APPENDIX P

LOS ANGELES RIVER NATURAL PARK PROPOSAL

LOS ANGELES RIVER NATURAL PARK

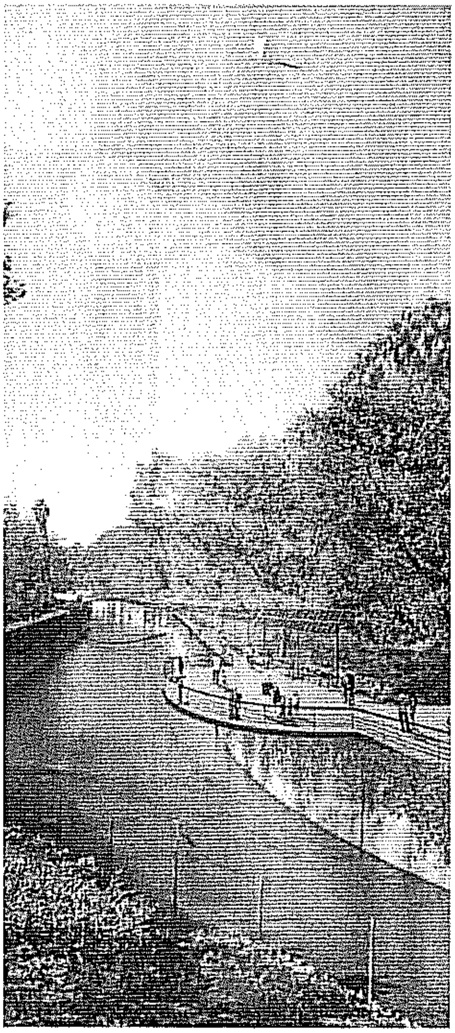
STUDIO CITY, SAN FERNANDO VALLEY

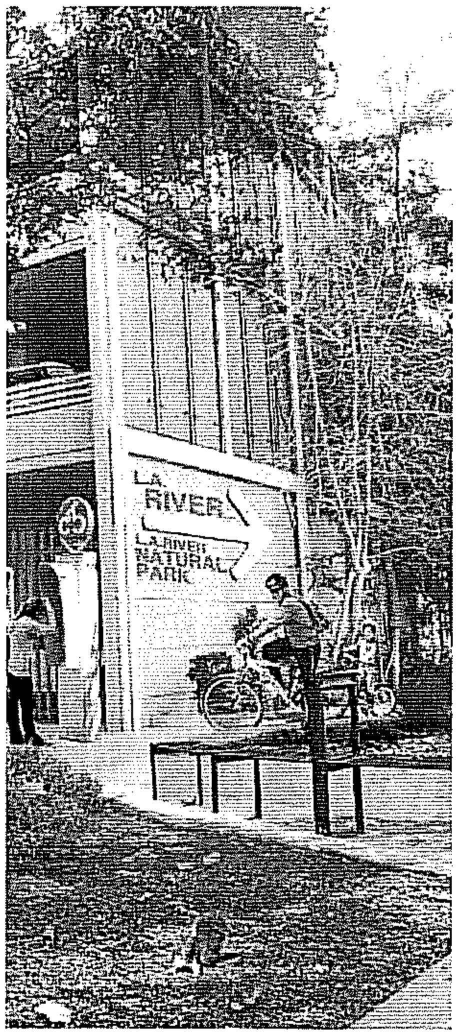
PSOMAS

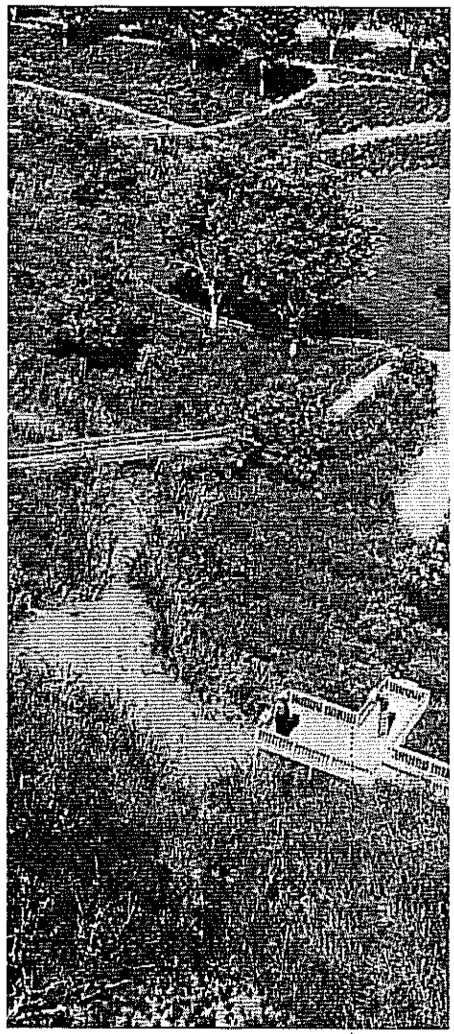
HYDROLOGY, HYDRAULICS & WATER QUALITY

MIA LEHRER + ASSOCIATES

L.A. RIVER REGIONAL PUBLIC ACCESS







TECHNICAL FEASIBILITY STUDIES

FUNDED BY:

SANTA MONICA MOUNTAINS CONSERVANCY & SAVE L.A. RIVER OPEN SPACE

ABOUT Community Conservation Solutions

COMMUNITY CONSERVATION SOLUTION'S MISSION is to tackle the most complex and challenging problems created when people and nature intersect. Community Conservation Solutions (CCS) does this by developing creative, practical and lasting solutions that unite diverse communities and interests and leverage investments of public funds. CCS has successfully crafted innovative solutions to serious environmental problems affecting California's natural and human communities by integrating the protection and restoration of natural lands and waters with compatible community uses, economic benefits and permanent public benefits.

Community Conservation Solutions works on diverse projects in urban and rural areas that help both natural habitats and people. Our projects range from parks and beaches to wilderness and watersheds, and from recreational sites to mixed-use developments. CCS is a 501(c)(3) non-profit, tax-exempt organization.

ABOUT The Los Angeles River Natural Park

THE LOS ANGELES RIVER NATURAL PARK is envisioned as a showcase "Green Solution" river-oriented park that will provide many public benefits. The 16-acre project site is the last remaining unprotected open space along 22 miles of the Los Angeles River in the San Fernando Valley. The L.A. River Natural Park presents a unique opportunity to help improve water quality in the L.A. River through creation of a wetlands habitat complex that will naturally capture and clean polluted runoff, while also providing people from throughout the region with easy, parking-friendly access to the L.A. River Trail. The Park will create an L.A. River Gateway and public access hub serving both pedestrians and bicyclists, and includes the public parking garage located 500 yards downstream, pedestrian bridges and improvements to the L.A. River Trail.

ABOUT The Project Team

CCS' PROJECT TEAM includes **PSOMAS** and **Mia Lehrer & Associates.** Psomas is a leading consulting engineering firm serving clients in the water/wastewater, transportation, public, institutional and private land development markets, and is committed to the advancement and implementation of sustainable stormwater solutions. Mia Lehrer + Associates is a full service, international landscape architecture practice. Under the leadership of Mia Lehrer, FASLA, the firm applies a comprehensive and intensely creative approach to all projects, and develops landscape design concepts that engender richly layered experiences, deploying the enduring qualities of natural and manmade elements as well as ephemeral characteristics of materials.

For a complete copy of this report, go to
www.conservationsolutions.org/larnp.html

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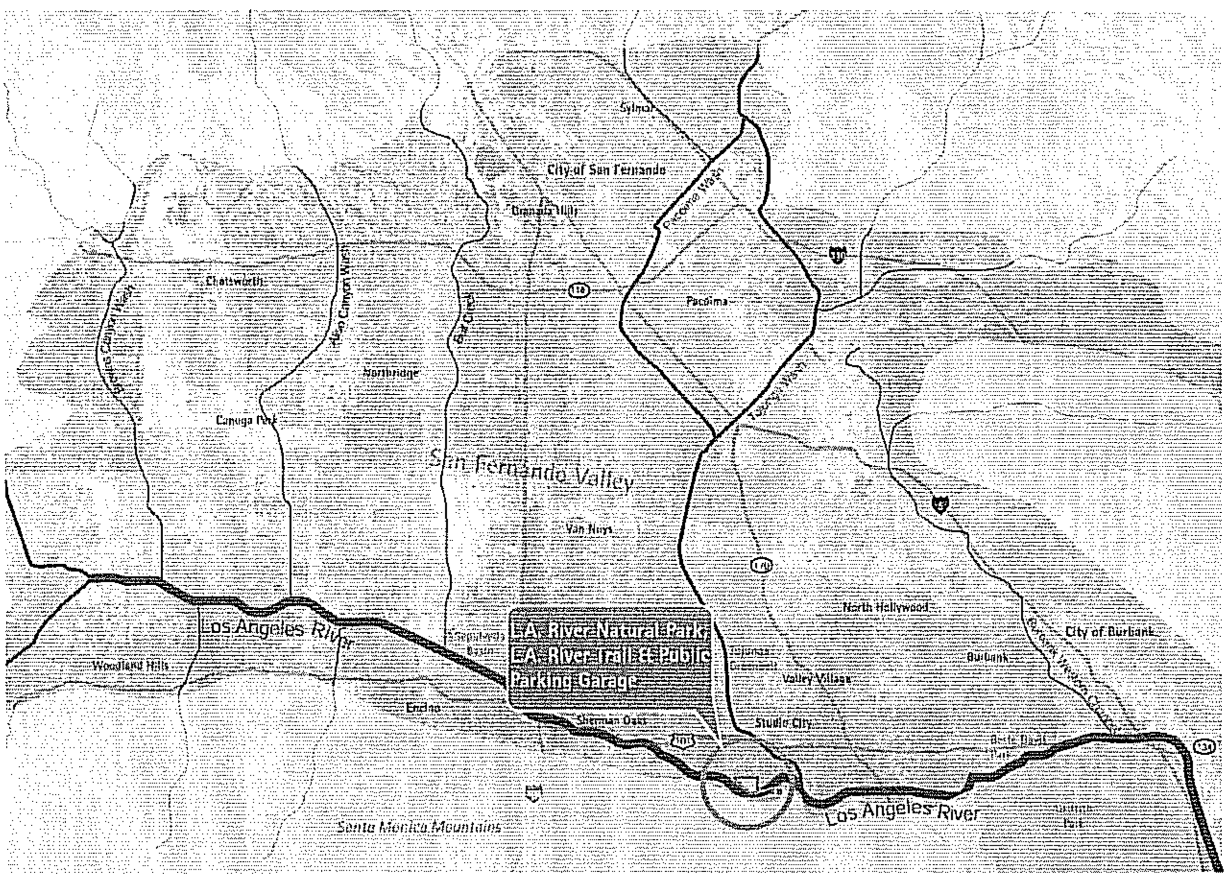
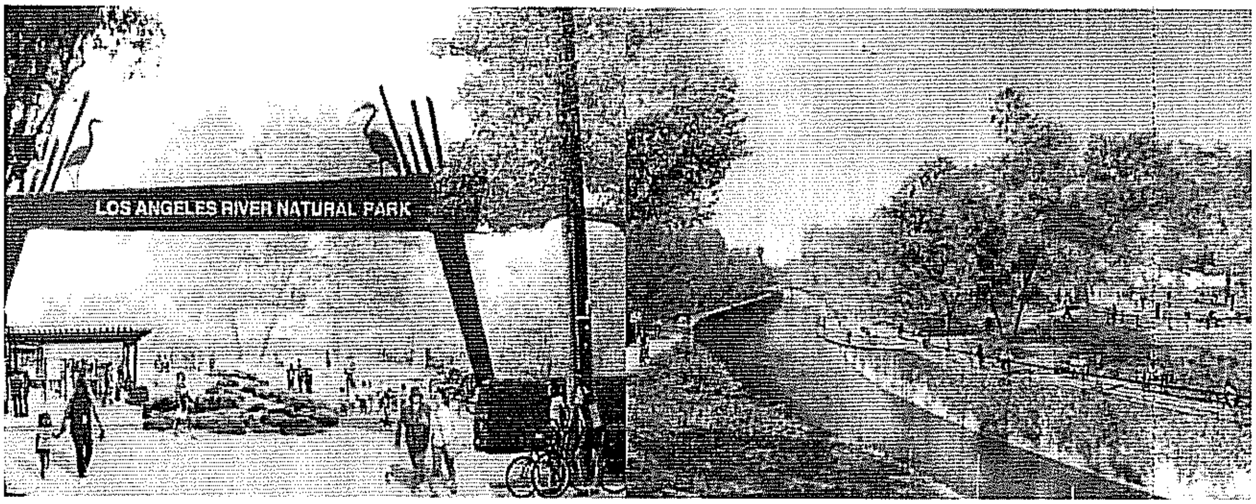


The 16-acre project site is the last remaining unprotected open space along 22 miles of the Los Angeles River in the San Fernando Valley. A 391-car public parking garage is located just downstream along the L.A. River Trail.

EXECUTIVE SUMMARY

Los Angeles River Natural Park: a showcase river project integrating natural water quality improvements with regional public access to the L.A. River



INTRODUCTION

Community Conservation Solutions is pleased to present these two technical feasibility studies for the Los Angeles River Natural Park: a Hydrology, Hydraulic & Water Quality Components Technical Memorandum, produced by **Psomas**, and a Los Angeles River Regional Public Access Feasibility Analysis, produced by **Mia Lehrer and Associates**. These studies were funded by the Santa Monica Mountains Conservancy and Save L.A. River Open Space.

The Los Angeles River Natural Park is envisioned as a showcase "Green Solution" river-oriented park that demonstrates how to naturally clean urban runoff and improve water quality, store and reuse runoff, preserve riverfront land and create native habitat, generate solar power, provide regional recreation amenities and establish an L.A. River Regional Public Access Hub and Trailhead for public access to the L.A. River in the San Fernando Valley.

The 16-acre project site is the last remaining unprotected open space along 22 miles of the Los Angeles River in the San Fernando Valley. The L.A. River Natural Park presents a unique opportunity to help improve water quality in the L.A. River through creation of a natural wetlands system, while also providing people from throughout the region with easy, parking-friendly access to the 51-mile L.A. River Trail and creating a central staging area for both pedestrians and bicyclists. The site's capacity to serve visitors is particularly significant because public access to the L.A. River is very limited elsewhere in the Valley.

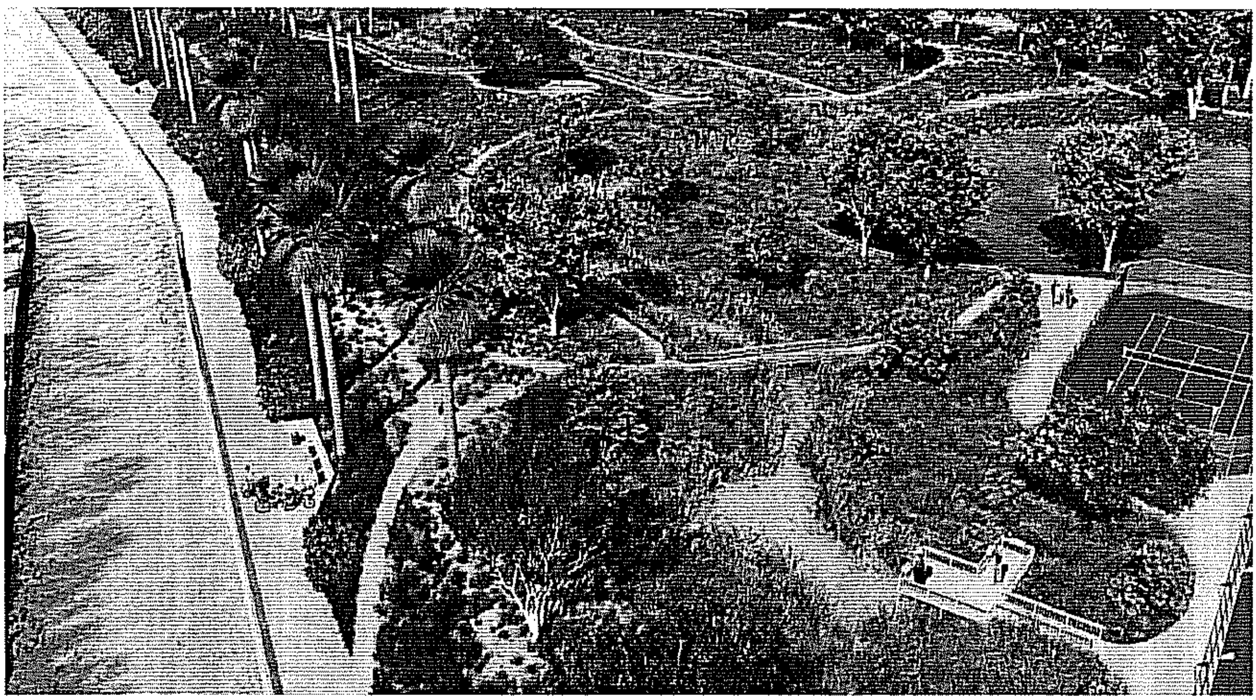
The project includes a public parking garage 500 yards downstream and L.A. River trail improvements from the parking garage to Coldwater Canyon. The site links to existing and planned trails and greenways along the Tujunga Wash, Pacoima Wash and Arroyo Seco, as well as to public transit and regional bicycle transportation networks.

The technical studies in this report were directed by Community Conservation Solutions (CCS) and funded by the Santa Monica Mountains Conservancy and Save L.A. River Open Space. The studies were based on the L.A. River Natural Park Vision and Concept Design developed by CCS and BlueGreen Consulting in 2008, with community input and technical assistance from Geosyntec. The feasibility studies provide preliminary analyses and estimated costs of the proposed urban and stormwater runoff management, water quality improvement, regional public access and bicycle hub elements of the Vision and Concept Design.

The L.A. River Natural Park would divert urban runoff from over 200 surrounding acres, providing a treatment volume of 11.4 acre feet and natural treatment of polluted runoff that otherwise flows directly to the L.A. River with no treatment of any kind. A "treatment train" would include vegetated swales, subsurface detention and retention, constructed wetlands and associated native habitat to capture and naturally clean all dry weather runoff and first flush storm events. Runoff would be stored under the driving range and would be re-used for irrigation, and solar power generated on site would offset normal site electricity usage.

This "Green Solution" approach to improving water quality in the L.A. River through creation of natural wetlands habitat would be integrated with a Los Angeles River Gateway providing bicycle-friendly, regional public access to the L.A. River that would serve people from throughout the entire San Fernando Valley and beyond. The L.A. River Natural Park would provide easily accessible linkages to ample public parking, adjacent public transit and regional bicycle networks, and connects to both the Metro Rail and Metro Bus systems.

Other project benefits would include walking trails, extension of the L.A. River Trail to Coldwater Canyon and preservation of green open space in the densely-developed Valley. Links to public transit and creation of a bicycle-friendly hub and staging area would connect to miles of planned regional bicycle networks. Preservation of the regional tennis components, putting green and driving range would help provide economic support necessary to maintain the park. The project would further the goals of the City of Los Angeles L.A. River Revitalization Master Plan and the Los Angeles City 2010 Bicycle Plan, and would help the City meet state-mandated air quality improvement goals.

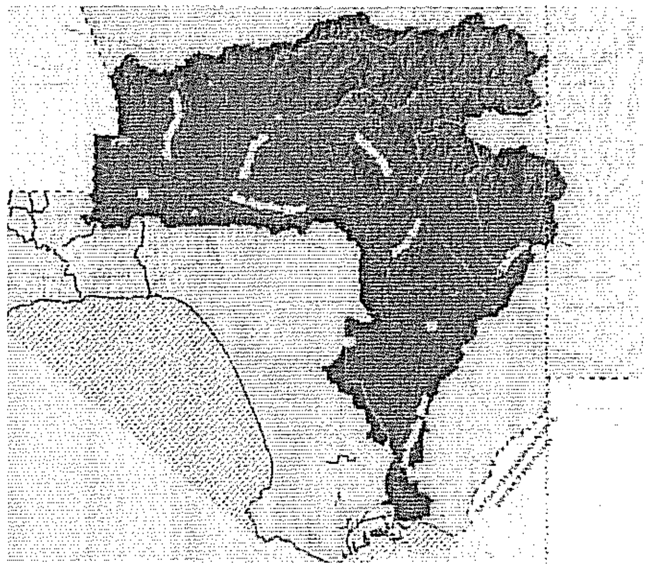


Naturally Improving Water Quality. *Using a system of wetland habitats, the L.A. River Natural Park would use a "Green Solution" approach to naturally capture and clean polluted runoff from the surrounding urban area.*

BACKGROUND

Why Water Quality Improvements are Important in the L.A. River

Polluted urban runoff is a serious problem in the heavily-paved San Fernando Valley. Additionally, the area around the project site has no storm drains, so dry weather runoff (from landscaping and other daily uses) and stormwater flow off these paved surfaces and directly into the L.A. River. Polluted runoff contaminates all 51 miles of the Los Angeles River, most of its tributaries, San Pedro Bay, beaches north and south of the L.A. River's mouth, and ocean waters.



Polluted Waters of the L.A. River Watershed. *Polluted runoff from urban areas flows directly into the L.A. River and to the ocean, without treatment of any kind*

All of the L.A. River and most of its' contributing waters are in violation of the U.S. Clean Water Act, with pollutant loads above state and federal standards developed to protect human health and marine and aquatic life. Local governments are under increasing pressure from the L.A. Regional Water Quality Control Board (Regional Board) to improve water quality in these water bodies. Pollutants in the L.A. River in violation of the U.S. Clean Water Act include: fecal coliform bacteria, nutrients, toxic substances, trash and metals, including copper, lead and selenium. The Regional Board has established Total Maximum Daily Loads (TMDLs) for trash, nutrients and metals, and is in the process of developing additional TMDLs for other pollutants. The anticipated pollutants of concern from the tributary area that would be treated by the L.A. River Natural Park include trash and debris, nutrients, oil and grease, suspended solids, heavy metals, and pesticides.

