Ballona Creek watershed were eradicated as a result of grazing, farming, and development in the late 1800s. Photos and accounts of prior vegetation are rare. As a result, neighboring terrain under similar conditions, historical soils and rancho maps showing vegetation were studied and used to speculate as to the native plant communities in the watershed. The following sections describe plant communities that were most likely present before humans developed the land (after Holland, 1986 and Schoenherr, 1997).

Coastal Sage Scrub

This plant community is typically knee-high and occurs on drier sites and lower elevations, especially on south-facing slopes. Most of its characteristic plants produce soil-holding fibrous roots, playing an important role in soil stabilization. Many plants are odoriferous. Soils underlying coastal sage scrub tend to be alluvial: low in nutrients, subject to rapid erosion, comprising a high percentage of sand and gravel. Characteristic plants include *Salvia leucophylla, Artemisia californica, Eriogonum fasciculatum, Malosma laurina, Baccharis pilularis*, and *Rhus integrifolia*. Many species in this community are summer or drought deciduous to conserve moisture.



Chaparral

Commonly associated with hillsides and many north-facing slopes, Chaparral is characterized by a dense, evergreen cover of deep-rooted, drought- and fire-adapted shrubs growing on coarse textured soils with limited water-holding capacity. In this community, the four-to twelve-foot high plants form a nearly impenetrable wall of stiff stems and tough leaves. The sclerophyllous (hard) leaves are often leathery, thick, small, fuzzy, and/or waxy. Typical plants include *Ceanothus* spp., *Adenostoma fasciculatum, Arctostaphylos* spp., *Cercocarpus betuloides, Heteromeles arbutifolia,* and *Rhus ovata*.

Coast Live Oak Woodland

As water becomes more plentiful in canyons or through groundwater, other plant communities with higher water requirements emerge. The Coast Live Oak woodland is one of the more distinctive environments of the region. The Coast Live Oak woodland generally occurs in upland areas, north slopes, foothill canyons, shaded ravines, and canyon bottoms of well-drained soils of coastal plains. Groves form across valleys and along streams and intermittent watercourses. This plant community is characterized by *Quercus agrifolia, Prunus ilicifolia, Umbellularia californica, Ribes* spp., *Rhamnus californica*, and *Toxicodendron diversilobum.*

Riparian Woodland - Foothills and Canyons

Where water has an even greater presence, either through perennial streams or intermittent streams with groundwater flows, Riparian woodland plant communities flourish. Riparian woodland of foothills and canyons occurs along canyon and valley bottoms with perennial or intermittent streams in nutrient-rich soils or within the drainage of steep slopes. This plant community may have soils that retain moisture longer, with larger amounts of organic matter and clay. There is usually multi-layered vegetation, with both an understory and an overstory. Dominant species typical of foothills and canyons include *Alnus rhombifolia, Umbellularia californica, Juglans californica,* and *Platanus racemosa.*

Riparian Woodland - Lower Reaches

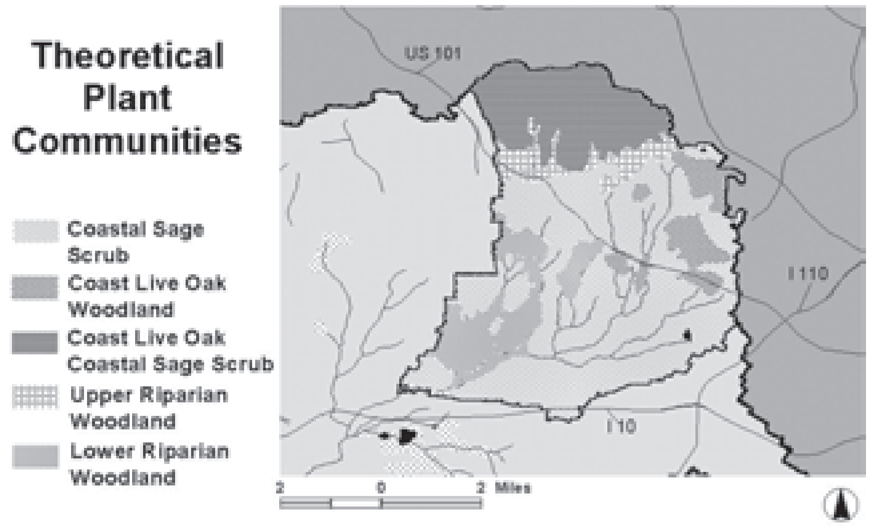
Riparian Woodlands of the lower reaches have loose, sandy, or fine gravelly alluvium deposited near stream channels during flood flows. Most stands become riparian thickets and are too dense to allow much understory development. Plants in this community are typically dense, broadleafed, winter-deciduous, and dominated by several *Salix* species, with scattered emergent *Populus fremontii, Baccharis salicifolia, Sambucus mexicana* and *Platanus racemosa*. Mule-fat-dominated riparian areas occur along intermittent streams, where flooding is frequent, and/or as an understory to sycamore trees.

Freshwater Marsh/Cienega

Where groundwater has surfaced, the Freshwater Marshes/Cienegas plant community may occur. These are quiet aquatic sites, that lack a significant current and are permanently flooded by fresh water. Prolonged saturation permits accumulation of deep, peaty soils. Freshwater marshes are dominated by perennial, emergent monocots -mostly *Typha* spp. and *Scirpus* spp.

Theoretical Distribution of Plant Communities

The history of the native plant communities is important in order to understand how the native vegetation contributed to watershed function. Because of this importance and the lack of data regarding actual location of the historical communities, the characteristics of each community were compared with the topography, aspect, soil types (see Appendix E), and availability of water in the study area to develop a theoretical plant community location model. Rancho maps and explorers' descriptions of the region provided additional clues used to confirm the theoretical placement of plant communities.



Theoretical distribution of plant communities in the upper Ballona Creek watershed.

Prehistoric Megafauna

The historical vegetation of the Ballona Creek watershed supported some impressive fauna. As far back as 8000 B.C.—during the Pliocene era—prehistoric megafauna existed, as evidenced by remains recovered from the La Brea Tar Pits. These include the woolly mammoth and saber-toothed tiger. Mammoth bones were found in the La Brea Tar Pits.

Prehistoric megafauna, counterclockwise from upper left: woolly mammoth, woolly mammoth bone, saber-toothed tiger. Courtesy of Photo Collection/Los Angeles Public Library and http://www.bogusnews.com/voafa/bnn/825d.htm.

Fauna

Recent history shows that the variety of geographical, hydrological, and vegetation resources within the Ballona Creek watershed supported a diversity of fauna. The fauna that consume the native vegetation (producers) of a watershed are considered herbivores. Herbivores are consumed by both secondary and top predators (see diagram at right). Both herbivores and predators are considered consumers in an ecosystem.

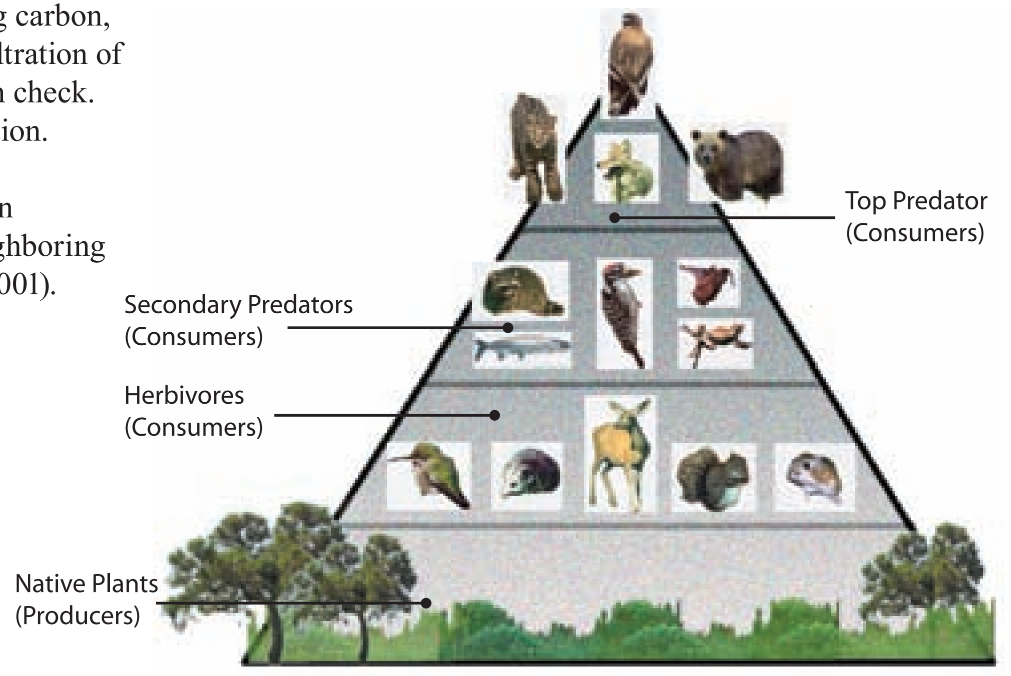
Historically a symbiotic relationship existed between the producers and the consumers of the Ballona Creek watershed. The producers provided a base in the ecological feeding (trophic) structure. The consumers dispersed the producer's seeds to promote successive plants. The plants, in turn, provided necessary microclimates and habitat for other plant and animal species while consuming carbon, releasing oxygen, preventing erosion and aiding in the infiltration of groundwater. Also, predators kept herbivore populations in check. These relationships contributed to healthy watershed function.

Although a complete report of historical fauna has not been conducted for the Ballona Creek watershed, studies of neighboring areas can be used to depict probable conditions (Garrett, 2001).

Historical Fauna Counts

	Santa Monica Mountains	*Los Angeles River*
Mammals	25+	N/A
Birds	384	428
Reptiles	25	38
Amphibians	11	17
Fish	20+	15+
Insects	N/A	N/A

For a complete listing, refer to National Park Service, 2000 and Garrett, 1993.



Historical trophic structure of Ballona Creek watershed. Adapted from Forman, 1995. Native species images from California Academy of Sciences.

Cultural History

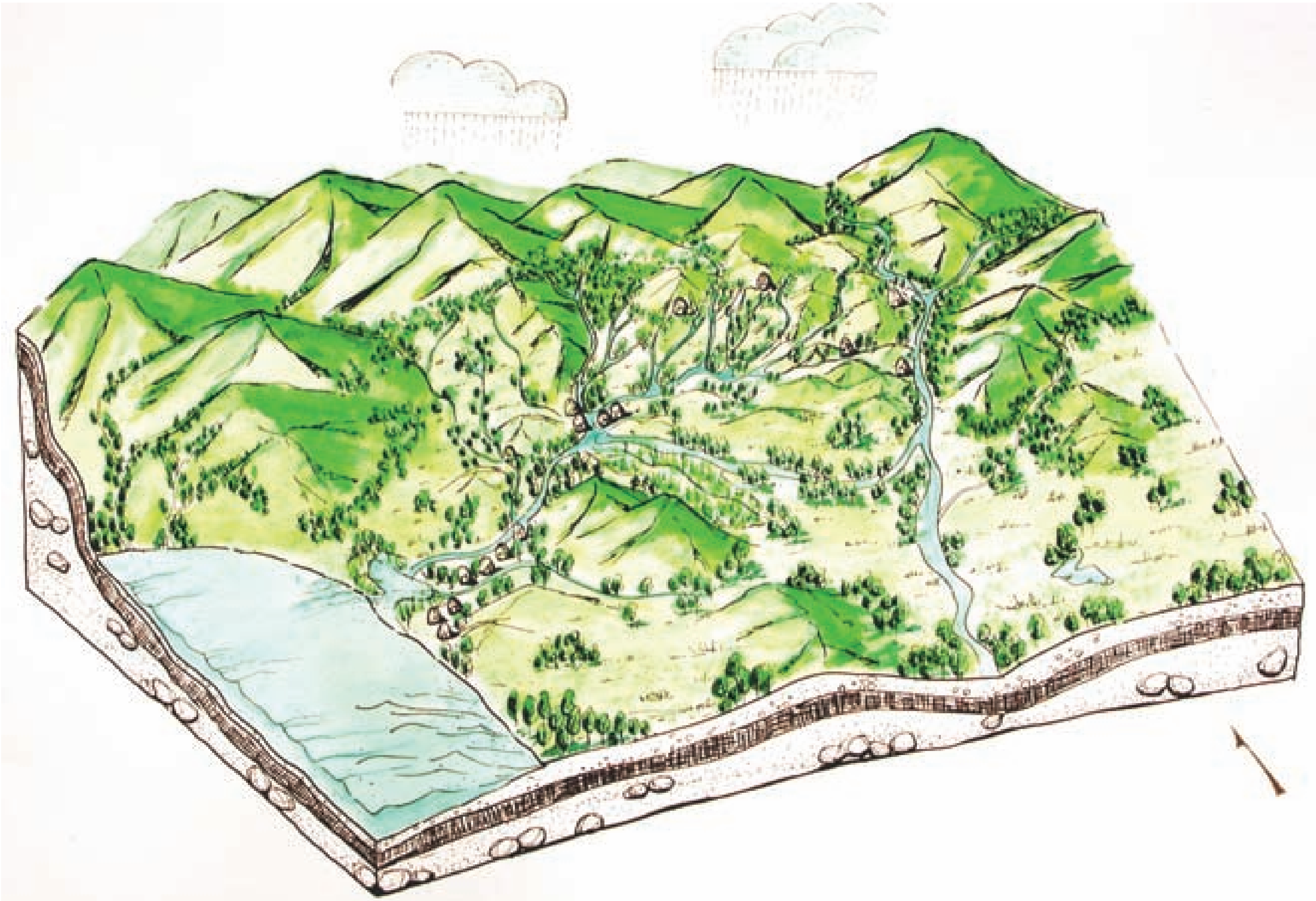
Photo: Aerial photo of Los Angeles looking west. Wilshire Blvd is marked by tall buildings. Westlake Park, now MacArthur Park, is prominent in the foreground. In the distance to the right is the Wilshire Country Club, where El Arroyo del Jardin de las Flores runs. Photo taken February 15, 1940. Courtesy Photo Collection/ Los Angeles Public Library.

The Ballona Creek watershed was shaped by millenia of intercontinental shifting, deposition, and rainfall. In a much shorter span of time, a few hundred years, human inhabitants altered the landscape in pursuit of production, protection, and pleasure (Woodward, 2000).

While the Tongva established small villages throughout the region and treated land as a communal resource, the Spanish and Mexican settlers placed land under private stewardship, spreading livestock over hill and plain. After becoming part of the United States, the region experienced tremendous growth pressures. The landscape has since been artificially supported by imported water, food supplies, and building materials. The collective impact of this human activity was deforestation, dessication of groundwater aquifers, and the deposition of pollutants.

As technological tools became more sophisticated, the ability to expand over the landscape increased and reliance on natural processes decreased. The subtle, but important, nature of local waterways was not appreciated by modern society. In recent history, creeks, streams, and rivers were placed into stormdrains and steep channels. Severe pollution problems called attention to the weaknesses of this approach.

The contemporary period is marked by an awareness of watershed function and a desire to integrate it with human needs.



Tongva period.

The Tongva

Little of the ancient history of Los Angeles is visible to the contemporary resident. Perhaps the most famous relics are the dinosaur bones kept in the Museum of Natural History, unearthed in an era of oil prospecting. In terms of ancient peoples, some of their sacred caves still exist, isolated in remote areas of the Santa Monica Mountains. The Native American presence in the region seems minimal: sacred spaces and burial grounds within the city were demolished, few place names remain, and the descendents themselves struggle to this day for recognition as a unique cultural and ethnic group.

The Tongva began arriving in Southern California about 4,000 years ago. They replaced an earlier group of Hokan speakers, associated with the Uto-Aztecan language groups. The Tongva used the local plant communities extensively, particularly for reed materials to make baskets, which were waterproofed with local, naturally occurring tar.

They established villages throughout Los Angeles and the San Gabriel valley. Their population was believed to be about 5,000 in the late 1700s (Gumprecht, 1999). Yang-na was located near present-day downtown Los Angeles, on high ground above the Los Angeles River (Goinn, 1901). Several villages existed in the Ballona Creek watershed. The village Kuruvangna, “place where we are in the sun,” has enjoyed a recent resurgence in awareness as Tongva nation members promote the natural springs at University High School in West Los Angeles, where the village was located. Sa’angna, “tar,” was located near the Ballona wetlands. No place markers are known. The village name Kawengna, meaning “place of the mountain,” has survived. Today it marks the low point in the Hollywood Hills where the 101 Freeway runs through Cahuenga Pass. It is believed that there were many villages at the base of the Hollywood Hills near freshwater sources.

Tongva village sites in the Los Angeles vicinity.

Rancho period.

Spanish Colonization and Mexican Ranchos (1770–1847)
Spanish explorers arrived in 1769. In their diaries, they described the area known today as the Ballona Creek watershed:

> *A grove of very large alders, high and thick, from which flows a stream of water..The banks were grassy and covered with fragrant herbs and watercress. The water flowed afterwards in a deep channel toward the southwest..some large marshes of a certain substance like pitch; they were boiling and bubbling, and the pitch came out mixed with an abundance of water..the water runs to one side and the pitch to the other..*
>
> *(*Bolton, 1927)

Juan Crespí, one of the explorers, described camping at a grove of sycamores—near presentday Highland Ave. and Venice Blvd.—by a "very copious spring" (Gumprecht, 1999). The explorers felt that the region had rich soil for agriculture. Shortly after their expedition, in 1771, the San Gabriel Mission was founded. Some Tongva were forced to convert to Christianity and provide free labor for the construction and operation of the missions (Fogelson, 1967).

The Spanish government needed a means of providing food and supplies to the forts that protected the inland missions and coastal territory. Eleven families were sent to settle the Pueblo de Nuestra Señora de los Angeles in 1771. Each family was given land outside of the pueblo for agriculture and livestock grazing. Residents of the pueblo built irrigation ditches, called *zanjas*, that were central to traditional community water-sharing practices. These ditches irrigated grapes and grains for small scale commerce and provided household water (Gumprecht, 1999; Fogilson, 1967).

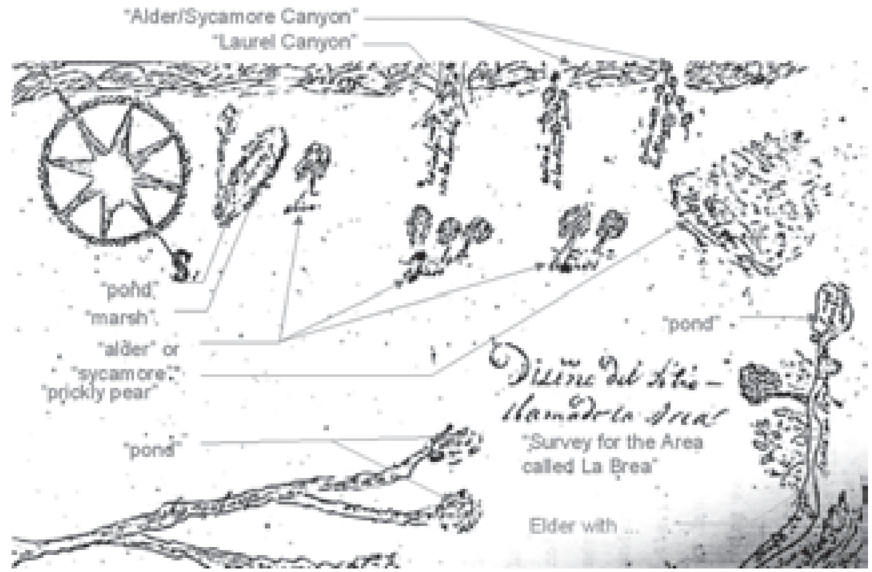
Map of Rancho La Ballona and surrounding areas. From The Machados and Rancho La Ballona.

Political affiliations changed in 1822, when Mexico declared its independence from Spain. The missions were secularized, and an era of large-scale ranching began. The residents received land grants from both the Spanish and Mexican governments. The boundaries of these land grants were shown on rancho maps, using significant landscape features as reference points.

The map at right, of the Rancho La Brea, provides clues to the historic vegetation and landforms of the region. Stands of alder trees, nopal clusters, and marshes or ponds were particularly significant. This rancho seems to have ranged a variety of vegetation types, from dry coastal sage scrub to riparian woodland to freshwater marsh. This ranch's namesake, tar or *brea*, was used by the settlers to seal roofs and water vessels.

The rancheros' lives were supported by the *patrón-peón* social and economic structure. Native people often lived on rancho land in exchange for providing labor. Rancheros socialized with each other in the private sphere of their homes (Fogilson, 1967). They even generally conducted business directly from their ranches, establishing a pattern of withdrawal from the public sphere which would continue into the twenty-first century.

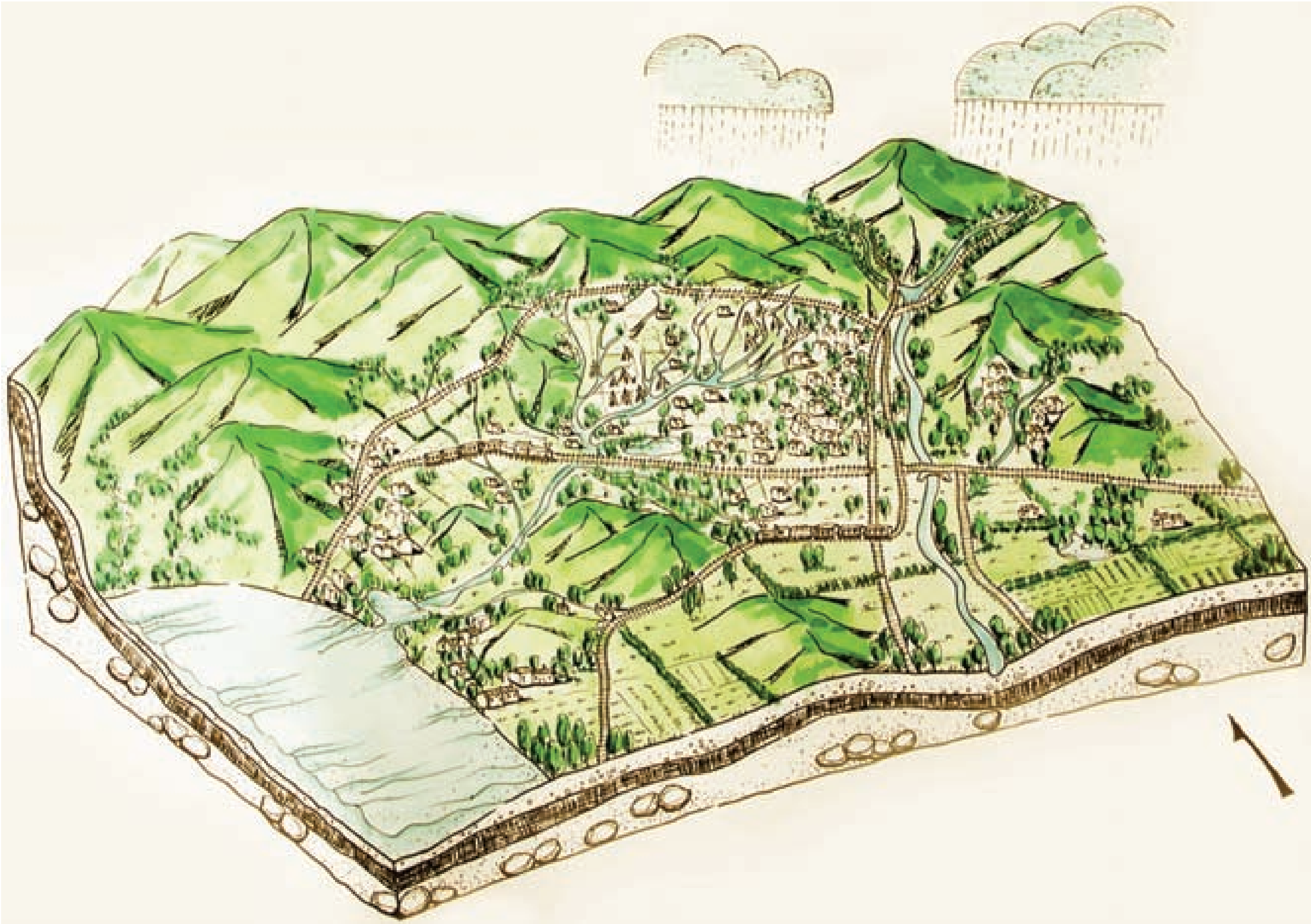
The Mexican-American War of 1846-48 sparked a period of significant change for the people of the region, ranchero and Native American alike. In the next year, with the Gold Rush of 1849 placing California in the consciousness of the world, Southern California would be touted as an agricultural paradise to the residents of the eastern seaboard and midwest of the United States. The region would soon flood with newcomers.



Map of the La Brea Rancho. Rancho maps frequently used landscape features, including vegetation, to reference their land. From A History of Rancho La Brea to 1900 *by Clarice Bennett (1938).*

Rancho period birds eye. Courtesy Photo Collection/Los Angeles Public Library.

Historical Rancho houses in the Ballona Creek watershed. From upper right down: Fremont home, Rancho Cienega, Rancho La Brea, and the Rancho La Ballona. Courtesy Photo Collection/Los Angeles Public Library.



Early Statehood period.

Early Statehood (1850-1930)
In 1850, shortly after the Mexican-American War, California attained statehood. A combination of factors, from unfamiliarity with a market economy to severe droughts and immigrant squatters, caused most of the rancheros to lose their lands to Anglo-Americans. Rancho land deeds were often disputed and frequently invalidated by American courts. New American owners of the deeds quickly set out to subdivide the properties, beginning a real estate development of the region that persists to the current day. For this reason, many subdivisions platted with the city echoed the boundaries of old ranchos.

1888 Irrigation map of the Ballona Creek watershed. Courtesy of UCLA Map Collection.

The newest settlers initially were farmers. Los Angeles became famous for its wines, fruits, and grains (Gumprecht, 1999). At the same time, the tar pits yielded to oil derricks as oil prospecting took over large tracts of land west of downtown Los Angeles. G. Allen Hancock not only benefited from his oil wells, but also later subdivided his land, creating Hancock Park (Gilman, 2001). Ice Age fossils were gleaned from the tar pits and placed in local museums between 1906 and 1915.

A variety of railroads facilitated commerce and residential expansion throughout the basin. The Pacific Electric Railroad, known as the "Red Car," is perhaps the most famous of these systems. It connected downtown Los Angeles with the beach communities of Long Beach, Santa Monica, and Redondo. These privately owned railway companies were eventually dismantled by petroleum interests. The peculiar widths of certain boulevards in Los Angeles are the only remnants of the rail systems.

Red Car 1940. Courtesy Photo Collection/Los Angeles Public Library.

Early farm in Hollywood area. Courtesy Photo Collection/Los Angeles Public Library.

Los Angeles was touted as a romantic, pastoral, and exotic locale. Images portraying the region often mixed these metaphors, combining classical Arcadian backdrops with Mission imagery and palm trees.

As population increased, so did the demand for water. The region's abundant groundwater was pumped for increasingly intensive agricultural and domestic uses. The groundwater level dropped rapidly, drying up some surface streams. The Los Angeles River's base flow was significantly reduced, and the river appeared dry during large parts of the year. Photographs from this period show barren landscapes in the study area. Several reservoir and water delivery projects were undertaken by entrepreneurs. These had uneven success and eventually were taken over by the municipal government (Fogelson, 1967). The Department of Water and Power undertook its massive Owens Valley Water Project, completed in 1913, fueling even greater growth within the region.

During this period, a variety of strategies seem to have been used to manage natural streams in the study area. Check dams were installed in Griffith Park to detain surface runoff. Bridges, like the one shown near Franklin St. (top right), cross over an intermittent stream from Bronson Canyon. Parks and golf courses—such as MacArthur Park, Lafayette Park, and the Wilshire Country Club—were designed with water features that replaced former streams. This was possibly done to create buffer zones for flooding.

Where technology permitted, however, streams were piped or filled in. Real estate developers rarely saw the waterways as attractive amenities that would augment the neighborhoods they were creating, but rather as nuisances that interfered with the grid of streets they were laying out. In at least one case, they laid out the sidewalk right up to a creek's edge, waiting to be able to remove the creek altogether.

Franklin St. bridge as it appeared in 1904. Courtesy Photo Collection/ Los Angeles Public Library

Early developers laid their street grid directly over streams. Courtesy Photo Collection/Los Angeles Public Library.

Particularly poignant was the fate of Sacatela Creek. A perennial stream supplemented by the flow of several intermittent streams, Sacatela was destroyed by developers. The dominant attitude of the time supported this action. As the *Los Angeles Times* reported in 1930:

> *Forty-five acres of ground, now a waste..will be reclaimed for use when this slough, which formerly carried away the waters of Sacatela Creek, is filled in. The live stream of this creek now flows through the Sacatela No. 3 stormdrain, leaving no excuse for the gullies and ravines which now exist.*

Fifteen million dollars (in 1930 dollars) was spent on this infill project. Local lore suggests that decommissioned trolley cars were used to fill the slough.

Combined with the increased paving of surfaces, floods became frequent events. The flood of 1914 was particularly severe and provoked a movement to channelize streams and rivers in the Los Angeles area. The Owens Valley Water Project increased technological knowledge about managing water, emboldening engineers to take on the rivers and creeks of Southern California. The following remarks, made about the Los Angeles River, can be seen as a fitting eulogy for the streams of the study area as well:

> *The aqueduct changed the way people viewed the river. No longer was it the city's lifeline. Now it was mainly a threat to life and property.*
>
> (Eberts, 1996)

1958 flood on Country Club Dr. Courtesy Photo Collection/ Los Angeles Public Library.

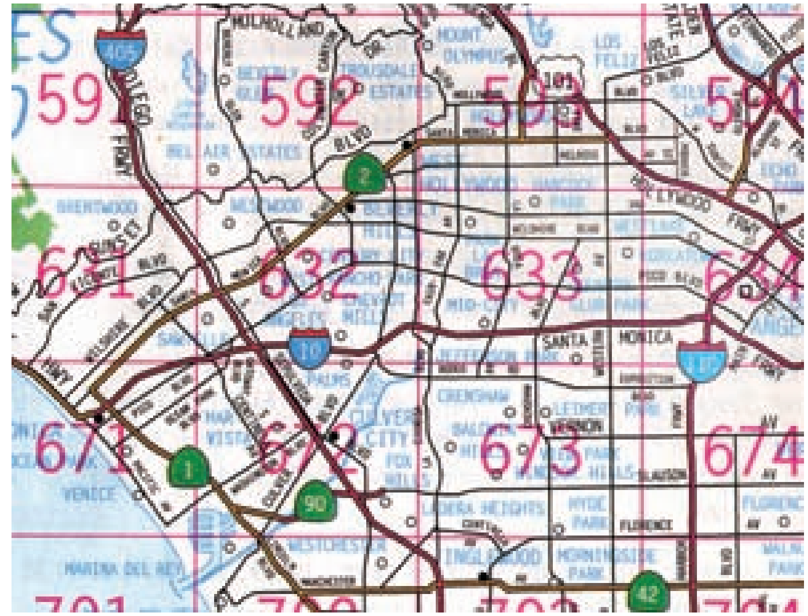
1920 flood on Mariposa Ave. Courtesy Photo Collection/ Los Angeles Public Library.

Contemporary Los Angeles.

Contemporary Period (1930–present)
As the population of Los Angeles continued to grow, the use of technology to enhance life and property became ever more important. From the 1930s on, railroads were decommissioned and freeways were built to facilitate automotive traffic.

Urban form also changed. Whereas the older areas of the city often featured multistory brick tenement buildings with light wells and courtyards, stately concrete churches, department stores, or commercial buildings or gracious Victorian homes that had an imposing presence on the street, later buildings receded from the street, creating a spatial void for pedestrians or bicyclists. Street widths expanded to accommodate multiple lanes of traffic and the turning radii of cars. Mass production techniques resulted in a simplification of architectural styles, and homes became increasingly boxy and nondescript during the post–World War II housing boom.

The entertainment industry boomed during World War II, as Hollywood produced propaganda and fantasy films to keep spirits high. Aerospace and tourism also took hold. Agricultural lands were replaced by a carpet of detached single-family dwellings, establishing a trend that continues to appeal to Americans. Encouraged by utopian ideals, these home-building trends continued the tendency of Angelenos to eschew the public realm, focusing more intensely on hearth and home. The side effect, however, was a lack of investment in public space and in social issues that extended beyond one's immediate sphere. Los Angeles' ethnic population grew, and ethnic and racial minorities languished in segregated communities (Davis, 1992). In 1965, the Watts Riots were a wake-up call to the city, one repeated almost 30 years later after the verdict on the Rodney King beatings. These events stand as important reminders of the need for investments that create healthy sustainable communities.



Navigation in contemporary Los Angeles requires a detailed and complicated set of maps. From The Thomas Bros. Maps*, 1996.*


Housing divisions built after World Ward II in the Los Angeles area. Courtesy Photo Collection/ Los Angeles Public Library.


Present-day temple in Koreatown.

With development, flood control projects dominated the landscape. The period from 1930 to 1980 was marked by an ongoing program of controlling waterways. When flood control efforts failed to constrain inundations, as in 1934, rather than question the merit of the strategies used, public agencies pursued greater interventions.

Engineering feats were greatly admired and deeply influenced the culture (McClung, 2000). The simple renaming of Ballona Creek as Ballona Channel Stormdrain disassociated the waterway from its ecosystematic role and focused on its utilitarian urban role. This broken link has become so extreme that many Angelenos find it difficult to comprehend that streams once flowed throughout Los Angeles. Stream representations are often contrived, communicating a simplistic and juvenile understanding of stream function.

UCLA naively proposed turning the mouth of Ballona Creek into a regatta course in 1937. This plan would have relied heavily on engineered solutions to fill the wetlands and restrict and provide a smooth, nonflooding channel. The plan included a railway so the audience could follow the boaters (Los Angeles Times, 1937).

In this time of ecological distress, voices did call out for a different approach. In 1930, the Olmsted brothers, sons of the famed landscape architect Frederick Law Olmsted, created a greenway plan for the city of Los Angeles. The Olmsted brothers believed that Ballona Creek's flood plain should be left in an undeveloped state in order to prevent flooding problems while also providing seriously needed park space. They envisioned an interconnected system of parks with "pools and basins in places," and a narrow channel for runoff. This plan allowed for the basic principles of watershed function to remain intact. If Ballona Creek were walled in, they insightfully said, it would "become a very ugly feature in the district, standing empty and dry most of the year, a receptacle for papers and rubbish" (Olmsted Brothers, 1930).

Ballona Creek was renamed Ballona Channel Stormdrain in the early 1930s. Courtesy Photo Collection/Los Angeles Public Library.

Olmsted Brothers 1930 open space plan for Los Angeles. From Parks, Playgrounds and Beaches for the Los Angeles Region.

In more recent years, environmental organizations have worked to resuscitate the beleaguered natural environment of Los Angeles. Friends of the Los Angeles River began operating in the late 1980s and serve as an inspiration to groups in other areas. The Wetlands Action Network is one of several groups working to preserve and restore the remaining areas of the Ballona wetlands. The Ballona Creek Renaissance has emerged as a leader in coordinating efforts to raise public awareness of the creek and promote its eventual rehabilitation. The Baldwin Hills Conservancy was formed to restore a portion of the hills bordering on Ballona Creek, and the Ballona Watershed Conservancy has recently formed to address restoration efforts as a whole, although they are more focused on the west side of Los Angeles.

*The Wetlands Action Network is promoting a restoration vision for the Ballona Wetlands. This painting by Lee Mathes—*A New Day*—represents that vision. From the Wetlands Action Network's website.*

These groups have government agencies like the Santa Monica Mountains Conservancy and the National Park Service Rivers and Trails Program that can provide support for their efforts. There are also organizations coordinating environmental planning efforts, like the Santa Monica Bay Restoration Project and the Los Angeles and San Gabriel Rivers Watershed Council.

Watershed planning, in which human needs and uses of the environment are viewed within the whole functioning system of a watershed, has become a priority for the city and county of Los Angeles. The Los Angeles County Department of Public Works is developing watershed plans with the coordination of community groups like Ballona Creek Renaissance to address the multiple issues of water quality, flood control, and open space needs. The City of Los Angeles Bureau of Sanitation is looking for innovative ways to reduce and recycle water and is considering implementation of regenerative design principles to support watershed management planning practices in meeting their objectives.

Current Issues

Photo: Aerial view northwest of downtown Los Angeles. The 101 Freeway is a visible dividing feature in the middle ground. Earlier natural features have all but disappeared. From Above Los Angeles *by Robert Cameron (1986).*

The effects of a socially and environmentally unsustainable past and current land development practices create ongoing problems in the Los Angeles region. In addition to the disappearance of surface water bodies, both inland and ocean water quality is compromised by point and nonpoint source pollution.

Inadequate public open space exacerbates the crowding and endangerment of pedestrians and bicyclists in areas where population densities exceed the capacity of existing structures and amenities. Commitment to civic life and participation in public life is dampened by the prevalence of restrictive messages in public spaces. Privately owned spaces, such as malls, often define social interactions. Los Angeles is often accused of being placeless and disjointed as residents struggle to find a sense of community in a land of dispersion.

Vermont St. struggles to create a distinct identity.

Compromised Watershed Function
As seen in the Stream Seeking section of this document, numerous streams, wetlands, and springs disappeared over the course of the twentieth century. Some dried up as groundwater was pumped for agricultural and domestic use. Others were piped or channelized to protect expanding subdivisions from floods. Ravines were filled and covered with buildings. The obliteration of streams dissociates Los Angeles from its natural context to such an extent that residents orient themselves almost entirely by engineered structures, like freeways, or architectural landmarks, like stadia and historic buildings. The effects of this dissociation range from insensitivity to problems caused by littering to ignorance of global environmental issues. Reconnecting residents with local natural features is an opportunity to broaden the public's understanding of natural processes and their own role within an ecosystem.

Greenways supported by streams typically function to provide corridors for the movement of animals and people. The absence of these greenways contributes to an "island effect," where animals are trapped in remote habitat patches, unable to refresh their gene pools and eventually become locally extinct (Odum, 1997). The Los Angeles General Plan expresses a desire to restore biological diversity where possible (Los Angeles City Planning Department, 1995). Local efforts to restore habitat patches would benefit from the greenway connections that streams provide.

Natural stream function also supports vegetation and bacteria that can break down toxins and pollutants. Restoring the cleansing properties of streams and greenways can provide a valuable, self-supporting, and relatively inexpensive method of mitigating pollution, which is a serious issue in the Los Angeles basin. Considering that 16.9% of water for Los Angeles was supplied through groundwater wells in 1997-98, cleansing runoff and replenishing the aquifers would be desirable goals.

Low flow portion of Ballona Creek's concrete channel.

Los Angeles County Department of Public Works installed a "trash net" at the mouth of Ballona Creek. This net captures between 30 and 60 tons of trash annually. From www.lacity.org.

Pollution

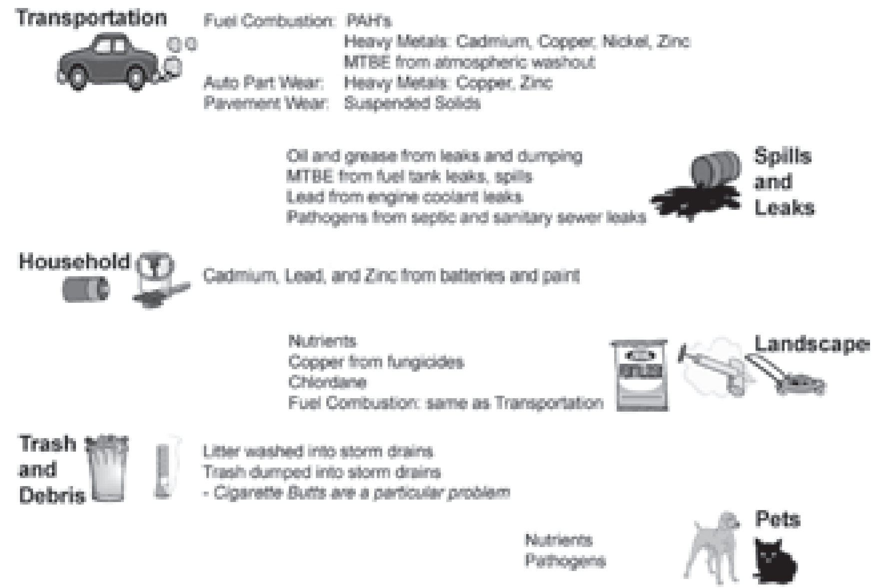
The urban environment has many negative effects on stormwater runoff quality. The most obvious, because it is most visible, is the trash that water picks up on its way to the ocean. To combat this problem, the Los Angeles County Department of Public Works built a steel-cable trash net across Ballona Creek near its outlet into the Pacific Ocean. Los Angeles County Department of Public Works spends over $7 million annually to keep both this net and the county's beaches clear of trash. According to one study, in an average month Angelenos drop more than 1,000,000 cigarette butts, 900,000 pieces of trash, and walk their dogs without picking up the droppings more than 125,000 times (Mozingo, 1997). This results in two tons of trash washing into the creek for every inch of rain (Cone, 1999).

Nonpoint Source Pollution

There are other less obvious sources of pollution. Impervious surfaces collect substances deposited from the atmosphere, leaked from vehicles, flecked from brake pads, and eroded from auto parts. These substances dissolve into rainwater and are the leading source of water quality problems in Southern California. They prevent waterways from being fishable and swimmable, the main beneficial uses defined by the Clean Water Act. They have caused beach closures and health problems for some of the 45 million annual visitors to those beaches. This mixture of pollutants is also toxic to some of Santa Monica Bay's marine life. Indeed, Ballona Creek ranks in the top 10% of polluted U.S. waterways (Cone, 1999).

Heavy metals in stormwater have been identified as a problem in the Ballona Creek watershed. If not addressed they could become a problem for residents. Exposure to heavy metals has been linked to developmental retardation, various cancers, kidney damage, autoimmunity, memory problems, and even death in the case of high concentration exposure.

Non-Point Pollution Sources in the Ballona Creek Watershed

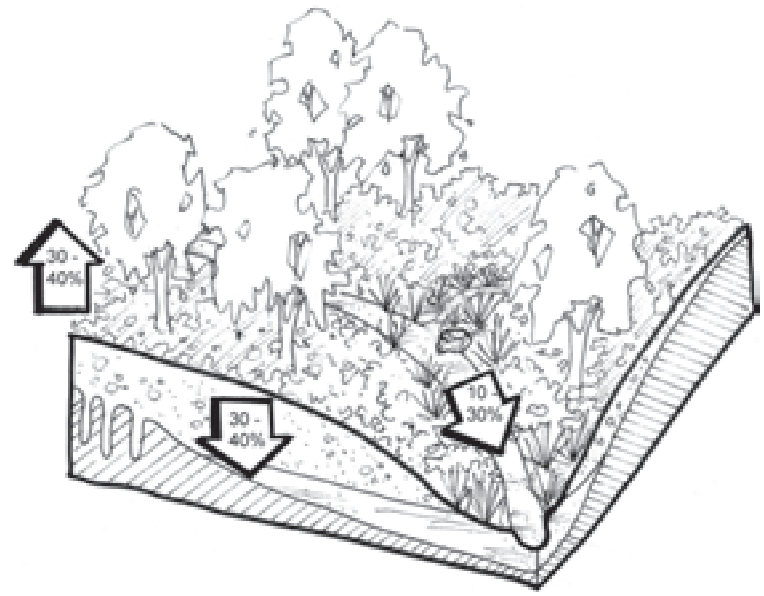


Runoff

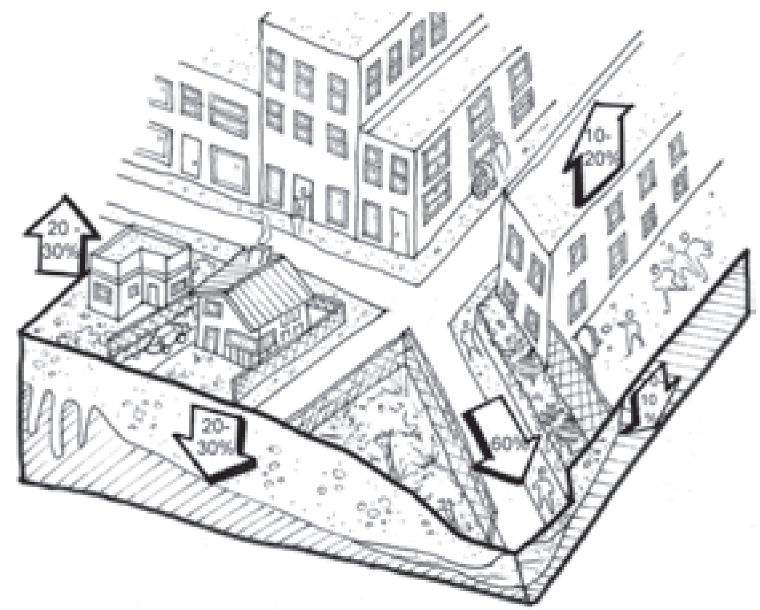
Current research shows that water quality and stream health is reduced when impervious area exceeds 10-15% of land area. Above this level, stream channels become unstable and erode, stream temperatures increase, and habitat quality is consistently poor. Furthermore, imperviousness is the key predictive value in empirical models used to estimate pollutant loads and bacteria levels (Schueler, 1994).

Above 25% impervious area, predevelopment channel stability and biodiversity cannot be maintained, even when best management practices are applied (ibid.). This does not mean that rehabilitation efforts for streams in these areas should be abandoned. Rather, the primary objective in this instance is to protect downstream water quality by removing urban pollutants. Allowing water to soak into the ground, a process known as infiltration, is one method of preventing pollutants from becoming part of a stream flow.

A common worry about this method of cleansing stormwater is that pollutants will contaminate groundwater and soils. According to the EPA, this is not true. Most stormwater pollutants pose a low risk to groundwater through surface infiltration (Pitt, 1994). This is because certain plants and soil microbes contained in infiltration areas filter, absorb, and convert common pollutants to an innocuous form. Vegetated buffers at least 100 feet wide are effective for preventing pollutants from entering a stream (Schueler, 1995). These areas could take the form of parkways, small neighborhood parks, and constructed wetlands. Porous pavement and vegetated roofs could also play a role in this function.



Disposition of stormwater before development.



Disposition of stormwater in Ballona Creek watershed.

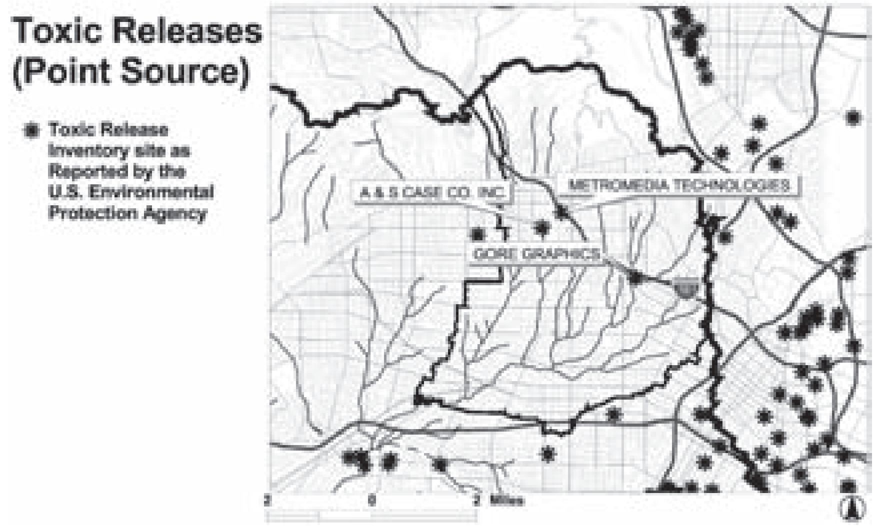
Current Attitudes toward Urban Runoff

Since the passage of the Clean Water Act in 1967, the EPA has focused much of its efforts on addressing pollution from sewage plants and industries. By 1990 those sources were largely under control and the agency turned its attention to nonpoint source pollution, such as urban stormwater. The agency is now working with state water quality officials to set pollution limits, or Total Maximum Daily Loads (TMDL), for about 130 water courses in Los Angeles and Ventura counties. The goal is for those waterways and also beaches to be safe for recreation. These limits will be phased in through 2011.

For Ballona Creek these limits will focus on trash and heavy metals including. zinc, copper, lead, cadmium, nickel, and silver. A maximum for each pollutant will be set by late 2003. Los Angeles County, Los Angeles, Culver City, West Hollywood, and Beverly Hills are jointly responsible for cleanup.

Because of the EPA's focus, government agencies have created mitigation programs and public education programs. In 1990 the City of Los Angeles created its Stormwater Management Division—recently renamed the Watershed Protection Division—to develop and implement stormwater pollution abatement projects within the city. Also, Los Angeles County Department of Public Works formed a Watershed Management Division in September, 2000.

Los Angeles County is currently in the process of adopting a Standard Urban Stormwater Mitigation Plan for Los Angeles County and cities in Los Angeles County. This was proposed in 2000 to effectively prohibit non-stormwater discharges and reduce to statutory standard the discharge of pollutants from stormwater conveyance systems. Postconstruction Best Management Practices (BMP) must mitigate runoff from at least the first 3/4" of precipitation and provide flood protection.



Point source polluters in the upper Ballona Creek watershed, according to the EPA.

A film of oil covers water emerging from Ballona Creek's current daylighting point.

Fauna

Because of the increase of human habitation, most of the original species' habitats found in the region have been marginalized to the borders of the watershed, and their numbers reduced. These borders include the Santa Monica Mountains to the north; the soft-bottom portions of the Los Angeles River to the east; the Baldwin Hills to the south; and the lower Ballona Creek remnant wetlands to the west. Many fish species have been extirpated from the area due to stream channelization.

The Ballona Creek watershed's fauna are represented primarily by species adapted to the urban environment. These are mostly birds, also known as avifauna, that include:

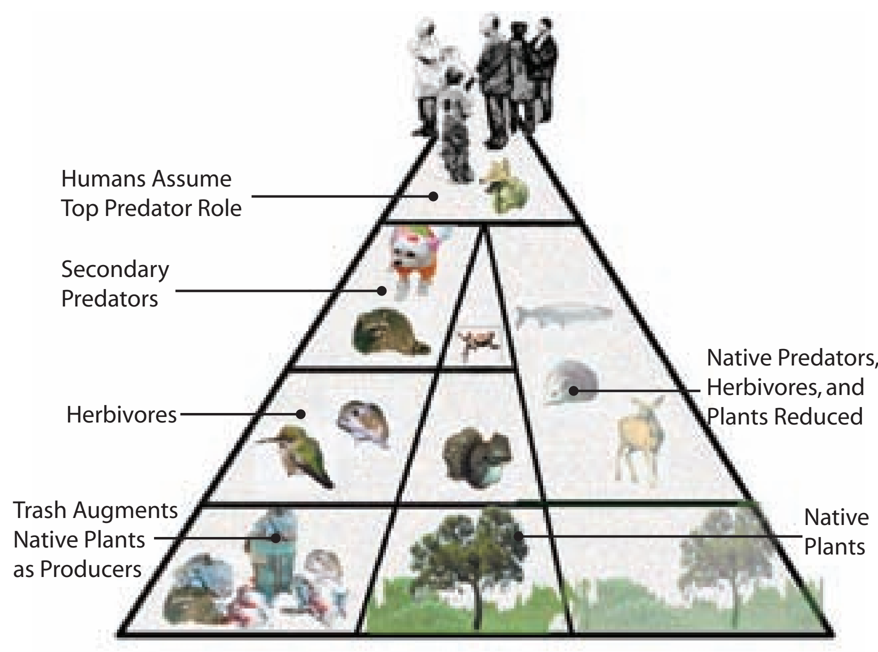
rock dove*	spotted dove*
mourning dove	Anna's hummingbird
black phoebe	western scrub jay
American crow	bushtit
American robin	northern mockingbird
European starling*	Brewer's blackbird
brown-headed cowbird	house finch
house sparrow*	

If park ponds, well-planted gardens or large bridges are present, additional urban avifauna include:

mallard	red-tailed hawk
American kestrel	American coot
killdeer	barn owl
great horned owl	white-throated swift
Allen's hummingbird	common raven
cliff swallow	hooded oriole
northern rough-winged swallow	

*Non-native, introduced species

Mammal, reptiles, and amphibians can occasionally be found in urban areas but are not common. Mammals include coyotes, skunks, opossum, rats and mice. Reptiles and amphibians include snakes, lizards and salamanders.



Current trophic structure of the Ballona Creek watershed. Adapted from Forman, 1995. Native species images from California Academy of Sciences.

Population and Urban Design

The city of Los Angeles has complex urban design and planning challenges. The city's population is projected to grow 24% from 1990 to 2010 (Los Angeles City Planning Department, 1995). Despite such an influence, commercial development has been a priority over housing for the past decade, leaving housing needs largely unmet. While infill development is an option to provide for some of the housing, existing properties will also have to be redeveloped over time. Existing open spaces are grossly inadequate compared to other cities in the United States.

Fences, barriers, and prohibition signs dominate open spaces; poor police-community relations in blighted areas similarly reinforces the sense that the public is not desired in the public realm. Streetscapes in Los Angeles also reinforce this attitude: they are designed to respond to the needs of people in automobiles, not pedestrians or bicyclists. Community gathering areas, or districts and nodes, also tend to be situated in areas convenient to automobilists. Future development that places priority on pedestrians and bicyclists can help to resolve these problems.

The city's erratic development practices produce "dead spaces" on streets.