Why Regional Public Access to the L.A. River is Necessary

In the densely-developed San Fernando Valley, there are few places where the public can easily access the L.A. River, and extremely limited opportunities to create a centralized gateway to the river that can serve communities throughout the Valley. In most of the Valley, buildings exist up to the river right-of-way for nearly its entire length, severely limiting opportunities for high-capacity public access. Existing public access to the L.A. River in the Valley is largely along busy streets, with very limited parking and no improved crossings or other visitor-serving amenities that would encourage use of the L.A. River Trail.

How the L.A. River Natural Park Contributes to Regional Bicycle Transportation Networks

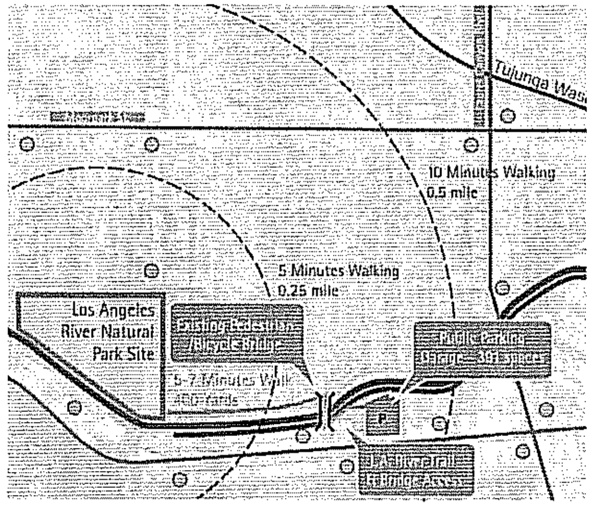
To help ensure that planned regional bicycle transportation networks succeed, there is a need for a regional bicycle hub and staging area that provides easy access to the L.A. River Trail, nearby visitor destinations and commercial areas, and safe connections to planned bicycle routes along surrounding streets. By providing bicycle-friendly parking, bicycle rental and related bicycle amenities at the public parking garage, the L.A. River Natural Park would help encourage regional bicycle use and reduction of car trips. Extensions of the L.A. River Trail would help create a contiguous, off-street bicycle path for riders of all ages.

ABOUT THE L.A. RIVER NATURAL PARK

The L.A. River Natural Park project site includes these three key components:

- 16 acres of L.A. riverfront land
- Adjacent 391-space public parking garage
- L.A. River Trail improvements

The site is located on the L.A. River in Studio City, and a county-owned and operated 20 to 40 foot right-of-way along the river is adjacent to the site. A 391-space public parking garage owned by the City of Los Angeles is located 500 yards downstream, and connects to the L.A. River Trail via an ADA-compliant ramp and pedestrian bridge. The garage connects to 1.5 miles of improved L.A. River Trail. The site is currently privately-owned and occupied by the Weddington Golf and Tennis facility. There is easy pedestrian access to many visitor-serving amenities along nearby Ventura Boulevard.



L.A. River Natural Park site, adjacent 391-car public parking garage, pedestrian/bicycle bridge and planned L.A. River Trail.

HYDROLOGY, HYDRAULIC & WATER QUALITY COMPONENTS

***Tributary Area.** The L.A. River Natural park site can capture stormwater and dry weather runoff from over 200 acres of surrounding urban area.*

Using a "Green Solution" system of natural treatment, the L.A. River Natural Park could divert and treat 11.4 acre-feet (or 3.7 million gallons) of runoff from over 200 acres of its surrounding tributary area. There would be cumulative storage of 11.4 acre-feet, including underground storage, which would provide 8 acre-feet for reuse for irrigation. In addition, during the dry season the project would draw up to 5,000 gallons per day of water from the L.A. River to sustain the wetlands, providing filtration and cleaning before discharging the treated water back into the L.A. River.

Because no storm drains currently exist in the surrounding area between the project site and Moorpark Avenue, diversion of stormwater to the L.A. River Natural Park would help provide needed flood control improvements.

Water Quality Improvements

The Green Solution water treatment strategy would consist of a series of urban runoff Best Management Practices (BMPs) that use a system of natural habitats to treat urban runoff on the project site prior to infiltration, detention and/or release into the Los Angeles River. A wetlands habitat complex would be created to provide open water, marsh, riparian and upland habitats, which would remove sediment, trash, metals, bacteria, oil & grease and organics from runoff flowing through the system. Removal of these pollutants would provide a significant water quality improvement to the L.A. River.

The treatment components consist of the following four stages:

- Pre-Treatment
  Structural pre-treatment using separators and vegetated pre-treatment basin to remove trash, debris, sediments, oil and grease.
- Constructed Wetlands and Underground Storage
  A series of natural wetland habitats over much of the site to allow dry weather and stormwater runoff to spread out, providing infiltration, absorption, evapotranspiration and storage. A subsurface detention tank under the driving range and an overflow detention/retention basin would provide water storage.
- Conveyance
  Vegetated swales promote sedimentation, infiltration and absorption, and mitigate peak runoff during storm events.
- Polishing
  A wet pond provides final treatment and additional habitat before water is discharged to the L.A. River.

Solar Power Potential

The site would be grid-neutral by using on-site solar panels to generate electricity to offset the park's electrical needs. Rooftop panels, free-standing panels on the site and along the L.A. River Trail, and shade-structure panels over on-site parking could provide approximately 37,000 square feet of solar panel coverage. Installation of energy-saving lighting and other energy conservation measures could further reduce electrical demand.

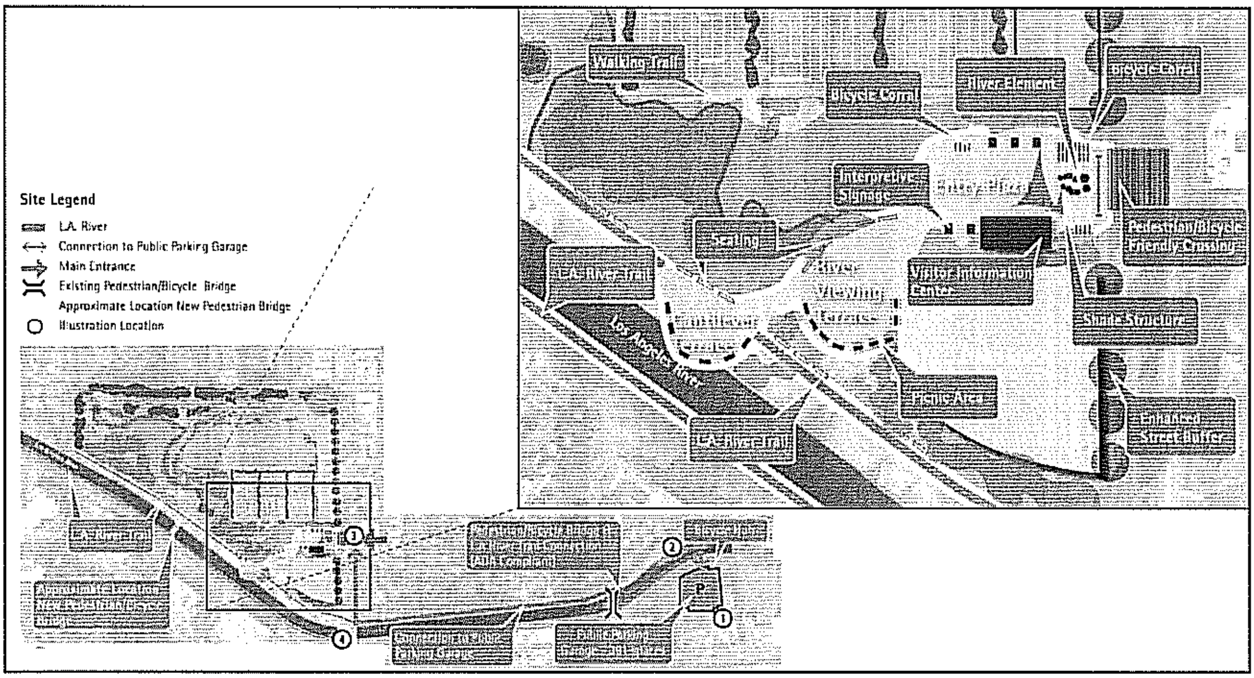
L.A. River Natural Park: Water Quality Improvement Components Concept Plan. Developed by PSOMAS

L.A. RIVER REGIONAL PUBLIC ACCESS COMPONENTS

With a combination of improvements to the site, the nearby public parking garage and the adjacent L.A. River Trail, the L.A. River Natural Park would provide centrally located regional public access to the L.A. River for people from throughout the region. With its unique riverfront location and connection via river trail to ample and easily accessible parking, the L.A. River Natural Park can become an exciting, user-friendly Gateway to the L.A. River in the San Fernando Valley, and can provide vital bicycle amenities that will link the site to regional bicycle networks.

The L.A. River Regional Public Access components include:

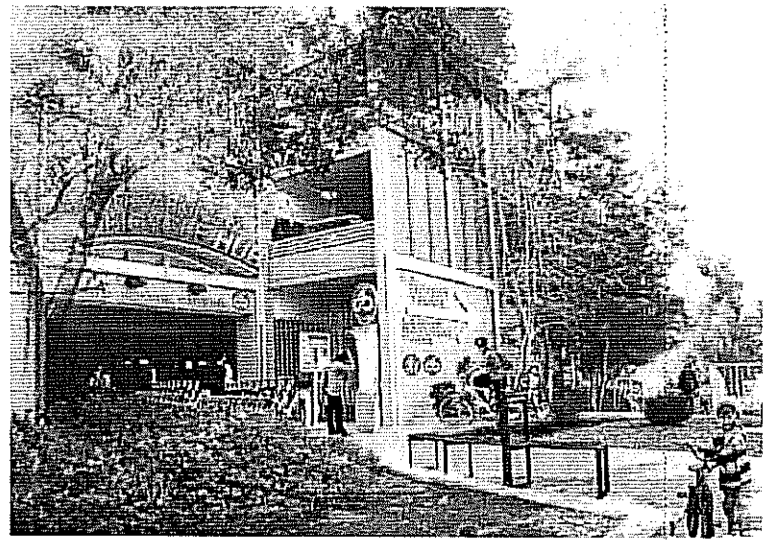
- **L.A. River Gateway**
  Entrance to L.A. River Natural Park linking to L.A. River Trail, with a public greeting area, information and interpretive kiosks, visitor information center, bicycle access, picnic areas, river observation decks, seating, walking paths and native landscaping.
- **L.A. River Public Parking Garage And Bicycle Hub**
  Off-site parking in the existing public garage on the L.A. River 500 yards downstream linked via the L.A. River Trail to the L.A. River Natural Park site; bicycle rental, repair, and parking/storage; a bicycle-friendly ramp and a pedestrian/bicycle bridge linking to the L.A. River Trail.
- **L.A. River Trail Improvements**
  Extension of the L.A. River Trail from the parking garage to Coldwater Canyon, native landscaping, and a new pedestrian/bicycle bridge across the river at the project site to connect to Ventura Boulevard.



L.A. River Natural Park: L.A. River Regional Public Access Components Concept Plan. Developed by Mia Lehrer + Associates

The project site offers all of the attributes needed to create a regional public access hub to the L.A. River and a key trailhead staging area, including:

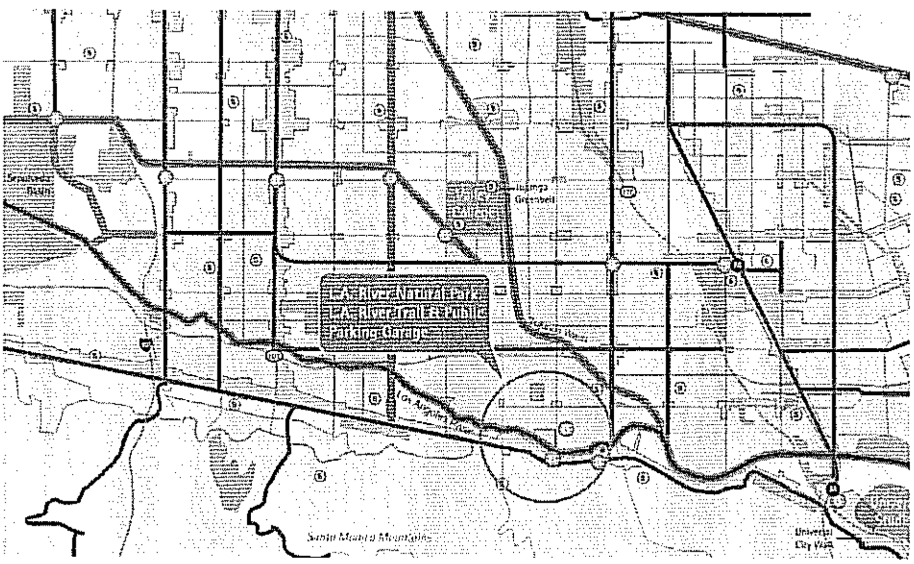
- Easy access to the L.A. River
- Centrally located
- Has ample parking readily available
- Bicycle-friendly and connects to a regional bikeway network
- Easily accessible by public transit
- Regional destination that can attract visitors
- Adjacent to visitor-serving infrastructure and amenities
- Potential for connection to other river trails
- Accessible via multiple modes of transportation, including mass transit, bicycle and walking



L.A. River Public Parking and Bicycle Hub. *Located on the L.A. River 500 yards downstream from the project site, the existing garage can provide off-site parking and bicycle amenities.*

Linking to Regional Bicycle Networks and Helping Improve Air Quality

The development of the L.A. River Natural Park as a regional access point to the L.A. River - and as a hub that links river trails, public transit, bicycle networks, commercial areas, schools and other visitor destinations to the L.A. River - will further local and state efforts to promote alternative forms of movement and build healthy communities. The L.A. River Natural Park will contribute to implementing the City of Los Angeles L.A. River Revitalization Master Plan, regional transportation alternative plans, and the Los Angeles City 2010 Bicycle Plan. By re-purposing the public garage as a regional bicycle hub and staging site, the project will encourage bicycle use and will help the City of Los Angeles meet state-mandated air quality improvement and sustainability goals.



Encouraging Bicycle Use: *The L.A. River Natural Park connects to existing and planned regional bicycle networks, and can provide easy access to commercial areas, parks, schools and other visitor destinations.*

ESTIMATED COSTS

A concept level engineer's estimate of probable construction costs for the water quality improvement components was prepared by Psomas based on projects of similar size and scope; the cost estimate for these components is $17.1 million. A landscape architect's opinion of probable cost was prepared by Mia Lehrer and Associates for the regional public access components; the cost estimate for these components is $9.5 million. These figures do not include costs for property acquisition. An additional $350,000-$600,000 is needed for project planning and design, community outreach and involvement, geotechnical and structural analyses, and environmental studies.

CONCLUSION

The L.A. River Natural Park can serve as a showcase Green Solution project on the L.A. River that sets a precedent for integrating the following important multiple benefits for both people and the environment:

Water Quality Improvements & Water Reuse
- Capture and treat polluted runoff from surrounding area
- Create wetland habitat and use soil and plants to naturally remove pollutants
- Store and reuse treated water for irrigation
- Use L.A. River water during dry season

L.A. River Regional Public Access
- Create a central "L.A. River Gateway" in the San Fernando Valley
- Provide easy visitor access to the L.A. River Trail
- Connect to high-capacity off-site public parking garage
- Build river observation decks, visitor center, walking paths and picnic areas
- Connect to other river trails, public transit and bicycle networks
- Install bicycle-friendly parking and links to bike paths

Habitat & Open Space
- Preserve unique L.A. riverfront land
- Create ecosystem complex of natural habitat types
- Preserve natural green space in heavily urbanized area

L.A. River Trail Improvements
- Extend L.A. River trail between garage and Coldwater Canyon
- Build new pedestrian bridge linking park site to Ventura Blvd.
- Create pedestrian and bicycle trails
- Integrate wayfinding signage
- Use native landscaping

Energy Efficiency
- Use solar power to be "grid-neutral"
- Install solar panels as shade structures along L.A. River Trail

Link to Regional Bicycle Transportation Networks

- Re-purpose parking garage to include bicycle hub
- Provide bicycle rental, storage and repair
- Link to regional bicycle paths and routes
- Connect to visitor destinations, commercial areas, parks and schools

Regional Recreation

- Integrate underground water storage with driving range
- Retain putting green and regional tennis facilities
- Preserve historic clubhouse

ABOUT The Project Team

COMMUNITY CONSERVATION SOLUTIONS

Community Conservation Solution's mission is to tackle the most complex and challenging problems created when people and nature intersect. CCS does this by developing creative, practical and lasting solutions that unite diverse communities and interests and leverage investments of public funds. CCS has successfully crafted innovative solutions to serious environmental problems affecting California's natural and human communities, by integrating the protection and restoration of natural lands and waters with compatible community uses, economic benefits and permanent public benefits.

CCS' successful project solutions include: the two-square mile Baldwin Hills Park in the heart of urban Los Angeles; wetland restoration in Upper Newport Bay; acquisition of the Spring Street Center for the Los Angeles Conservation Corps; the Los Angeles River Natural Park to naturally treat urban runoff while creating a regional river public access gateway; and developing new, quantified approaches to improving water quality through the Green Solution Project.

Community Conservation Solution works on diverse projects in urban and rural areas that help both natural habitats and people. Our projects range from parks and beaches to wilderness and watersheds, and from recreational sites to mixed-use developments. CCS is a non-profit, 501(c)(3) organization.

PSOMAS

Psomas is a leading consulting engineering firm serving clients in the water/wastewater; transportation; and public, institutional and private land development markets. Ranked as one of Engineering News Record (ENR) magazine's Top 100 Pure Design Firms in the United States, Psomas offers civil engineering, land surveying, planning and entitlements, program/construction management, natural resources, GIS consulting, and Special District Financing services to the public and private sector. Founded over 60 years ago, Psomas provides services from offices throughout California, Arizona, and Utah.

Psomas specializes in delivery of sustainable storm water management consulting and design solutions to municipalities, public and quasi-public organizations, and private sector clients. Psomas' projects range from studies to constructed solutions; challenging infill development to city and county-wide initiatives; and from integrated low impact development measures to purpose-built treatment wetland systems.

MIA LEHRER

MIA LEHRER & ASSOCIATES

Mia Lehrer + Associates is a full service, international landscape architecture practice located in Los Angeles, California. Under the leadership of Mia Lehrer, FASLA, the firm has been responsible for the design and development of a diverse range of public and private projects. The firm applies a comprehensive and intensely creative approach to all projects, which vary in scale from large urban projects engaging community members and public agency stakeholders, to intimate gardens where collaboration and coordination of architecture and site are the primary objective.

We work closely with local communities and public agencies to create parks, open spaces and streetscapes that meet the diverse needs of the people who will visit them. Our firm has been responsible for master planning and concept development for both large, regional and small pocket parks that have been developed with funding from grants, infrastructure programs and public private partnerships. Our experienced staff, with seven licensed landscape architects, includes world class designers and senior technical staff who deliver comprehensive construction documents and provide comprehensive construction administration services.

Mia Lehrer + Associates is a recognized leader in the field of sustainable design, and approach sustainable design as a tool to improve our environment and achieve higher and healthier levels of integration with natural systems. We believe that all projects, whether large parks or urban courtyards, deserve innovative design matched by intelligent, sustainable practices. Our primary focus is on envisioning and creating exceptional urban environments. We do not begin any of our projects with a preconceived notion; rather, we ask questions of ourselves, our client, and our team, which informs the design and development process. Regardless of scale or level of complexity, we remain committed to innovative design, quality service, the process of collaboration, and the belief that landscape has the power to enhance the livability of a city and heal the land.

PSOMAS

Los Angeles River Natural Park

Studio City – San Fernando Valley, CA

Technical Memorandum

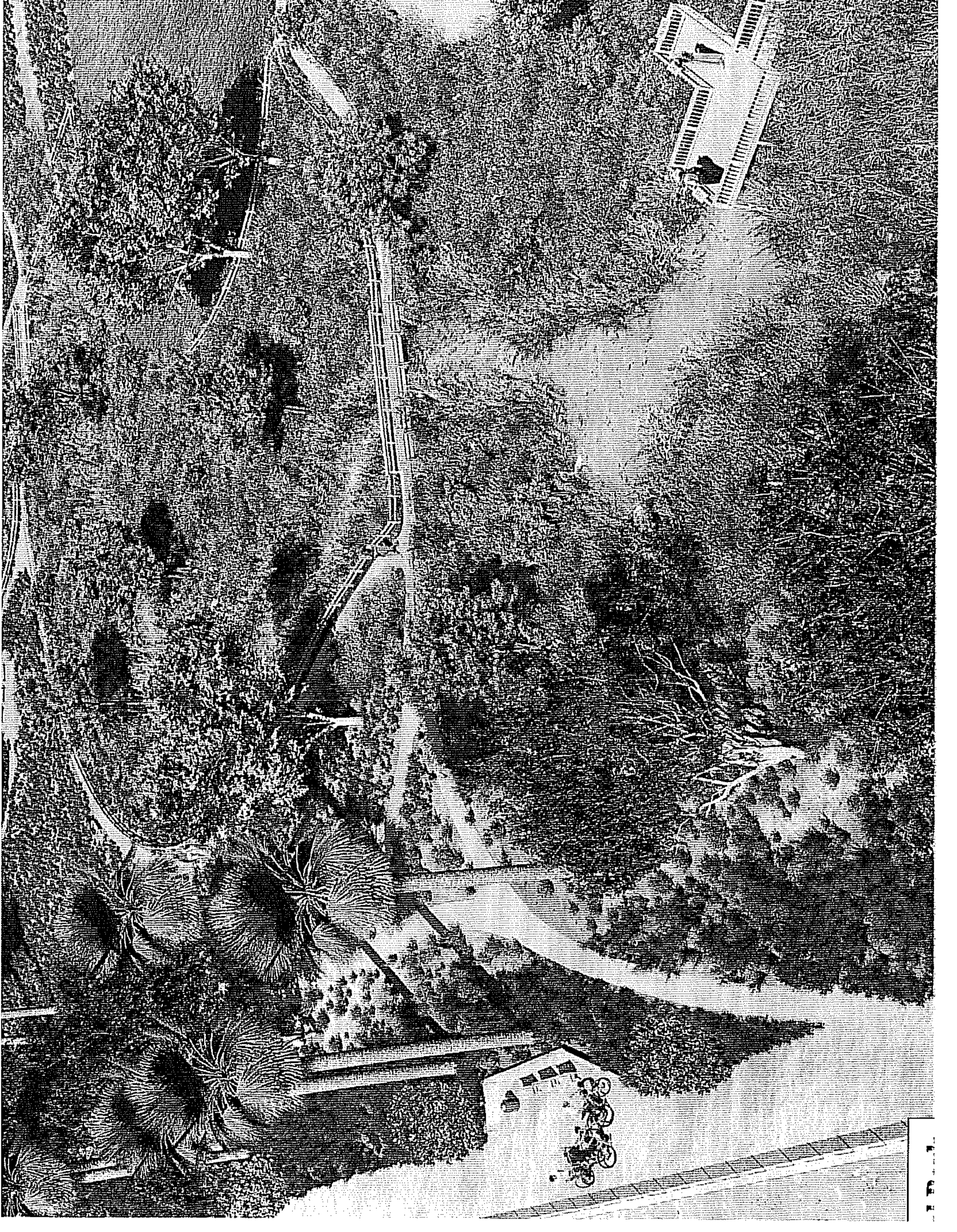
Prepared For:

COMMUNITY CONSERVATION SOLUTIONS

April 2010

Psomas Project No.
1CCI010102

Balancing the Natural and Built Environment



EXECUTIVE SUMMARY

The Los Angeles River Natural Park project proposes to improve water quality within and discharging to the Los Angeles River by creating native habitat and constructing multiple Best Management Practices (BMPs). The 16-acre project site would divert runoff (both dry and wet weather) from approximately 200 acres of the surrounding tributary area, bordered by Coldwater Canyon, Landale Street and Laurel Grove Avenue, and treat it through a series of BMPs, referred to as a "treatment train." This treatment train would include a vegetated pre-treatment basin, subsurface detention/retention facility, constructed wetland, vegetated swales, detention/retention tank and basin, and a wet pond. The detention/retention tank is also planned as storage for reuse water for irrigation purposes. The primary BMP would be the constructed wetland, which is effective at removing multiple pollutants and provides habitat for many species of native plants and birds. Diverted surface runoff would be treated and would be used to sustain the wetland areas and native habitats during the wet season. During the dry season normally untreated water would be drawn from the Los Angeles River for treatment via the constructed wetland prior to release back into the Los Angeles River. Based on the Los Angeles County Department of Public Works Manual for the Standard Urban Stormwater Management Plan the project would provide enough treatment volume to capture dry weather runoff and to treat the "first flush" (first 0.75" of a rainfall event) for +/-250 acres, which exceeds the 200 acres anticipated to be delivered to the site. The project also proposes to be grid neutral, in that, solar power generated on site would offset the normal site electricity usage. The project would integrate the runoff treatment capabilities of the site with habitat creation, open space and recreational uses. The project will include trails and pathways connecting to the Los Angeles River network of trails, walking paths, tennis courts and driving range. Overall, the Los Angeles River Natural Park would serve as a showcase multi-benefit project that demonstrates how to significantly improve the quality of urban runoff, reuse and recycle runoff, create native habitat, and provide regional recreational facilities and regional public access to the Los Angeles River.

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TABLE OF CONTENTS

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A. INTRODUCTION

This technical memorandum is focused on further developing the **hydrologic and water quality elements** to support the proposed Los Angeles River Natural Park in Studio City, California. The project as a whole has multiple objectives and sustainable features which will be touched on in this memorandum; however the focus of this memorandum is the hydrologic and hydraulic aspects, and the urban runoff treatment and water quality improvement potential of the park. The analysis included in this memorandum is limited to publicly available data. Opportunities and constraints of the conceptual site design are discussed, as is habitat creation potential. Estimates are presented for component sizes, potential water quality improvements, as well as a concept-level engineer's estimate of construction costs and preliminary investigations. Urban runoff as described in this report includes dry and wet weather flows.

B. SITE DESCRIPTION

The 16-acre project site is located in the Studio City area of Los Angeles, California between Whitsett Avenue and Bellaire Avenue. The site is bounded on the north by Valley Spring Lane and by the Los Angeles River on the south. It is currently occupied by the Weddington Golf and Tennis facility, including a nine-hole golf course, driving range, 16 tennis courts, clubhouse, and associated parking lots. The site is somewhat undulated due to the golf course grading but generally slopes to the south and has a 10 to 15 foot grade differential to the County access road adjacent to the Los Angeles River. The site contains mature trees as well as shrubs, ground cover, turf and hardscape.

C. PROJECT OVERVIEW

The vision and concept design prepared by Community Conservation Solutions and BlueGreen Consulting for the project indicated a desire to improve water quality by integrating natural treatment of urban runoff, creating native habitat, and meeting regional water quality improvement goals. The treatment strategy would include a series of urban runoff best management practices (BMPs) to improve the quality of runoff water diverted through the project site prior to infiltration or detention and/or release into the Los Angeles River. The anticipated pollutants of concern from the tributary area include trash and debris, oil and grease, suspended solids, heavy metals, and pesticides. More discussion on pollutants of concern can be found in Section H of this memorandum. BMPs that target these anticipated pollutants include: structural and vegetated pre-treatment; underground retention/detention; a storm water treatment wetland; and vegetated swales. As shown on Exhibit 3, the project includes a combination of these BMPs which could cumulatively provide a treatment volume of approximately 11.4 acre-feet. Wet weather and dry weather runoff would be collected and treated by the treatment train from the +/-200-acre tributary portion of the sub-watershed.

The 200-acre tributary area can be generally described as the area bounded by Coldwater Canyon on the west, Landale Street on the north, Laurel Grove Avenue on the east, and the Los Angeles River on the south. Please refer to Exhibit 1 for the Tributary Sub-Watershed exhibit.

Based on our experience with projects of this nature within the City of Los Angeles, diverted dry weather surface runoff from the tributary watershed would not on its own be sufficient to sustain the wetland habitat. In order to minimize potable water usage and promote water reuse and recycling, the project proposes to draw water from the Los Angeles River for treatment and to sustain the proposed habitat during normally dry periods. The diverted water would be pumped to the wetland area and travel through the BMP treatment train for filtration and treatment before being discharged again to the river.

D. SITE OPPORTUNITIES AND CONSTRAINTS

The site's location immediately adjacent to the Los Angeles River provides a unique opportunity to draw impaired water from the river, treat it, and then return the treated water to the river, while sustaining wetland and riparian habitat. This process can help address pollutant loading issues in the river. Furthermore, since the site is adjacent to the river, the tributary area intercepted can be maximized. Some of the site constraints include the existing recreational uses and the potential grading limitations caused by the presence of existing mature trees located throughout the site.

E. CONTRIBUTING DRAINAGE AREA

A concept-level analysis was completed to confirm the contributing drainage areas previously identified and to refine the area that could be feasibly intercepted and treated on the project site. During our analysis a potential, but inconclusive, contributing area north of Moorpark Avenue was identified for further investigation in a future phase. Exhibit 1 shows the tributary areas for the surrounding sub-watershed. Drainage Basins 1B and 1C could be collected and routed to the project site with the construction of a local storm drain collection system, as shown on Exhibit 2. Drainage Basins 2A and 2C surface flow by the site and could be collected via parkway drains and/or other surface types of drainage facilities. The project site itself is comprised of Drainage Basin 2B. Drainage Basins 3A, 3B, and 3C are not hyrdologically or hydraulically connected to the project site. Therefore, an extensive collection and distribution system including pumps would be required for collection and treatment of runoff from these areas. Existing collection systems at the end of Rhodes Avenue and Laurel Canyon Avenue should allow for diversion structures to be installed so that dry weather and first flush events could be pumped to the site for treatment from these sub-areas.

The project proposes to accept dry weather and first flush runoff from all of the tributary areas indicated in this report as well as accepting larger storm events from some tributary areas. Exhibit 2 shows that the project accepts runoff from Drainage Basins 1A, 1B, 1C, and the westerly portion of 2A through diversion structures. Similarly, Drainage Basins 3A, 3B, and 3C would utilize diversion structures but would also utilize pump facilities to deliver the diverted runoff to the wetland headworks. This configuration allows the "first flush" storm events to be diverted to the site while larger storm events continue to drain to the Los Angeles River as they do currently. Conversely, the middle and eastern portions of 2A, all of 2C and 2B do not use diversion structures. Rather the project site could accept larger portions of runoff from these basins at the indicated locations. This arrangement allows the project site to treat the "first flush" storm event, but it also allows it to detain, thereby treat, larger storm events before discharging to the Los Angeles River.

F. URBAN RUNOFF TREATMENT

Runoff that is currently un-treated from the tributary area can be treated on-site through a treatment train approach, which utilizes a series of BMPs. Since multiple BMPs will be implemented in series the treatment efficiency of each BMP is maximized. The train for this site would consist of four stages: pre-treatment, treatment, conveyance and polishing. Each stage can include a single BMP or multiple BMPs. See Exhibit 3 for a complete site schematic. The four stages are detailed below:

1. The initial **pre-treatment** stage includes two different BMPs proposed at different locations on the site. Structural pre-treatment via hydrodynamic separation or continuous deflective separation would be located in the southwesterly area of the site. The separator would remove trash, debris, sediments, oil and grease prior to runoff entering the subsurface detention facility. Detention allows fine particles to settle out of runoff as well as aid in attenuating peak runoff flow rates. Surface runoff entering the site in the northwesterly, northerly, and northeasterly areas would pass through a vegetated pre-treatment basin. The basin would also remove trash, debris and sediment, as well as provide a small amount of in-line detention. These initial BMPs efficiently remove sediment, trash & debris thereby reducing the potential for clogging in downstream BMPs.

2. The second **treatment** stage utilizes multiple BMPs to accomplish infiltration, absorption, evapotranspiration, and storage. By employing appropriate vegetation and necessary ponding depths, the constructed wetland can accomplish all of these goals. The wetland area spreads out in the northwesterly area of the site, and then becomes more linear as it passes through the site toward the wet pond located in the south-central area of the site. Additional storage would also be provided by a subsurface detention tank under the driving range as well as an overflow detention/retention basin adjacent to the wet pond.

3. The third stage, consisting of **conveyance**, utilizes vegetated swales to promote sedimentation, infiltration and absorption as well as mitigate peak runoff during storm events. The vegetated swales employed for the project would intercept runoff from the northeasterly and north-central areas of the site and carry runoff south toward the driving range detention tank and the wet pond.

4. The final stage, **polishing**, would be accomplished by the wet pond located in the south-central area of the site. The wet pond provides additional habitat and beneficial uses prior to discharging treated runoff to the Los Angeles River.

The project site as programmed consists of normally wet zones and normally dry zones. As shown on Exhibit 3, the areas indicated in blue, primarily on the western and southern portions of the site, would be kept wet year round to sustain the appropriate habitat areas. The riparian transitional habitat (light green) would be inundated by large storm events during the rainy season and might require supplemental irrigation water to sustain this habitat during the dry season. Ideally supplemental irrigation water would be drawn from the reuse tank located underneath the driving range. For more discussion regarding irrigation water see section L.

During the dry season diverted flow would be drawn from the Los Angeles River utilizing a sub-surface supply pump system, located adjacent to the subsurface detention facility on the western portion of the site. The system would be utilized to distribute water from the wet well to the headworks of the wetland.

The northern and eastern areas of the site indicated as dark green would be upland type habitats that are normally dry and drought-resistant. The mustard and brown colored areas are also normally dry areas and would be utilized as storage and conveyance facilities during the rainy season but would not be kept wet year round. Depending on the plant palette chosen for these areas, some supplemental irrigation may be required, particularly as this habitat type is becoming established. Supplemental water would be provided by diverted Los Angeles River water, as discussed above. See Section J for a discussion of proposed habitat creation.

The overall treatment volume necessary to handle the tributary area was determined using the Los Angeles County Department of Public Works (LADPW) Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP). The plan requires that the BMPs treat the volume of runoff produced from a 0.75-inch storm event. Exhibit 1 shows the tributary areas surrounding the project site. Based on the topography of the area, sub-area 1B and 1C can be intercepted by a storm drain system and directed to the subsurface detention facility. Sub-area 2A would enter the project site at 3 different locations and sub-area 2C would enter at the northeast corner of the site. The project site itself is identified as sub-area 2B. Tributary areas 3A, 3B and 3C would be intercepted by a storm drain system and the targeted treatment amount would be pumped to the project headwaters for treatment. Based on these tributary areas and the required rainfall depth the project must provide for approximately 8.8 ac-ft of treatment volume in order to satisfy the SUSMP requirements. However, the project proposes to exceed this minimum treatment volume by providing a cumulative storage volume of nearly 11.4 ac-ft. This additional storage volume would allow the site to treat the first 1-inch of rainfall versus the minimum of 0.75-inch required by the SUSMP. The treatment volume calculations can be found in Appendix A.

G. TREATMENT COMPONENTS

As shown on Exhibit 3, the project consists of the following six main treatment components:

1. Vegetated Pre-treatment Basin – Vegetated pre-treatment areas must be large enough to allow for maintenance and to dissipate energy from the surface inflow prior to discharging to the wetland or vegetated swale system. Where feasible a sub-drain system may be utilized underneath the pre-treatment basin.

2. Subsurface Detention Facility – A tank with approximate dimensions of 150'x 60' x 3' would provide about 27,000 ft^3 (0.62 ac-ft) of storage. This size tank would provide ample storage for dry season water drawn from the Los Angeles River as well as flow rate attenuation from sub-areas 1B and 1C, as shown on Exhibit 3, during the rainy season.

3. Constructed Wetland – The primary wetland as depicted can provide about 65,000 ft^3 (1.5 ac-ft) of storage. This wetland configuration provides an approximate length to width ratio of 3.4 which exceeds the recommended minimum of 1.5. As shown on Exhibit 3 after runoff passes through the primary treatment area the wetland takes on a more linear shape and provides 500-feet of additional length.

Based on the natural ecosystem characteristics of wetland, riparian and upland habitats of Southern California, the following habitat regions for the constructed wetland are proposed: Open Water Habitat, Marsh Habitat, Riparian Transitional Habitat, and Upland Habitat. Each habitat region is described below:

a) **Open Water Habitats** include the forebay and all channels and deep pools. Water depth should be up to 4 feet in channels and up to 6 feet in the forebay and pools. Water depths greater than 3 to 4 feet may be required to reduce the proliferation of emergent vegetation. A water depth greater than 5 feet in some Open Water habitat throughout the wetland system is important because deep water zones:

- Promote downstream flow by mixing and redistributing water flowing from marsh areas where short-circuiting may occur,
- Enhance wind-driven oxygenation of water,
- Limit the area in the wetland colonized by emergent vegetation,
- Provide a sump for particulate matter, and
- Create conditions that are less conducive for mosquito production (UC ANR 2003).

Wind disturbance at the water surface in Open Water areas can disrupt mosquito egg laying and can drown immature mosquitoes. Open Water zones also enhance predation by mosquito fish (*Gambusia affinis*) and other fauna on mosquito larvae and pupae (UC ANR 2003). Furthermore, deep water areas promote the development of anaerobic conditions in wetland sediments, which is essential for sequestration of heavy metals. Anaerobic areas are critical for denitrification (conversion of nitrate to nitrogen gas), which is the most important mechanism for the permanent removal of nitrogen (Reddy et al 1989).

b) **Marsh habitat** is permanently inundated with water at depths of approximately 0.5 to 3 feet. The marsh habitat is the primary region where the water column interacts with the sediments, biota (algae, macrophytes, bacteria, fungi), and the water/air interface. Mechanisms of water treatment in this habitat include settling and filtration of suspended matter, volatilization of compounds, adsorption and desorption of compounds from particles, biological uptake and transformation, and photolysis of pathogens.

c) **Riparian habitats** are transitional areas between terrestrial and aquatic ecosystems that have a high water table and are subject to periodic flooding (USEPA 2001, NRC 2002). Riparian habitat occurs around the perimeter of the proposed wetland.

d) The **Upland habitat** occurs above the riparian habitat and outside of the wetland footprint. Many of the characteristic vegetation species of upland habitat are trees that can grow to large sizes with correspondingly large root zones. The upland habitat areas will likely require some supplemental irrigation until established.

4. Vegetated Swales –A vegetated swale system with a bottom width of 10-feet, side slopes of 5:1, a longitudinal slope of 1%, and an assumed Manning's coefficient of 0.025 will provide conveyance and treatment. A swale that fits these design criteria should maintain velocities below 3 fps and depths below 5-inches which meet the CASQA recommendations. Vegetated swales are effective in reducing flow velocities, promoting infiltration, and allowing particulates to attach to vegetation or other suspended solids.

5. Sub-surface Detention/Retention Basin – It is yet to be determined if the basins located within the project will be detention basins, retention basins, or a combination. Retention/Infiltration basins are more effective BMPs than detention, but the infiltration potential of the site can not be determined at this time; therefore, we shall assume that they would be detention facilities. The detention facility underneath the driving range has an approximate footprint of 2.7-acres and a depth of 3-feet, providing +-350,000 ft^3 (8.0 acre-ft) of storage. The subsurface driving range detention facility will also allow the reuse of detained water for irrigation purposes. See Section L for further discussion

on water reuse. The second detention facility located adjacent to the wet pond could have an approximate footprint of 250' x 120' x 1', providing +-30,000 ft^3 (0.7 ac-ft) of storage.

6. Wet Pond – The permanent pond area could be of any configuration but should provide approximately 11,000 ft^2 of surface area with an additional 1-foot of storage, thus providing 11,000 ft^3 (0.25 ac-ft) of storage. The permanent pond depth should be at least 6-feet in order to provide adequate habitat that was discussed in previous sections. The wet pond located downstream of the constructed wetlands offers some of the same advantages listed under the Open Water habitat section of the Constructed Wetland.

All treatment areas will be separated from public viewing areas with fencing or appropriate planting in order to prevent contact with surface water as well as to prevent habitat degradation.

H. WATER QUALITY IMPROVEMENT ASSESSMENT

The treatment train approach proposed for the Natural Park will be effective in removing different types of pollutants. Efficiencies for each BMP will vary depending on its location within the treatment train. Efficiencies should not be added together in the treatment train; however some BMPs provide redundancy to improve the overall water quality. Below is a table of individual BMP's efficiencies.

Table 1 – BMP Efficiencies

	Targeted Pollutants						
	Sediment	Nutrients	Trash	Metals	Bacteria	Oil & Grease	Organics
BMP Type	Efficiency						
Constructed Wetlands	H	M	H	H	H	H	H
Extended Detention Basin	M	L	H	M	M	M	M
Infiltration Basin	H	H	H	H	H	H	H
Vegetated Swale	M	L	L	M	L	M	M

H = high, M = medium, L = low

The Pollutant Load Removal table below presents removal estimates as calculated by the City of Los Angeles BMP Planning Application for a wetland BMP with pre-treatment and summarizes anticipated pollutant removal efficiencies for the constructed wetland BMP. The removal rates utilized by the BMP Planning Application are from published values from the Caltrans BMP Retrofit Pilot Program, the U.S. EPA, and the Center for Watershed Protection, and the American Society of Civil Engineers. Most of the removal data were taken from the references used in the Planning Application. In the cases where the City's Planning Application did not provide a reference for percent removal of a pollutant, values were taken from the Ballona Freshwater Marsh Annual Monitoring Report – Year 4 (Section 8.4.2) based on its similarity in runoff quality and function. Removal in the table is in pounds (lbs) unless specified otherwise.

Table 2 - Pollutant Load Removal

Constituent	Influent Load (lbs)	Total Removed (lbs)	Effluent Total (lbs)	Percent Removal
Total Petroleum Hydrocarbons	0.15	0	0.15	0%
Total Coliforms*	399088	299317	99771	75%
Fecal Coliforms*	245756	184317	61439	75%
Fecal Enterococcus*	124970	93728	31242	75%
Total Suspended Solids	10318	9930	388	96%
Oil & Grease	153.33	153.33	0	100%[1]
Total Aluminum	164.42	65.77	98.65	40%
Total Cadmium	0.02	0.01	0.01	50%
Total Copper	2.49	1.25	1.24	50%
Total Lead	1.27	0.76	0.51	60%
Total Mercury	0.06 ug/L	0	0.03 ug/L	50%[2]
Total Nickel	0.53	0.21	0.32	40%
Total Zinc	21.1	10.55	10.55	50%
Dissolved Copper	1.23	0.43	0.80	35%[2]
Dissolved Lead	1.22 ug/L	0	0.52 ug/L	57%[2]
Dissolved Zinc	12.97	6.61	6.36	51%[2]
Nitrate as Nitrogen	71.2	29.19	42.01	41%[2]
Total Kjeldahl Nitrogen	291.2	34.94	256.26	12%[2]
Total Phosphorous	0.32 mg/L	0	0.21 mg/L	34%[2]

* = MPN
1 = Hydrodynamic separator unit
2 = Balbona Freshwater Marsh

Based on the expected removal efficiencies listed, a significant water quality improvement could be anticipated to the urban runoff being diverted to and treated at the site, as well as to the diverted flow from the Los Angeles River.