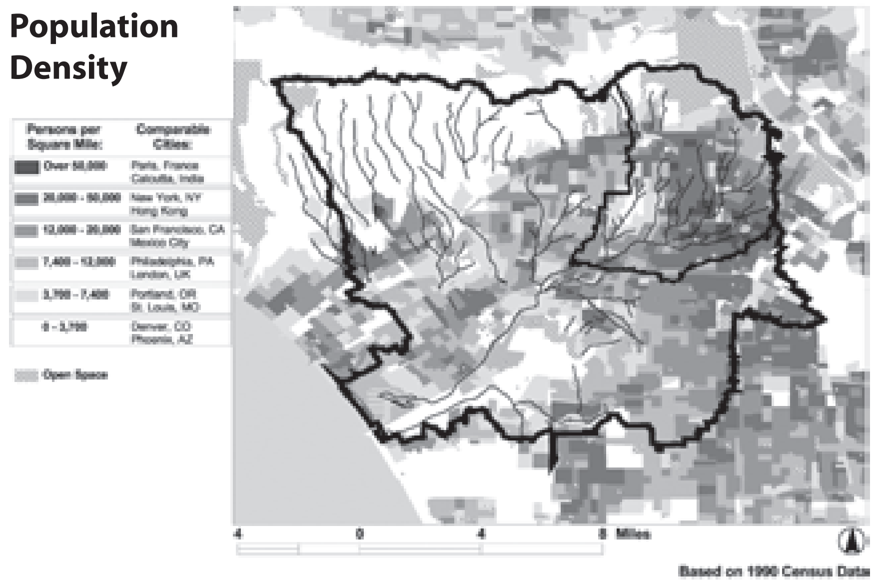
Density

Many people view Los Angeles as a city with low buildings and low population density. However, the numbers tell a different story. In the 1990 census, the city had an overall density of 7,400 people per square mile.* This is denser than all but seven other American cities. Furthermore, Los Angeles has several large park areas on its fringes that have zero density, private golf courses with restricted access, and large affluent areas with low density. The result is that a significant portion of the city's land is occupied by a relatively small number Angelenos. The density of the remaining area is comparable to densities of the world's most populous cities. In fact, several blocks in Koreatown have a density greater than Paris' 52,000 people per square mile.

Furthermore, low-income wage earners—those who earn less than 80% of the countywide Median Family Income (MFI)—make up a large part of the study area. In 1990 almost half of the city's households fell into this category. According to the U. S. Department of Housing and Urban Development, this situation continues to worsen (Martinoff, 1995). In the upper Ballona Creek watershed, the combination of population density and low-income households has resulted in a large population of residents with little money and almost no access to recreational facilities.

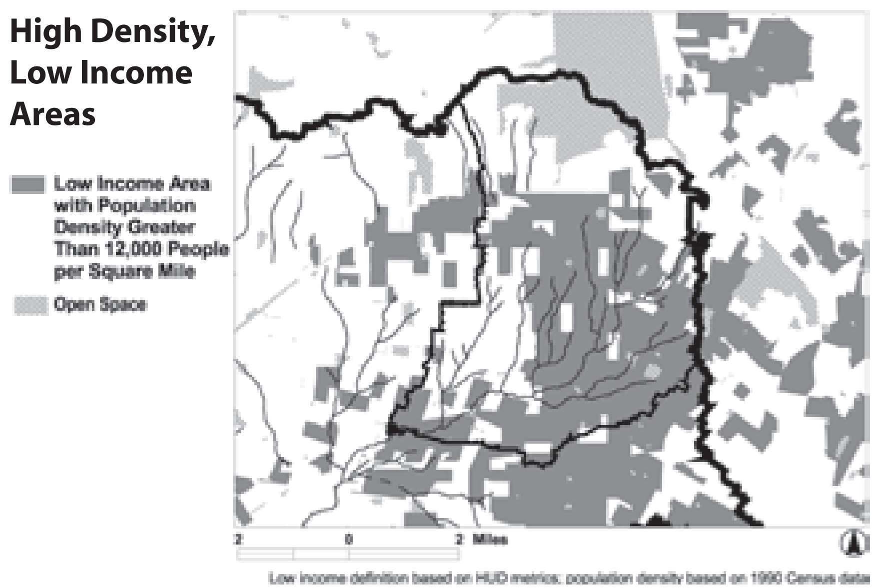
This situation has intensified because the city has become more congested with little provision for parkland. In 1950 the city had 4,368 people per square mile. The population grew by 70% in the following 40 years without increase in land area or park space. As a result, the 10% of total city land now devoted to parks is inadequate for residents' needs.

Population Density



Population density in the Ballona Creek watershed.

High Density, Low Income Areas



High density, low-income areas in the upper Ballona Creek watershed.

* 1990 census used because geographically detailed 2000 census was unavailable at the time of this report.

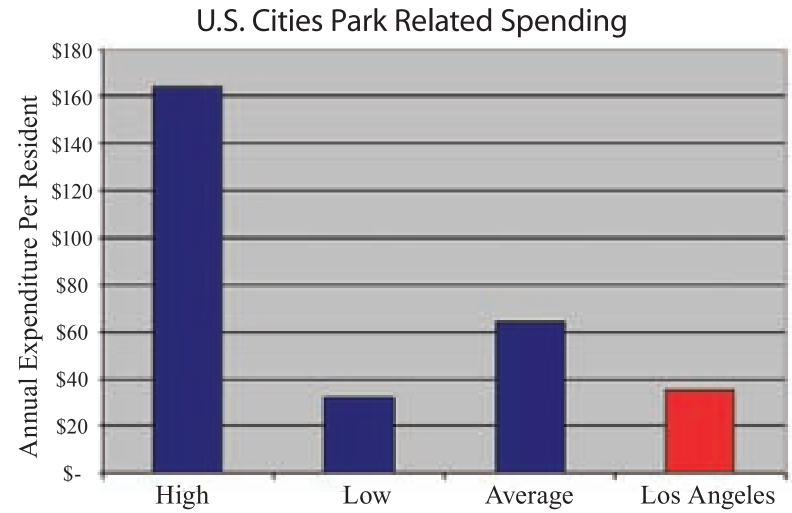
Open Space

Los Angeles' naturally inviting location combined with low-density development practices undermined the political will required to create a quality park system. In its heyday it was hard to imagine that the area's open space would become overused or depleted and need to be supplemented with parks. In addition, backyards provided private open space for many people. Los Angeles seemed likely to be the first city with so much private lawn space that parks would be unnecessary (Harnick, 2000).

With this attitude prevailing, the city's park spending per resident has been far below the national average. This has resulted in fewer acres of city parks per capita and more acres of commodified gallerias, lands, and walks than any other region in the nation (Waldie, 1999). According to the national standard of 10 acres of open space per thousand residents, the upper Ballona Creek watershed should have 5,600 acres of local parks and playgrounds. It has 100 acres. This is all the more important in a city where 60-70% of all land is dedicated to the automobile (Ward, 1963).

Peace and Hope Park represents the dire park situation in Los Angeles. It began as a vacant lot local children used to play outdoor games. In October 2000, residents convinced the city to buy it and create an official park. However, for insurance liability reasons the city immediately fenced off the one-third-acre area until a park could be built. It is now inaccessible to residents (Mozingo, 2001).

Yet these residents—many of whom fall into the low income category—are the people most likely to need access to open space. They have little or no discretionary income and no position that admits them to privately owned spaces such as golf courses. This group needs cost-free activities without travel or high equipment costs (Kelly, 1999). Clearly the people of the upper Ballona Creek watershed need more publicly owned open space.



Based on 2000 study of 25 largest U.S. cities annual park operating expenses and capital costs (Harnik, 2000).

Peace and Hope Park in February 2001.

Housing Shortage
Between 1996 and 1998, total housing units in the Community Planning Areas intersecting the study area declined by 180. In Silverlake alone, housing units dropped by 530 (LA City, 2000). While this is in part due to damage from the 1994 Northridge earthquake, it exemplifies the need for developing additional housing. However, this seems to not have been a priority for the city over the past few years.

For example, the City of Los Angeles spent only $24.6 million, or 27%, of its federal Community Development Block Grant funds on housing in 2000. In comparison, New York City spent $137.6 million, or 65%, of its funding on housing. Furthermore, New York City spent $265 million of its own funds on housing last year, while the City of Los Angeles allocated only $5 million, according to Peter Dreier, an urban planner at Occidental College. This housing shortage poses a particular problem for the city's low-income families, who make up a large portion of the study area's population. Almost three-quarters of Los Angeles County's low-income families spend more than half their income on housing (Wedner, 2001).

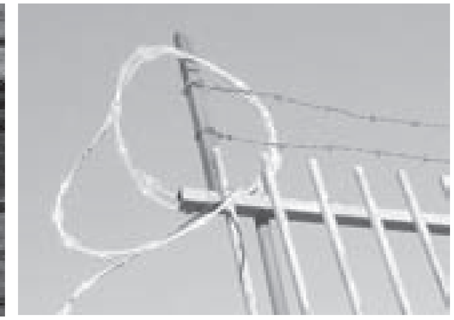
The Los Angeles General Plan has several recommendations to address the housing shortage. Single-family areas can be zoned for increased densities in select areas where they are adjacent to high-density developments (Objective 3.6). Mixed-use developments, with commercial storefronts on the ground floor and dwelling units above, are also encouraged at neighborhood districts, community centers, and mixed-use boulevards.

Derelict apartment building on Temple Ave..

Housing mixed with commercial uses contributes to the vitality of street life.

Restrictors

Newcomers to Los Angeles are often struck by both subtle and blatant messages that control activities in public space. Chain-link fences and even razor wire line many public amenities, such as the Silver Lake Reservoir. Prohibitive signs abound: “No left turns 7 AM - 7 PM,” “No photographs,” “No U-Turns 12 AM - 6 AM.” In some cases the effort to control public behavior seems extreme: at Echo Park Lake extensive fencing blocks the path of an historic bridge connecting to an island in the park’s lake. While the messages seem to express municipal concern for public safety, their roots seem more philosophically grounded in the tendency of Angelenos to eschew the public realm for the private, relegating public space to wasted space. Ironically, this disavowal of the public realm results in greater dangers. The absence of vibrant public activities leaves few eyes on the street, resulting in a lack of natural surveillance. Fencing creates dead zones, which are ideal for undesirable activities. Many people do not feel safe in these spaces and are less likely to use them.



Fencing at Silverlake Reservoir, and elsewhere.

Signs typical in the landscape of Los Angeles.

The bridge at Echo Park lake is gated and locked at all times.

Street Design

As the General Plan states: "(m)any parts of the City, but especially commercial corridors, are unattractive and lack open space, community facilities and visual and recreational amenities." The streets of the study area are designed more for traffic efficiency than civic experience. Some boulevards are 100 feet wide; traffic signals are timed for cars, not pedestrian crossing. Buildings often have their backs to the street. Sidewalks are often narrow. Additionally, the sense of elongated plaza, or paseo, is compromised by the uneven building heights and setbacks of the buildings and the placement of parking lots in front of buildings.

The study area is comprised of several significant streets and avenues, generally categorized as Class I and II Highways. The map at right shows concentrations of traffic by the thickness of the line at the given street. There are minimal bike lanes in Los Angeles. The only lane within the study area runs along a stretch of Sunset Blvd., and is shown on the map at right in a dotted yellow line. This lack of lanes makes bicycling difficult. In fact, several streets in the study area have been designated as "uncomfortable" for bicycling (Mowery, 2000).

Areas with higher pedestrian emphasis are shown in a pink dotted line. Highways and freeways pose significant barriers to pedestrians and cyclists. The skull symbol sizes are proportionate to incidence of injury accidents of pedestrians or bicyclists and motor vehicles. The red skulls show the incidence of mortality (Williams, 2001). The most risky areas are the Westlake/Lafayette Park areas, Pico-Union, and the area immediately adjacent to the Braille Institute of America on Vermont.

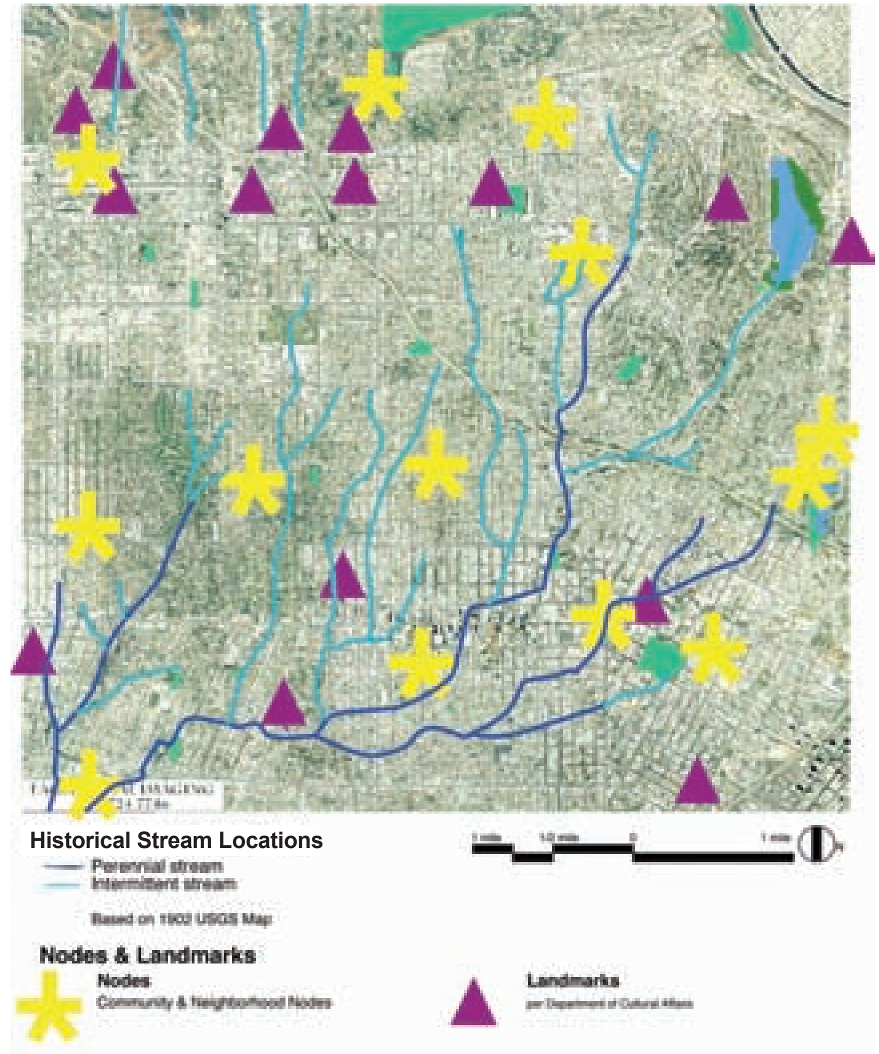
Transportation routes, barriers, and mortality sinks in the study area.

Disjointed Urban Spaces

Inadequate housing, insufficient open space, excessive restictors, and hostile streets combine to produce disjointed urban spaces. While Los Angeles is characterized by vibrant communities like Koreatown and Los Feliz, the connection between neighborhood districts or nodes is often obscured by large, bland streetscapes.

Community nodes (see map at right) sometimes develop in less opportune locations, such as the shopping district along Beverly Blvd. near Vermont Ave. Despite the fast-flowing traffic and narrow sidewalks, many pedestrians and bicyclists brave the streets to patronize the groceries, restaurants, and shops in that area. The node of Sunset Junction is likewise located along a street with fast traffic and narrow sidewalks. By contrast, the pedestrian-oriented node of Larchmont is located in a low-density neighborhood. Clearly many of its patrons drive to the area, defeating its neighborhood-oriented character.

Functional nodes, where people cross paths, do not necessarily align with structural nodes, places where paths cross. Aligning structural nodes, like paths, with major landmarks, districts, parks, or amenities would increase spatial connectedness and awareness of the city. The General Plan recognizes the need to encourage the development of pedestrian-oriented districts and mixed-use boulevards to create more cohesive connections between districts of the city.



Community nodes are widely separated by automobile zones.

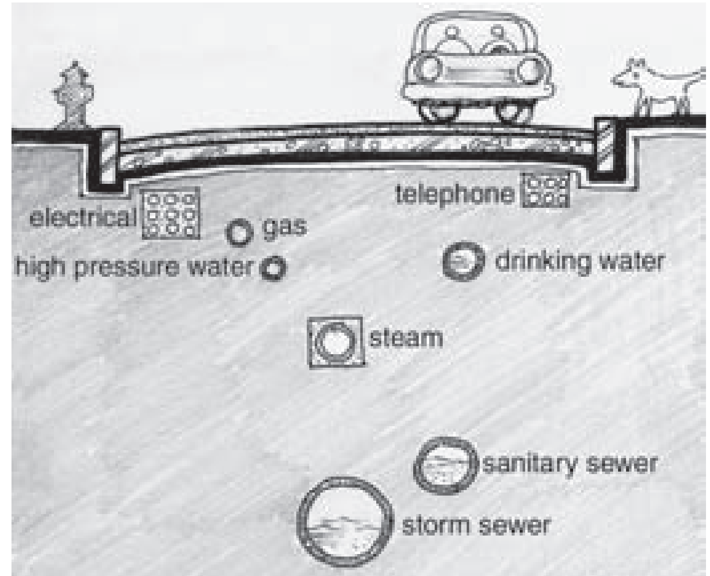
Typical urban space in the study area.

Urban Underground

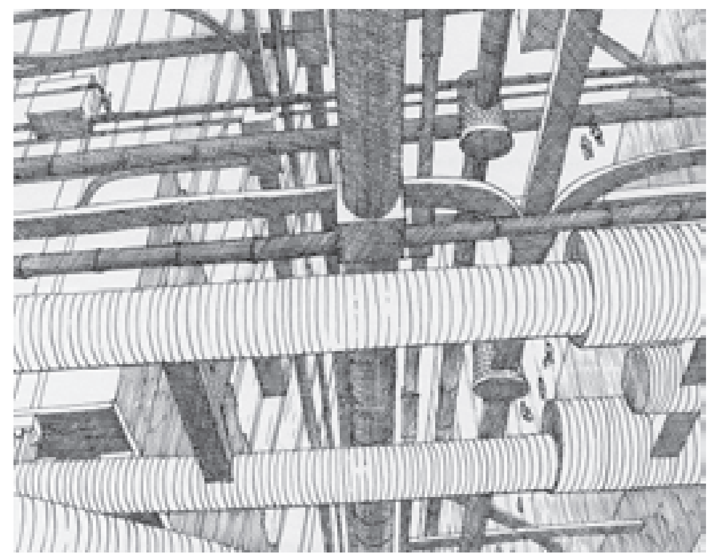
Beneath the buildings and streets of any modern city exists a network of walls, columns, cables, pipes, and tunnels required to satisfy the basic needs of its inhabitants. The larger the city, the more intricate this network becomes. Also, since this massive root system is rarely seen, even in part, its complexity is difficult to imagine. Walls and columns support the city's buildings, bridges, and towers. Cables, pipes, and tunnels carry life-sustaining elements such as water, electricity, and gas, with larger tunnels carrying subway trains. It is the latter infrastructure set that is most relevant to urban stream restoration.

The basic systems of a city, those we call utilities, include water, sewage removal, stormwater drainage, electricity, steam, gas, and telecommunication. They are typically located under sidewalks and streets, as these places are usually in the public domain and provide easy access for maintenance and reconfiguration. The stormdrain and sewer are located furthest beneath the surface. Above them is the steam system, which needs at least six feet of surrounding soil because of the heat it radiates. Closer to the surface and to the sides of the street are the water and gas pipes, while just two feet below the surface are the electric and telephone cables (Macaulay, 1976).

When land is developed, it is usually regraded to place each street at the low point of its surrounding block. This allows the utilities, including stormdrains, to be placed within the street while allowing gravity to drain them. Of course, this layout is not always consistent and can vary based on needs at the time of construction. Because of the substantial expense of relocating utilities, stream restoration will have to take place over a long period of time. This will allow restoration to occur in tandem with efforts that require relocation of utilities, creating an opportunity for funding projects with multiple, rather than single, purposes.



Typical utility layout. Adapted from Underground *by David Macaulay.*



View from under a city street. From Underground *by David Macaulay.*

Conclusion

While there are many other issues that affect daily life for Angelenos, the issues presented here can be addressed through stream daylighting projects.

Developing a strategy to deal with these issues will be the focus of the following section.

An Urban Stream Paradigm

Photo: Aerial photo showing the Bimini Slough, also known as Sacatela Creek, between 1st and 4th Street, east of Vermont Ave.. The slough was filled in 1930. Photo taken in 1924. Courtesy Photo Collection/Los Angeles Public Library.

While stream daylighting is becoming increasingly popular in the United States, it is a new concept to Los Angeles. The pressures of growth on Los Angeles have created many of the described issues. A well-designed stream daylighting project can help to resolve some of those issues.

What makes an urban stream successful? How can the public be protected from floods? Will stream corridors create mugging zones?

These are among the questions that directed research and brainstorming sessions prior to design. Brainstorming identified particular ideas that could be applied in different ways to a stream to accomplish the following goals:

- to enhance the functioning of *natural processes*
- to promote *cultural expression*
- to ensure public *safety*

Precedents for urban waterway restoration both within and outside Los Angeles were gathered for inspiration and guidance.

Design Guidelines
Concepts to address each of the goals were organized into design guideline thumbnails.

Natural Processes
Streams in the Los Angeles Basin have a peculiar nature: some have perennial above-ground flow, while others have primarily subsurface flow that is hidden yet continues to support vegetation and wildlife. Stream designs can explore these tendencies. In Los Angeles, freshwater marshes at elevations of 200-300' above sea level were not uncommon. As an historic landform, they can be given new meaning by integrating them with constructed wetlands for graywater and stormwater cleansing. Through infiltration, cleansed graywater can also help to restore the once-plentiful aquifers in the study area. Groundwater from aquifers can provide a base flow for streams during the dry months of the year. Soils in most of the study area allow for moderate infiltration, suggesting that stream daylighting projects could explore designs that detain or partially retain and infiltrate stormwater.

Cultural Expression
As streams become daylighted, urban form can respond to their presence: buildings can front on streams, promenades and pathways can provide connections between different neighborhoods, and active recreation can be integrated with flood management. Signs, site furnishings, and art installations can provide opportunities for cultural expression that build a local sense of identity in harmony with streams. Functional devices, such as stormdrain outlets and energy dissipators, can be given expressive and multi-purpose uses for different seasons.

Safety
Stream reaches can be designed to accommodate for 100-year storm events with gentle slopes to allow hapless individuals to climb safely out. Lights, pathways, and emergency phones contribute to a safe social atmosphere that in-turn encourages park use.

These guidelines influenced the stream reach design and the concept plans for a park.

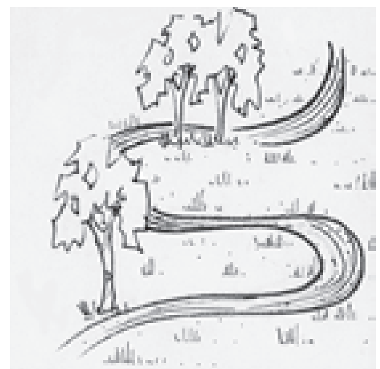
Precedents
The identified precedents confirm that stream daylighting can fuel both economic and socially-oriented urban revitalization projects. They become valued destinations for local residents. At school sites, they are places of wonder and exploration. Streams that have been daylighted process stormwater runoff naturally.

Design Guidelines: Natural Process

Characterize design based on the ***stream location***, from headwaters to the ocean.

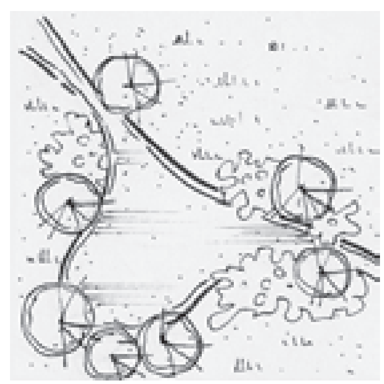
Design for ***groundwater infiltration***, as well as surface stream flows.

Provide space for streams to make minor ***course adjustments*** over time.



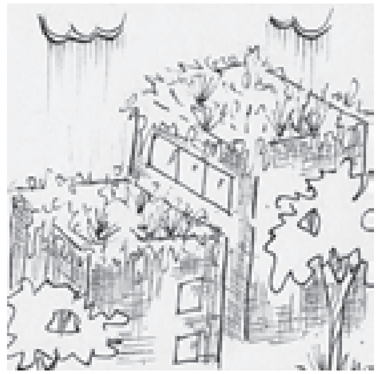
Coordinate plantings that are compatible with the natural process of the microenvironment.

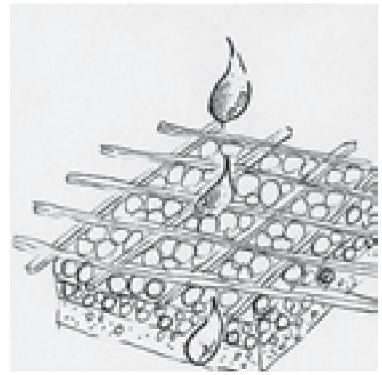
Design for the characteristics of ***intermittent and perennial*** streams.



Provide stormwater ***detention and retention*** ponds to slow runoff rate.

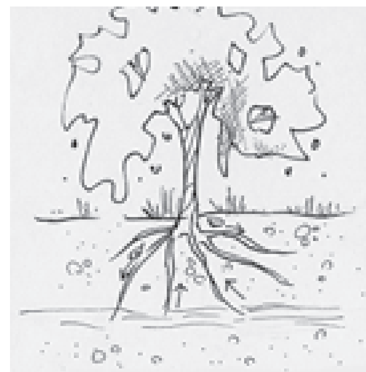
Install ***vegetated roofs*** on buildings to capture rainfall, cleanse water, and provide energy-saving insulation.





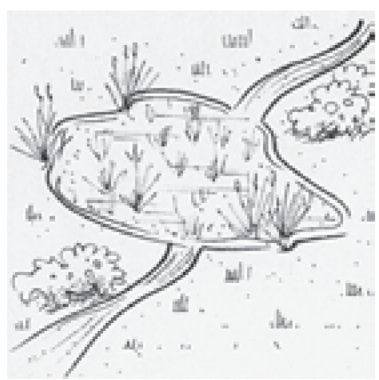
Use ***porous paving*** materials to cleanse water by filtration.

Cycle ***gray water*** from buildings through the landscape. This supplements stream flows and supports vegetation.



Plant trees to improve infiltration and cleanse stormwater. Their roots provide a path for water to soak into the soil and cleanse water by absorbing pollutants.

Combine below-surface sand filters and above-surface ***constructed wetlands*** to cleanse toxins from storm and gray water.



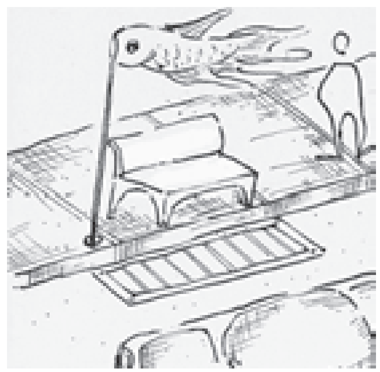
Make visible the process of ***oil seeps***, while protecting people from interacting with the oil.

Design Guidelines: Cultural Expression

Reinforce sense of place and orientation with ***public-awareness maps*** of the historic watershed.

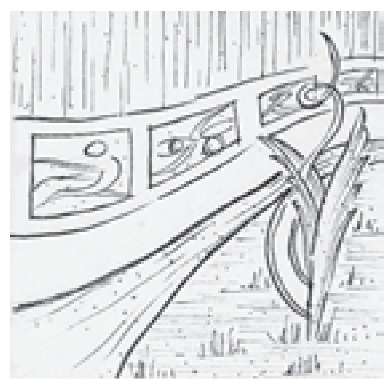
Establish ***community gardens***.

Memorialize the location of former streambeds using ***symbolic landscaping***: vegetation, windsocks, signs, or other artistic gestures.