I. WATER BALANCE

Since the project includes a wetland system; pool and channel water depths must be sustained throughout the year. Therefore a concept-level analysis was completed to determine the annual balance of water in the system. The potential evapotranspiration rate is assumed to equal 85% of the pan evaporation rate. The pan evaporation rate data was estimated for the Los Angeles airport using a form of the Penman equation (Source:http://www.ocs.oregonstate.edu/page_links/comparative_climate/California/california.html). Assuming an average monthly pan evaporation rate during the dry season of 6.8-inches we arrive at an average monthly evapotranspiration of 5.8-inches. Approximately 80,000 gallons/month (2,700 gpd) during the dry season would need to be drawn from the Los Angeles River to replace water lost purely to evapotranspiration. More precise percolation tests along with other soil testing must be completed prior to design in order to confirm loss due to infiltration. For planning purposes it can be assumed that up to 4,000 – 5,000 gpd may need to be drawn from the Los Angeles River during the dry season to maintain the appropriate water requirements of the created habitat.

J. POTENTIAL HABITAT CREATION

During the design phase, Upland, Riparian and Wetland Planting Plans will be prepared that will address the specific species to be planted in each of the habitat areas of the project. Subsequent phases will require monitoring and possible replacement planting during the establishment period, as well as potential supplemental irrigation. The lists below provide a range of potential plant species that could be used. The targeted vegetation listed below has been compiled from similar types of projects in Southern California.

Table 3 - Targeted Vegetation

Species	Growth Form	Wetland Indicator
Open Water		
Water Cress *Rorippa nasturtium-aquaticum*	Perennial herb (aquatic)	OBL
Water Plantain *Alisma plantago-aquatica*	Perennial herb (aquatic)	OBL
Duckweed *Lemna minor*	Perennial herb	OBL
Marsh		
Santa Barbara Sedge *Carex barbarae*	Perennial herb	FACW
San Diego Sedge *Carex spissa*	Perennial herb	FAC
Common Rush *Juncus patens*	Perennial herb	FAC
Irisleaf Rush *Juncus xiphioides*	Perennial herb	OBL
Mexican Rush *Juncus mexicanus*	Perennial herb	FACW
California Tule *Scirpus californicus*	Perennial herb	OBL
Hardstem Bulrush *Scirpus acutus var. occidentalis*	Perennial herb	OBL
Big Bulrush *Scirpus robustus*	Perennial herb	OBL
Arrow Weed *Pluchea sericea*	Shrub	FACW
Smooth Flatsedge *Cyperus laevigatus*	Perennial herb	FACW+
Black Flatsedge *Cyperus niger*	Perennial herb	FACW+
Common Spikerush *Eleocharis macrostachya*	Perennial herb	OBL
California Sunflower *Helianthus californicus*	Perennial herb	OBL

Table 3 - Targeted Vegetation

Species	Growth Form	Wetland Indicator
Wild Mint *Mentha arvensis*	Perennial herb	FACW
Meadow Barley *Hordeus brachyantherum*	Perennial herb	FACW
Spike Bentgrass *Agrostis exarata*	Perennial herb	FACW
Water Foxtail *Alopecurus aequalis*	Perennial herb	OBL
Riparian		
Arroyo Willow *Salix lasiolepis*	Tree, Shrub	FACW
Sand Bar Willow *Salix exigua*	Tree, Shrub	FACW
Red Willow *Salix laevigata*	Tree, Shrub	FACW+
White Alder *Alnus rhombifolia*	Tree	FACW
Blue Elderberry *Sambucus mexicana*	Shrub	FACU
Red Twig Dogwood *Cornus sericea occidentalis*	Shrub	FACW
California Rose Rosa californica	Shrub	FAC+
California Blackberry Rubus ursinus	Vine, Shrub	FAC+
Mulefat Baccharis salicifolia	Shrub	FACW
Riparian Woodland		
California Sycamore *Platanus racemosa*	Tree	FACW
Velvet Ash *Fraxinus velutina*	Tree	FACW
Black Cottonwood *Populus balsamifera ssp. trichocarpa*	Tree	FACW
Box Elder *Acer negundo var. californicum*	Tree	FACW
Upland		
California Black *Walnut Juglans californica*	Tree	FAC
Fremont Cottonwood *Populus fremontii*	Tree	FAC+
Bigleaf Maple *Acer macrophyllum*	Tree	FAC
California Laurel *Umbellularia californica*	Tree	FAC
Spreading Gooseberry *Ribes divaricatum*	Shrub	FACW
Coast Live Oak *Quercus agrifolia*	Tree	NL
Interior Live Oak *Quercus wislizeni*	Tree	NL

Table 3 - Targeted Vegetation

Species	Growth Form	Wetland Indicator
Valley Oak *Quercus lobata*	Tree	FACU
Black Sage *Salivia mellifera*	Shrub	NL
Purple Sage *Salvia leucophylla*	Shrub	NL
Coyote Bush *Baccharis pilularis*	Shrub	NL
Blue Wildrye *Elymus glaucus*	Grass	FACU

Wetland Indicator:
OBL: Obligate Wetland - occurs almost always under natural wetland conditions.
FACW: Faculatative Wetland - usually occurs in wetlands, but occasionally found in non-wetlands.
FAC: Facultative - equally likely to occur in wetlands and non-wetlands.
FACU: Faculatative Upland - usually occurs in non-wetlands, but occasionally found in wetlands.
UPL: Obligate Wetland - occur in wetlands in another region, but occur almost always under natural conditions in non- wetlands in the region specified.
NL: Not Listed - always occurs in non-wetlands.

Dense planting of certain species relative to others, at certain locations, may be desirable in the final design and therefore affect cost. For example, strategic planting of California rose along pathways provides a spreading and dense thorny habitat that can provide a natural barrier to human intrusion in lieu of fences. Coyote bush, a species with lower water consumption requirements than California rose, could also provide such a natural barrier if kept pruned as a hedge to maintain public views of the wetlands and open water. Further detailed site and habitat planning and design, as well as soil and light analysis, is required to determine specific plant locations and combinations.

K. SOLAR POWER POTENTIAL

The project site proposes to strive toward a goal of grid neutrality, which means that throughout the entire year the site would use on-site solar panels to generate enough electricity and give it back to the grid to offset the site's annual power usage. Utilizing solar panel shade structures over parking stalls, conventional roof panels on top of the clubhouse and driving range tee area, and conventional solar panels placed along the slope adjacent to the river, the site could provide approximately 37,000 ft^2 of solar panel coverage. Assuming average sun exposure and generation rates the site could generate approximately 1500 kWh/day or 550 mWh/year. Due to weather patterns and the solar cycle solar generation is not constant throughout the year, which is why grid neutrality is evaluated on a yearly basis. The table below indicates the potential electricity generated by the site throughout the year as well as the electricity savings and/or costs associated with generating electricity for the grid.

Table 4 - Potential Solar Generation

*assumed electricity cost = $0.119/kWh			
	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value
Jan	3.93	31,586	$3,804.24
Feb	4.60	33,992	$4,059.32
Mar	5.63	45,803	$5,469.79
Apr	6.38	49,477	$5,908.54
May	7.05	56,368	$6,731.47
Jun	7.19	54,710	$6,533.47
Jul	7.09	55,137	$6,584.46
Aug	6.94	53,596	$6,400.43
Sep	6.11	45,691	$5,456.42
Oct	4.96	39,121	$4,671.83
Nov	4.31	33,623	$4,015.26
Dec	3.66	29,529	$3,526.35
Yearly total	5.66	548,904	$63,161.72

The site proposes to use electricity for:

- driving range, tennis court and parking lot lighting
- clubhouse amenities
- multiple storm water pump stations for runoff delivery
- re-circulation and application of stored water
- site lighting and irrigation

Based on these typical uses we can estimate that the project site will need approximately 550 to 730 mWh/year of electricity. The programming for the site including the driving range and tennis courts hours of operation would have the largest effect on the electricity demands due to the necessary lighting. Future planning phases of the project would need to develop the site programming further in order to progress towards the project goal of grid neutrality. However, based on the estimates included in this memorandum it can be concluded that grid neutrality is possible. Installation of energy-saving lighting and other energy conservation measures can further reduce electrical demand.

L. URBAN RUNOFF REUSE POTENTIAL

The subsurface detention under the driving range proposes to detain approximately 2.6 MG of runoff. In order to advance toward the project's goal of potable irrigation water independence, a portion of the driving range detention could be set aside for storage and treatment of runoff for reuse as irrigation water. A more detailed analysis is required to determine the size of the reuse storage based on expected irrigation demands for the project. However, for planning purposes we can assume that the reuse storage would be half of the total driving range detention, 1.3 MG. Recirculation pumps would be required to circulate the stored water to enhance the quality and reduce the potential for stagnation and odor issues. The pump outputs would be directly related to the overall storage volume and should be sized to recirculate the entire volume in a 48-hour period. The recirculation system would also include a disinfection component that would lessen the chance of bacteria and virus problems as well as vector issues. The circulation pumps would generally operate continually unless the reuse tank is empty, in which case a low level signal could turn the pumps off.

The irrigation distribution system would be a packaged booster irrigation system with a hydro-pneumatic tank.

Storm water reuse for irrigation is relatively new to the Southern California area and all of the issues associated with this reuse have not been completely addressed yet. Some of the issues include:

- Determining whether the water should be treated to Title 22 standards[1]
- If not to Title 22 standards, what level of treatment is adequate?
- What water quality testing procedures are needed?
- How often should the influent and effluent be tested and monitored?

Under the current regulatory setting it is recommended that the reuse irrigation water only be applied in landscape areas using either drip irrigation systems or sub-surface distribution systems. Areas that need spray irrigation application may need to utilize potable water for irrigation until some of the issues associated with storm water reuse have been evaluated.

[1] Title 22 of the Official California Code of Regulations (also known as the Health and Safety Code)

M. COST ANALYSIS

A concept level engineer's estimate of probable construction costs was prepared based on projects of similar size and scope.

Table 5 – Cost Estimate

Description	Total
Site Demolition	$250,000
Earthwork	$1,600,000
Diversion, Collection & Pump Works	$2,380,000
Surface Inflow, Normal Dry Conveyance & Outfalls	$120,000
Subsurface Detention	$200,000
Sub-Surface Driving Range Detention [1]	$865,000
Wetland, Wet Pond & Habitat Creation	$770,000
Upland landscaping and park elements	$1,900,000
Re-use water treatment & irrigation	$350,000
Public Access & Off-site Trails	$50,000
Solar panels and equipment	$2,000,000
Sub-Total (1)	$10,485,000
Estimating Contingency - 30% of Subtotal (1)	$3,145,500
Subtotal (2)	$13,630,500
Mobilization - 7% of Subtotal (2)	$954,135
Permits - 2% of Subtotal (2)	$272,610
Allowances - 5% of Subtotal (2)	$681,525
Subtotal (3)	$15,538,770
Construction Contingency - 10% of Subtotal (3)	$1,553,877
Cost to Construct	**$17,092,647**

[1]Earthwork for tank included in separate line item

N. ADDITIONAL INVESTIGATION

A geotechnical analysis or investigation must be completed for the project site in order to identify the expected percolation rates, pH levels, corrosion potential, etc. of on-site soil, as well as overall performance expectations for a constructed wetland. Approximately $60,000 should be anticipated for preliminary geotechnical investigations and analysis. An historical environmental review of the area should be completed in order to identify appropriate habitats to be created in the natural park. Migratory bird patterns as well as existing nearby regional habitat connectivity should also be investigated. Comprehensive survey data also must be collected for the project site as well as potential tributary areas located upstream of the site. Further analysis of the area north of Moorpark Avenue could be completed with additional topographic information. Approximately $30,000 should be anticipated for these additional survey investigations. Depending on the outcome of such an analysis, additional runoff from this area could also potentially be captured and treated by the project site, providing additional water quality improvement benefits.

O. NEXT STEPS

A Preliminary Design Report (PDR) should be prepared for the project. The PDR would include detailed data collection such as site reconnaissance, boundary mapping and utility base mapping. Permit requirements will be reviewed and preliminary investigations regarding necessary environmental compliance would be completed. Further review, validation, and updates of the concepts set forth in this document would also be included. The PDR would include design and planning coordination for public day use, public access, recreational facilities, trail/path connections, solar capabilities, coordination with public agencies (Santa Monica Mountains Conservancy, City of Los Angles, County of Los Angles, U.S. Army Corps of Engineers, California Department of Fish & Game), regional community planning workshops, and public outreach. The PDR budget should range from $300,000 to $450,000 depending on the levels of detailed field investigation and outreach required.

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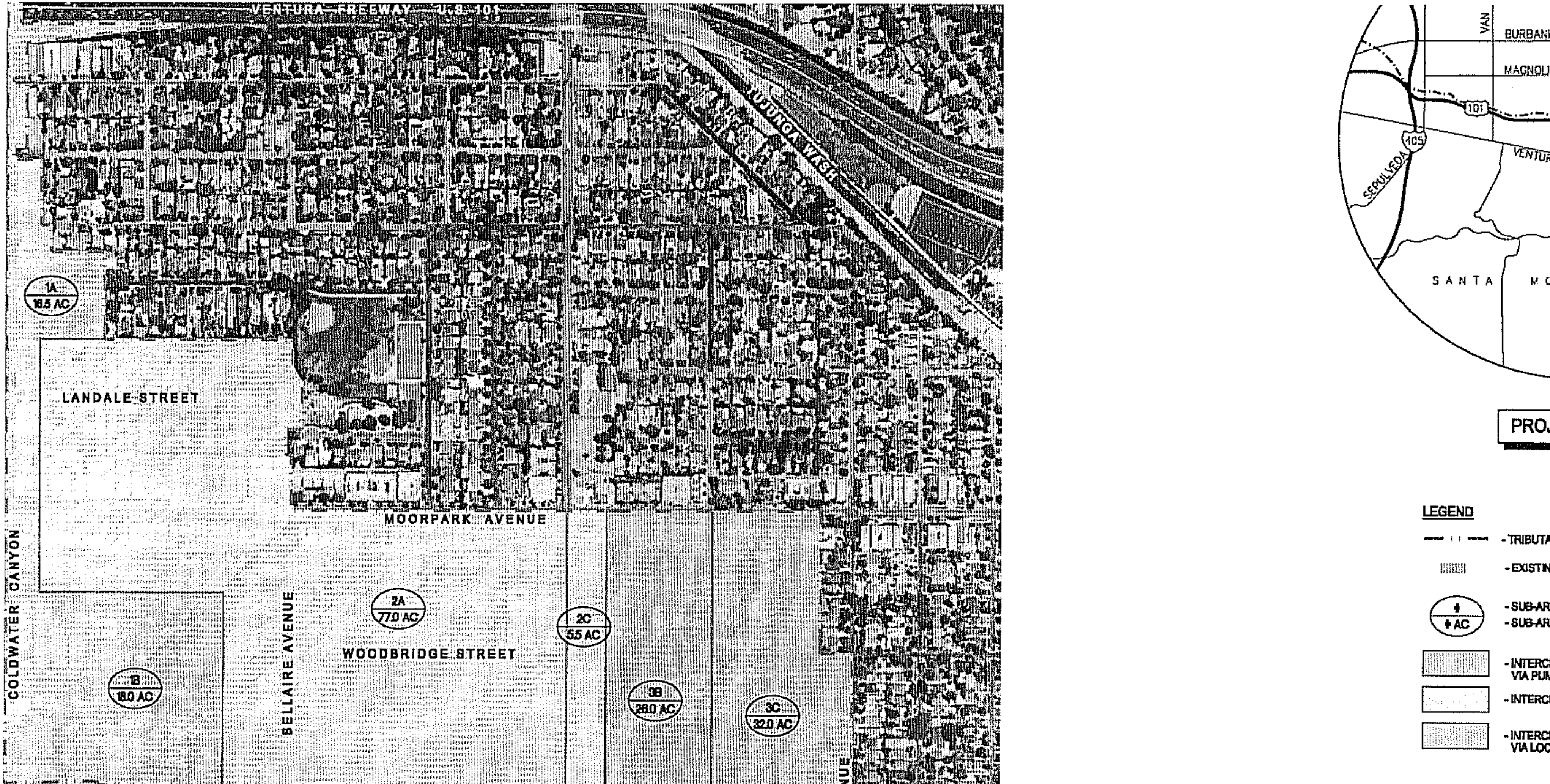
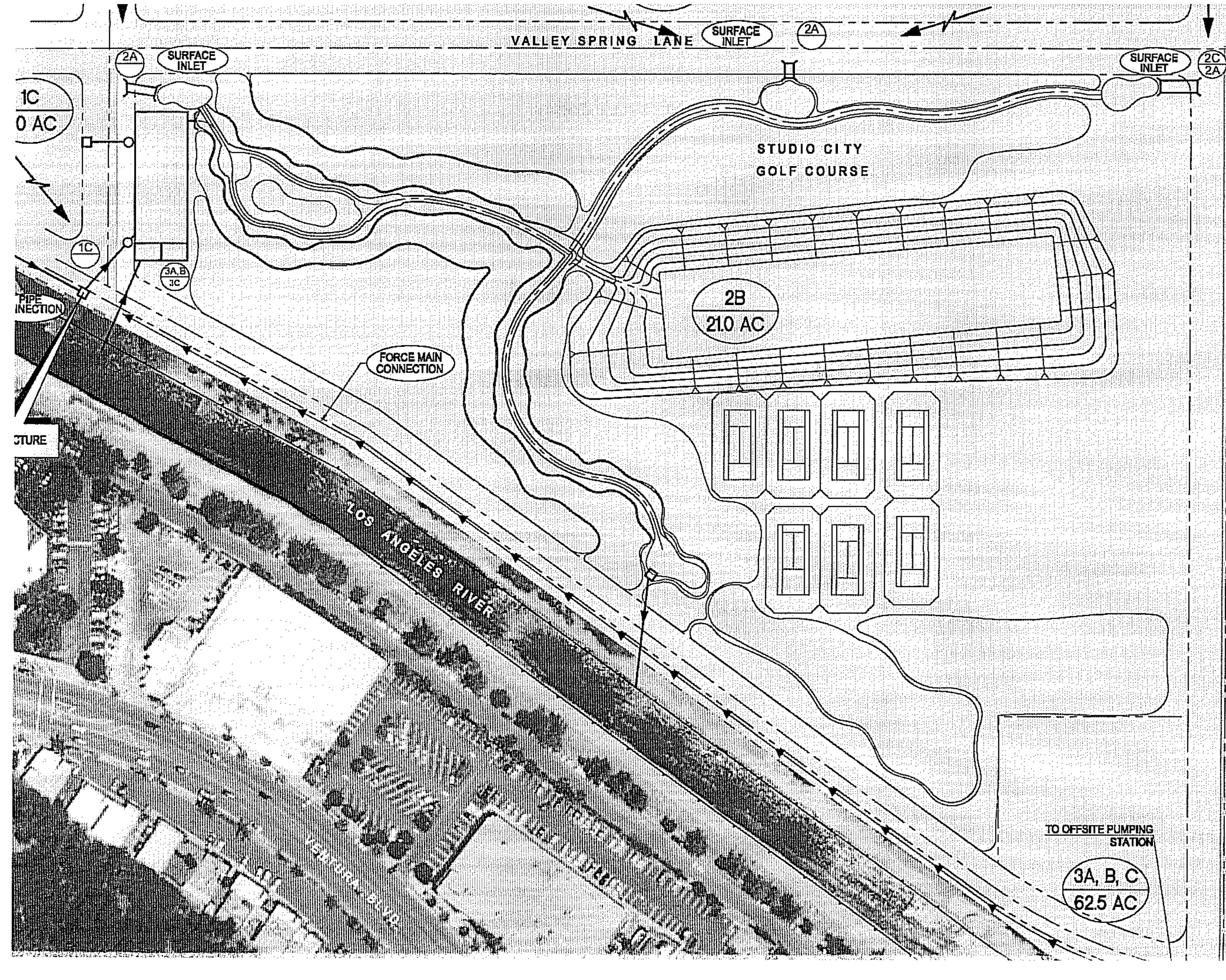
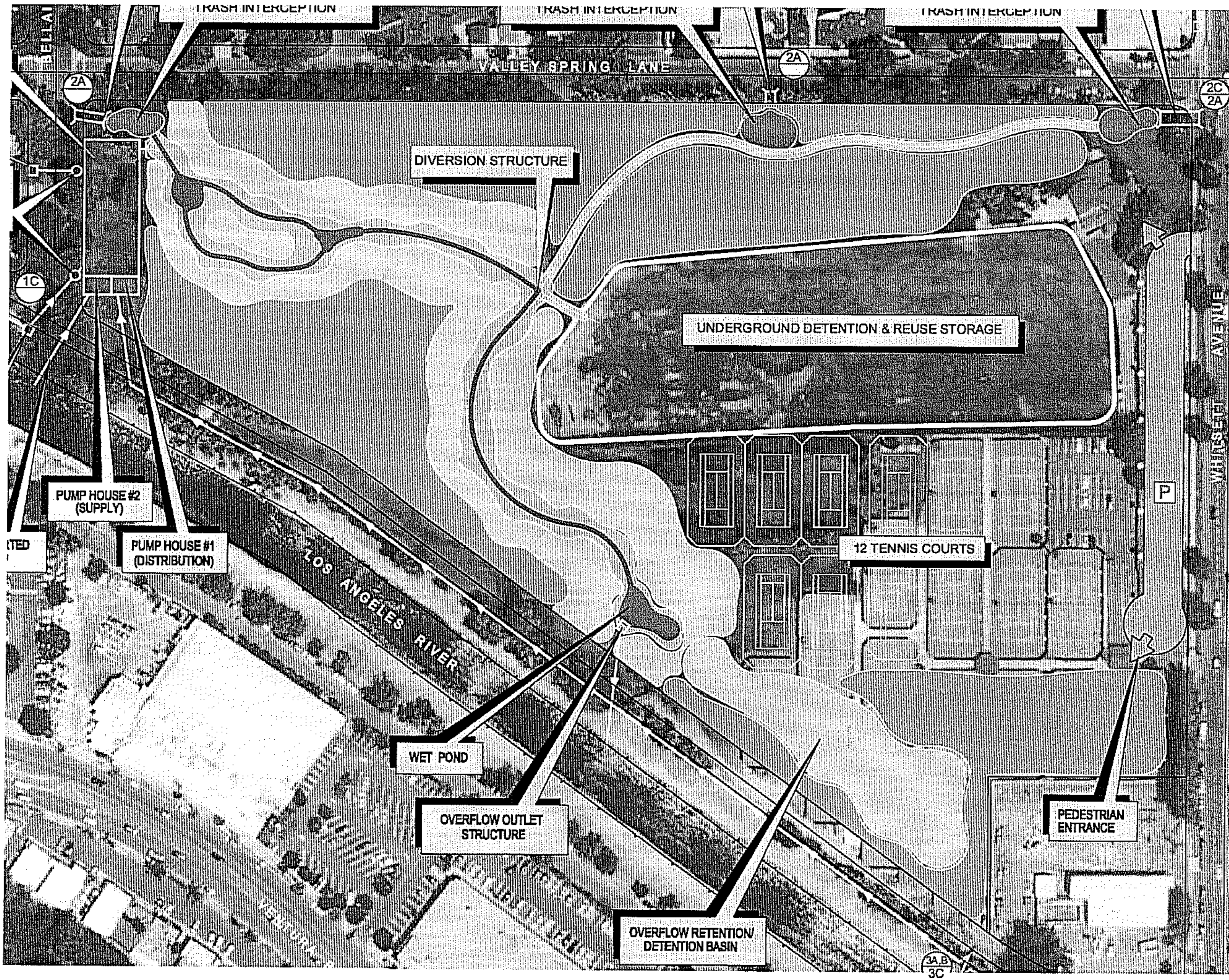