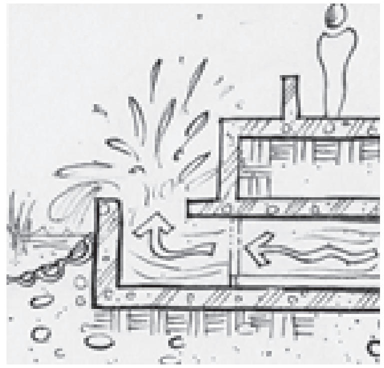
Allow ***urban form*** to celebrate the stream's presence.

Use ***interpretive signs*** or historic symbols where appropriate.



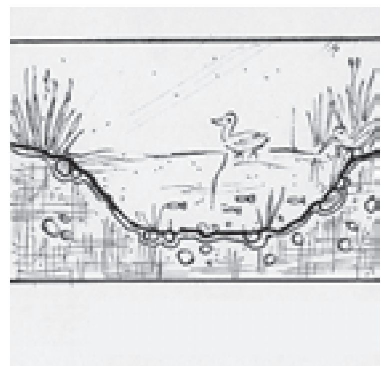
Invite ***local artists*** to contribute aesthetic values to public spaces.

Utilize water's energy to create dramatic ***hydraulic displays***.



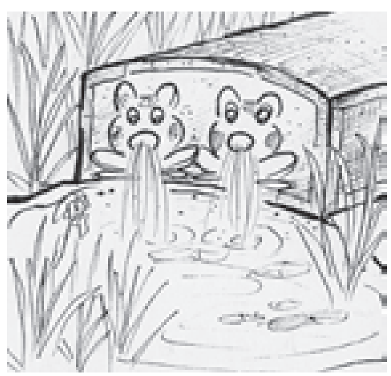
Use active ***recreation fields*** as detention/retention areas for large storm events.

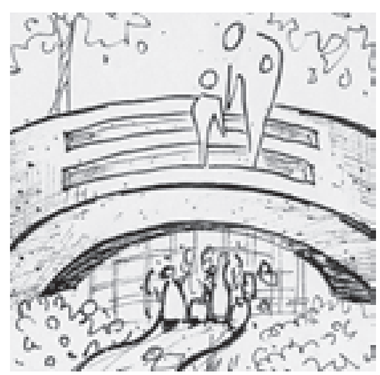
Design ***energy dissipators*** that double as recreation opportunities during dry periods.



Create ***wildlife viewing*** areas.

Incorporate ***playful details*** at outlet of secondary water treatment areas.

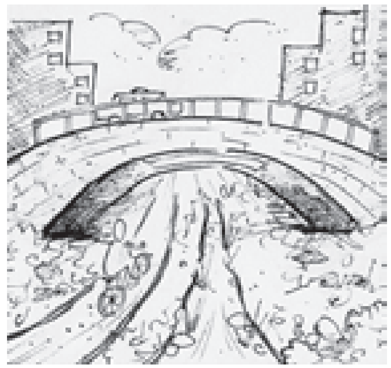


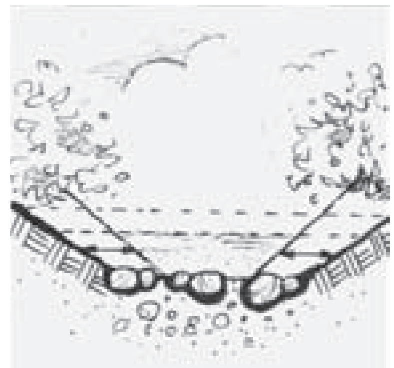


Locate ***trash nets*** at strategic points along the stream. This makes visible the connection between littering habits and water quality.

Design Guidelines: Safety

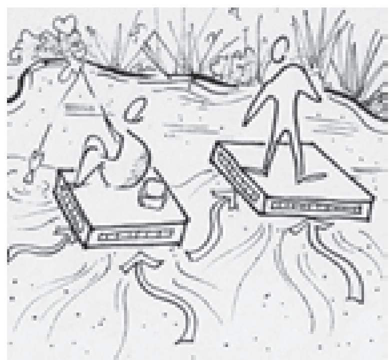
Provide ***alternative transportation*** routes that minimize conflicts with automobile traffic.





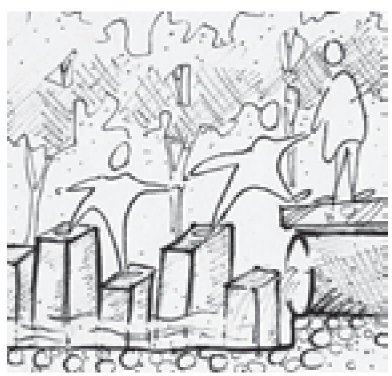
Utilize ***100 year storm*** figures to design stream channel width.

Design ***safe stormdrain inlets*** for people using the park.



Design ***gentle stream banks*** wherever possible, to prevent people from becoming trapped in stream.

Provide playful ***stream crossings*** that also dissipate the stream's erosive energy.



Supply adequate ***lighting and emergency phones*** along stream paths.

Design Precedents

The renewed interest in urban streams has provided many examples of stream daylighting to benefit ecological and economic health of cities. Many of these examples are inspirational, indicating a bright future for people seeking streams in their neighborhood environment. They illustrate successful use of many of the design principles this report advocates. Most importantly, they provide precedent and direction for similar efforts within the city of Los Angeles.

The following case studies describe projects in several contexts: park, schoolyard, and commercial district. Also, two of the studies represent cities embracing surface drainage networks as an armature for development and civic identity as well as to reduce water treatment costs. The studies demonstrate integration of waterways into a city's everyday environment while avoiding both flood and health risks.

Precedent: Local

Fern Dell, Los Angeles, CA

While not a true stream restoration project, Fern Dell represents a local effort to enhance a stream for recreational purposes. Located in a finger of Griffith Park that extends into Los Feliz, Fern Dell has a romantic aesthetic. In 1914 the Parks Commission supplemented the stream's seasonal flows with water from a local spring.
The Montgomery Brothers, prominent local landscape architects, redesigned the stream with terraced pools and ferns, both native and exotic. The stream's channel is unpaved, allowing its banks and bed to absorb, filter, and infiltrate water.

The dell quickly became a local landmark and was expanded by the Civilian Conservation Corps in 1940–41. Recent maintenance efforts have restored the park to its original character. It is used heavily by both local residents and tourists, and is a frequent filming location for the movie industry.

Fern Dell provides a cool respite for park visitors.

Precedents: Parks

Woonasquatucket River, Providence, RI

What today is Water Place and a centerpiece of Providence's renewal scheme was a decade ago a melange of rail lines and parking lots. The Woonasquatucket River was hidden under railroad tracks and blacktop dating from the days when the city's rivers were eyesores, not assets.

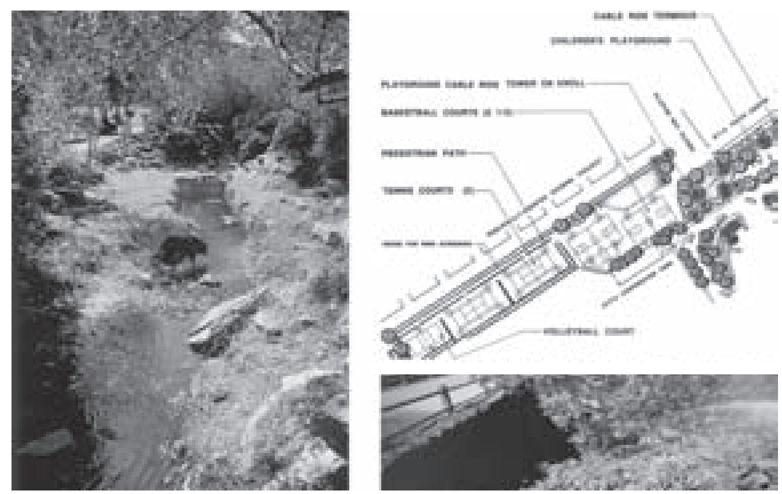
In 1994 the river was exposed, highlighted by a series of pedestrian bridges and walkways, and a four-acre public park was built. It is now the site for concerts and other cultural events. It is also the end point for the Woonasquatucket River Greenway. The Greenway brings bicycle riders to the heart of downtown Providence to shop, work, or just enjoy the water (Grant, 2000).

Water Place. From the City of Providence website.

Strawberry Creek, Berkeley, CA

One of the first daylighting projects in the United States, Strawberry Creek anchors a popular urban park in a mixed-density residential neighborhood of Berkeley. In 1984 four acres of abandoned railyard were transformed into Strawberry Creek Park, featuring playing courts, hillocks, meadows, native trees, and 200 feet of babbling brook. This was brought about through using money slated to repair the culvert beneath the park instead on daylighting its waters. The successful restoration sparked other local daylighting efforts and is considered a model project.

Strawberry Creek Park draws dozens to hundreds of people per day, many for the opportunity the creek presents children and adults alike to see, hear, smell, and feel flowing water and to enjoy the birds and aquatic creatures. Property values in the neighborhood have increased. Once a high-crime area and drug-dealing hotspot, the area now has a family-oriented culture (Pinkham, 2000).



Strawberry Creek Park. From Powell,1991.

Precedents: Schools

Blackberry Creek, Berkeley, CA

In 1995, a 250-foot section of Blackberry Creek was daylighted from a culvert beneath Thousand Oaks Elementary School. Instead of making repairs to the culvert for earthquake related damage, the school decided repair money was better spent on bringing the creek back to the surface. Blackberry Creek is now used as an outdoor environmental education classroom and living laboratory. As a result, the school has become one of Berkeley's magnet schools, focusing on ecology.

Instead of fencing off this part of the schoolyard from the surrounding community, the school allows the area to be used as a park during nonschool hours. Its tot-lot is one of the most popular in Berkeley, perhaps because older children can distract themselves in the stream while their younger siblings play. (Pinkham, 2000).

Blackberry Creek. Courtesy of Wolfe Mason Associates.

Crest View Elementary School, Boulder, CO

Built in 1990, the Crest View Wetland Habitat offers many benefits to students, teachers, and the Crest View community. The habitat was conceived and designed by a team of parents and teachers.

Supported by pumped groundwater, rather than streamflow, the wetland allows students an opportunity to test water quality, record groundwater levels, and study aquatic ecosystems. The area is used regularly for class experiments, nature journaling, and theater performances. It also offers students a place to sit and reflect on nature while observing what is living in the ecosystem.

The site includes an 80-seat flagstone amphitheater, 70-foot boardwalk with classroom space, and 1.3 acres of rolling prairies, thickets, streams, ponds, and wetland areas.

Wetland at Crest View Elementary School. From Leccese, 1998.

Precedents: Commercial Areas

Strawberry Creek, Berkeley, CA

The success of initial daylighting efforts on Strawberry Creek has prompted the city of Berkeley to consider daylighting in the heart of downtown. The section under study is about six blocks upstream of the 1984 Strawberry Creek Park project, described earlier.

A 1999 study prepared by Wolfe Mason Associates presents five scenarios: “no constraints,” full-flow restoration allowing for property acquisition; full-flow restoration primarily in a public right-of-way; creation of a partial-flow but naturalized stream in a public right-of-way; partial-flow restoration in an architectural canal; and symbolic acknowledgment of the buried creek using fountains and signs in lieu of daylighting (Pinkham, 2000).

Strawberry Creek concept simulation. Courtesy of Wolfe Mason Associates.

San Luis Creek, San Luis Obispo, CA

San Luis Creek provides a vernacular example of integrating stream and city. Instead of having to be daylighted, much of the creek was left aboveground as the city of San Luis Obispo developed.

Many retail establishments now front the creek, and a greenway with public artworks has been developed along its banks. The city promotes it as an attraction to the downtown area, saying that both children and downtown business people enjoy reading along its banks, chasing tadpoles, or dangling their feet in the water. Its cool banks and soothing sounds provide an amenity scarce in most American cities.

San Luis Creek in San Luis Obispo.

Precedents: Streetside Stream Network

Bellevue, WA

In 1970 Bellevue citizens concerned about the impact of increasing urbanization on streams, wetlands, and open spaces, identified these landscapes as important civic resources. Along with community leaders, engineers prepared a 1976 master plan recommending a natural drainage system of swales, constructed ponds, and existing water bodies. The resulting drainage system combines 50 miles of open streams, wetlands, and ground infiltration with 500 miles of enclosed stormwater pipes, and nine detention sites.

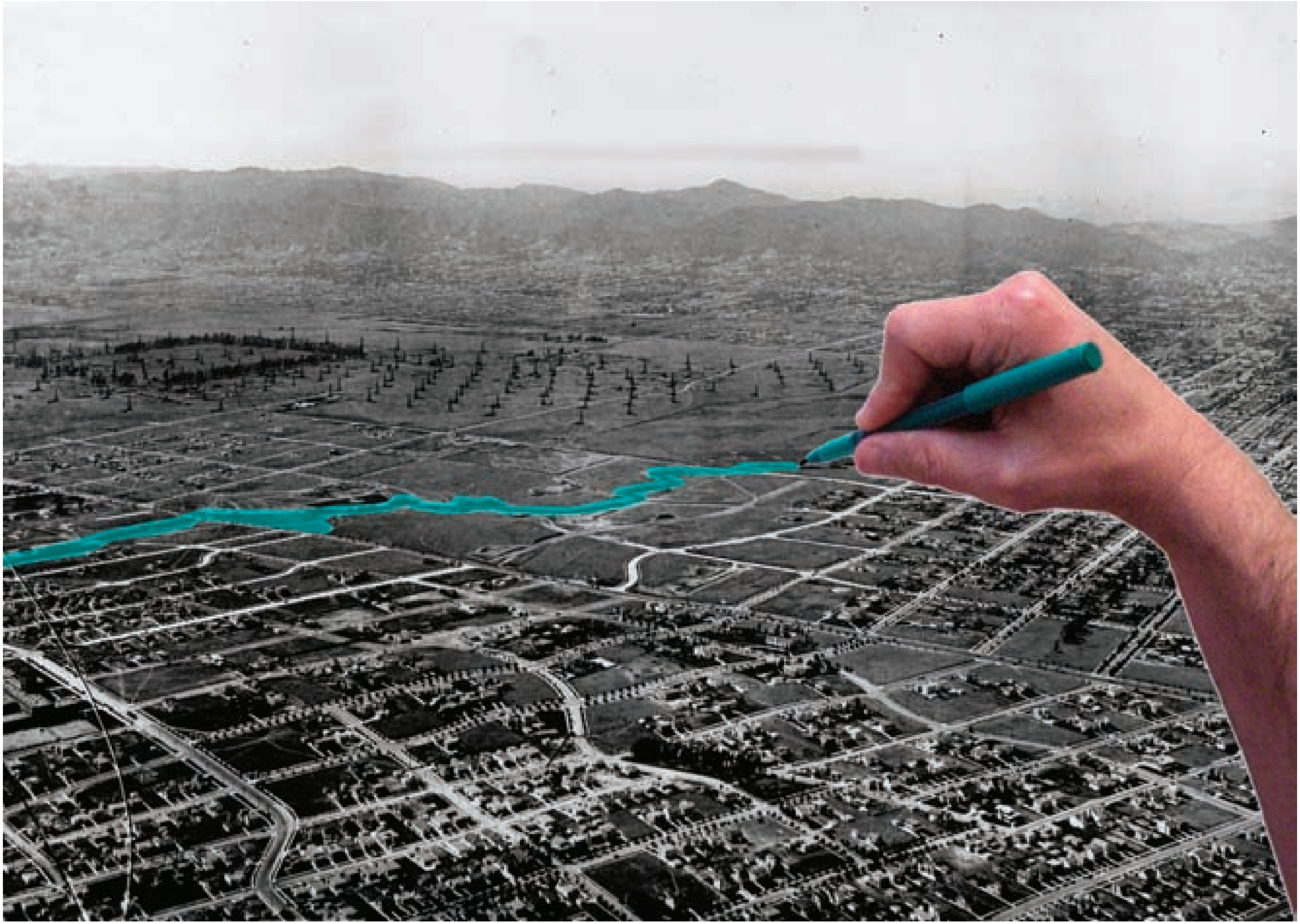
The city's leaders have realized that when rivers, creeks, and streams course through private land, they could provide a physical armature for future development and civic identity. The structure has helped create neighborhoods with definitive boundaries not ever expanding borders. By maintaining the connectivity of the hydrological network, Bellevue offers its citizens the opportunity to form clear cognitive relationships that reinforce their understandings of the city's topography, hydrology, range of ecosystems, and relationships to the larger environment of surrounding lakes (Poole, 2000).

Wetlands and roads co-exist, and neighborhood streams are common in Bellevue, WA. Courtesy of Kathy Poole.

Zurich, Switzerland

During the last 130 years, over 60 miles of streams running from hillsides around Zurich have disappeared into underground pipes. Now, because of a 1991 Swiss law mandating removal of clean water inputs to combined sewer systems, the city of Zurich is hard at work re-creating surface streams. Engineers are rerouting spring water and storm runoff from the piped system into new, naturalized channels that run to the Limmat River. To date, the city has daylighted over nine miles of streams and stormwater drainages. When complete, the system will have over 18 miles of re-created streams (Pinkham, 2000).

Counterclockwise from top left: before and after of street project; typical high-density area. Courtesy of Zurich Sewerage Department.



Design

Base Photo: Aerial of Hancock Park in early stages of subdivision. No date. The stream being highlighted is the Arroyo del Jardin de las Flores. Courtesy Photo Collection/Los Angeles Public Library.

Daylighting streams requires various scales of work. Stream reaches pass through unique neighborhoods, each with its own history: some stable, some on the rise, others in decline. Streams can enhance all of these neighborhoods. Some areas, however, may benefit more than others.

Regardless of the potential benefits of a daylighting project, objections could prevent it. The property acquisition task required to consolidate open space for streams would be considerable. Negotiations with current owners of streambeds could involve land swaps with other city lands, transfers of development rights with density bonuses, or leases of the air rights over the stream greenway. The development of a Stream Conservancy could minimize liability for the City of Los Angeles and encourage outright donations of property. (See Appendix B).

The plans that follow are a guide for daylighting streams of the study area. The first diagram prioritizes streams for daylighting based on a combination of political, economic, urban design, and ecological criteria. Next, the plans for Sacatela Creek, with accompanying vignettes, provide a model for addressing urban design, ecological, and stormwater management issues on the level of a stream reach. This study is schematic by nature. Lastly, an immediate stream rehabilitation opportunity is presented at Lafayette Park. The concept plans included in the study show two approaches to integrating the active and passive recreation needs of park users with stream function and stormwater management.

Framework

Developing a stream daylighting framework for Los Angeles is a complex process incorporating not only watershed function, but also the social, political, and economic issues of the communities where the streams flow. A matrix of those issues was developed to determine which areas should be daylighted first. Stream reaches were scored for each issue based on the extent to which the stream could help resolve issues on the matrix. These issues include: Implementation Timeframes, History and Culture, Open Space, Transportation, and Stormwater Management. (Appendix G)

The category Implementation Timeframes relates to politics and economics. Where are the current planning or redevelopment efforts in the city? Do they intersect with stream paths? Do stream paths run through currently vacant or publicly owned property? Daylighting streams involves property acquisition; because of population displacement concerns, minimizing acquisition of residential properties is desirable. On the other hand, owners of commercial properties may feel that a stream in their development is an inviting amenity. Streams near commercial areas, therefore, have a better political chance of being daylighted, and were scored higher than streams primarily in residential areas. Property values were also evaluated. The streams most likely to be daylighted first will be those in the more affordable areas. In many regards, this category drives prioritization.

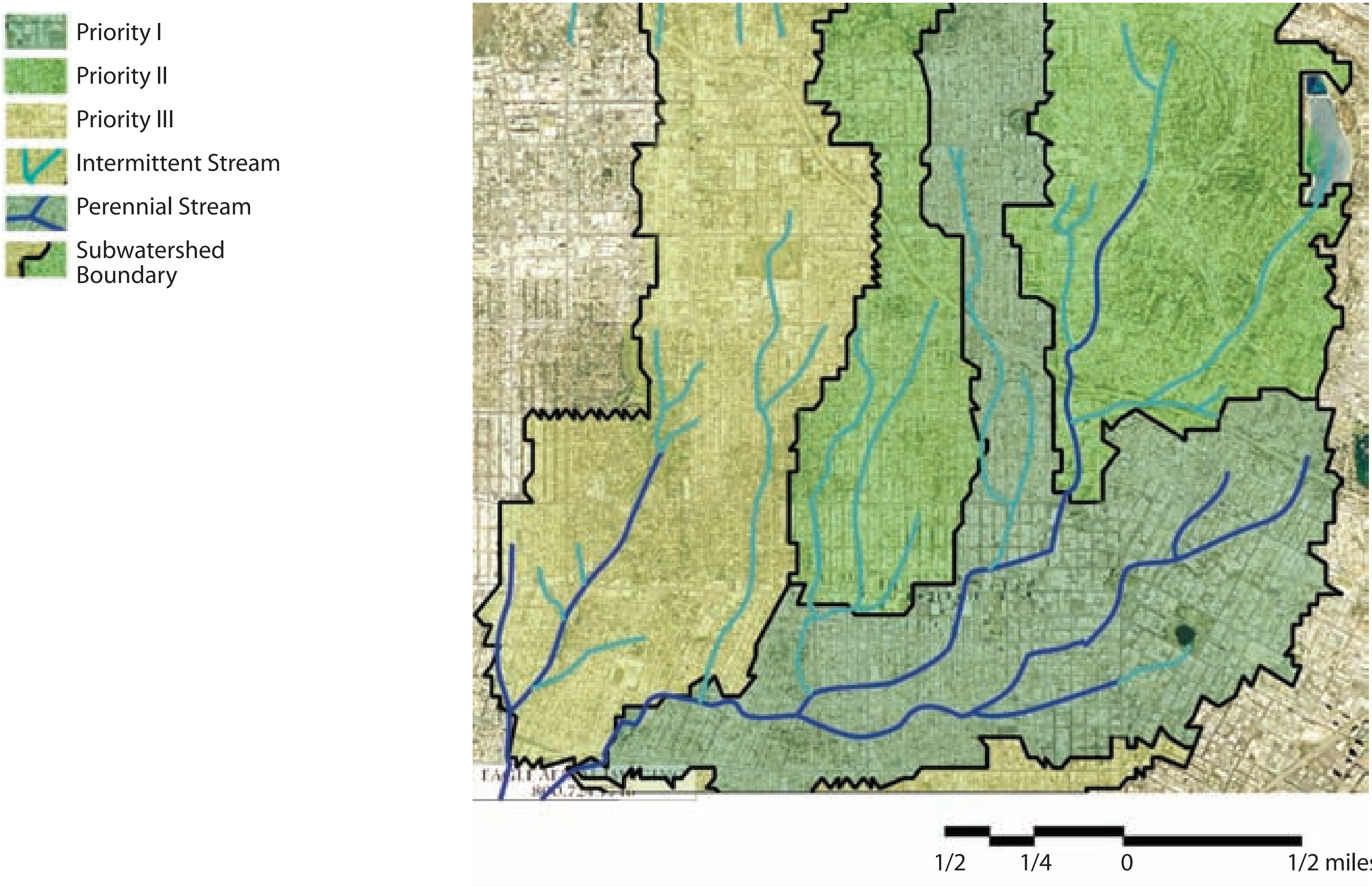
Consideration of other factors, however, is also crucial for the streams to be reintegrated into the urban fabric. The categories of History and Culture, Open Space, Transportation, and Stormwater Management explore correlations of the streams with historic landmarks or landforms; key social districts and nodes; linkages between other parks, neighborhoods, and public transportation stops; and areas with open space shortfalls. Areas correlating with the current 100-year or 500-year flood zones are also considered.

The stream ranking diagram shows the stream reach subwatersheds according to Los Angeles County's stormdrain subwatershed boundaries. Stream planning efforts need to take into consideration entire drainage areas, as infiltration and runoff detention areas at higher elevations play a crucial role in preventing floods at lower elevations. They also support watershed function.

The first stream reaches recommended for daylighting are clustered in the general areas of Koreatown, Westlake, and East Hollywood, where there is a relatively high concentration of population, landmarks, low property values, redevelopment zones, and a lack of open space. Lafayette Park, on the border of the Westlake and Wilshire Community Planning Areas, represents an immediate stream daylighting opportunity explored later in this document.

The second set of stream reaches is located in Silverlake and East Hollywood where higher property values and fewer commercial areas are limiting factors. Most of these streams were intermittent in their historic flows. However, Sacatela Creek is perennial for most of its length. It has greater potential for creating open space and spatial linkages than other segments of the study area.

The final grouping of stream reaches is located in parts of Hollywood, Koreatown, and Hancock Park. This group is affected by higher property values, an absence of redevelopment zones, and fewer opportunities for meaningful linkages of streams with neighborhoods, districts, and public transportation.



Priority framework for stream daylighting based on political and economic factors.

Sacatela Creek

Through the stream seeking and research processes, it became evident that Sacatela Creek had a significant presence in the landscape of the study area. Landmarks such as the Shakespeare Bridge and the Ambassador Hotel anchor its ends. The former Bimini Hot Springs were located along its midsection. The creek passes through the Thomas Starr King Junior High School, flows down Myra St., where it creates a 100-year flood zone, crosses Santa Monica Blvd, intersects with the Madison tributary near the Dayton Heights Elementary School, and continues south, passing through Virgil Junior High School. The school sites present several opportunities for immediate small-scale daylighting.

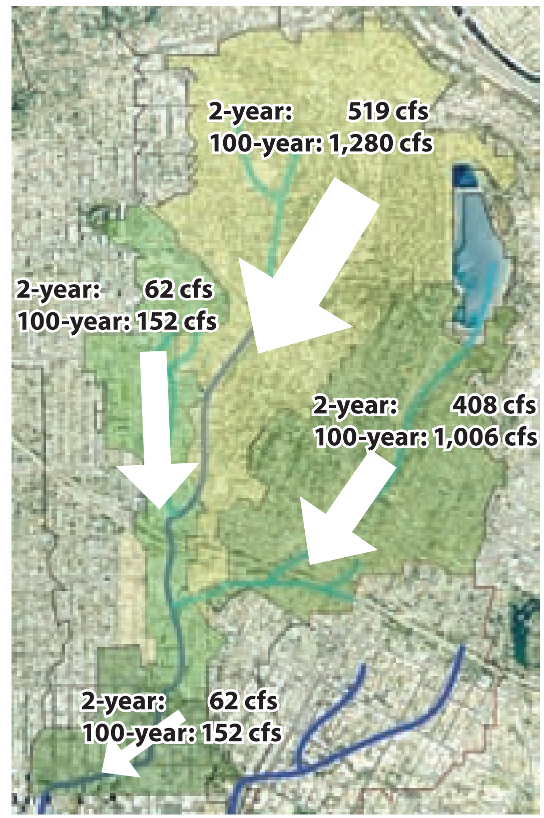
The community of Eco-Village, located near Virgil Junior High School, is concerned with local urban ecology and social history. This community could be an advocate to spur the rehabilitation of the Bimini Slough, as the creek was known in that area. Eco-Village is also adjacent to a redevelopment zone.