Tributary
Treatme
Los Angeles
Studio City, S



VALLEY SPRING LANE
SURFACE INLET
2A
SURFACE INLET
2A
SURFACE INLET
2C
2A
1C
0 AC
1C
3A,B
3C
PIPE
NECTION
CTURE
STUDIO CITY
GOLF COURSE
2B
21.0 AC
FORCE MAIN CONNECTION
LOS ANGELES RIVER
VENTURA BLVD.
TO OFFSITE PUMPING STATION
3A, B, C
62.5 AC



TRASH INTERCEPTION
TRASH INTERCEPTION
TRASH INTERCEPTION
VALLEY SPRING LANE
2A
2A
2C
2A
1C
DIVERSION STRUCTURE
UNDERGROUND DETENTION & REUSE STORAGE
WHITSETT AVENUE
P
PUMP HOUSE #2 (SUPPLY)
PUMP HOUSE #1 (DISTRIBUTION)
12 TENNIS COURTS
LOS ANGELES RIVER
WET POND
OVERFLOW OUTLET STRUCTURE
PEDESTRIAN ENTRANCE
OVERFLOW RETENTION/ DETENTION BASIN
3A,B
3C

Natu
S

MOORPARK AVENUE
WOODBRIDGE STREET
BELLAIRE AVENUE
VALLEY SPRING LANE
AVENUE
HODES AVENUE
GROVE AVENUE
PUBLIC ACCESS: PEDESTRIAN ENTRANCE
REGIONAL RIVER PUBLIC ACCESS STAGING AREA
PUBLIC ACCESS: PEDESTRIAN ENTRANCE
EXISTING PEDESTRIAN BRIDGE
REGIONAL RIVER BICYCLE HUB AND PUBLIC PARKING
FUTURE PEDESTRIAN BRIDGE
LOS ANGELES RIVER
P
P

BELLAIRE AVE
VALLEY SPRING LANE
WHITSETT AVENUE
RHODES AVENUE
LOS ANGELES RIVER
VENTURA BLVD
VEGETATED SWALE TO CAPTURE, CONVEY, AND INFILTRATE RUN-OFF
CATCH BASINS DIRECT RUN-OFF TO SITE
PUBLIC ACCESS: PEDESTRIAN ENTRANCE
UNDERGROUND DETENTION & REUSE STORAGE
(DRIVING RANGE)
SOLAR PANEL SHADE STRUCTURES OVER PARKING
P
12 TENNIS COURTS
REGIONAL RIVER PUBLIC ACCESS STAGING AREA
PUBLIC ACCESS: PEDESTRIAN ENTRANCE
LUENT DIVERTED RIVER FLOW
PUMP HOUSES
SOLAR PANELS ALONG SLOPE BANK
RIVER VIEWING AREA
FUTURE PEDESTRIAN BRIDGE
OVERFLOW RETENTION/ DETENTION BASIN
TO REGIONAL RIVER BICYCLE HUB AND PUBLIC PARKING

APPENDIX A

Runoff-Area-Volume Calculations

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RUNOFF-AREA-VOLUME CALCULATIONS

1CCI010102
Studio City Golf Course / Los Angeles River Park
15-Oct-09 cmoran/dbeck
rev Feb 22, 2010

Hydrology Map	1-H1.27	
Soil Types	15	
	16	
Impervious Area	0.74	Assumed Mixed Multi Family Residential per Los Angeles County Hydrology Manual
Tc	30 Min	Assumed per Los Angeles County Hydrology Manual
Intensity (Ix)	0.193	Per Los Angeles County SUSMP
Cu	0.1	Per Los Angeles County Hydrology Manual

Vm = (0.75in)*[((At*impervious%)*0.9)+(At*pervious%)*Cu]*(1ft/12in)*(43560sf/1ac)

Sub Area	Area (Ac.)	Vm (ft^3)	Vm (Ac-ft)	Impervious Ia (Ac.)	Pervious Pa (Ac.)
1A	16.50	31085.51	0.71	12.21	4.29
1B	18.00	33911.46	0.78	13.32	4.68
1C	2.00	3767.94	0.09	1.48	0.52
	36.50				
2A	77.00	145065.69	3.33	56.98	20.02
2B	21.00	39563.37	0.91	15.54	5.46
2C	5.50	10361.84	0.24	4.07	1.43
	103.50				
3A	4.50	8477.87	0.19	3.33	1.17
3B	26.00	48983.22	1.12	19.24	6.76
3C	32.00	60287.04	1.38	23.68	8.32
	62.50				
			Min volume required		
Total Area (Ac.)	202.50	381503.93	8.76		

	Max. Treatable Area (Ac.)	Vm provided (ft^3)	Vm provided (Ac-ft)
treatment volume provided by project	263.00	495484.11	11.37

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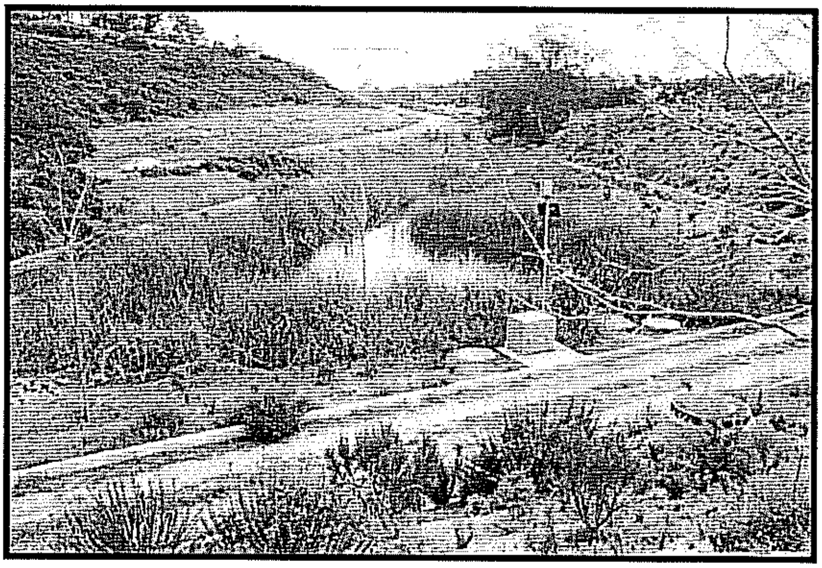
APPENDIX B

California Stormwater Quality Association Best Management Practices Reference

California Stormwater Quality Association (CASQA) Best Management Practices (BMPs) are techniques, measures or structural controls to manage and improve the quality of stormwater runoff.

Links to the CASQA BMPs referenced in this report are listed below:

Wet Ponds
  http://www.cabmphandbooks.com/Documents/Development/TC-20.pdf
Infiltration Basin
  http://www.cabmphandbooks.com/Documents/Development/TC-11.pdf
Extended Detention Basin
  http://www.cabmphandbooks.com/Documents/Development/TC-22.pdf
Vegetated Swale
  http://www.cabmphandbooks.com/Documents/Development/TC-30.pdf
Constructed Wetlands
  http://www.cabmphandbooks.com/Documents/Development/TC-21.pdf



Design Considerations

- Area Required
- Slope
- Water Availability
- Aesthetics
- Environmental Side-effects

Description

Wet ponds (a.k.a. stormwater ponds, retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season) and differ from constructed wetlands primarily in having a greater average depth. Ponds treat incoming stormwater runoff by settling and biological uptake. The primary removal mechanism is settling as stormwater runoff resides in this pool, but pollutant uptake, particularly of nutrients, also occurs to some degree through biological activity in the pond. Wet ponds are among the most widely used stormwater practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain stormwater runoff and promote settling. The schematic diagram is of an on-line pond that includes detention for larger events, but this is not required in all areas of the state.

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

California Experience

Caltrans constructed a wet pond in northern San Diego County (I-5 and La Costa Blvd.). Largest issues at this site were related to vector control, vegetation management, and concern that endangered species would become resident and hinder maintenance activities.

Advantages

- If properly designed, constructed and maintained, wet basins can provide substantial aesthetic/recreational value and wildlife and wetlands habitat.
- Ponds are often viewed as a public amenity when integrated into a park setting.

- Due to the presence of the permanent wet pool, properly designed and maintained wet basins can provide significant water quality improvement across a relatively broad spectrum of constituents including dissolved nutrients.

- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Some concern about safety when constructed where there is public access.

- Mosquito and midge breeding is likely to occur in ponds.

- Cannot be placed on steep unstable slopes.

- Need for base flow or supplemental water if water level is to be maintained.

- Require a relatively large footprint

- Depending on volume and depth, pond designs may require approval from the State Division of Safety of Dams

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.

- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be detrimental to downstream fisheries.

- Permanent pool volume equal to twice the water quality volume.

- Water depth not to exceed about 8 feet.

- Wetland vegetation occupying no more than 25% of surface area.

- Include energy dissipation in the inlet design and a sediment forebay to reduce resuspension of accumulated sediment and facilitate maintenance.

- A maintenance ramp should be included in the design to facilitate access to the forebay for maintenance activities and for vector surveillance and control.

- To facilitate vector surveillance and control activities, road access should be provided along at least one side of BMPs that are seven meters or less in width. Those BMPs that have shoreline-to-shoreline distances in excess of seven meters should have perimeter road access on both sides or be designed such that no parcel of water is greater than seven meters from the road.

Construction/Inspection Considerations

- In areas with porous soils an impermeable liner may be required to maintain an adequate permanent pool level.

- Outlet structures and piping should be installed with collars to prevent water from seeping through the fill and causing structural failure.

- Inspect facility after first large storm to determine whether the desired residence time has been achieved.

Performance

The observed pollutant removal of a wet pond is highly dependent on two factors: the volume of the permanent pool relative to the amount of runoff from the typical event in the area and the quality of the base flow that sustains the permanent pool. A recent study (Caltrans, 2002) has documented that if the permanent pool is much larger than the volume of runoff from an average event, then displacement of the permanent pool by the wet weather flow is the primary process. A statistical comparison of the wet pond discharge quality during dry and wet weather shows that they are not significantly different. Consequently, there is a relatively constant discharge quality during storms that is the same as the concentrations observed in the pond during ambient (dry weather) conditions. Consequently, for most constituents the performance of the pond is better characterized by the average effluent concentration, rather than the "percent reduction," which has been the conventional measure of performance. Since the effluent quality is essentially constant, the percent reduction observed is mainly a function of the influent concentrations observed at a particular site.

The dry and wet weather discharge quality is, therefore, related to the quality of the base flow that sustains the permanent pool and of the transformations that occur to those constituents during their residence in the basin. One could potentially expect a wide range of effluent concentrations at different locations even if the wet ponds were designed according to the same guidelines, if the quality of the base flow differed significantly. This may explain the wide range of concentration reductions reported in various studies.

Concentrations of nutrients in base flow may be substantially higher than in urban stormwater runoff. Even though these concentrations may be substantially reduced during the residence time of the base flow in the pond, when this water is displaced by wet weather flows, concentrations may still be quite elevated compared to the levels that promote eutrophication in surface water systems. Consequently comparing influent and effluent nutrient concentrations during wet weather can make the performance seem highly variable.

Relatively small perennial flows may often substantially exceed the wet weather flow treated. Consequently, one should also consider the load reduction observed under ambient conditions when assessing the potential benefit to the receiving water.

Siting Criteria

Wet ponds are a widely applicable stormwater management practice and can be used over a broad range of storm frequencies and sizes, drainage areas and land use types. Although they have limited applicability in highly urbanized settings and in arid climates, they have few other restrictions. Wet basins may be constructed on- or off-line and can be sited at feasible locations along established drainage ways with consistent base flow. An off-line design is preferred. Wet basins are often utilized in smaller sub-watersheds and are particularly appropriate in areas with residential land uses or other areas where high nutrient loads are considered to be potential problems (e.g., golf courses).

Ponds do not consume a large area (typically 2–3 percent of the contributing drainage area); however, these facilities are generally large. Other practices, such as filters or swales, may be "squeezed" into relatively unusable land, but ponds need a relatively large continuous area. Wet basins are typically used in drainage basins of more than ten acres and less than one square mile (Schueler et al., 1992). Emphasis can be placed in siting wet basins in areas where the pond can also function as an aesthetic amenity or in conjunction with other stormwater management functions.

Wet basin application is appropriate in the following settings: (1) where there is a need to achieve a reasonably high level of dissolved contaminant removal and/or sediment capture; (2) in small to medium-sized regional tributary areas with available open space and drainage areas greater than about 10 ha (25 ac.); (3) where base flow rates or other channel flow sources are relatively consistent year-round; (4) in residential settings where aesthetic and wildlife habitat benefits can be appreciated and maintenance activities are likely to be consistently undertaken.

Traditional wet extended detention ponds can be applied in most regions of the United States, with the exception of arid climates. In arid regions, it is difficult to justify the supplemental water needed to maintain a permanent pool because of the scarcity of water. Even in semi-arid Austin, Texas, one study found that 2.6 acre-feet per year of supplemental water was needed to maintain a permanent pool of only 0.29 acre-feet (Saunders and Gilroy, 1997). Seasonal wet ponds (i.e., ponds that maintain a permanent pool only during the wet season) may prove effective in areas with distinct wet and dry seasons; however, this configuration has not been extensively evaluated.

Wet ponds may pose a risk to cold water systems because of their potential for stream warming. When water remains in the permanent pool, it is heated by the sun. A study in Prince George's County, Maryland, found that stormwater wet ponds heat stormwater by about 9°F from the inlet to the outlet (Galli, 1990).

Additional Design Guidelines

Specific designs may vary considerably, depending on site constraints or preferences of the designer or community. There are several variations of the wet pond design, including constructed wetlands, and wet extended detention ponds. Some of these design alternatives are intended to make the practice adaptable to various sites and to account for regional constraints and opportunities. In conventional wet ponds, the open water area comprises 50% or more of the total surface area of the pond. The permanent pool should be no deeper than 2.5 m (8 feet) and should average 1.2 – 2 m (4-6 feet) deep. The greater depth of this configuration helps limit the extent of the vegetation to an aquatic bench around the perimeter of the pond with a nominal depth of about 1 foot and variable width. This shallow bench also protects the banks from erosion, enhances habitat and aesthetic values, and reduces the drowning hazard.

The wet extended detention pond combines the treatment concepts of the dry extended detention pond and the wet pond. In this design, the water quality volume is detained above the permanent pool and released over 24 hours. In addition to increasing the residence time, which improves pollutant removal, this design also attenuates peak runoff rates. Consequently, this design alternative is recommended.

Pretreatment incorporates design features that help to settle out coarse sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In ponds, pretreatment is achieved with a sediment forebay. A sediment forebay is a small pool (typically about 10 percent of the volume of the permanent pool). Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool, eliminating the need to dredge the entire pond.

There are a variety of sizing criteria for determining the volume of the permanent pool, mostly related to the water quality volume (i.e., the volume of water treated for pollutant removal) or the average storm size in a particular area. In addition, several theoretical approaches to determination of permanent pool volume have been developed. However, there is little empirical evidence to support these designs. Consequently, a simplified method (i.e., permanent pool volume equal to twice the water quality volume) is recommended.

Other design features do not increase the volume of a pond, but can increase the amount of time stormwater remains in the device and eliminate short-circuiting. Ponds should always be designed with a length-to-width ratio of at least 1.5:1, where feasible. In addition, the design should incorporate features to lengthen the flow path through the pond, such as underwater berms designed to create a longer route through the pond. Combining these two measures helps ensure that the entire pond volume is used to treat stormwater. Wet ponds with greater amounts of vegetation often have channels through the vegetated areas and contain dead areas where stormwater is restricted from mixing with the entire permanent pool, which can lead to less pollutant removal. Consequently, a pond with open water comprising about 75% of the surface area is preferred.

Design features are also incorporated to ease maintenance of both the forebay and the main pool of ponds. Ponds should be designed with a maintenance access to the forebay to ease this relatively routine (every 5–7 year) maintenance activity. In addition, ponds should generally have a drain to draw down the pond for vegetation harvesting or the more infrequent dredging of the main cell of the pond.

Cold climates present many challenges to designers of wet ponds. The spring snowmelt may have a high pollutant load and a large volume to be treated. In addition, cold winters may cause freezing of the permanent pool or freezing at inlets and outlets. Finally, high salt concentrations in runoff resulting from road salting, and sediment loads from road sanding, may impact pond vegetation as well as reduce the storage and treatment capacity of the pond.

One option to deal with high pollutant loads and runoff volumes during the spring snowmelt is the use of a seasonally operated pond to capture snowmelt during the winter and retain the permanent pool during warmer seasons. In this option, proposed by Oberts (1994), the pond has two water quality outlets, both equipped with gate valves. In the summer, the lower outlet is closed. During the fall and throughout the winter, the lower outlet is opened to draw down the permanent pool. As the spring melt begins, the lower outlet is closed to provide detention for the melt event. The manipulation of this system requires some labor and vigilance; a careful maintenance agreement should be confirmed.

Several other modifications may help to improve the performance of ponds in cold climates. Designers should consider planting the pond with salt-tolerant vegetation if the facility receives road runoff. In order to counteract the effects of freezing on inlet and outlet structures, the use of inlet and outlet structures that are resistant to frost, including weirs and larger diameter pipes, may be useful. Designing structures on-line, with a continuous flow of water through the pond, will also help prevent freezing of these structures. Finally, since freezing of the permanent pool can reduce the effectiveness of pond systems, it is important to incorporate extended detention into the design to retain usable treatment area above the permanent pool when it is frozen.

Summary of Design Recommendations

(1) Facility Sizing – The basin should be sized to hold the permanent pool as well as the required water quality volume. The volume of the permanent pool should equal twice the water quality volume.