Sacatela is within walking distance of Metro stops as well as several medium- and high-density neighborhoods in need of open space. The lower portions of Sacatela correlate with commercial zones. In the upper zone of Sacatela, the stream runs along Myra Ave. Thus, a variety of streamside experiences, in school, residential, and commercial environments can be explored. Removing a portion of Myra Ave. to create a stream corridor is also considered.

The creek can facilitate the reestablishment of native vegetation in urban Los Angleles. In the riparian and wetland areas, the vegetation, and the micro-organisms supported by it, will play a key role in breaking down or uptaking contaminants from storm- and graywater. The greenway established by Sacatela Creek can also provide habitat for birds and small animals, thus taking a modest step to reestablish wildlife in the city.

Sacatela Creek receives stormwater from several other streams: Monon, Medea, Madison, and Silverlake. These stream subwatersheds now closely approximate stormdrain subwatersheds, as seen in the image below. The diagram indicates water flows estimated for these subwatersheds in 2- and 100-year storm events. (See Appendix H).

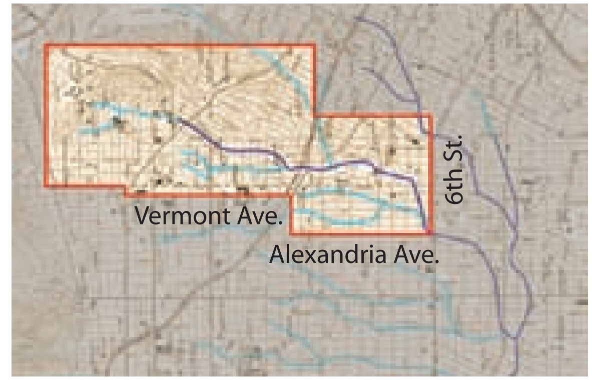
These other tributaries flowing into Sacatela will need to be taken into account when developing plans. In addition, open lands in other parts of the subwatershed will need to be incorporated into a stream plan that allows for detention and infiltration of runoff.

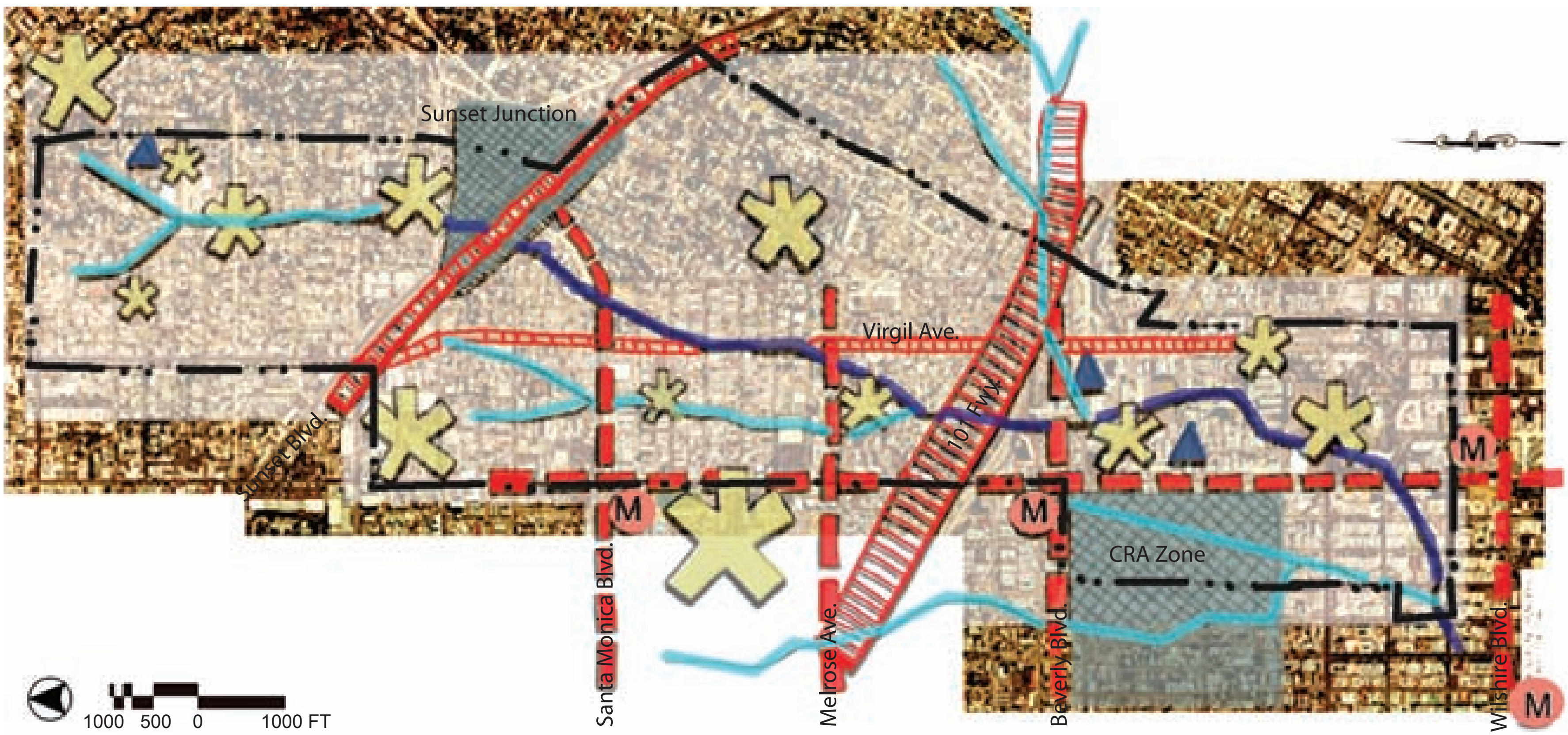


Total stormflows calculated for this reach of Sacatela Creek are 1,235 cubic feet per second (CFS) for a two-year storm event, and 3,047 CFS for a 100-year storm event. The diagram at right illustrates the four subwatersheds that drain into the creek. See Appendix H for more information.

Legend:

- Landmark
- Nodes
- Metropolitan Transportation Authority (MTA) - Red Line
- District
- Intermittent Stream
- Perennial Stream
- Main Road
- Edge
- Study Area



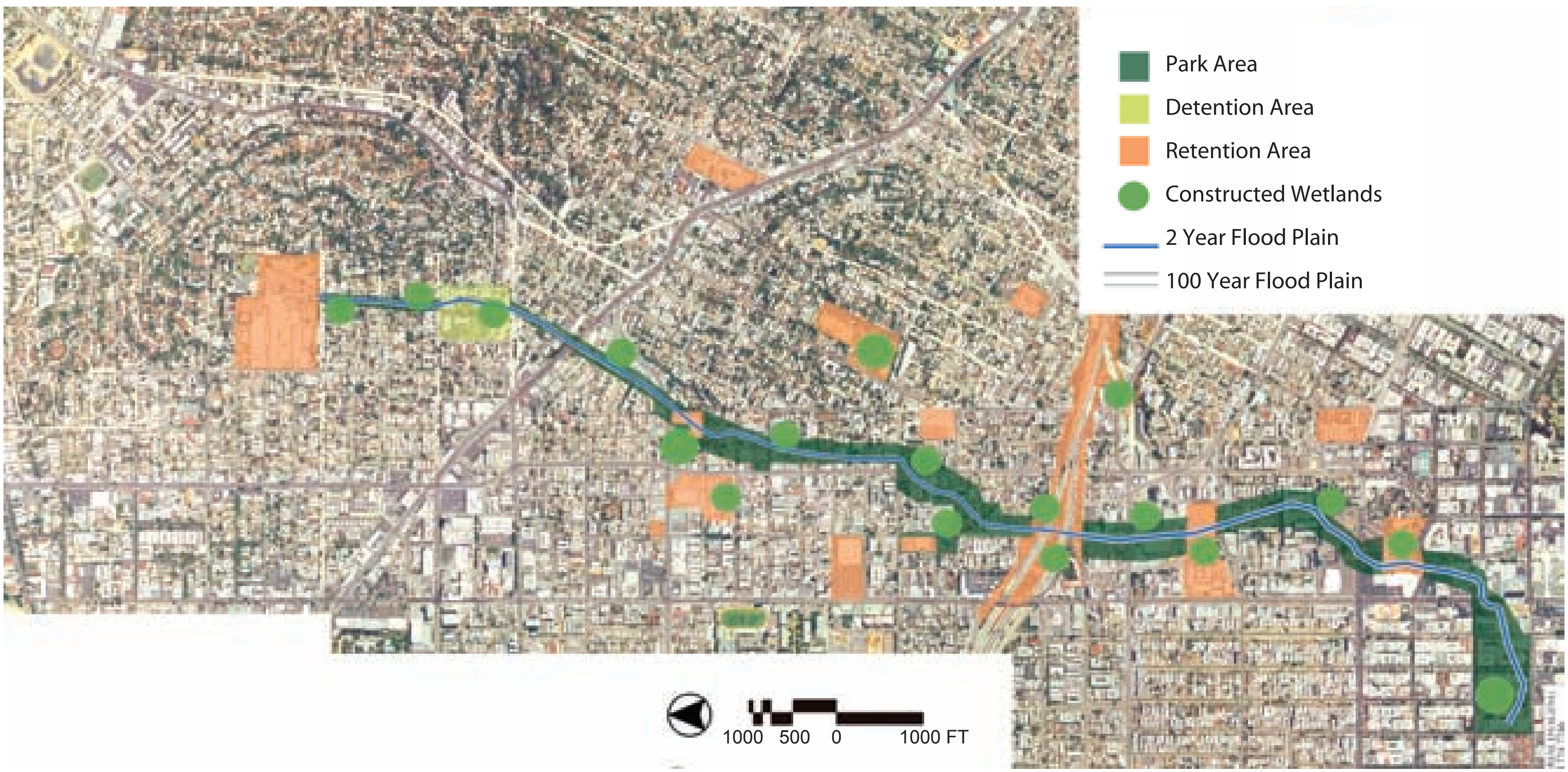


Spatial analysis of Sacatela Creek.

Stream Plan

The stream plan takes into account several factors, including the historical shape of Sacatela Creek as observed in 1902, the tendency of streams to widen as they take in additional flows, and stream widths based on runoff calculations. The plan also considers the broader role of watershed function in providing detention and infiltration opportunities. In order to promote the cleansing of runoff, constructed wetlands and vegetated swales are placed throughout the stream reach in conjunction with retention areas. Retention areas are envisioned to capture a portion of surface runoff and provide opportunities for cleansing and infiltration.

Detention areas also retard the rate of overland flow. Large tracts appropriate for retention are found along Sacatela. One such case is Virgil Junior High School. These retention areas are spreading grounds that capture floodwaters and allow for recharge of local groundwater sources. This stream accommodates 100-year storm events while having gently sloping side banks. This protects property, minimizes erosion and allows for safe access into and out of the stream.

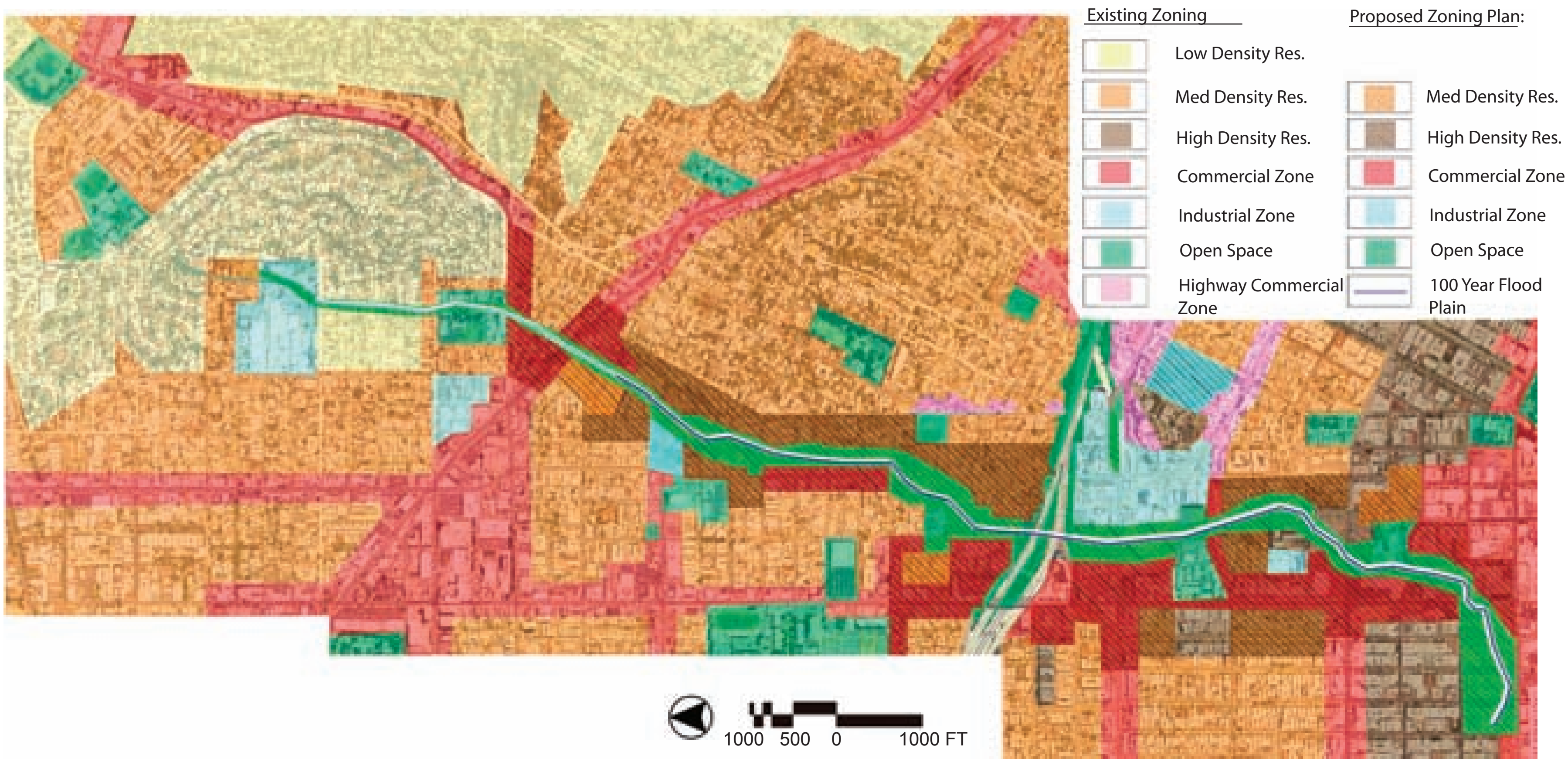


Priority Area Plan

Implementation of a stream plan will take many years to complete. Therefore, establishing priority areas for stream daylighting is necessary. Prioritization is partly based on practicality: many of the first priority properties were chosen because they are owned by a public agency. These properties have potential for short-term conversion because they are already in the public domain. Beyond first priority properties, the key consideration shifts to watershed function. For this purpose the upper portion of Sacatela was given priority over the lower portion. Focusing first on daylighting Sacatela's upper reaches and and establishing retention and detention areas reduces the potential for downstream flooding and improves water quality. Holding water back from flowing downstream also recharges groundwater. This approach to stormwater management provides protection for properties along lower reaches. If the reverse strategy were taken, lower reaches would be more likely to flood because imperviousness of the upper watershed has not been addressed.

Rezoning Plan

The stream plan depends on rezoning to accumulate land required for stream function. The amount of land required, approximately 150 acres, is estimated to displace 4,000 dwelling units based on 1990 census data. According to the community plans, the area surrounding Sacatela Creek is projected to grow 28% from 1990–2010. Therefore, plans to relocate lost dwelling units must account for growth. This results in a requirement of 5,120 new dwelling units. The map below shows how zoning in the subwatershed could be changed to accommodate both stream and housing. The two main strategies shown involve designating areas along major streets as mixed-use residential and commercial. These streets would take on a more formal character as building heights would rise and create the "street wall" and commercial frontage so desirable in pedestrian-oriented communities. Medium- and low-density areas adjacent to existing high-density areas were also "upzoned" in this plan to provide additional housing capacity. Also, additional light-industrial space was established to maintain an economic presence in the subwatershed. (See Appendix I).



Transportation Plan

An increased population density in the area surrounding Sacatela Creek would place greater demand on existing transportation routes and mass transit resources. Using Sacatela Creek as a pedestrian and bike corridor could give some residents a safe alternative for commuting. While existing bike lanes are often fragmented, a bikeway along Sacatela Creek could connect to the existing Sunset Blvd. bike lane, thus increasing the alternate transportation network. At the south end of the creek, the bike lane could connect to a designated bike route at 4th St. This route terminates in downtown Los Angeles to the east and the Park La Brea apartments in the Miracle Mile area to the west.

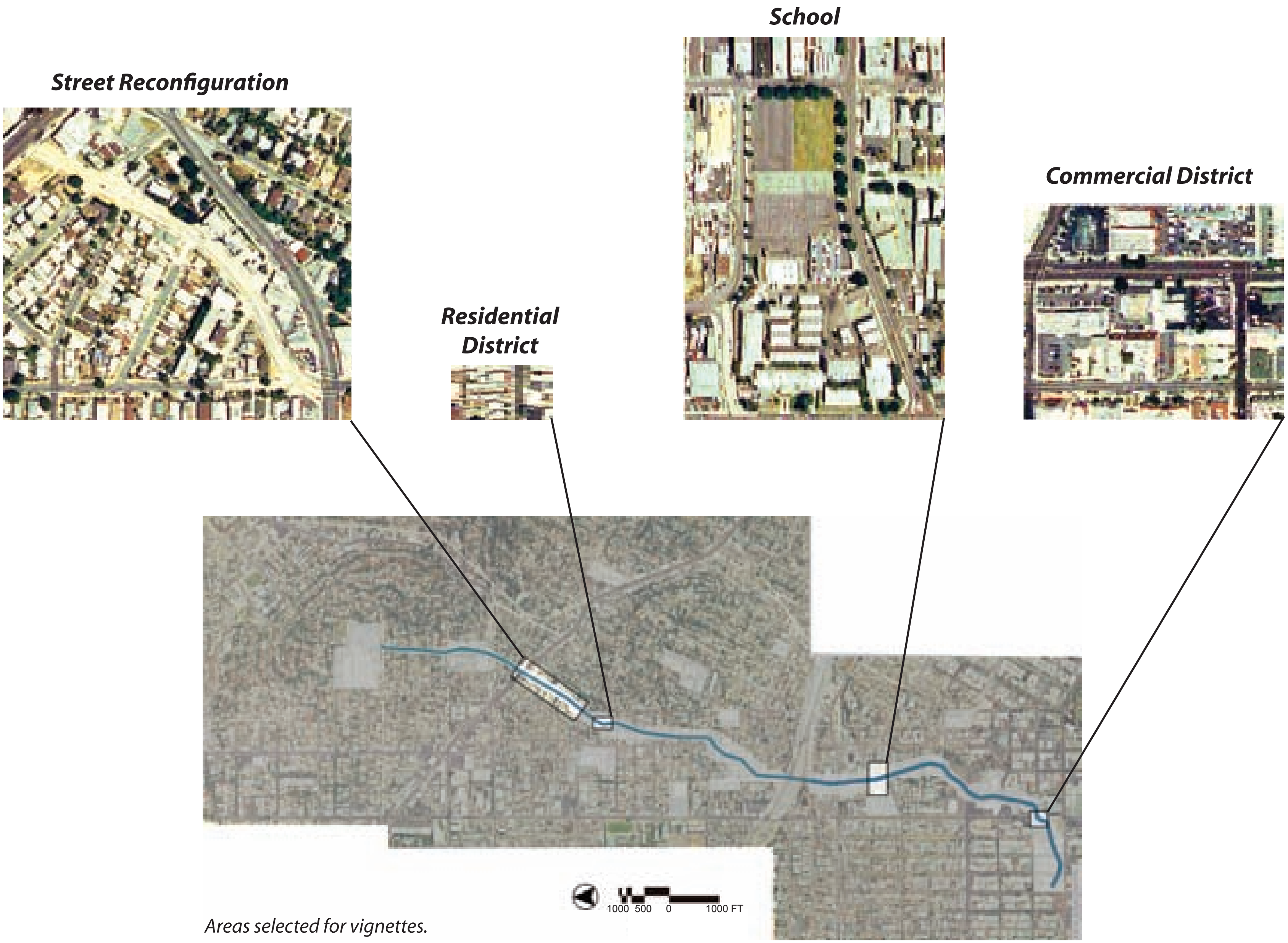
Bus stops could be repositioned to create nodes at open space entrances along the stream. This will reinforce the stream's role of pathway and destination. Additional subway stops are recommended to promote redevelopment of adjacent areas to mixed-use and high-density. These stops could relieve higher density areas of automobile traffic congestion.

Vignettes: Sacatela Creek

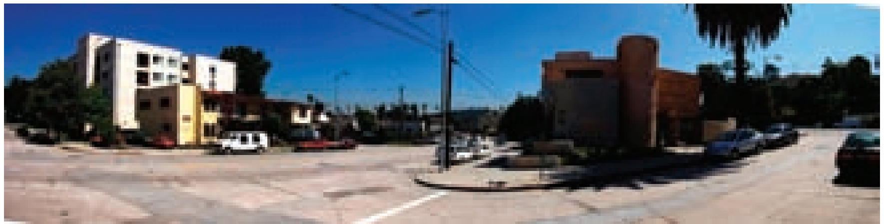
A stream can influence urban form. Waterside promenades can spur development and create romantic memories. Buildings can front onto streams, ensuring greater physical safety for visitors. Adjacent streets can mimic the flowing curves of the stream or deliberately pull closer and further away in response to floodplains. The greenway, which generally accompanies streams, can visually stitch together disparate nodes or neighborhoods.

The following vignettes demonstrate the potential of Sacatela Creek to redefine its adjacent neighborhoods in varying contexts. The needs of residential, commercial mixed-use, and school communities vary. While residential areas may need to incorporate community gardens and playing fields into their flood zones, schools may need special areas for outdoor education. Mixed use commercial areas will take advantage of the broad paseos and terraces afforded by streams, with customers lingering and socializing at many hours of the day and night. The street vignette looks at the potential to redefine an otherwise lackluster street to promote redevelopment and regain a sense of place.

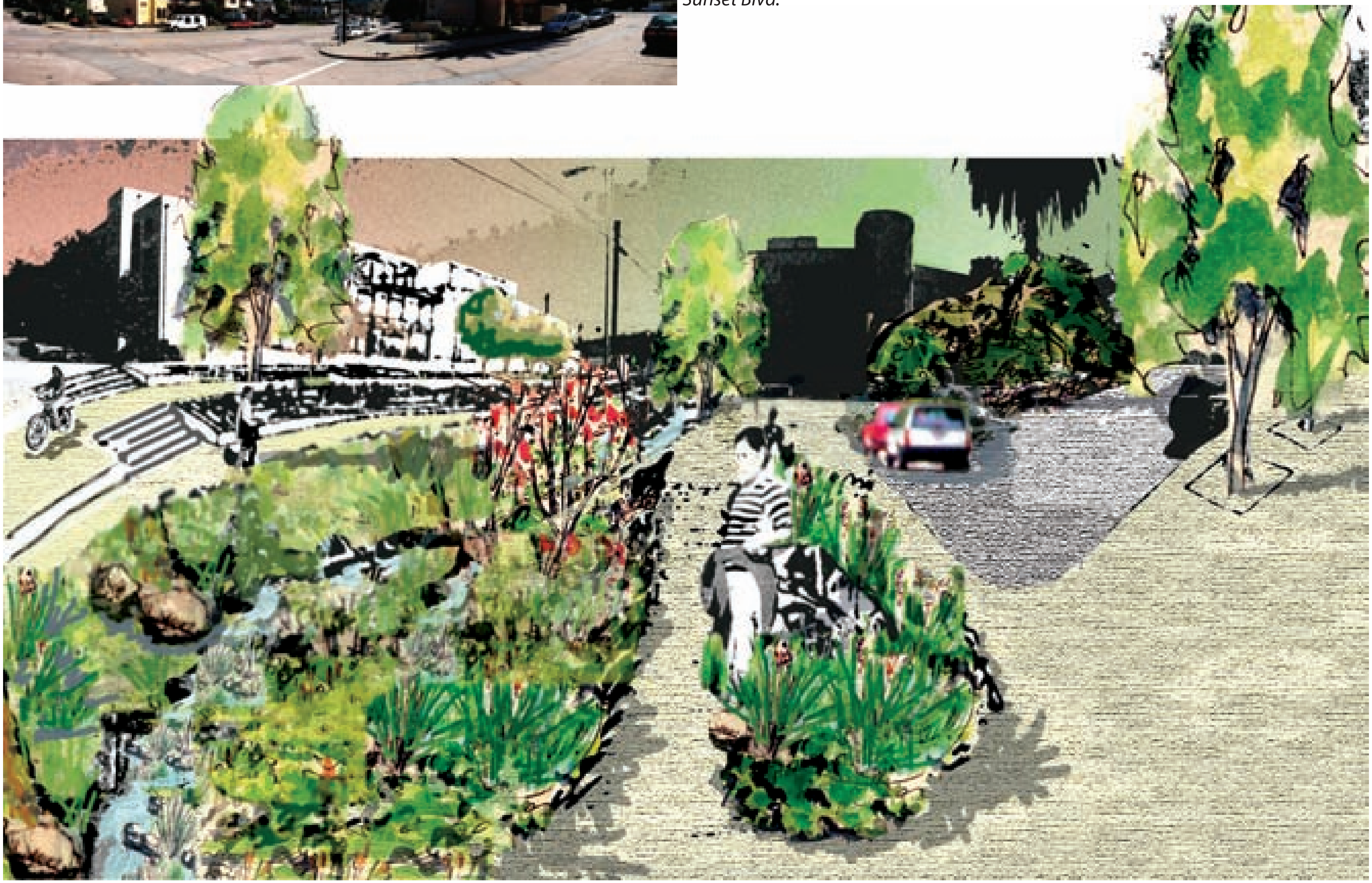
The vignettes draw from the design guidelines established in the Urban Stream Paradigm section of this document. Constructed wetlands and vegetated swales are located along the stream to cleanse pollutants. Street edges are also lined with vegetated swales. Asphalt paving within the subwatershed is replaced with permeable or semipermeable paving. Vegetated roofs slow water runoff, moderate microclimates through plant transpiration, and reduce the energy requirements of their host buildings. Lower terraces, paths, and fields are designed to accommodate flooding in the event of severe storms. Graywater from neighboring buildings is naturally filtered in constructed wetlands and used to provide supplemental base flow to the creek. The graywater wetlands are designed to protect the public from potentially contaminated early releases of water. As the water purifies, it moves outward in concentric rings through the wetlands, finally being accessible when it is clean.



Areas selected for vignettes.



Current streetscape on Myra Ave. near Sunset Blvd.



Visualization of reconfigured street with mixed residential and commercial zoning.

Street Reconfiguration

A short and underutilized stretch of Myra St. is converted entirely to a greenway and stream with mixed use redevelopment along its banks. Cafes and small shops are supported by the increased population density. Santa Monica Blvd. provides access to residents on the east side of the banks; access to the west side is gained via Lexington Ave. or Hoover St.

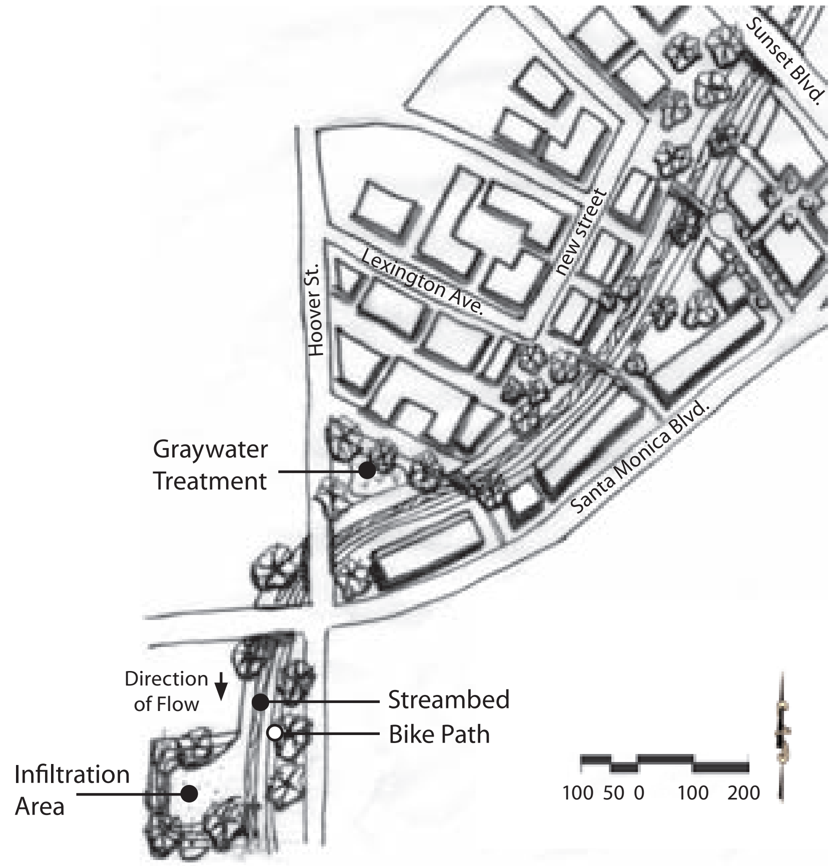
A series of terraces on one bank provides a more formal sensibility. On the other bank, paths and softer slopes mark a more casual feel. Paths along the banks accommodate pedestrians and bicyclists.

Within the terraces are graywater treatment ponds. Graywater flows from the inner ring of ponds gradually outward as it becomes cleaner, thus keeping it safely out of reach of curious passersby. The three and four story buildings in this area are covered with vegetated roofs.

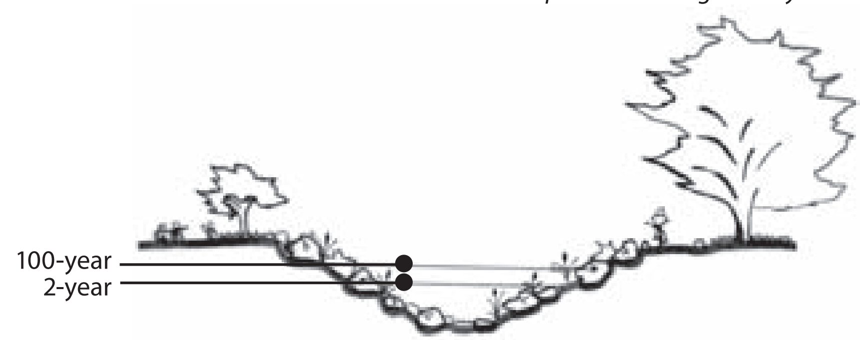
The popular Sunset Junction commercial district is nearby and the elegant bridge at Sunset Blvd. can be seen at the northeast end of the stream.

Design guidelines used in this vignette:

- Intermittent and perennial streams
- Coordinate planting
- Vegetated roof
- Graywater
- Constructed wetlands
- Porous paving
- Plant trees
- Symbolic landscaping
- Urban form
- Local artists
- Energy dissipators
- Trash net
- Alternative transportation
- Stream crossings
- Gentle stream banks
- 100-year storm
- Lighting and emergency phones



Schematic plan of reconfigured Myra St.



Sacatela Creek's channel is designed to accommodate 100-year flood events.

Residential district's current streetscape.

Visualization of residential district with stream corridor.

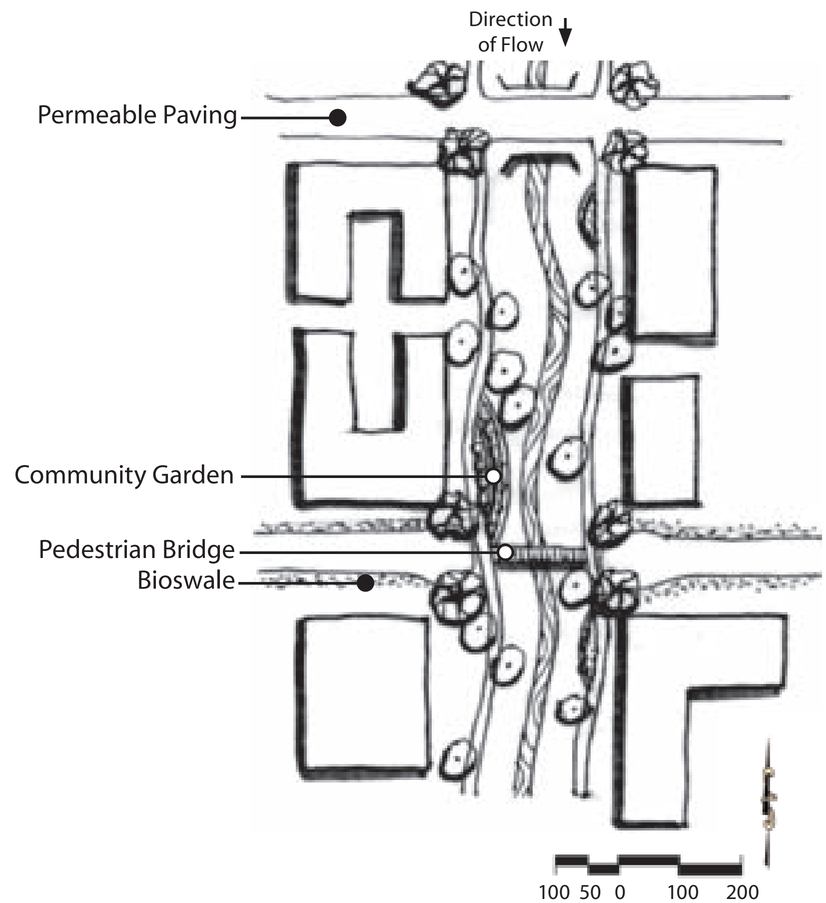
Residential District

As Sacatela flows through this residential community, it provides bankside space for community gardens, paths for pedestrian, and bicycle commuting and recreational jogging and walking. The change in zoning from medium to high density helps to maintain a range of affordability, preventing gentrification of the neighborhood.

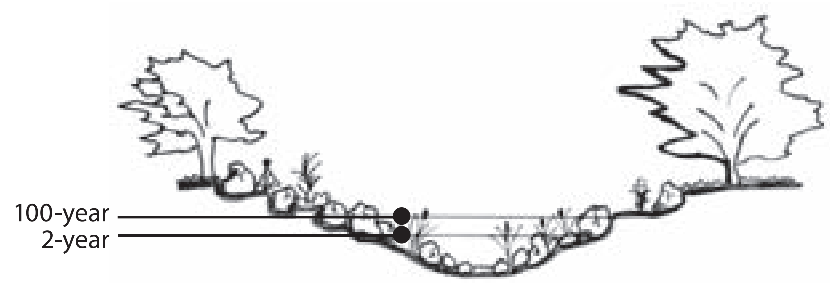
Native vegetation enhances the greenway and provides opportunity for community tree planting and maintenance programs.

As the stream continues through this neighborhood, alternate streets are closed, creating a rhythm of bridges and cul-de-sacs at stream intersections. Streets are repaved with permeable paving to infiltrate water as well as to slow traffic.

Design guidelines used in this vignette:
- Intermittent and perennial streams
- Coordinate planting
- Vegetated roof
- Porous paving
- Plant trees
- Alternative transportation
- Gentle stream banks
- 100-year storm
- Lighting and emergency phones



Schematic plan of reconfigured residential district.



Sacatela Creek's channel is designed to accommodate 100-year flood events.

Panoramic photograph of Virgil Elementary School's current schoolyard.

Visualization of schoolyard with stream, graywater marsh and athletic field that infiltrates stormwater.

School

A school site poses unique conditions. At Virgil Junior High School, the stream is carved out of the playground. A running track is overlaid on the stream. The edges of the track define protected edges between the playground and the stream. A soccer field doubles as a stormwater retention and infiltration area.

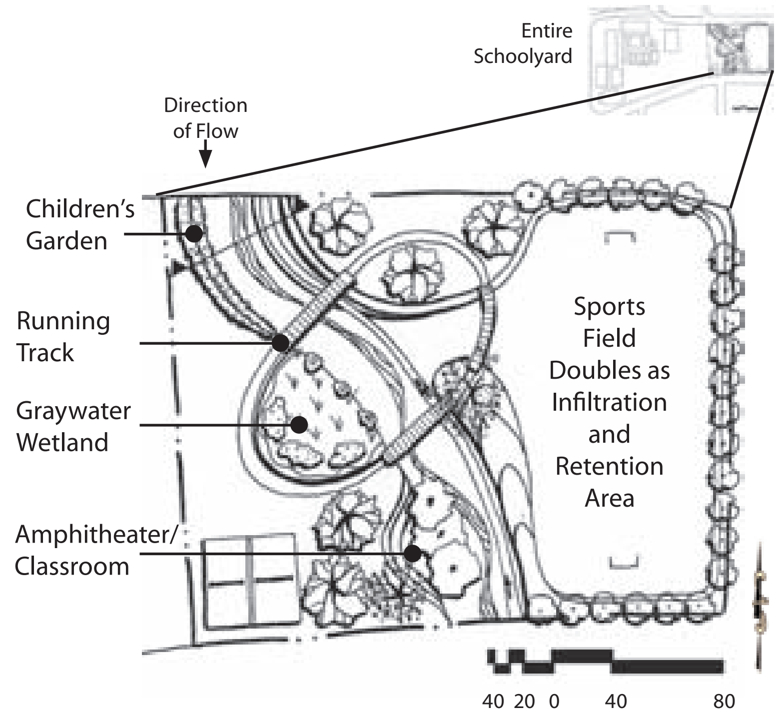
An outdoor education space provides room for teachers to conduct lessons along the stream. Students will be given firsthand experience observing seasonal stream phenomena in an academic environment.

Community needs are also integrated into this site. The bicycle/pedestrian path is restricted to the east bank of the stream, limiting the ability of trespassers to access the school. The jogging track provides multiple views into the stream. After school hours, the soccer field is open to the community for sporting events.

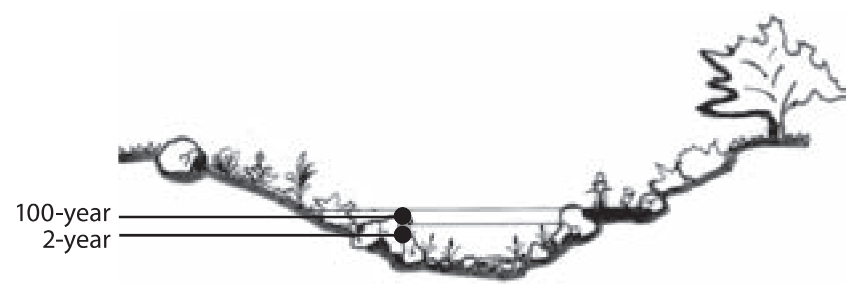
A fenced graywater treatment marsh is slightly below the playround level to keep it out of the reach of students, and its terrace is slightly above the stream. This protects both students and stream from water that may not have been completely treated. Native marsh plants are used to cleanse the graywater to safe standards for human contact.

Design guidelines used in this vignette:

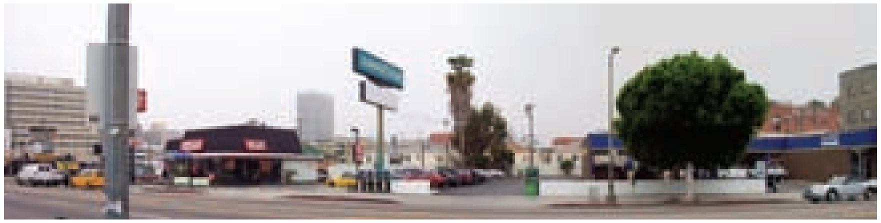
- Course adjustments
- Groundwater infiltration
- Intermittent and perennial streams
- Coordinate planting
- Detention and retention
- Vegetated roof
- Graywater
- Constructed wetlands
- Porous paving
- Recreation fields
- Wildlife viewing
- Alternative transportation
- Gentle stream banks
- 100-year storm
- Lighting and emergency phones



Schematic plan of reconfigured schoolyard.



Sacatela Creek's channel is designed to accommodate 100-year flood events.



Current commercial district on Vermont Ave. and 6th St.

Visualization of stream corridor within commercial district.

Commercial District

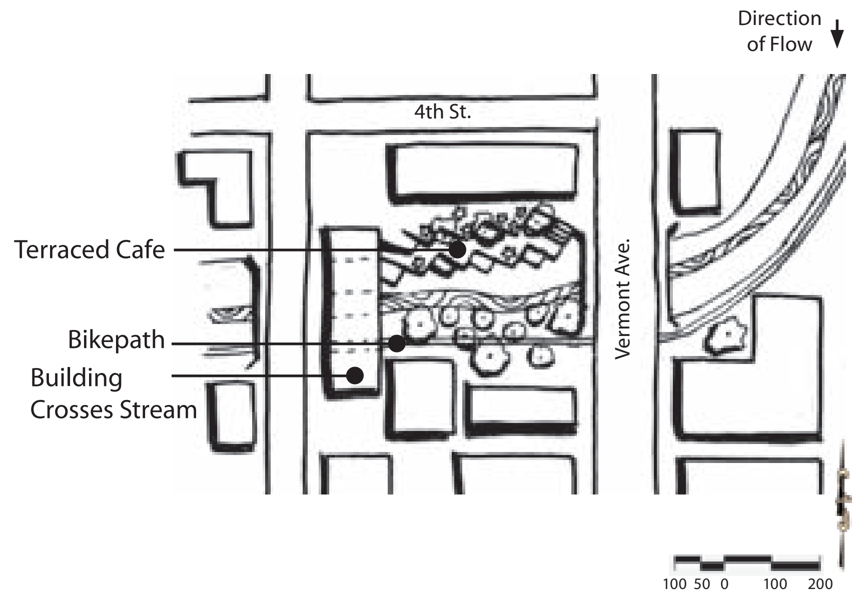
Near the intersection of 6th St. and Vermont Ave., Sacatela Creek enters a mixed-use area. Shops that cater to the local population face the broad terraces that step down to the creek. In a 100-year storm, the lower terraces would flood.

Multiple stories of residential units keep the terraces socially active into the night. Innovative buildings cross over the stream, creating stream plazas. Vegetation takes on a showy dimension to convey a civic, yet romantic, sensibility.

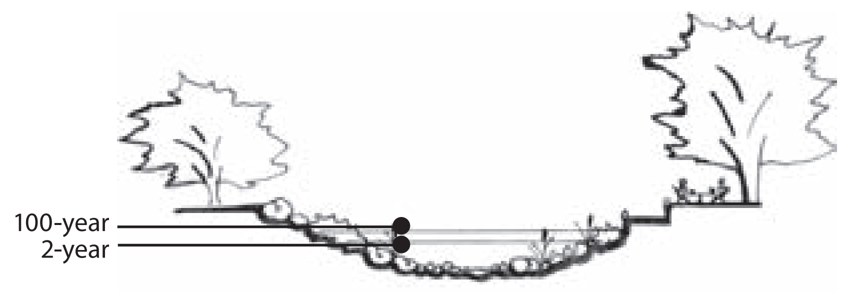
Immediately downstream of the mixed-use district, constructed wetlands cleanse contaminants from stormwater runoff. This protects the creek from urban pollutants likely to occur in the district's heavily used spaces.

Design guidelines used in this vignette:

- Groundwater infiltration
- Intermittent and perennial streams
- Detention and retention
- Vegetated roof
- Graywater
- Porous paving
- Plant trees
- Symbolic landscaping
- Urban form
- Local Artists
- Hydraulic displays
- Alternative transportation
- Stream crossings
- Gentle stream banks
- 100-year storm
- Lighting and emergency phones



Schematic plan of reconfigured commercial district.



Sacatela Creek's channel is designed to accommodate 100-year flood events.

Lafayette Park: Background

The 11 acre Lafayette Park is one of the most intensively used open spaces in the study area. The park shows signs of heavy wear and tear, and minimal maintenance. The park's reputation suffered in the late 1980s and through the 1990s as a location for drug dealers and gang bangers. In one three-year period, six homicides occurred in the park.

Yet Lafayette Park, formerly known as Sunset Park, was once a gracious and expansive space. Donated to the City of Los Angeles in 1899, its bowl-like formation accommodated a variety of exotic horticulture, a lengthy pond (the approximate location of a former stream), and a winding path system. Its pastoral lawns were informed by the Arcadian sensibility of Frederick Law Olmsted.

Two conceptual plans for Lafayette Park are presented. Both interweave a daylighted stream with an acknowledgement of Lafayette Park's historic role as a beautiful, Arcadian space of respite while also providing forms that can accommodate current user and stormwater management needs.

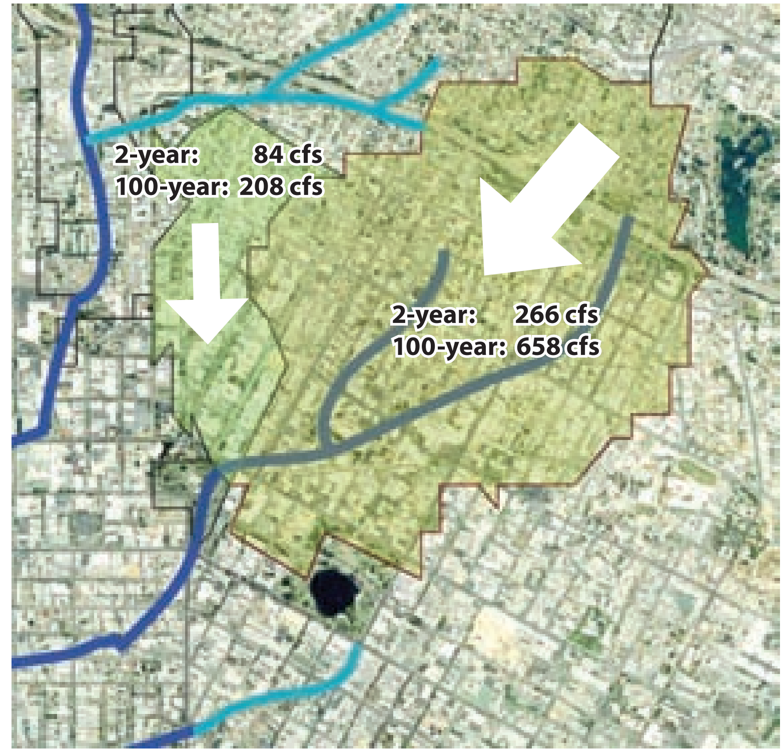
Both designs incorporate the use of on site recycled graywater. This helps to maintain vegetation during the dry months. Special wetland areas and sand filled trenches filter and cleanse the graywater. Graywater treatment areas allow for viewing of the marshes, but keep the uncleansed water out of arm's reach.

The stream beds have soft bottoms: sand and stones characterize their dry-season appearance, in addition to the vegetation supported by the recycled graywater.

1913 aerial view of Lafayette Park looking northwest. Courtesy of Photo Collection/Los Angeles Public Library.

Calculations for water flows include flows of upstream sources of water. The design assumed a soft bottom trapezoidal channel. The stream banks slope at a horizontal to vertical ratio of 3:1. This slope helps to minimize erosion and also allows for access in and out of the stream. (See Appendix H).

The designs include flood zones for a 100-year storm. Calculated stormflows into the park are 350 cubic feet per second (CFS) for a two-year storm event, and 866 CFS for a 100-year storm event. The diagram at right illustrates the area that drains into the park. Active recreation fields in the park designs act as a sponge and retain excess drainage, allowing for infiltration.



Stormflow diagram for Lafayette Park.

Spatial Analysis

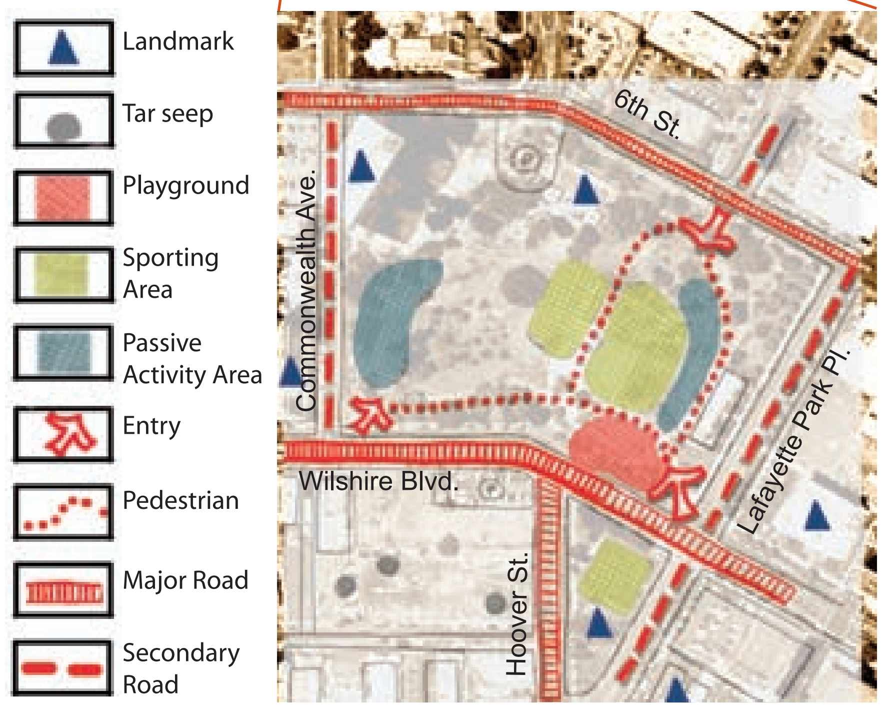
The existing boundaries of Lafayette Park are 6th St. on the north, Lafayette Park Pl. on the east, Hoover St. on the southeast, Wilshire Blvd. on the south, and Commonwealth Ave. on the west. Fences line the periphery of the park. Additional fencing encloses the courthouse, recreation center, library, and tot-lot. Although there are many designed entries, only five are open. Three stormdrains run beneath the park.

The Los Angeles County Courthouse tower dominates many views within the park. The Felipe de Neve Library is an elegant brick building facing 6th St. A graceful terrace and fountain step down from its south face into the park. The fountain is currently disused and vandalized. Portable toilets stand in the northeast corner of the park. On the east end sits a recreation center. This is a modern building of little character. A terrace from one of its classrooms looks out over the park. Two basketball courts are heavily used into the night. One "soccer field" has a dirt base and is surrounded by a low fence. Another field is an open green that receives so little maintenance that it exposes large areas of bare soil. A large children's tot-lot is busy throughout the day. Picnic tables are distributed throughout the northeast portion of the park.

South of Wilshire Blvd. is a triangular area of the park. The distinctive 1930s Art Nouveau "Power of Water" statue stands facing oncoming traffic on Hoover St. This statue was formerly a fountain and is subject to periodic vandalism. Its pool has been filled. Two tennis courts, which are frequently in use, face Wilshire Blvd. Homeless people often camp behind the tennis courts.

Empty lots to the west of the triangle provide an opportunity for park expansion. Three active oil seeps were observed on the grounds. A parking lot and a florist shop occupy small areas of the acquisition site.

Lafayette Location Map



Lafayette spatial analysis map.

The Superior Court building is a prominent landmark in the park.

Vacant lot to the south of Lafayette Park. Wilshire Blvd. is in the foreground.

Lafayette Park is heavily used for both active and passive recreation.


Stormdrain Outlet
Courthouse
Graywater Treatment Pond
Waterfall
Picnic Area
Wetland
B
Stream
Riparian Trees
Cafe w/ Terrace
Tennis Courts
Stream Inlet
Tar Seep Amphitheater
A
Existing Library
Basketball Courts
Flood Zone w/ Informal Soccer Field
Stormdrain Outlet
B
Community Center
Stormdrain Inlet
Main Entry w/ Ballona Watershed Map
Playground
Power of Water Fountain
Commonwealth Ave.
6th St.
Wilshire Blvd.
Lafayette Park Pl.
Hoover
A
0 20 40 60

One Alternative: Wetland Retreat

This design celebrates wetlands. Stormdrains in the northwest area of the park release water which is joined by naturally treated graywater from the Courthouse. Wetlands provide cleansing before releasing their flow into an undulating stream that crosses under Wilshire Blvd. The stream passes through a playful spiral energy dissipator, then rejoins the stormdrain system. An open green is centrally located, providing space for two informal soccer fields as well as picnic and lounging space. This green holds floodwaters in severe storm events. A large wetland marsh is adjacent to the green, providing visitors with an opportunity to interact with the cleansed water. Basketball courts are raised to higher ground on the northeast side of the park.

Another use of water is expressed along the east side of the park. The third stormdrain that lies beneath Lafayette Park daylights, directing its waters into a more formal channel that defines the eastern edge of the open green.

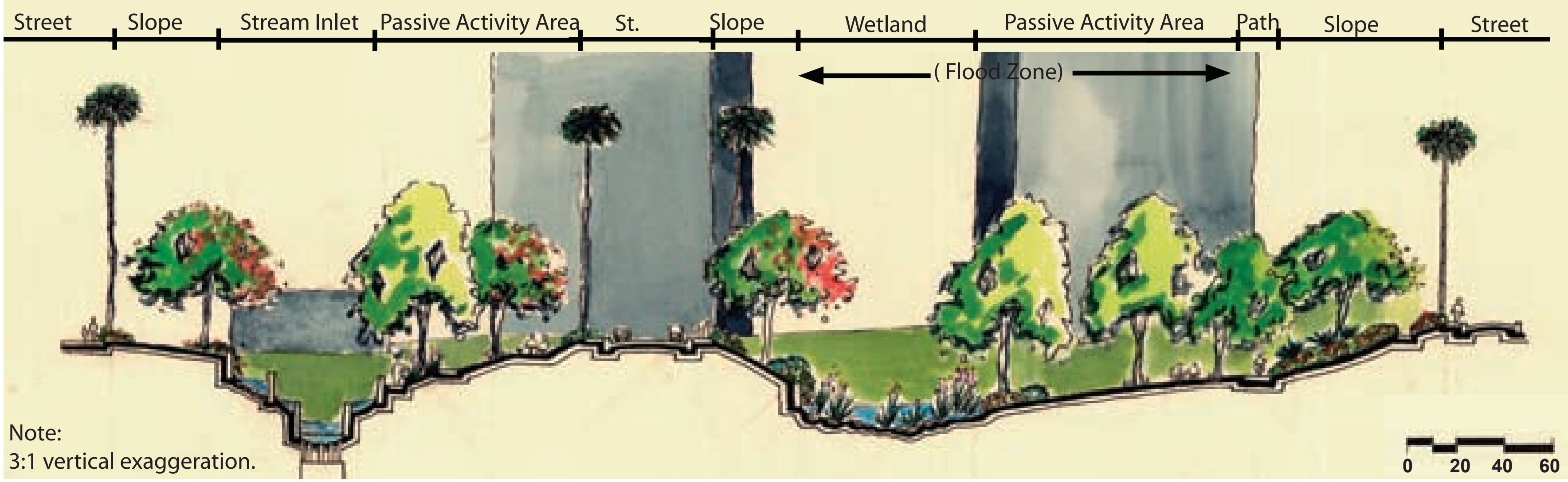
The principal entries to the park, at Lafayette Park Pl. and Wilshire Blvd., are inlaid with maps showing the historic streams of the watershed.