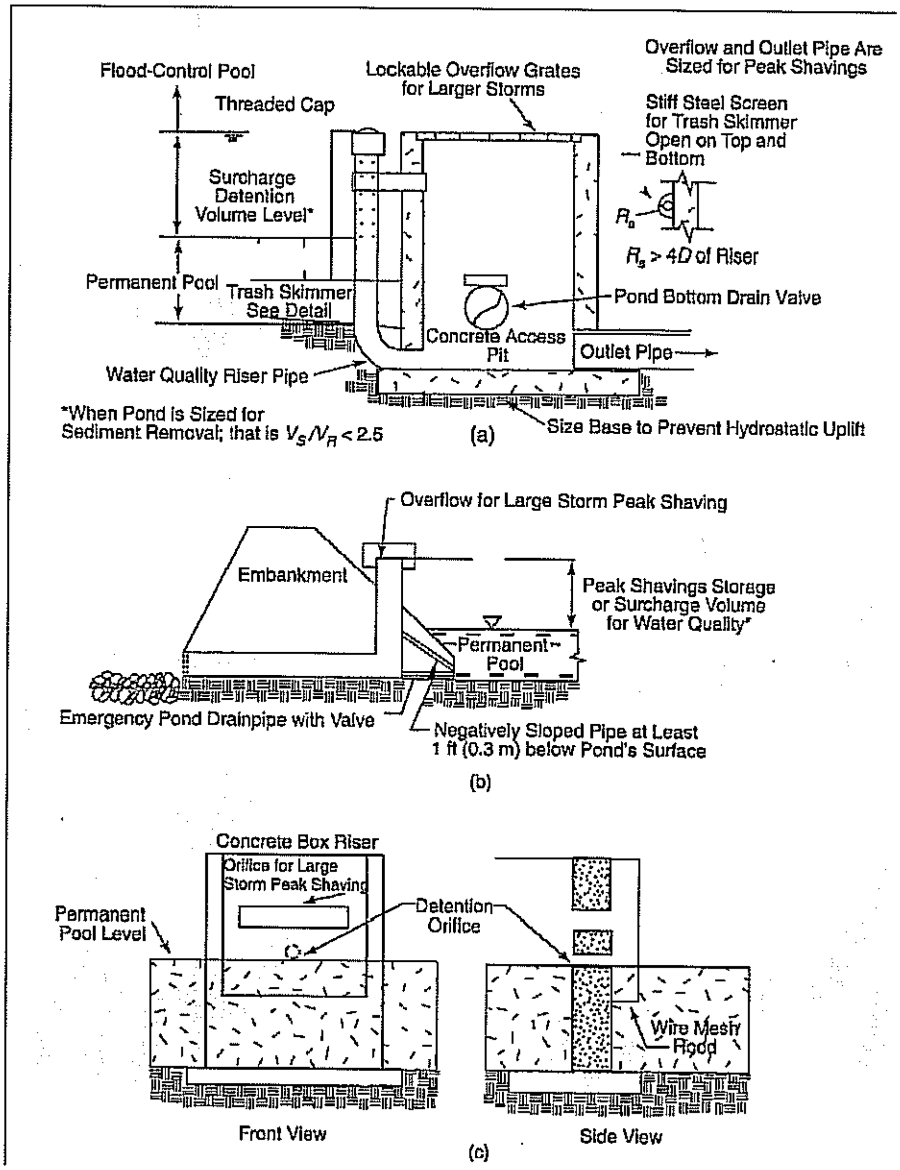
(2) Pond Configuration - The wet basin should be configured as a two stage facility with a sediment forebay and a main pool. The basins should be wedge-shaped, narrowest at the inlet and widest at the outlet. The minimum length to width ratio should be 1.5 where feasible. The perimeter of all permanent pool areas with depths of 4.0 feet or greater should be surrounded by an aquatic bench. This bench should extend inward 5-10 feet from the perimeter of the permanent pool and should be no more than 18 inches below normal depth. The area of the bench should not exceed about 25% of pond surface. The depth in the center of the basin should be 4 – 8 feet deep to prevent vegetation from encroaching on the pond open water surface.

(3) Pond Side Slopes - Side slopes of the basin should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 should be stabilized with an appropriate slope stabilization practice.

(4) Sediment Forebay - A sediment forebay should be used to isolate gross sediments as they enter the facility and to simplify sediment removal. The sediment forebay should consist of a separate cell formed by an earthen berm, gabion, or loose riprap wall. The forebay should be sized to contain 15 to 25% of the permanent pool volume and should be at least 3 feet deep. Exit velocities from the forebay should not be erosive. Direct maintenance access should be provided to the forebay. The bottom of the forebay may be hardened (concrete) to make sediment removal easier. A fixed vertical sediment depth marker should be installed in the forebay to measure sediment accumulation.

(5) Outflow Structure - Figure 2 presents a schematic representation of suggested outflow structures. The outlet structure should be designed to drain the water quality volume over 24 hours with the orifice sized according to the equation presented in the Extended Detention Basin fact sheet. The facility should have a separate drain pipe with a manual valve that can completely or partially drain the pond for maintenance purposes. To allow for possible sediment accumulation, the submerged end of the pipe should be protected, and the drain pipe should be sized to drain the pond within 24 hours. The valve should be located at a point where it can be operated in a safe and convenient manner.

For on-line facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the 100-year flood. The embankment should be designed in accordance with all relevant specifications for small dams.



(6) Splitter Box - When the pond is designed as an off-line facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Vegetation - A plan should be prepared that indicates how aquatic and terrestrial areas will be vegetatively stabilized. Wetland vegetation elements should be placed along the aquatic bench or in the shallow portions of the permanent pool. The optimal elevation for planting of wetland vegetation is within 6 inches vertically of the normal pool elevation. A list of some wetland vegetation native to California is presented in Table 1.

Table 1 California Wetland Vegetation	
Botanical Name	**Common Name**
BACCHARIS SALICIFOLIA	MULE FAT
FRANKENIA GRANDIFOLIA	HEATH
SALIX GOODINGII	BLACK WILLOW
SALIX LASIOLEPIS	ARROYO WILLOW
SAMUCUS MEXICANUS	MEXICAN ELDERBERRY
HAPLOPAPPUS VENETUS	COAST GOLDENBRUSH
DISTICHIS SPICATA	SALT GRASS
LIMONIUM CALIFORNICUM	COASTAL STATICE
ATRIPLEX LENTIFORMIS	COASTAL QUAIL BUSH
BACCHARIS PILULARIS	CHAPARRAL BROOM
MIMULUS LONGIFLORUS	MONKEY FLOWER
SCIRPUS CALIFORNICUS	BULRUSH
SCIRPUS ROBUSTUS	BULRUSH
TYPHA LATIFOLIA	BROADLEAF CATTAIL
JUNCUS ACUTUS	RUSH

Maintenance

The amount of maintenance required for a wet pond is highly dependent on local regulatory agencies, particular health and vector control agencies. These agencies are often extremely concerned about the potential for mosquito breeding that may occur in the permanent pool. Even though mosquito fish (*Gambusia affinis*) were introduced into a wet pond constructed by Caltrans in the San Diego area, mosquito breeding was routinely observed during inspections. In addition, the vegetation at this site became sufficiently dense on the bench around the edge of the pool that mosquito fish were unable to enter this area to feed upon the mosquito larvae. The vegetation at this site was particularly vigorous because of the high nutrient concentrations in the perennial base flow (15.5 mg/L NO_3-N) and the mild climate, which permitted growth year round. Consequently, the vector control agency required an annual harvest of vegetation to address this situation. This harvest can be very expensive.

On the other hand, routine harvesting may increase nutrient removal and prevent the export of these constituents from dead and dying plants falling in the water. A previous study (Faulkner and Richardson, 1991) documented dramatic reductions in nutrient removal after the first several years of operation and related it to the vegetation achieving a maximum density. That content then decreases through the growth season, as the total biomass increases. In effect, the total amount of nutrients/m2 of wetland remains essentially the same from June through September, when the plants start to put the P back into the rhizomes. Therefore harvesting should occur between June and September. Research also suggests that harvesting only the foliage is less effective, since a very small percentage of the removed nutrients is taken out with harvesting.

Since wet ponds are often selected for their aesthetic considerations as well as pollutant removal, they are often sited in areas of high visibility. Consequently, floating litter and debris are removed more frequently than would be required simply to support proper functioning of the pond and outlet. This is one of the primary maintenance activities performed at the Central Market Pond located in Austin, Texas. In this type of setting, vegetation management in the area surrounding the pond can also contribute substantially to the overall maintenance requirements.

One normally thinks of sediment removal as one of the typical activities performed at stormwater BMPs. This activity does not normally constitute one of the major activities on an annual basis. At the concentrations of TSS observed in urban runoff from stable watersheds, sediment removal may only be required every 20 years or so. Because this activity is performed so infrequently, accurate costs for this activity are lacking.

In addition to regular maintenance activities needed to maintain the function of wet ponds, some design features can be incorporated to ease the maintenance burden. In wet ponds, maintenance reduction features include techniques to reduce the amount of maintenance needed, as well as techniques to make regular maintenance activities easier.

One potential maintenance concern in wet ponds is clogging of the outlet. Ponds should be designed with a non-clogging outlet such as a reverse-slope pipe, or a weir outlet with a trash rack. A reverse-slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and establishes the water elevation of the permanent pool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris.

Typical maintenance activities and frequencies include:

- Schedule semiannual inspections for burrows, sediment accumulation, structural integrity of the outlet, and litter accumulation.

- Remove accumulated trash and debris in the basin at the middle and end of the wet season. The frequency of this activity may be altered to meet specific site conditions and aesthetic considerations.

- Where permitted by the Department of Fish and Game or other agency regulations, stock wet ponds/constructed wetlands regularly with mosquito fish (*Gambusia spp.*) to enhance natural mosquito and midge control.

- Introduce mosquito fish and maintain vegetation to assist their movements to control mosquitoes, as well as to provide access for vector inspectors. An annual vegetation harvest in summer appears to be optimum, in that it is after the bird breeding season, mosquito fish can provide the needed control until vegetation reaches late summer density, and there is time for re-growth for runoff treatment purposes before the wet season. In certain cases, more frequent plant harvesting may be required by local vector control agencies.

- Maintain emergent and perimeter shoreline vegetation as well as site and road access to facilitate vector surveillance and control activities.

- Remove accumulated sediment in the forebay and regrade about every 5-7 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Sediment removal may not be required in the main pool area for as long as 20 years.

Cost

Construction Cost

Wet ponds can be relatively inexpensive stormwater practices; however, the construction costs associated with these facilities vary considerably. Much of this variability can be attributed to the degree to which the existing topography will support a wet pond, the complexity and amount of concrete required for the outlet structure, and whether it is installed as part of new construction or implemented as a retrofit of existing storm drain system.

A recent study (Brown and Schueler, 1997) estimated the cost of a variety of stormwater management practices. The study resulted in the following cost equation, adjusting for inflation:

$$C = 24.5^{V^{0.705}}$$

where:

C = Construction, design and permitting cost;

V = Volume in the pond to include the 10-year storm (ft^3).

Using this equation, typical construction costs are:

$45,700 for a 1 acre-foot facility

$232,000 for a 10 acre-foot facility

$1,170,000 for a 100 acre-foot facility

In contrast, Caltrans (2002) reported spending over $448,000 for a pond with a total permanent pool plus water quality volume of only 1036 m^3 (0.8 ac.-ft.), while the City of Austin spent $584,000 (including design) for a pond with a permanent pool volume of 3,100 m^3 (2.5 ac.-ft.). The large discrepancies between the costs of these actual facilities and the model developed by Brown and Schueler indicate that construction costs are highly site specific, depending on topography, soils, subsurface conditions, the local labor, rate and other considerations.

Maintenance Cost

For ponds, the annual cost of routine maintenance has typically been estimated at about 3 to 5 percent of the construction cost; however, the published literature is almost totally devoid of actual maintenance costs. Since ponds are long-lived facilities (typically longer than 20 years), major maintenance activities are unlikely to occur during a relatively short study.

Caltrans (2002) estimated annual maintenance costs of $17,000 based on three years of monitoring of a pond treating runoff from 1.7 ha. Almost all the activities are associated with the annual vegetation harvest for vector control. Total cost at this site falls within the 3-5% range reported above; however, the construction costs were much higher than those estimated by Brown and Schueler (1997). The City of Austin has been reimbursing a developer about $25,000/yr for wet pond maintenance at a site located at a very visible location. Maintenance costs are mainly the result of vegetation management and litter removal. On the other hand, King County estimates annual maintenance costs at about $3,000 per pond; however, this cost likely does not include annual extensive vegetation removal. Consequently, maintenance costs may vary considerably at sites in California depending on the aggressiveness of the vegetation management in that area and the frequency of litter removal.

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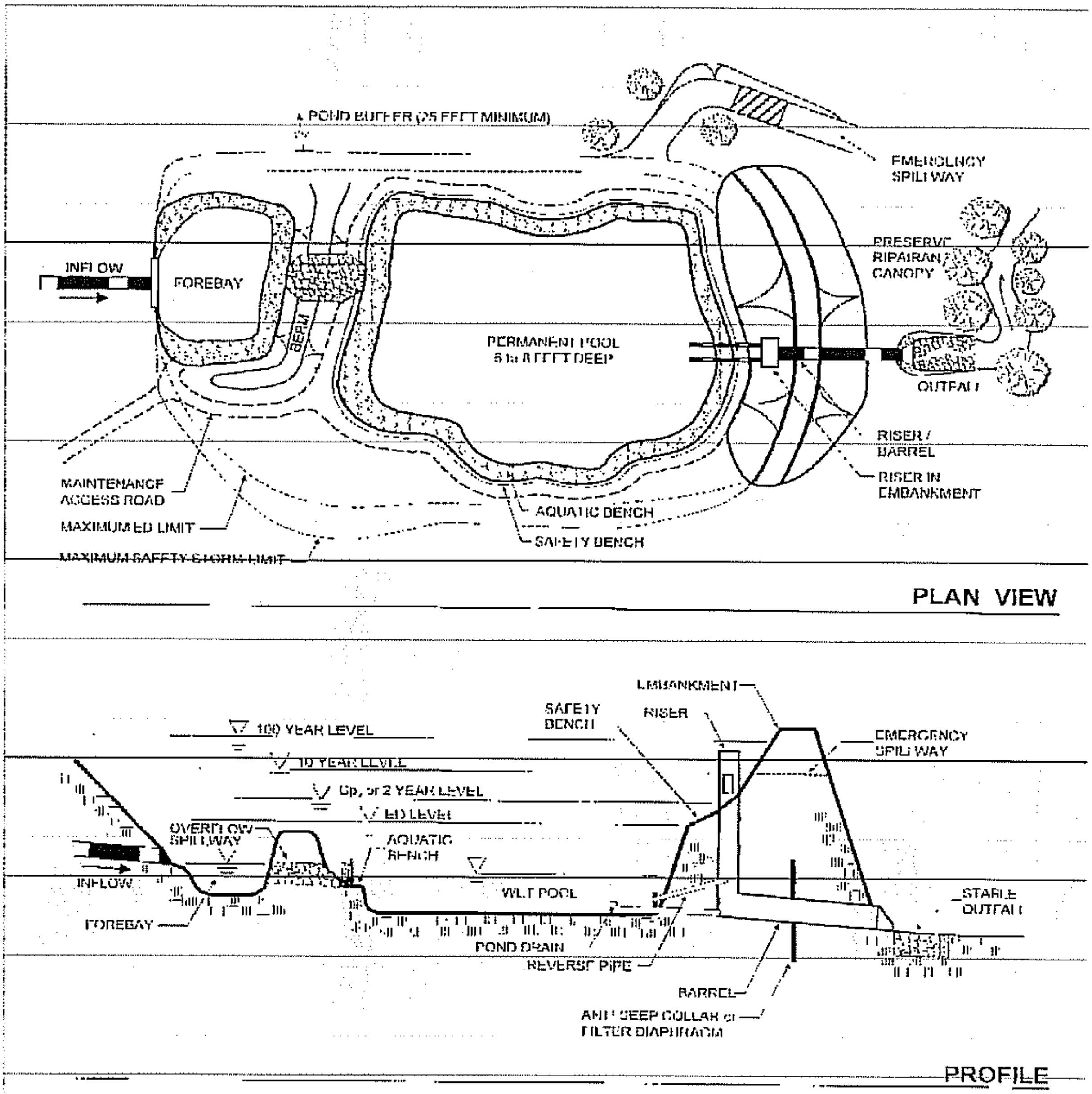
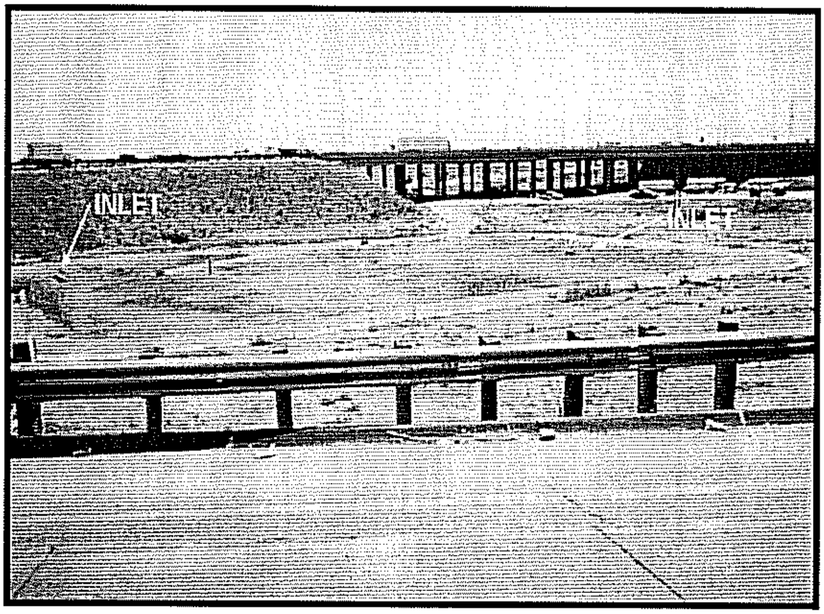


POND BUFFER (25 FEET MINIMUM)
EMERGENCY SPILLWAY
INFLOW
FOREBAY
BERM
PERMANENT POOL
PRESERVE RIPAIRAN CANOPY
OUTFALL
RISER / BARREL
RISER IN EMBANKMENT
MAINTENANCE ACCESS ROAD
MAXIMUM ED LIMIT
MAXIMUM SAFETY STORM LIMIT
AQUATIC BENCH
SAFETY BENCH
PLAN VIEW
EMBANKMENT
SAFETY BENCH
RISER
100 YEAR LEVEL
10 YEAR LEVEL
2 YEAR LEVEL
ED LEVEL
EMERGENCY SPILLWAY
OVERFLOW SPILLWAY
AQUATIC BENCH
INFLOW
WET POOL
STABLE OUTFALL
FOREBAY
POND DRAIN
REVERSE PIPE
BARREL
ANTI SEEP COLLAR or FILTER DIAPHRAGM
PROFILE



Design Considerations

- Soil for Infiltration
- Slope
- Aesthetics

Targeted Constituents

☑	Sediment	■
☑	Nutrients	■
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

Description

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater. Infiltration basins use the natural filtering ability of the soil to remove pollutants in stormwater runoff. Infiltration facilities store runoff until it gradually exfiltrates through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge groundwater, thus helping to maintain low flows in stream systems. Infiltration basins can be challenging to apply on many sites, however, because of soils requirements. In addition, some studies have shown relatively high failure rates compared with other management practices.

California Experience

Infiltration basins have a long history of use in California, especially in the Central Valley. Basins located in Fresno were among those initially evaluated in the National Urban Runoff Program and were found to be effective at reducing the volume of runoff, while posing little long-term threat to groundwater quality (EPA, 1983; Schroeder, 1995). Proper siting of these devices is crucial as underscored by the experience of Caltrans in siting two basins in Southern California. The basin with marginal separation from groundwater and soil permeability failed immediately and could never be rehabilitated.

Advantages

- Provides 100% reduction in the load discharged to surface waters.
- The principal benefit of infiltration basins is the approximation of pre-development hydrology during which a

CASQA
CALIFORNIA STORMWATER

significant portion of the average annual rainfall runoff is infiltrated and evaporated rather than flushed directly to creeks.

- If the water quality volume is adequately sized, infiltration basins can be useful for providing control of channel forming (erosion) and high frequency (generally less than the 2-year) flood events.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, not appropriate at sites with Hydrologic Soil Types C and D.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.
- Not suitable on fill sites or steep slopes.
- Risk of groundwater contamination in very coarse soils.
- Upstream drainage area must be completely stabilized before construction.
- Difficult to restore functioning of infiltration basins once clogged.

Design and Sizing Guidelines

- Water quality volume determined by local requirements or sized so that 85% of the annual runoff volume is captured.
- Basin sized so that the entire water quality volume is infiltrated within 48 hours.
- Vegetation establishment on the basin floor may help reduce the clogging rate.

Construction/Inspection Considerations

- Before construction begins, stabilize the entire area draining to the facility. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction or remove the top 2 inches of soil after the site is stabililized. Stabilize the entire contributing drainage area, including the side slopes, before allowing any runoff to enter once construction is complete.
- Place excavated material such that it can not be washed back into the basin if a storm occurs during construction of the facility.
- Build the basin without driving heavy equipment over the infiltration surface. Any equipment driven on the surface should have extra-wide ("low pressure") tires. Prior to any construction, rope off the infiltration area to stop entrance by unwanted equipment.
- After final grading, till the infiltration surface deeply.
- Use appropriate erosion control seed mix for the specific project and location.

Performance

As water migrates through porous soil and rock, pollutant attenuation mechanisms include precipitation, sorption, physical filtration, and bacterial degradation. If functioning properly, this approach is presumed to have high removal efficiencies for particulate pollutants and moderate removal of soluble pollutants. Actual pollutant removal in the subsurface would be expected to vary depending upon site-specific soil types. This technology eliminates discharge to surface waters except for the very largest storms; consequently, complete removal of all stormwater constituents can be assumed.

There remain some concerns about the potential for groundwater contamination despite the findings of the NURP and Nightingale (1975; 1987a,b,c; 1989). For instance, a report by Pitt et al. (1994) highlighted the potential for groundwater contamination from intentional and unintentional stormwater infiltration. That report recommends that infiltration facilities not be sited in areas where high concentrations are present or where there is a potential for spills of toxic material. Conversely, Schroeder (1995) reported that there was no evidence of groundwater impacts from an infiltration basin serving a large industrial catchment in Fresno, CA.

Siting Criteria

The key element in siting infiltration basins is identifying sites with appropriate soil and hydrogeologic properties, which is critical for long term performance. In one study conducted in Prince George's County, Maryland (Galli, 1992), all of the infiltration basins investigated clogged within 2 years. It is believed that these failures were for the most part due to allowing infiltration at sites with rates of less than 0.5 in/hr, basing siting on soil type rather than field infiltration tests, and poor construction practices that resulted in soil compaction of the basin invert.