A slight elevation of Wilshire Blvd. and the installation of a bridge will be required at the location where the stream passes below.

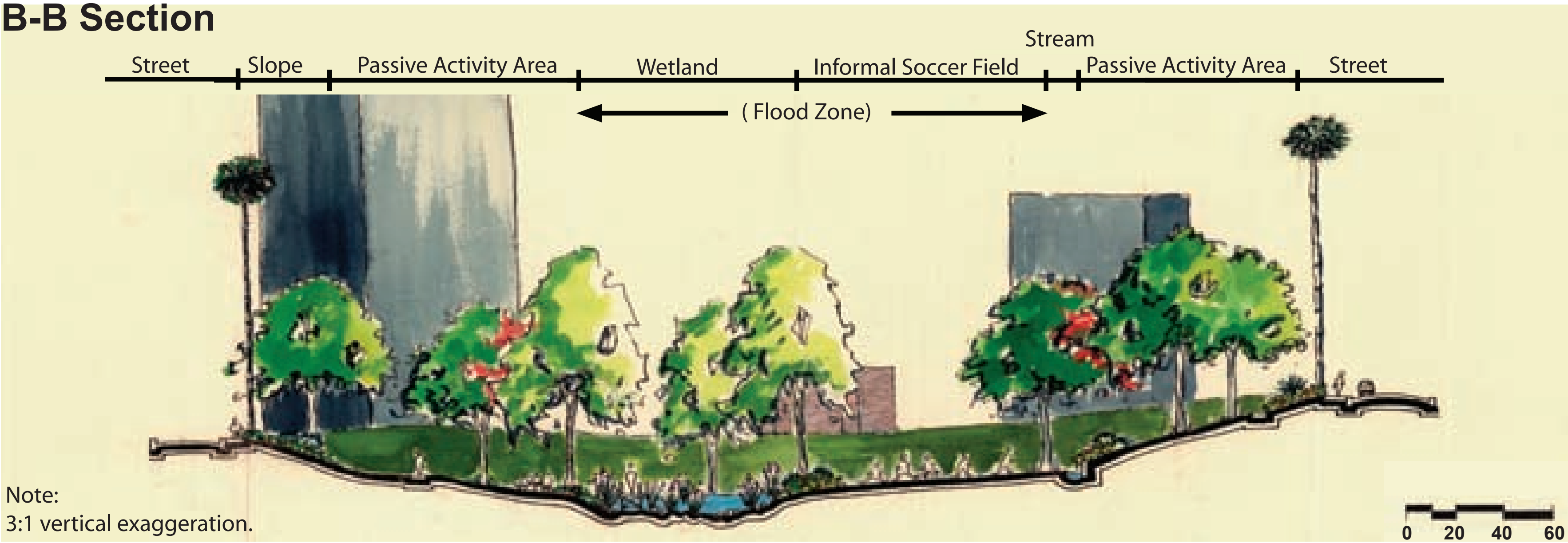
South of Wilshire, Hoover St. is closed and the triangular space and the vacant properties are joined together. The florist shop is converted into a cafe with a terrace facing the stream. The largest tar seep is incorporated into a small public amphitheater.

Perspective of stormdrain outlet wetlands and Courthouse's graywater wetlands.

A-A Section

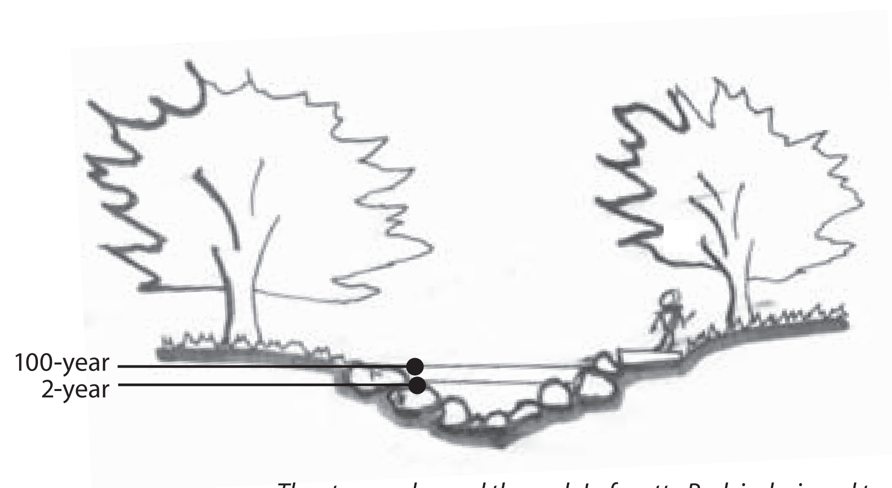


B-B Section



Design guidelines incorporated into this design:

- Course adjustments
- Intermittent and perennial streams
- Groundwater infiltration
- Coordinate planting
- Detention and retention
- Graywater
- Constructed wetlands
- Plant trees
- Oil seeps
- Gentle stream banks
- Public awareness maps
- Energy dissipators
- Playful details
- Recreation fields
- Wildlife viewing
- Alternative transportation
- Safe stormdrain inlets
- Stream crossing
- 100-year storm
- Lighting and emergency phones



The stream channel through Lafayette Park is designed to accommodate 100-year flood events.


Courthouse
Graywater Treatment Pond
Stormdrain Outlet
Flood Zone
Riparian Trees
Stream
Cafe w/ Terrace
Tennis Courts
A
Stream Inlet
Waterfall Terrace
Tar Seep Fountain
6th St.
Commonwealth Ave.
C
B
Wilshire Blvd.
Hoover St.
Lafayette Park Pl.
Existing Library
Stormdrain Outlet
Wetland
Basketball Courts
Community Center
Informal Soccer Field
Main Entry
New Mixed-used Building
Parking Area
Power of Water Fountain
0 20 40 60

Another Option: Civic Stream

This design used concepts of weaving and stream function to develop a more formal, civic-oriented plan. Land and water are alternately revealed and hidden by each other.

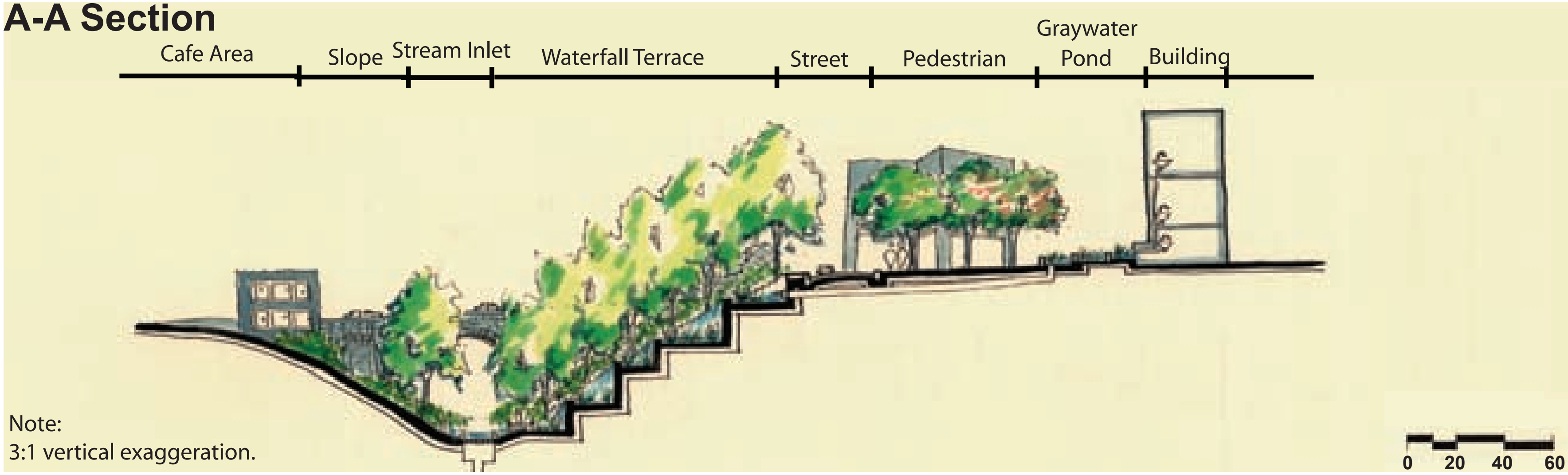
"Tributaries" of stormdrains and graywater feed the main stream. These tributaries are sized in accordance with their flow, and tributaries fan out to allow wetland vegetation to cleanse the water. Graywater treatment ponds are located by all park buildings; this includes historic fountains which are refurbished, expanded, and retrofitted to filter graywater. Wetland vegetation occupies lower pools of the fountains to continue the cleansing process. This water then flows via sand-filled trenches to the main stream. A "water-stain" of denser, darker vegetation will appear on the surface where the trenches exist. This also suggests the function of water within a stream system.

A two-tiered pathway system defines flat open greens which accommodate informal sports on one level and floodable banks leading to the stream on the lower level. Vegetation by the stream is denser. Small wetlands along the stream maintain water quality. Basketball courts are relocated to the north side of the recreation center and the tot-lot is moved to the entry at Wilshire Blvd. and Lafayette Park Pl., maintaining visibility from the recreation center.

The stream passes under a bridge at Wilshire Blvd. The florist shop is converted into a cafe, and the tar seep is fenced with a viewing area. Tennis courts are terraced at different heights into the sloping hillside, obscuring the fencing at street level. A new mixed-use building occupies the prior location of the tennis courts, providing a source of revenue for the city and an increased social presence in the park. Lafayette Park Pl. is closed next to the triangle and parking spaces are provided. The Power of Water fountain is relocated to the Granada Building and a tree-lined allée creates a pedestrian connection into the park.

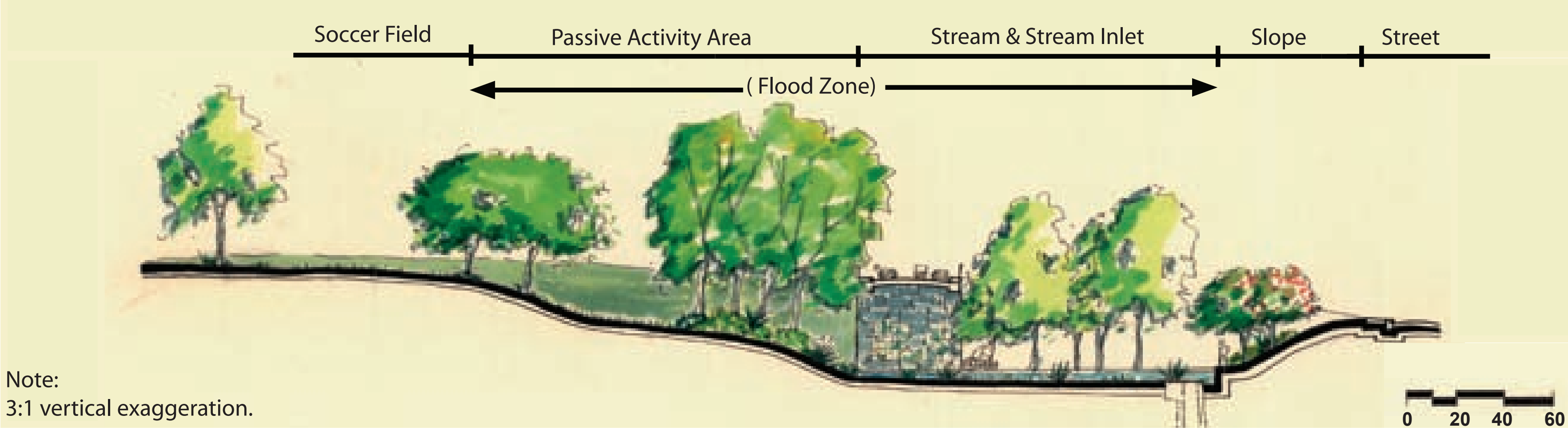
Perspective looking north toward Courthouse.

A-A Section



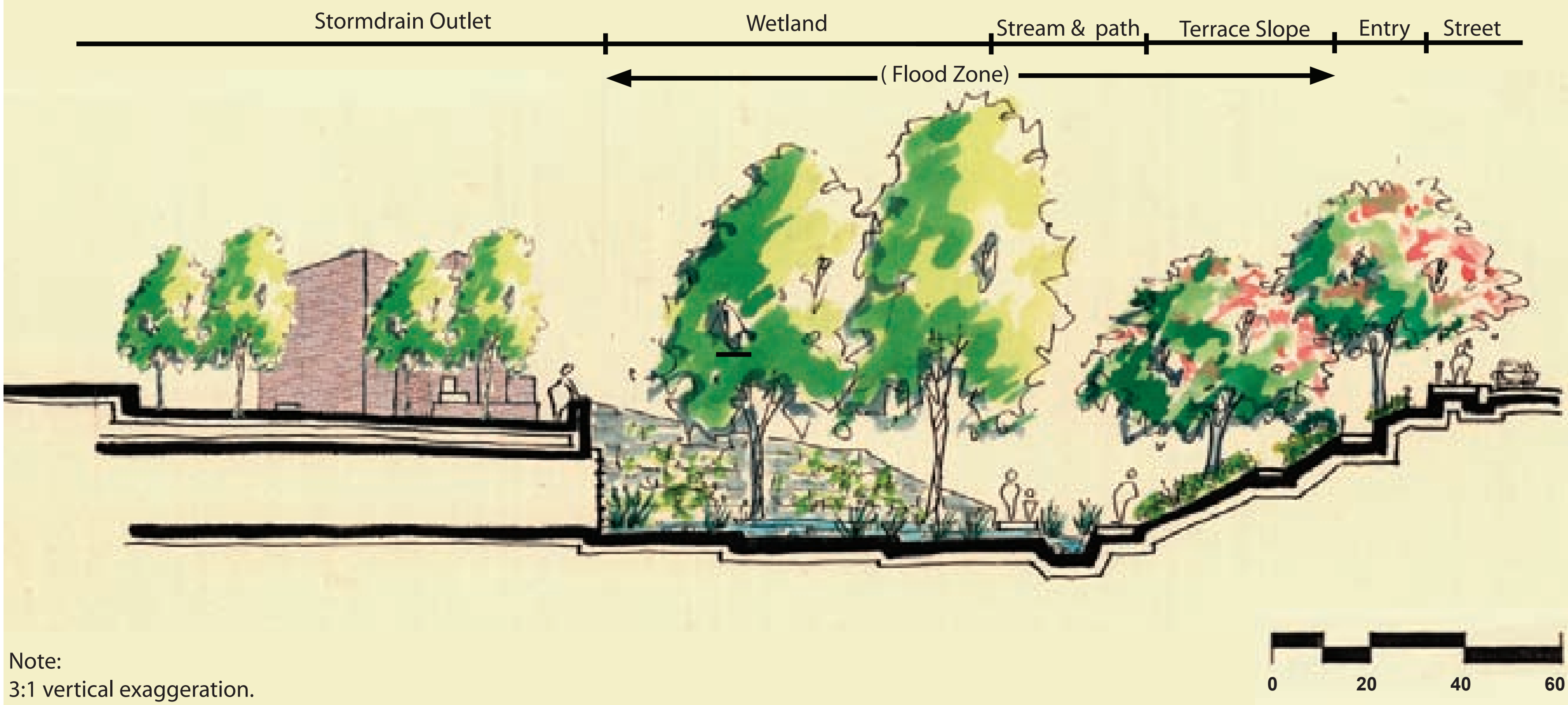
Note:
3:1 vertical exaggeration.

B-B Section



Note:
3:1 vertical exaggeration.

C-C Section



Note:
3:1 vertical exaggeration.

Design Guidelines incorporated into this design:

- Course adjustments
- Intermittent and perennial streams
- Groundwater infiltration
- Coordinate planting
- Detention and retention
- Graywater
- Constructed wetlands
- Plant trees
- Oil seeps
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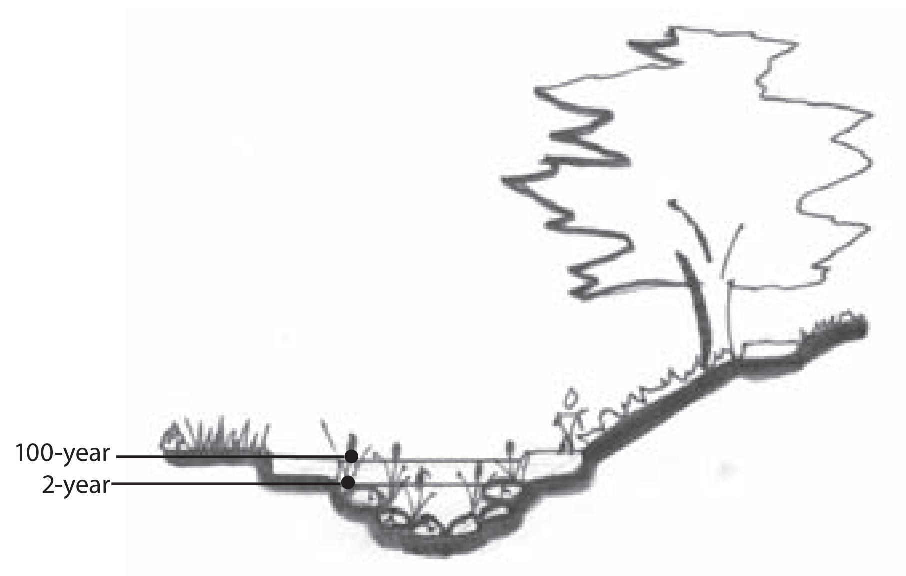


The stream channel through Lafayette Park is designed to accommodate 100-year flood events.

Conclusion

The plans and designs presented in this section are intended to provide direction for the City of Los Angeles and citizens who want to improve the city's ecological and aesthetic environment. They contain many options for both cleansing water—thus improving the health of Santa Monica Bay—and providing open space. Implementing them should enhance the feeling of safety and civic connectedness and increase the economic health of affected neighborhoods.

The concepts proposed by these plans can provide solutions to issues identified by both this report and the City's general plan. However, the City must act decisively if it wishes to rectify existing problems. This effort will require several departments to work together: Planning, Parks and Recreation, Public Works, and possibly others. These departments ideally should form a coalition and coordinate with organizations outside of the City's government: Los Angeles County Public Works, the Army Corps of Engineers, California Transportation Department, the Metropolitan Transportation Authority, the U.S. Environmental Protection Agency, and citizen-based advocacy groups. In this way, funds spent to accomplish one organization's objectives can be leveraged with others' to accomplish several goals efficiently.

Prospect

Photo: View looking east towards downtown Los Angeles. Wilshire Blvd. is the major street to the extreme left. Sacatela Creek is in the foreground. The Ambassador Hotel is behind it. MacArthur Park can be seen in the distance. 1924. Courtesy Photo Collection/Los Angeles Public Library

This report provides a vision of improved watershed and community function in Los Angeles. The benefits of daylighting streams are myriad, and realizing the vision will undoubtedly unearth other opportunities. While studying daylighting streams, many issues were "daylighted" that fell outside the scope and timeframe of this study. Further exploration of these issues will create a stronger constituency and case for pursuing this vision.

One key issue is the current condition of groundwater within the watershed. The individual who typically oversees issues related to groundwater is known as a Water Master. Currently, the groundwater in the study area is unadjudicated; or is without a Water Master (Mullins, 2001).

Groundwater health is an important concern. Low groundwater tables could result in subsidence as earth compacts to fill voids. Groundwater contaminants may have caused wells in the Hollywood area to be abandoned in the 1950's. Also, contamination from urban pollutants continues to be a threat. These problems could be avoided by a stream daylighting program that includes a well thought-out infiltration component. Oversight of groundwater health and adjudication of its rights is essential. Establishing a Water Master for the area would provide this oversight and ensure groundwater quality.

A management plan should be established for Ballona Creek's headwaters in the Santa Monica Mountains. Rain that falls in the headwaters is typically the purest water in a watershed. Infiltrating a significant portion of this water, rather than the current practice of piping it directly to the ocean, would improve overall groundwater health through replenishment with clean water.

Stream daylighting efforts could be coordinated with stormdrain maintenance programs. Streams daylighted in other communities have many times been financed with money that would have been otherwise used to repair and upgrade culverts and pipes.

While narrowing the list of target opportunities for this study, several geographic locations for further study were identified:

Hollywood Cemetery
The Hollywood Cemetery is located around the Bronson Canyon stream, and experiences significant flooding that requires crews to use sump pumps during the rainy season. Flooding could be mitigated by incorporating a stream into the cemetery's design.

Silverlake Blvd.
Another site that has potential for stream daylighting is the commercial district on Silverlake Blvd. This street winds down a canyon where there once was a visible stream; its waters contribute significantly to the flows of Sacatela Creek.

Wilshire Country Club
The Wilshire Country Club has a live stream running through its greens. Access, of course, is restricted to members and golf course maintenance introduces many contaminants. Creating a pathway along the stream could provide a through-way for the community, and swales and wetlands along its course can process contaminants. This would significantly improve watershed function and community interaction in this stream reach.

Leimert Park/Crenshaw District
A slough historically occupied the eastern base of the Baldwin Hills; it was drained to develop the area into the Crenshaw District. Groundwater is now far below the District's peat soils and ground under the fire station has subsided, possibly due to lost groundwater.

Strategies for the Future

The process of daylighting streams is complex and will require a number of strategies and key considerations to ensure its success. These strategies and key considerations include:

Land Acquisition—converting land for stream development:
- Use transfers of development rights to acquire land
- Provide density bonuses for developments swapped for streamside properties
- Transfer or lease air rights over stream
- Accept donations

Ownership—potential owners of a stream easement:
- City of Los Angeles Department of Recreation and Parks
- Conservancies (e.g. The Trust for Public Land, The Nature Conservancy, etc.)
- National Park Service
- State Park Service

Urban & Stream Design—enhance stream/community interface
- Reposition retail and residential areas to face streams
- Ensure that views through streams are clear for safety reasons
- Require building setbacks to allow for sunlight (e.g., tiered away from the stream)
- Minimize fencing
- Incorporate local art
- Remove litter and graffiti in a timely fashion
- Plant native vegetation
- Use vegetated roofs
- Establish community gardens
- Provide dog parks
- Provide adequate lighting for safety
- Provide bilingual and accessible signs

Accessibility—create stream reaches that all users can enjoy:
- Design streamside amenities to be barrier free
- Ensure that bus and other public transportation stops are accessible to stream paths
- Keep streams through school campuses open after school and on weekends
- Provide visitor parking

Naming Streams—establish names of stream reaches according to:
- Tongva names
- Local neighborhood names
- Historically significant features in the area
- Geologically and environmentally significant features in the area

Maintenance—Maintenance is integral to ensure the success of the stream parks and can occur through:
- Community involvement and school/work programs
- City of Los Angeles Department of Recreation and Parks
- Adopt-A-Creek programs
- Property owner as the "Lead Agency"
- Provision of adequate number of trash receptacles
- Placement of trash nets in each community
- Establishing a litter recycling program

Liability Management—through ensuring public safety:
- Determine liability
- Maintain safe slopes
- Use curbs along paths
- Be mindful of gross negligence issues

Social Safety—maximize enjoyment and use for all people:
- Ensure lighting is ample
- Provide emergency phones and panic buttons at regular intervals
- Post hours of operation and allow for pathways always to be open for alternative commuters
- Patrol area frequently with police bike units
- Establish neighborhood watch programs

Signs—inform the public for safety and educational purposes:
- Provide critical signs for safety and social responsibility
    - "Graywater is recycled in stream, could be hazardous to your health"
    - "Do not enter during storms"
    - "When flooded, seek higher ground"
    - "Dogs must be on leash", "Curb your dog"
- Provide stream map for orientation and stream names at street crossings
- Explain the purpose of daylighting streams (i.e. to improve watershed function)
- Provide interpretive signs of regional plant and wildlife names

Water Quality—monitoring quality and its improvement:
- Establish monitoring programs through
    - Landowners
    - Schools
    - Community
    - Stormwater Management/Public Works
- Use constructed wetlands and swales to buffer streams and filter contaminants
- Use plants with remediative qualities
- Keep first phase of graywater out of public reach

Social Investment/Revenue—seek opportunities to support stream development and communities:
- Develop buildings for sale or lease
- Establish concessions and cafes
- Rent equipment (e.g., balls, bikes, rollerblades)
- Establish community gardens
- Develop a large gift and donations program
- Provide subsidies where necessary
- Establish park staff to run community and after school programs for topics including:
    - Community plantings/Urban Forestry programs
    - Birding tours
    - Botanical tours

Stream Daylighting and Fauna

Given the limited amount of stream habitat suggested for rehabilitation, and public safety issues that limit the introduction of dense vegetation required by certain species, it is highly unlikely that listed threatened or endangered species of the region (e.g. California Gnatcatcher or Least Bell's Vireo) would necessarily benefit from such area improvements (Garrett, 2001). However, there are other species that might flourish in these conditions. Providing several layers of native vegetation including tall trees (sycamores, cottonwoods, willows and alders), a dense shrub layer (willows and mulefat, etc.) and an herbaceous layer (aquatic and emergent marsh plants), vertebrate diversity should improve, even in small parks within urban areas (Garrett, 2001).

A good measure of the biotic success of stream restoration in the Ballona Creek watershed would be to identify target species that are generally absent from the area and monitor their return or increase in numbers. Target species that could adapt to small urban stream parks are primarily avifauna, including:

red-shouldered hawk	Cooper's hawk
black-chinned hummingbird	Nuttall's woodpecker
downy woodpecker	northern flicker
Pacific-slope flycatcher	oak titmouse
Bewick's wren*	common yellowthroat*
spotted towhee*	song sparrow*
bullock's oriole	lesser goldfinch

In addition, two amphibians (Pacific tree frogs and slender salamanders) could adapt to small stream parks (Garrett, 2001).

*Only if extensive shrub layer is established.