A study of 23 infiltration basins in the Pacific Northwest showed better long-term performance in an area with highly permeable soils (Hilding, 1996). In this study, few of the infiltration basins had failed after 10 years. Consequently, the following guidelines for identifying appropriate soil and subsurface conditions should be rigorously adhered to.

- Determine soil type (consider RCS soil type 'A, B or C' only) from mapping and consult USDA soil survey tables to review other parameters such as the amount of silt and clay, presence of a restrictive layer or seasonal high water table, and estimated permeability. The soil should not have more than 30% clay or more than 40% of clay and silt combined. Eliminate sites that are clearly unsuitable for infiltration.

- Groundwater separation should be at least 3 m from the basin invert to the measured ground water elevation. There is concern at the state and regional levels of the impact on groundwater quality from infiltrated runoff, especially when the separation between groundwater and the surface is small.

- Location away from buildings, slopes and highway pavement (greater than 6 m) and wells and bridge structures (greater than 30 m). Sites constructed of fill, having a base flow or with a slope greater than 15% should not be considered.

- Ensure that adequate head is available to operate flow splitter structures (to allow the basin to be offline) without ponding in the splitter structure or creating backwater upstream of the splitter.

- Base flow should not be present in the tributary watershed.

Secondary Screening Based on Site Geotechnical Investigation

- At least three in-hole conductivity tests shall be performed using USBR 7300-89 or Bouwer-Rice procedures (the latter if groundwater is encountered within the boring), two tests at different locations within the proposed basin and the third down gradient by no more than approximately 10 m. The tests shall measure permeability in the side slopes and the bed within a depth of 3 m of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 13 mm/hr. If any test hole shows less than the minimum value, the site should be disqualified from further consideration.

- Exclude from consideration sites constructed in fill or partially in fill unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed rather than flocculated state, greatly reducing permeability.

- The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Additional Design Guidelines

(1) Basin Sizing - The required water quality volume is determined by local regulations or sufficient to capture 85% of the annual runoff.

(2) Provide pretreatment if sediment loading is a maintenance concern for the basin.

(3) Include energy dissipation in the inlet design for the basins. Avoid designs that include a permanent pool to reduce opportunity for standing water and associated vector problems.

(4) Basin invert area should be determined by the equation:

$$A = \frac{WQV}{kt}$$

where A = Basin invert area (m^2)

WQV = water quality volume (m^3)

k = 0.5 times the lowest field-measured hydraulic conductivity (m/hr)

t = drawdown time (48 hr)

(5) The use of vertical piping, either for distribution or infiltration enhancement shall not be allowed to avoid device classification as a Class V injection well per 40 CFR146.5(e)(4).

Maintenance

Regular maintenance is critical to the successful operation of infiltration basins. Recommended operation and maintenance guidelines include:

- Inspections and maintenance to ensure that water infiltrates into the subsurface completely (recommended infiltration rate of 72 hours or less) and that vegetation is carefully managed to prevent creating mosquito and other vector habitats.
- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with an erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis. Always remove deposited sediments before scarification, and use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

Cost

Infiltration basins are relatively cost-effective practices because little infrastructure is needed when constructing them. One study estimated the total construction cost at about $2 per ft (adjusted for inflation) of storage for a 0.25-acre basin (SWRPC, 1991). As with other BMPs, these published cost estimates may deviate greatly from what might be incurred at a specific site. For instance, Caltrans spent about $18/ft^3 for the two infiltration basins constructed in southern California, each of which had a water quality volume of about 0.34 ac.-ft. Much of the higher cost can be attributed to changes in the storm drain system necessary to route the runoff to the basin locations.

Infiltration basins typically consume about 2 to 3% of the site draining to them, which is relatively small. Additional space may be required for buffer, landscaping, access road, and fencing. Maintenance costs are estimated at 5 to 10% of construction costs.

One cost concern associated with infiltration practices is the maintenance burden and longevity. If improperly maintained, infiltration basins have a high failure rate. Thus, it may be necessary to replace the basin with a different technology after a relatively short period of time.

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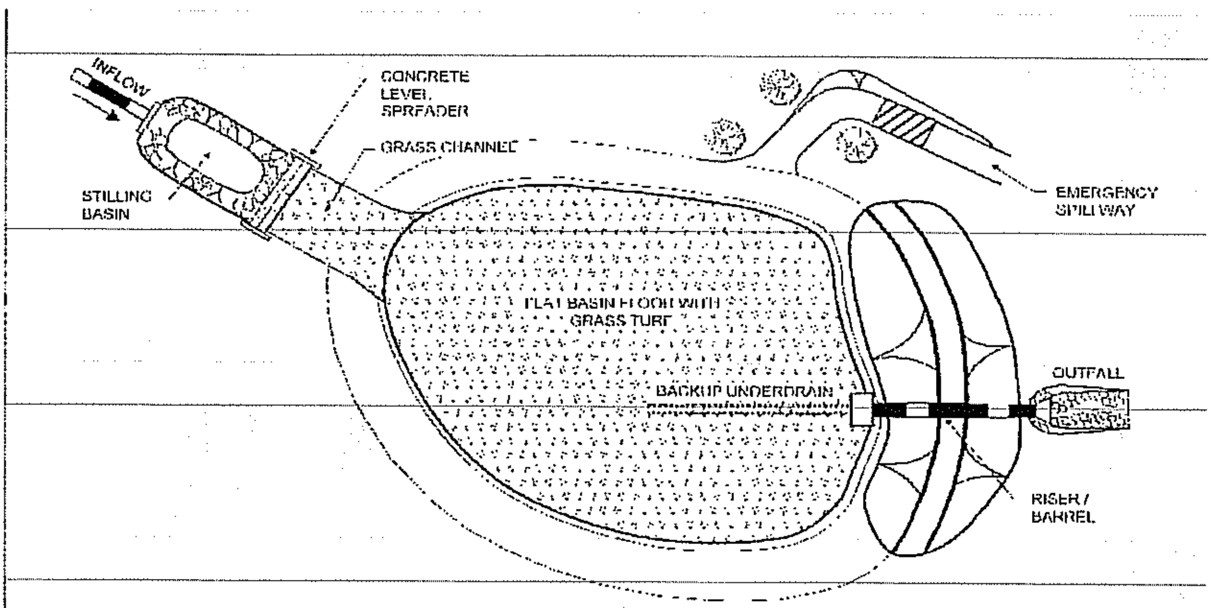
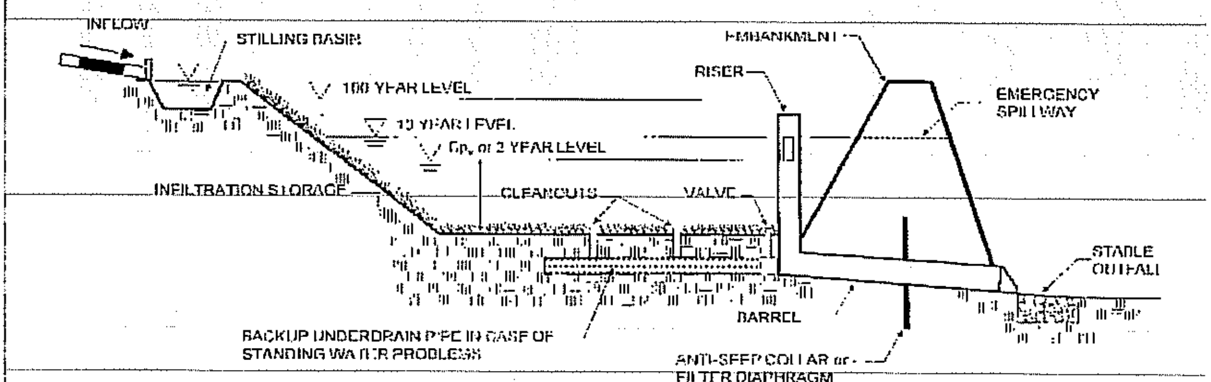
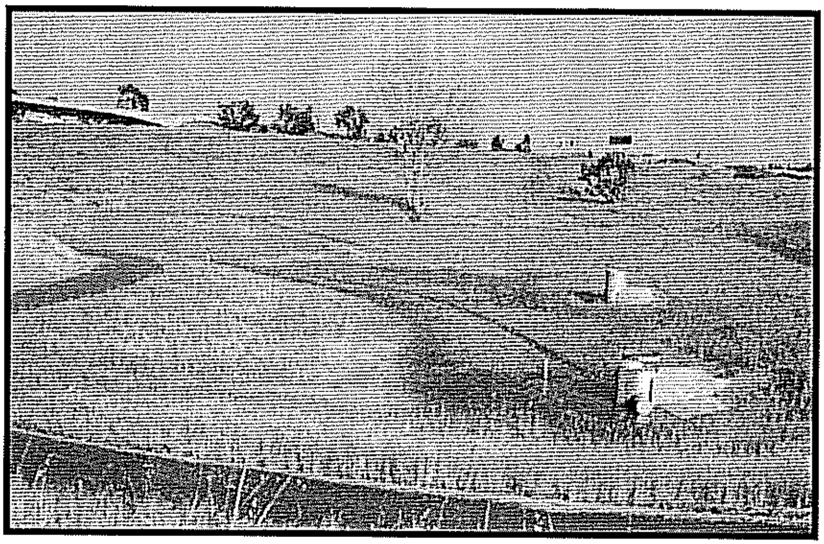


PLAN VIEW



PROFILE



Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	■
☑	Metals	▲
☑	Bacteria	▲
☑	Oil and Grease	▲
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.
- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of hours.
- Length to width ratio of at least 1.5:1 where feasible.
- Basin depths optimally range from 2 to 5 feet.
- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.
- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.
- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.
- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

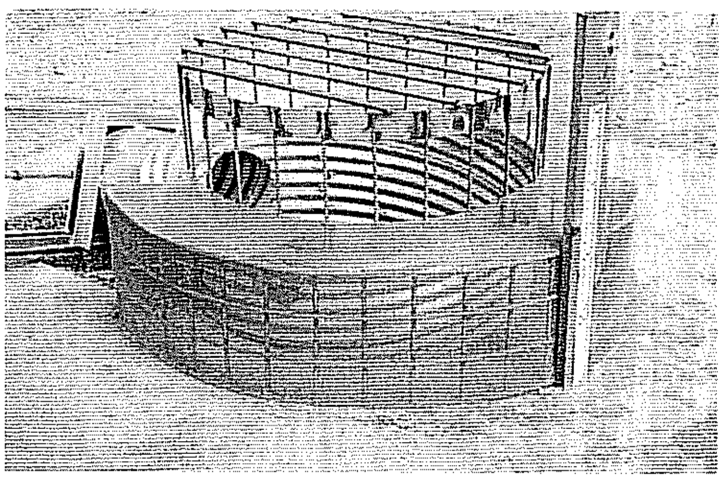


Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2g(H-H_o))^{0.5}$$

where:
Q = discharge (ft^3/s)
C = orifice coefficient
A = area of the orifice (ft^2)
g = gravitational constant (32.2)
H = water surface elevation (ft)
H_o= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and re-grade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

\$ 41,600 for a 1 acre-foot pond

\$ 239,000 for a 10 acre-foot pond

\$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about \$160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	**56**	**$668**	**$3,132**

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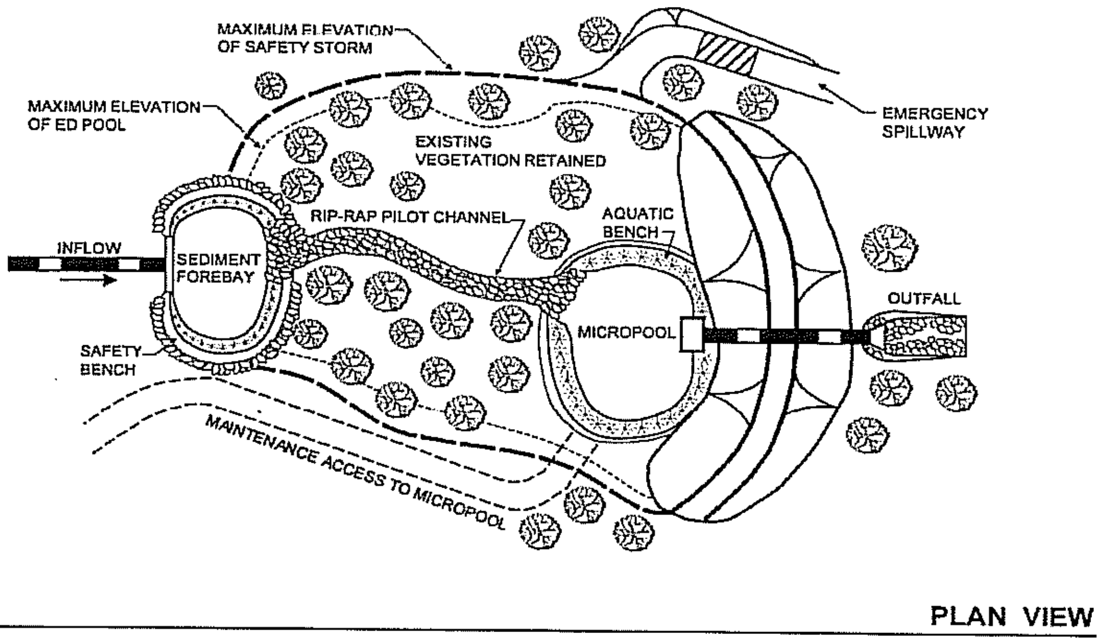
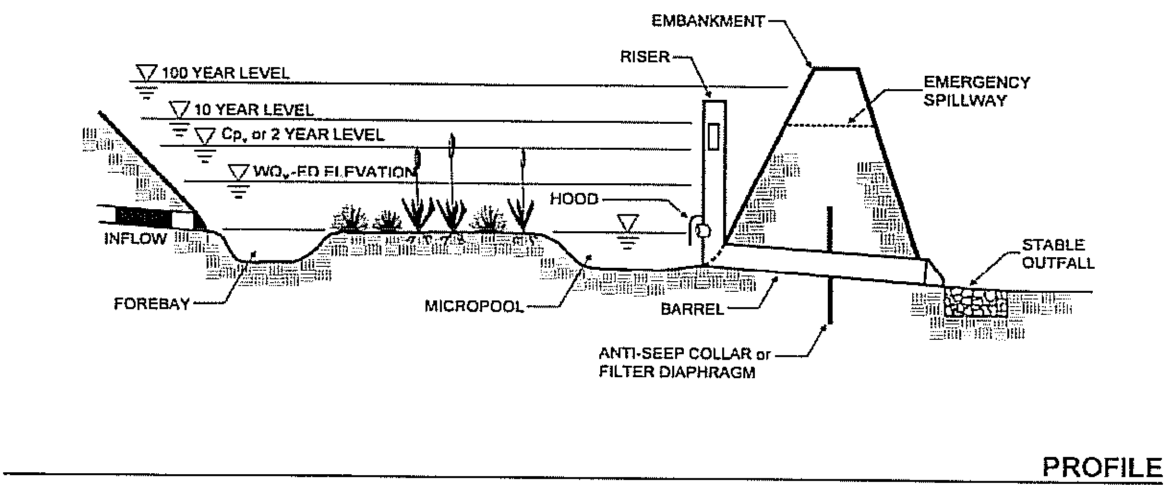
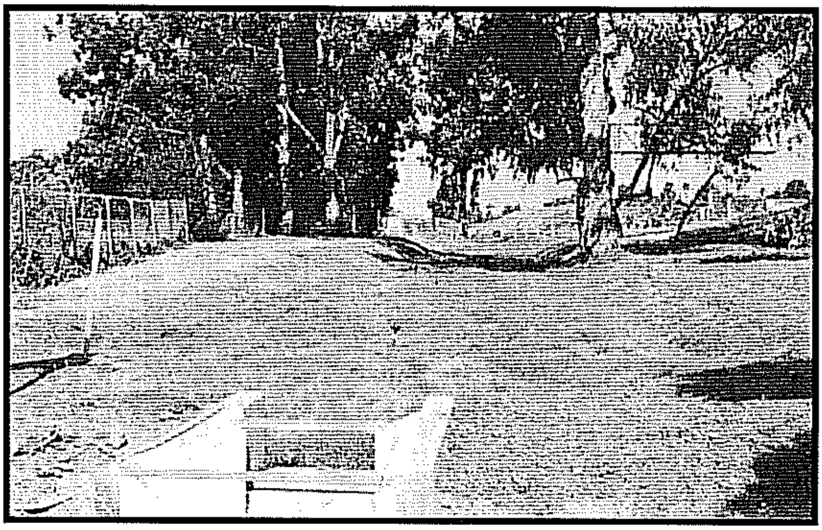




Schematic of an Extended Detention Basin (MDE, 2000)



Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	●
☑	Metals	▲
☑	Bacteria	●
☑	Oil and Grease	▲
☑	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data

Study	Removal Efficiencies (% Removal)						
	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,660
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width)		Comment
		1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	
Lawn Mowing	$0.85 / 1,000 ft^2/ mowing	$0.14 / linear foot	$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	$9.00 / 1,000 ft^2/ year	$0.18 / linear foot	$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	$0.10 / linear foot / year	$0.10 / linear foot	$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	$0.30 / yd^2	$0.01 / linear foot	$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	$0.15 / linear foot / year, plus $25 / inspection	$0.15 / linear foot	$0.15 / linear foot	Inspect four times per year
Total	--	**$0.58 / linear foot**	**$ 0.75 / linear foot**	--

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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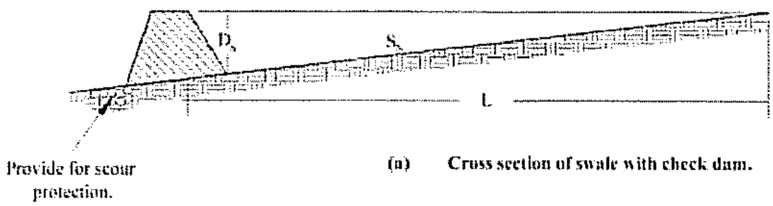
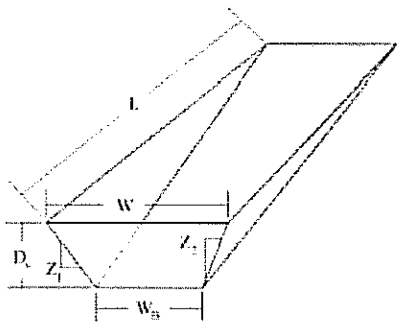


(a) Cross section of swale with check dam.



(b) Dimensional view of swale impoundment area.

Notation:

L = Length of swale impoundment area per check dam (ft)
D_S = Depth of check dam (ft)
S_S = Bottom slpe of swale (ft/ft)
W = Top width of check dam (ft)
W_B = Bottom width of check dam (ft)
$Z_{1\&2}$ = Ratio of horizontal to vertical change in swale side slope (ft/ft)

Description

A multiple treatment system uses two or more BMPs in series. Some examples of multiple systems include: settling basin combined with a sand filter; settling basin or biofilter combined with an infiltration basin or trench; extended detention zone on a wet pond.

California Experience

The research wetlands at Fremont, California are a combination of wet ponds, wetlands, and vegetated controls.

Advantages

- BMPs that are less sensitive to high pollutant loadings, especially solids, can be used to pretreat runoff for sand filters and infiltration devices where the potential for clogging exists.
- BMPs which target different constituents can be combined to provide treatment for all constituents of concern.
- BMPs which use different removal processes (sedimentation, filtration, biological uptake) can be combined to improve the overall removal efficiency for a given constituent.
- BMPs in series can provide redundancy and reduce the likelihood of total system failure.

Limitations

- Capital costs of multiple systems are higher than for single devices.
- Space requirements are greater than that required for a single technology.

Design and Sizing Guidelines

Refer to individual treatment control BMP fact sheets.

Performance

- Be aware that placing multiple BMPs in series does not necessarily result in combined cumulative increased performance. This is because the first BMP may already achieve part of the gain normally achieved by the second BMP. On the other hand, picking the right combination can often help optimize performance of the second BMP since the influent to the second BMP is of more consistent water quality, and thus more consistent performance, thereby allowing the BMP to achieve its highest performance.

Design Considerations

- Area Required
- Slope
- Water Availability
- Hydraulic Head
- Environmental Side-effects

Targeted Constituents

☑	Sediment	■
☑	Nutrients	●
☑	Trash	■
☑	Metals	■
☑	Bacteria	▲
☑	Oil and Grease	■
☑	Organics	■

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA

CALIFORNIA STORMWATER

- When addressing multiple constituents through multiple BMPs, one BMP may optimize removal of a particular constituent, while another BMP optimizes removal of a different constituent or set of constituents. Therefore, selecting the right combination of BMPs can be very constructive in collectively removing multiple constituents.

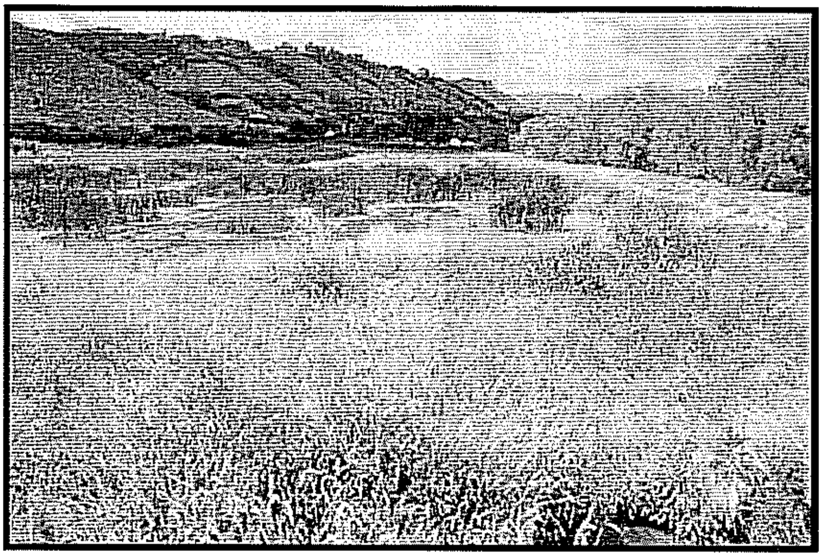
Siting Criteria
Refer to individual treatment control BMP fact sheets.