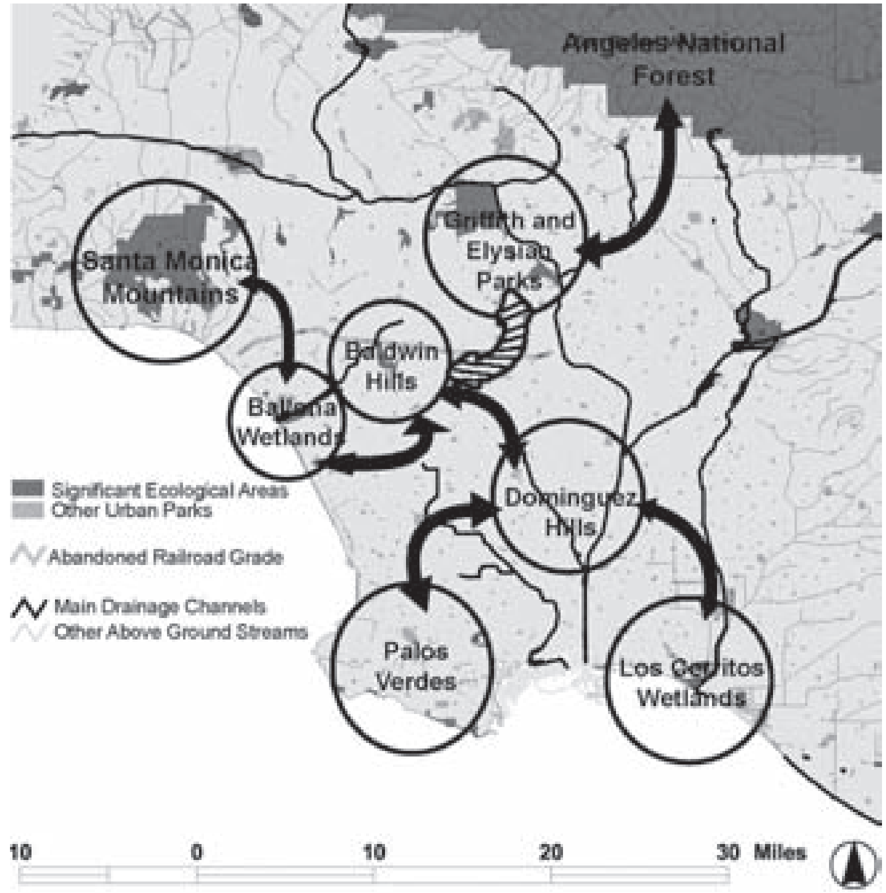
Stream restoration should not affect problem species, as most are currently present within the city (e.g. non-native sparrows, European starlings, rats, mice, etc.) It is highly unlikely that the urban streams would encourage larger predator species like bobcats or coyotes (Garrett, 2001).

Future: Links to Other Areas

Although not addressed explicitly as a part of this study, future research on the upper Ballona Creek watershed should consider opportunities to link open spaces and ecological areas in the region surrounding Los Angeles. The watershed lies in a central area and could provide a missing connection for isolated recreational and significant ecological areas.

Significant ecological areas in the Los Angeles region have been designated by the State Water Resources Control Board, the Los Angeles County Department of Regional Planning, and the California Department of Fish and Game (Los Angeles County, 2000). These areas have been identified as containing unique or unusual species assemblages, or areas of habitat that are rapidly declining. Advocacy groups are working to enlarge these areas and provide corridors between them for wildlife. Without corridors (see map at right) these areas are meaningless: wildlife populations living within them will not have sufficient genetic diversity to survive in the long-term. Wildlife also needs to migrate from the Angeles National Forest to lower elevations, but currently cannot.

As discussions grow regarding opportunities associated with daylighting streams, there will be many constituent voices raised. With so many interest groups, it will be essential to form coalitions where concerns can be raised, acknowledged, and incorporated. Using this approach, a plan to daylight streams will not only meet differing needs and ensure watershed function, but may link to improvement plans in adjacent areas.



Connections are necessary to maintain biological diversity in the significant ecological areas of the Los Angeles region.

Appendices

Photo: Many streams, like the ones seen in the foreground, used to flow through the La Brea-Hancock Park area of the city. No Date. Courtesy Photo Collection/ Los Angeles Public Library.

Appendix A: Soil Characteristics

The Los Angeles basin consists of extensive young alluvial deposits, which are many hundreds of feet deep in most places. The sediments have been spread broadly by larger streams resulting in the appearance of an extensive, nearly level water-laid plain, with elevated hilly remnants of older, unconsolidated deposits occurring at intervals over the surface and around the valley margin.

Based on a 1902 United States Department of Agriculture Soils Survey, soils in the upper Ballona Creek watershed are categorized and described in the accompanying table. This information provides insight to native vegetation and infiltration rates.

Name	Origin	Elevation	Slope
Residual Soils			
Formed by the weathering in place of consolidated rocks, usually in hilly positions. They are well drained and are eroded or de			
Altamont Clay Loam	Sedimentary rocks, residual from associated or interbedded shales, sandstones, and similar sedimentary rocks.		Occupy slopes and rolling, hilly or mountainous areas.
Altamont Loam	Sedimentary rocks, residual from associated or interbedded shales, sandstones, and similar sedimentary rocks.		Small rolling hills with a smooth, rounded surface.
Diablo Clay Adobe	Sedimentary rocks, a residual from shales, sandstones, impure limestones and similar rocks of more calcareous formations than Altamont.		Gently to moderately rolling hills.
Coastal Plains Soils			
These soils are from coastal plain deposits. In many instances, their geological origin is unclear. Their subsoils are not well-ae			
Madera Fine Sandy Loam	Weathered and variously modified old unconsolidated water-laid deposits from a wide range of rocks.	600-1000'	0-15%
Montezuma Clay Adobe	Laid from old water deposits considerably altered by weathering and erosion since original deposition subsoil is calcareous.		Gently sloping undulating, or rolling with a smooth surface traversed by drainage ways with rounded banks.
Ramona Loam	Most extensive types in Los Angeles. Old, unconsolidated water-laid deposits altered by weathering, leaching and erosion.		0 - 25%; varied - old alluvial fans, foot slopes, marine terraces and elevated mesa-like areas. Gently sloping or undulating to rolling and dissected surface.
Recent Alluvium			
These soils have permeable subsoils and are derived from a variety of granites, schists, shales and sandstones. A high water t			
Hanford Sandy Loam		700-1500'	2-9%; sloping alluvial fans and stream bottoms.
Yolo Clay Loam	Alluvial deposits washed from upland regions of sedimentary rocks. Non micaceous.		Gently sloping allivual fans, footslopes and stream bottoms or recent terraces of gentle slope.

Color	Depth to Subsurface	Permeability/ Moisture Retention	Runoff/ Drainage	Erodibility	Reaction	Vegetation	Texture	Organic Matter
eply furrowed in most places. The Altamont and Diablo in the Los Angeles area are from sedimentary rocks.								
Light, medium or dark-brown. Sub-soil is reddish.	12-18" to < 6'	Slow; retains moisture at 4'+	Rapid; well-drained.		Slightly acid to mildly alkaline.	Annual Grasses, scrub oaks, coast live oaks, root zone is 20-36" deep.	Soft, few rocks, dry-hard and compact, wet-plastic and sticky.	Moderate.
Light, medium or dark-brown. Sub-soil is reddish.	8-12"	Subsoil is permeable to roots and water. Retains moisture under normal conditions.	Good surface and subsurface drainage.				Free from gravel, some shales.	Small to moderate.
Dark gray to black with dark brownish gray color in some places.	10-36" to < 6'	Retains moisture well.	Rapid; good drainage.				Dry-cracks are numerous and deep. Wet-sticky.	High.
rated and are less permeable.								
Lighter-textures are light brown, heavier textures are dark to reddish brown.	Subsoils 18-30" to <6 ft resting on an impervious hardpan 6'+	Very slow; not very permeable to roots and water.	Very slow permeability; well-drained.	Slight	Slightly alkali.	Annual grasses, forbs and chamise, root zone is 18-36" deep.	Dense, poorly aerated.	Low.
Dark gray to black, some brownish.	18-36"	Slow	Drainage is good except flat areas in wet weather.				Some gravel in winter miry and almost impassible due to heavy texture.	High.
Brown with reddish and grayish variations.	12-24"; to 6' or more	Slow permeabilty; subsoil is semi-cemented hardpan.	Medium to well-drained except in depressions and flat areas with heavy subsoils.	Medium to high.	Slightly acid; neutral to medium acid.	Mostly brush, consisting of forbs, chamise, salvia and buckwheat with an understory of annual grasses. Effective rooting depth of 60" or more.	Small quantities of gravel spread throughout.	Moderate to high.
able exists in much of the lower plains portion. Injurious amount of alkali have accumulated in these soils.								
Brown to grayish brown.	12 to 15" to 6'	Moderatly rapid permeability; moisture-retentive in greater depth areas.	Well-drained; subject to overflows.	Slight to moderate.	Slightly acid.	Annual grasses, forbs & chamise effective rooting depth is 60" or more.	Small quantities of gravel and gritty material uniformly to 6'.	Generally low.
Light to dark brown with grayish variations.	1' to 6'	Retains moisture well.	Flooding packs and puddles the soil.				Friable and free from gravel or coarse material.	Moderate to high.

Appendix B: Typical Wildlife by Plant Community (Holland, 1986)

Coastal Sage Scrub
Anna's hummingbirds, rufous-sided towhees, California quail, greater roadrunners, Bewick's wrens, coyotes and coast horned lizards.

Chaparral
Wrentits, bushtits, spotted towhees, California thrashers, bobcats, brush mice, dusky-footed woodrats, Western fence lizards, and rattlesnakes.

Coast Live Oak Woodland
Acorn woodpeckers, plain titmice, Northern flickers, Cooper's hawks, Western screech owls, mule deer, gray foxes, ground squirrels, jackrabbits, and a variety of bats.

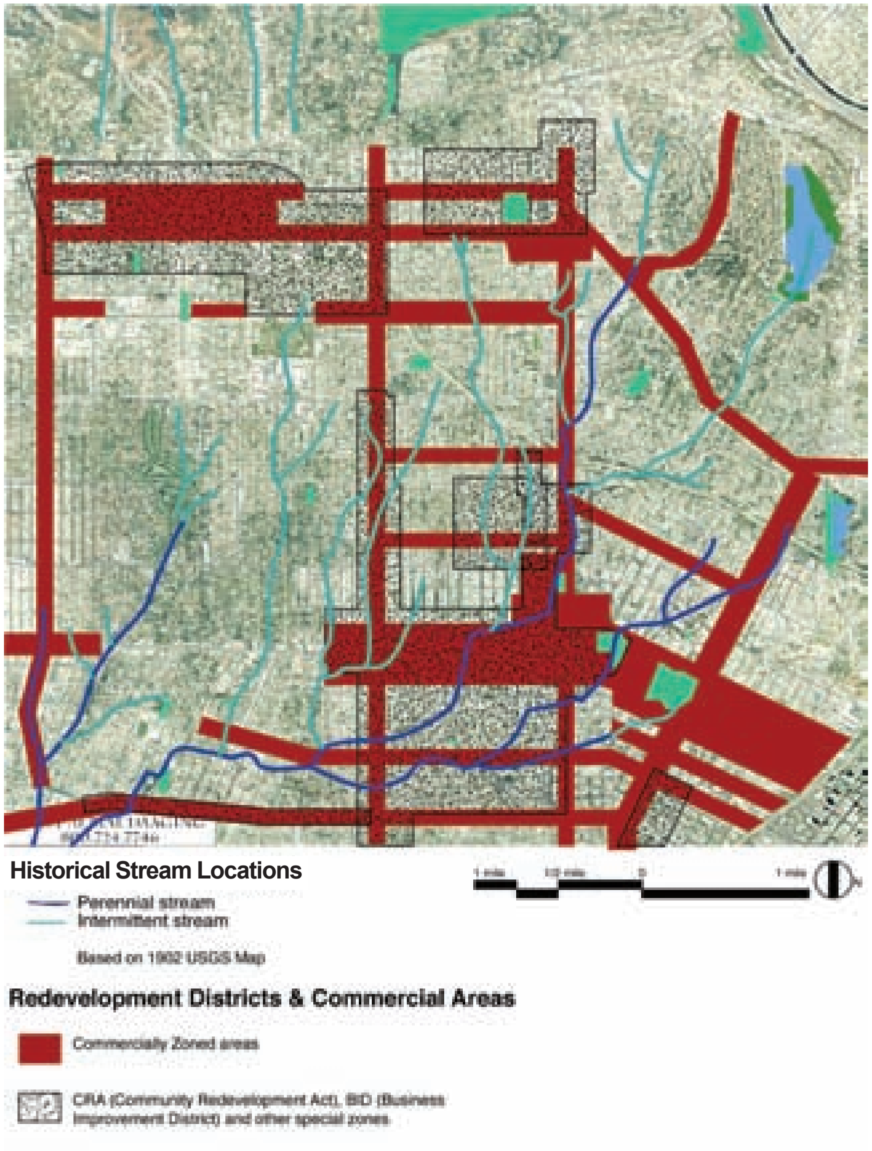
Riparian Woodland
American goldfinches, black phoebes, warbling vireos, song sparrows, belted kingfishers, raccoons, California and Pacific tree frogs, threespine sticklebacks, and steelhead trout.

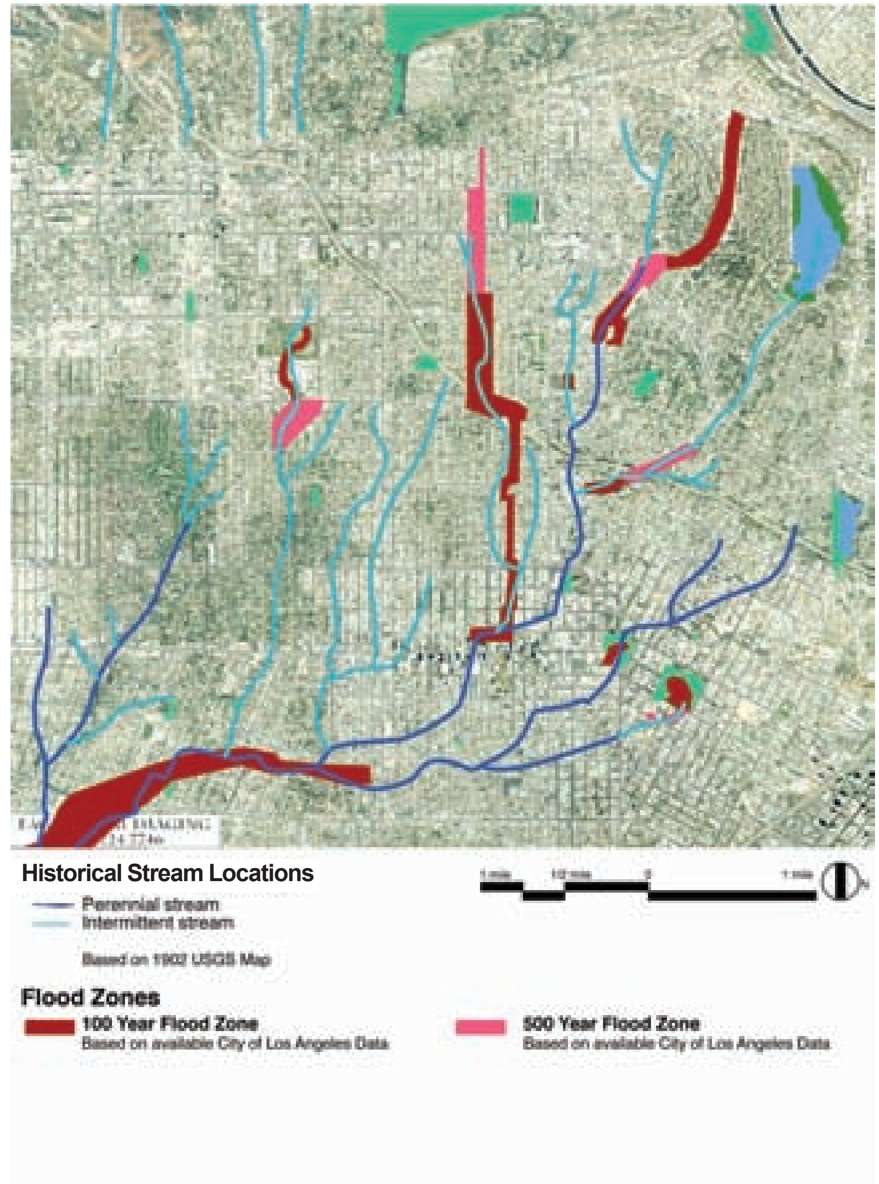
Freshwater Marsh
Abundant avifauna (birds).

Appendix C: Framework Plan Considerations

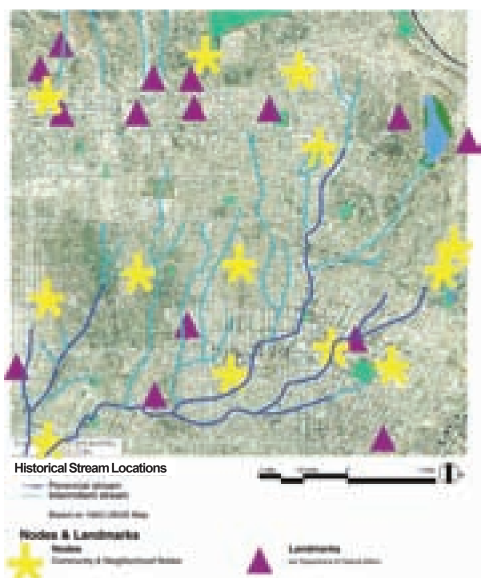
A matrix was developed to prioritize stream reaches in the upper watershed. This matrix was informed by diagrams included on the following pages.

Objective, Stream Reach													
	Implementation Timeframes				*History & Culture*			*Open Space*		*Transportation*		*Stormwater*	
	Plan Correlations	Commercial Zoning	Available Land	Property Values	Historic Sites	Historic Landforms	Lynch Correlation	Need - High Density	Possible Links	Neighborhood Links	Transit Links	Flood Zone	High Groundwater
1 Ballona Creek	✓	✓	✓	M	L	✓	-	-	✓	✓	✓	✓	NR
2 S.F. - Ballona Creek	✓	-	-	L	M	✓	✓	✓	✓	✓	✓	✓	NR
3 N.F. - Ballona Creek	✓	✓	✓	L	H	✓	✓	✓	✓	✓	✓	✓	NR
4 Todd	-	-	-	L	L	✓	-	✓	-	✓	-	-	NR
5 Lower Sacatela	✓	✓	-	M	H	-	✓	✓	-	✓	✓	-	NR
6 Mid Sacatela	✓	✓	-	H	M	✓	✓	✓	✓	✓	✓	-	NR
7 Upper Sacatela	-	✓	-	L	M	✓	✓	✓	-	✓	✓		NR
8 Bob	-	-	-	M	L	-	-	✓	-	-	-	✓	NR
9 Sliver	-	-	-	M	L	-	-	✓	-	-	-	✓	NR
10 Silverlake	-	✓	-	M	H	✓	-	✓	✓	✓	✓	-	NR
11 Monon	-	-	-	H	M	✓	-	-	-	-	-	-	NR
12 Medea	-	-	-	H	L	-	-	-	-	-	-	-	NR
13 Madison	-	-	-	L	L	✓	✓	✓	-	✓	✓	-	NR
14 Rufus	-	-	✓	L	L	-	-	✓	-	-	-	-	NR
15 Tweety	✓	-	-	H	L	-	✓	✓	-	-	✓	-	NR
16 Sears	✓	✓	✓	L	L	-	-	✓	✓	✓	-	✓	NR
17 Abel	✓	-	-	M	M	-	✓	✓	-	✓	✓	-	NR
18 Cain	✓	-	-	H	M	-	✓	✓	-	✓	✓	✓	NR
19 Leo	✓	✓	-	H	L	-	✓	✓	-	-	✓	✓	NR
20 Lower Bronson	-	-	-	M	M	✓	-	-	✓	✓	✓	✓	NR
21 Loulou	-	-	-	H	L	-	-	✓	-	-	-	✓	NR
22 Mid Bronson	-	✓	-	H	H	✓	-	-	✓	-	-	✓	NR
23 Upper Bronson	-	-	-	H	M	✓	-	-	✓	-	-	-	NR

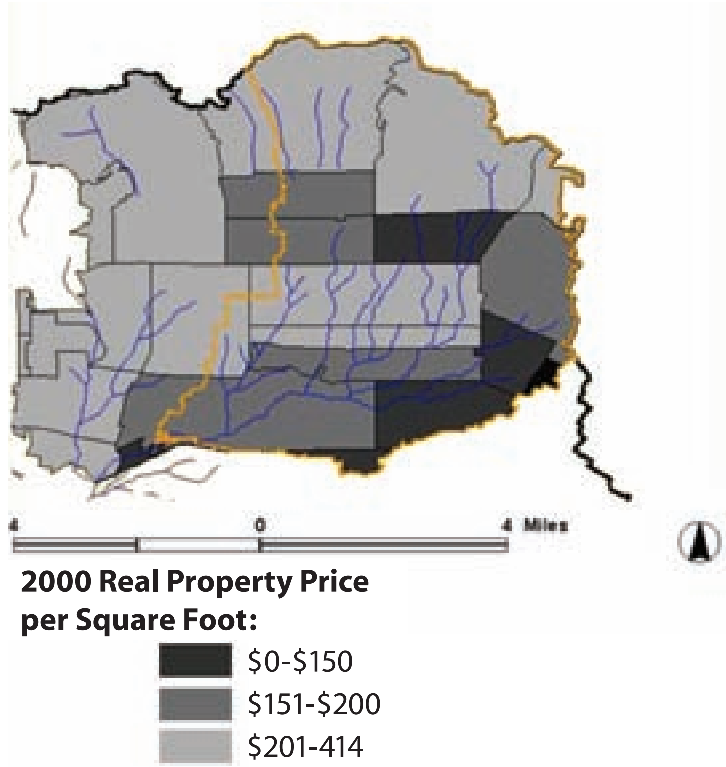

Historical Stream Locations
Perennial stream
Intermittent stream
Based on 1902 USGS Map
Redevelopment Districts & Commercial Areas
Commercially Zoned areas
CRA (Community Redevelopment Act), BID (Business Improvement District) and other special zones


Historical Stream Locations
Perennial stream
Intermittent stream
Based on 1902 USGS Map
Flood Zones
100 Year Flood Zone
Based on available City of Los Angeles Data
500 Year Flood Zone
Based on available City of Los Angeles Data

See page 74 for a larger version of this map.



See page 75 for a larger version of this map.



Appendix D:
Stormwater Runoff and Stream Channel Calculations

Determining stream widths for design purposes required using a commonly accepted method. This study used the rational method for stormwater calculations. A model was created for both a two and one hundred year storm event. Stream widths were determined using the Manning Formula. Details of the methods follow:

Part I

1) Obtained sub-watershed boundaries from City of Los Angeles, Division of Stormwater Management
2) Calculated square feet and slope of sub-watershed areas
3) Selected the Rational Method for determining storm flows in cubic feet per second.
   Q=CIA
   Where: C=Runoff coefficient
   I=Rainfall intensity at time of concentration
   A=Watershed area in acres
4) Applied a permeability factor of .8 for "C", the runoff coefficient (composite figure from Table 330-10, Dines)
5) Used the Kirpich Formula (Dines, 1998) to determine Time of Concentration:
   $Tc=KL^{0.77}S^{0.385}$
   Where: K=constant (.0078 for U.S. units)
   L=length of travel (in ft)
   S=average slope of flow path
6) Used the Steel Formula (Dines, 1998) to determine rainfall intensity for 2-year and 100-ear storm events: I=K/Tc+b
   Where: Tc= time of concentration in minutes
   K and b= coefficients for region of the U.S. and storm frequency
7) Converted square feet (from subwatershed area calculations) into acres by dividing them by 43,560 (square feet per acre).
8) Applied calculations for various sections of Sacatela Creek and Lafayette Park to determine cubic feet per second of flow for 2-year and 100-year storm event.

Part II

1) Selected the Manning Formula to determine stream width.
2) Used CFS calculations and various depths and side-slopes as variables.
3) Solved for "K"=$Qn/(D^{8/3}*S^{1/2})$
   Where: Q=cubic feet per second of flow
   n=Manning's "n" value for stream condition
   D=Selected depth
   S=longitudinal slope
4) Used Table 7-10 from Brater's Handbook of Hydraulics (1976) to locate "K" value and it's associated D/b value based on a 4:1 side slope for Sacatela and a 3:1 side slope for Lafayette Park.
5) Various depths are then divided by the D/b value to determine bottom channel width.
6) Top channel width is then estimated by adding the bottom channel width to the following formula:
   (side slope * depth) * 2 (to account for both sides of the channel).

Part III

1) Using Table 7-10 (Brater, 1976) we extrapolated depths and stream widths for 2-year and 100-year storm events for a consistent stream bottom width.
2) This approach provided the top widths for the same stream bottom widths for both 2-year and 100-year storm events.
3) This information was then used to show the high water marks of peak storm event flows for 2-year and 100-year storms.

Appendix E: Sacatela Rezoning Plan Calculations

Two main calculations were considered:
I. Calculations for Relocation of Dwelling Units
II. Calculation for Rezoning to Accommodate Relocated Dwelling Units

I. Calculations for Relocation of Dwelling Units
Geographic Information Systems (GIS) were used to identify the number of dwelling units that would need to be relocated to accommodate a stream greenway, using 1990 Census Data.

For every 100' width of stream greenway, approximately 1,000 dwelling units would need relocation. Based on a greenway width of 400', 4,000 dwelling units would need relocation. The designed greenway is often 200' or less wide, so the estimate of 4,000 units is high.

Expected growth for the region from 1990-2010, based on SCAG/City of Los Angeles statistics for the Wilshire, Hollywood, Silverlake-Echo Park, and Westlake Planning Areas, averages 28%. This leaves a need for 5,120 dwelling units.

II. Calculations for Rezoning to Accommodate Relocated Dwelling Units
Zoning categories were generalized as follows:

Rezoning Plan Category:	*Zoning Classifications Covered:*
Low Density	RS1, R1
Medium Density	R2, RD5, RD4, RD3, RD1.5, R3
High Density	R4, R5
Commercial	C4, C2, C1, C1.5, CR, P, PB,

An increase in zoning, called "upzoning" here, would provide additional units in each zone, except high density. The increase was applied to the acreage adjacent to the stream greenway, with the following considerations:

- to preserve as much single family residential housing as possible
- to cluster High Density housing and Mixed Use around the Metro Red Line to the greatest extent possible

Rezoning Plan Category:	*Change in Density Calculated when "Upzoned"*	*Acres "Upzoned"*	*Quantity of New Dwelling Units Created*
Low Density	+12 D.U./acre	14.6	175.2
Medium Density	+20 D.U./acre	96.7	1934.0
High Density	No change	-	-
Commercial/ Mixed Use (R3)	+24 D. U./acre	133.4	3201.6
Total			5,310.8 D.U.

This number exceeds the estimated need by 191 dwelling units.

A small quantity of Light Industrial was relocated in order to maintain an economic presence in the area. The potential loss of housing caused by that relocation could be taken up by the excess 191 units indicated here.


UNDERGROUND
Macaulay
HMCo
Sensitive Chaos
Restoring Streams in Cities
RILEY
MARSH
LANDSCAPE PLANNING
ENVIRONMENTAL APPLICATIONS
THIRD EDITION
people places
Design Guidelines for Urban Open Space
waterstained
landscapes
WOODWARD
ECOLOGY
A Bridge Between Science and Society
LYLE
Design for Human Ecosystems
ISLAND PRESS
Strom • Nathan
SITE ENGINEERING FOR LANDSCAPE ARCHITECTS
Second Edition
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LANDSCAPE ARCHITECTURE
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HARRIS
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Photographs

Aerial photographs provided by North East Trees.
Historic photographs of Los Angeles courtesy of Photo Collection/ Los Angeles Public Library.