Additional Design Guidelines
- When using two or more BMPs in series, it may be possible to reduce the size of BMPs.
- Existing pretreatment requirements may be able to be avoided when using some BMP combinations.

Maintenance
Refer to individual treatment control BMP fact sheets.

Cost
Refer to individual treatment control BMP fact sheets.

Resources and Sources of Additional Information
Refer to individual treatment control BMP fact sheets.



Design Considerations

- Area Required
- Slope
- Water Availability
- Aesthetics
- Environmental Side-effects

Targeted Constituents

☑	Sediment	■
☑	Nutrients	▲
☑	Trash	■
☑	Metals	■
☑	Bacteria	■
☑	Oil and Grease	■
☑	Organics	■

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

Description

Constructed wetlands are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season) and differ from wet ponds primarily in being shallower and having greater vegetation coverage. The schematic diagram is of an on-line pond that includes detention for larger events, but this is not required in all areas of the state.

A distinction should be made between using a constructed wetland for storm water management and diverting storm water into a natural wetland. The latter practice is not recommended and in all circumstances, natural wetlands should be protected from the adverse effects of development, including impacts from increased storm water runoff. This is especially important because natural wetlands provide storm water and flood control benefits on a regional scale.

Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic value. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the wetland. Flow through the root systems forces the vegetation to remove nutrients and dissolved pollutants from the stormwater.

California Experience

The City of Laguna Niguel in Orange County has constructed several wetlands, primarily to reduce bacteria concentrations in dry weather flows. The wetlands have been very successful in this regard. Even though there is not enough perennial flow to maintain the permanent pool at a constant elevation, the wetland vegetation has thrived.

Advantages

- If properly designed, constructed and maintained, wet basins can provide substantial wildlife and wetlands habitat.
- Due to the presence of the permanent wet pool, properly designed and maintained wet basins can provide significant water quality improvement across a relatively broad spectrum of constituents including dissolved nutrients.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency relationships resulting from the increase of impervious cover in a watershed.

Limitations

- There may be some aesthetic concerns about a facility that looks swampy.
- Some concern about safety when constructed where there is public access.
- Mosquito and midge breeding is likely to occur in wetlands.
- Cannot be placed on steep unstable slopes.
- Need for base flow or supplemental water if water level is to be maintained.
- Require a relatively large footprint
- Depending on volume and depth, pond designs may require approval from the State Division of Safety of Dams

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.
- Outlet designed to discharge the capture volume over a period of 24 hours.
- Permanent pool volume equal to twice the water quality volume.
- Water depth not to exceed about 4 feet.
- Wetland vegetation occupying no more than 50% of surface area.
- Include energy dissipation in the inlet design and a sediment forebay to reduce resuspension of accumulated sediment and facilitate maintenance.
- A maintenance ramp should be included in the design to facilitate access to the forebay for maintenance activities and for vector surveillance and control.
- To facilitate vector surveillance and control activities, road access should be provided along at least one side of BMPs that are seven meters or less in width. Those BMPs that have shoreline-to-shoreline distances in excess of seven meters should have perimeter road access on both sides or be designed such that no parcel of water is greater than seven meters from the road.

Construction/Inspection Considerations

- In areas with porous soils an impermeable liner may be required to maintain an adequate permanent pool level.
- Outlet structures and piping should be installed with collars to prevent water from seeping through the fill and causing structural failure.
- Inspect facility after first large storm to determine whether the desired residence time has been achieved.

Performance

The processes that impact the performance of constructed wetlands are essentially the same as those operating in wet ponds and similar pollutant reduction would be expected. One concern about the long-term performance of wetlands is associated with the vegetation density. If vegetation covers the majority of the facility, open water is confined to a few well defined channels. This can limit mixing of the stormwater runoff with the permanent pool and reduce the effectiveness as compared to a wet pond where a majority of the area is open water.

Siting Criteria

Wet ponds are a widely applicable stormwater management practice and can be used over a broad range of storm frequencies and sizes, drainage areas and land use types. Although they have limited applicability in highly urbanized settings and in arid climates, they have few other restrictions. Constructed wetlands may be constructed on- or off-line and can be sited at feasible locations along established drainage ways with consistent base flow. An off-line design is preferred. Constructed wetlands are often utilized in smaller sub-watersheds and are particularly appropriate in areas with residential land uses or other areas where high nutrient loads are considered to be potential problems (e.g., golf courses).

Wetlands generally consume a fairly large area (typically 4-6 percent of the contributing drainage area), and these facilities are generally larger than wet ponds because the average depth is less.

Wet basin application is appropriate in the following settings: (1) where there is a need to achieve a reasonably high level of dissolved contaminant removal and/or sediment capture; (2) in small to medium-sized regional tributary areas with available open space and drainage areas greater than about 10 ha (25 ac.); (3) where base flow rates or other channel flow sources are relatively consistent year-round; (4) in settings where wildlife habitat benefits can be appreciated.

Additional Design Guidelines

Constructed wetlands generally feature relatively uniformly vegetated areas with depths of one foot or less and open water areas (25-50% of the total area) no more than about 1.2 m (4 feet) deep, although design configuration options are relatively flexible. Wetland vegetation is comprised generally of a diverse, local aquatic plant species. Constructed wetlands can be designed on-line or off-line and generally serve relatively smaller drainage areas than wet ponds, although because of the shallow depths, the footprint of the facility will be larger than a wet pond serving the same tributary area.

The extended detention shallow wetland combines the treatment concepts of the dry extended detention pond and the constructed wetland. In this design, the water quality volume is detained above the permanent pool and released over 24 hours. In addition to increasing the residence time, which improves pollutant removal, this design also attenuates peak runoff rates. Consequently, this design alternative is recommended.

Pretreatment incorporates design features that help to settle out coarse sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In ponds, pretreatment is achieved with a sediment forebay. A sediment forebay is a small pool (typically about 10 percent of the volume of the permanent pool). Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool, eliminating the need to dredge the entire pond.

Effective wetland design displays "complex microtopography." In other words, wetlands should have zones of both very shallow (<6 inches) and moderately shallow (<18 inches) wetlands incorporated, using underwater earth berms to create the zones. This design will provide a longer flow path through the wetland to encourage settling, and it provides two depth zones to encourage plant diversity.

There are a variety of sizing criteria for determining the volume of the permanent pool, mostly related to the water quality volume (i.e., the volume of water treated for pollutant removal) or the average storm size in a particular area. In addition, several theoretical approaches to determination of permanent pool volume have been developed. However, there is little empirical evidence to support these designs. Consequently, a simplified method (i.e., permanent pool volume equal to twice the water quality volume) is recommended.

Design features are also incorporated to ease maintenance of both the forebay and the main pool of ponds. Ponds should be designed with a maintenance access to the forebay to ease this relatively routine (every 5–7 year) maintenance activity. In addition, ponds should generally have a drain to draw down the pond for vegetation harvesting or the more infrequent dredging of the main cell of the pond.

Summary of Design Recommendations

(1) Facility Sizing – The basin should be sized to hold the permanent pool as well as the required water quality volume. The volume of the permanent pool should equal twice the water quality volume.

(2) Pond Configuration - The wet basin should be configured as a two stage facility with a sediment forebay and a main pool. The basins should be wedge-shaped, narrowest at the inlet and widest at the outlet. The minimum length to width ratio should be 1.5 where feasible. The depth in the center of the basin should be about 4 feet deep to prevent vegetation from encroaching on the pond open water surface.

(3) Pond Side Slopes - Side slopes of the basin should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 should be stabilized with an appropriate slope stabilization practice.

(4) Sediment Forebay - A sediment forebay should be used to isolate gross sediments as they enter the facility and to simplify sediment removal. The sediment forebay

should consist of a separate cell formed by an earthen berm, gabion, or loose riprap wall. The forebay should be sized to contain 15 to 25% of the permanent pool volume and should be at least 3 feet deep. Exit velocities from the forebay should not be erosive. Direct maintenance access should be provided to the forebay. The bottom of the forebay may be hardened (concrete) to make sediment removal easier. A fixed vertical sediment depth marker should be installed in the forebay to measure sediment accumulation.

(5) Splitter Box - When the pond is designed as an off-line facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year event while providing at least 1.0 foot of freeboard along pond side slopes.

(6) Vegetation - A plan should be prepared that indicates how aquatic and terrestrial areas will be vegetatively stabilized. Wetland vegetation elements should be placed along the aquatic bench or in the shallow portions of the permanent pool. The optimal elevation for planting of wetland vegetation is within 6 inches vertically of the normal pool elevation. A list of some wetland vegetation native to California is presented in the wet pond fact sheet.

Maintenance

The amount of maintenance required for a constructed wetland is highly dependent on local regulatory agencies, particular health and vector control agencies. These agencies are often extremely concerned about the potential for mosquito breeding that may occur in the permanent pool.

Routine harvesting of vegetation may increase nutrient removal and prevent the export of these constituents from dead and dying plants falling in the water. A previous study (Faulkner and Richardson, 1991) documented dramatic reductions in nutrient removal after the first several years of operation and related it to the vegetation achieving a maximum density. Vegetation harvesting in the summer is recommended.

Typical maintenance activities and frequencies include:

- Schedule semiannual inspections for burrows, sediment accumulation, structural integrity of the outlet, and litter accumulation.
- Remove accumulated trash and debris in the basin at the middle and end of the wet season. The frequency of this activity may be altered to meet specific site conditions and aesthetic considerations.
- Where permitted by the Department of Fish and Game or other agency regulations, stock wet ponds/constructed wetlands regularly with mosquito fish (*Gambusia spp.*) to enhance natural mosquito and midge control.
- Introduce mosquito fish and maintain vegetation to assist their movements to control mosquitoes, as well as to provide access for vector inspectors. An annual vegetation harvest in summer appears to be optimum, in that it is after the bird breeding season, mosquito fish can provide the needed control until vegetation reaches late summer density, and there is

time for re-growth for runoff treatment purposes before the wet season. In certain cases, more frequent plant harvesting may be required by local vector control agencies.

- Maintain emergent and perimeter shoreline vegetation as well as site and road access to facilitate vector surveillance and control activities.
- Remove accumulated sediment in the forebay and regrade about every 5-7 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Sediment removal may not be required in the main pool area for as long as 20 years.

Cost

Construction Cost

Wetlands are relatively inexpensive storm water practices. Construction cost data for wetlands are rare, but one simplifying assumption is that they are typically about 25 percent more expensive than storm water ponds of an equivalent volume. Using this assumption, an equation developed by Brown and Schueler (1997) to estimate the cost of wet ponds can be modified to estimate the cost of storm water wetlands using the equation:

$$C = 30.6^{V0.705}$$

where:

C = Construction, design, and permitting cost;

V = Wetland volume needed to control the 10-year storm (ft3).

Using this equation, typical construction costs are the following:

$ 57,100 for a 1 acre-foot facility

$ 289,000 for a 10 acre-foot facility

$ 1,470,000 for a 100 acre-foot facility

Wetlands consume about 3 to 5 percent of the land that drains to them, which is relatively high compared with other storm water management practices. In areas where land value is high, this may make wetlands an infeasible option.

Maintenance Cost

For ponds, the annual cost of routine maintenance has typically been estimated at about 3 to 5 percent of the construction cost; however, the published literature is almost totally devoid of actual maintenance costs. Since ponds are long-lived facilities (typically longer than 20 years), major maintenance activities are unlikely to occur during a relatively short study.

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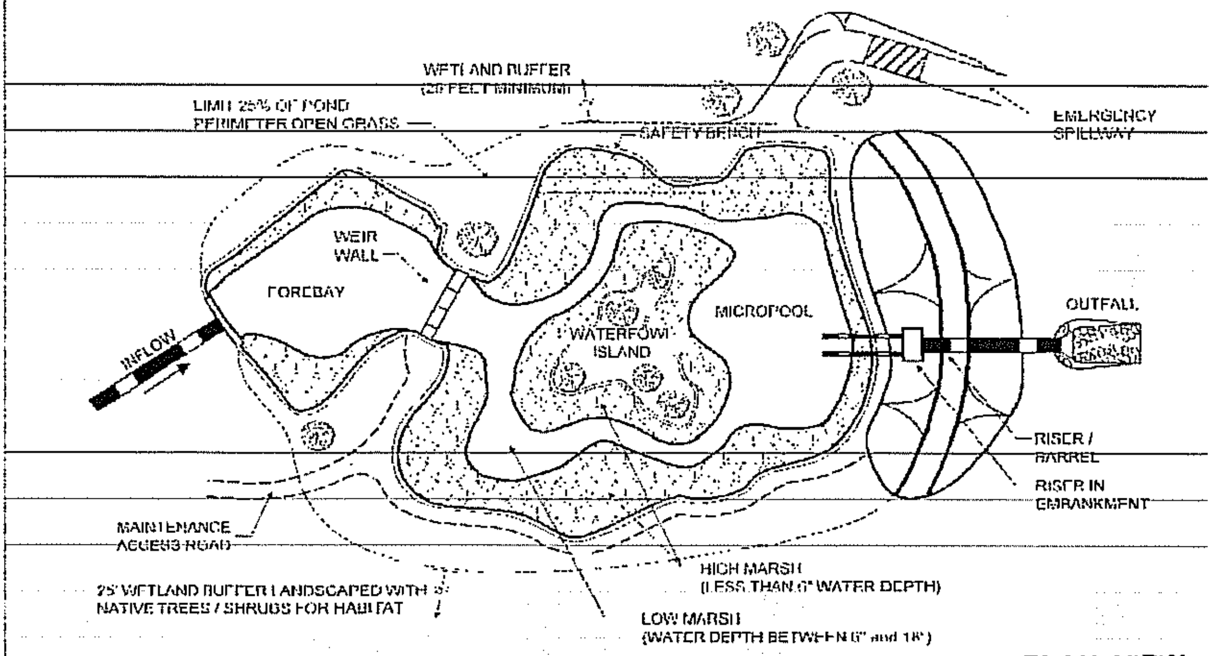
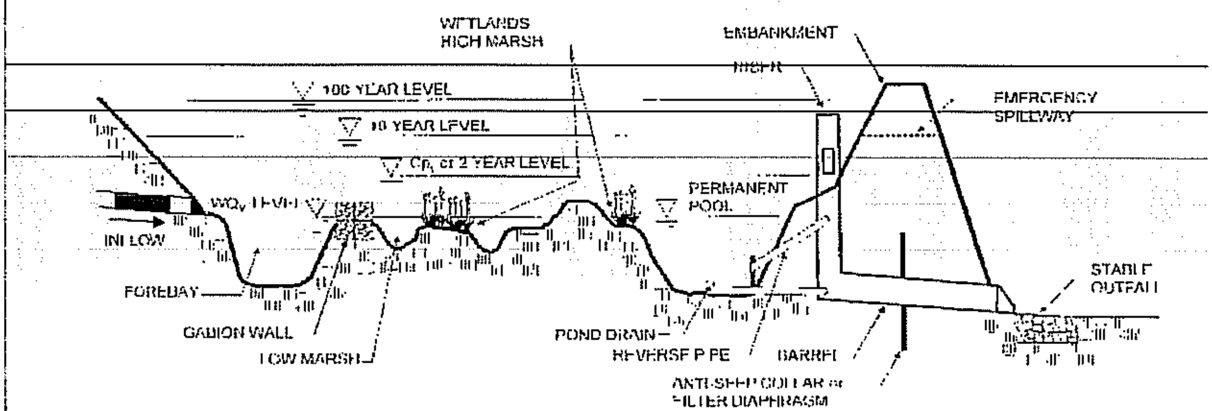


PLAN VIEW



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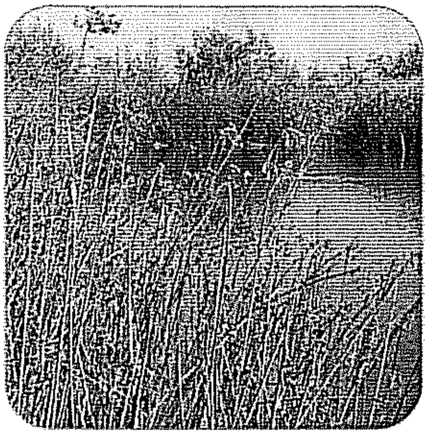

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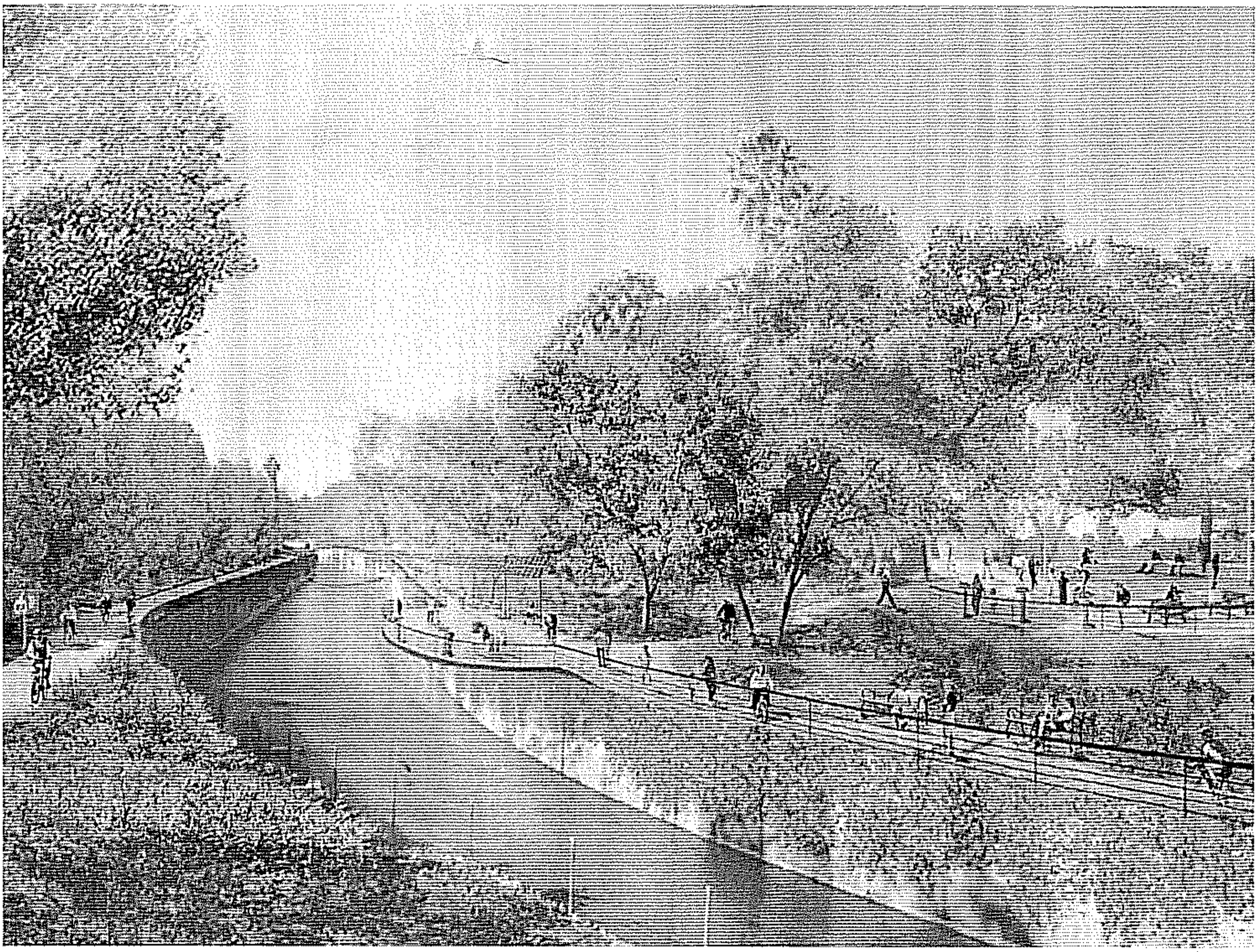

LOS ANGELES RIVER REGIONAL PUBLIC ACCESS FEASIBILITY ANALYSIS

STUDIO CITY, SAN FERNANDO VALLEY

PREPARED FOR:

FUNDED BY:
SANTA MONICA MOUNTAINS CONSERVANCY & SAVE L.A. RIVER OPEN SPACE

MIA LEHRER + ASSOCIATES
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SUMMARY

The Los Angeles River Natural Park site is located in Studio City, CA and has tremendous potential to become a multi-benefit, precedent-setting project with an emphasis on water quality improvements and regional public access to the Los Angeles River. Known as the Weddington Golf and Tennis facility, the 16-acres site abuts the Los Angeles River. A nearby public parking garage and improvements on the Los Angeles River trail are an integral part of the vision for the park, and have been incorporated into the definition of the project site.

This Los Angeles River Regional Public Access Feasibility Analysis evaluates the site's potential as a regional staging area and public access point for the Los Angeles River. This study identifies the river-related public access elements as well as the opportunity for connecting to existing and future bicycle networks to provide an opportunity for alternate methods of transportation. This study integrates the creation of regional public access with "Green Solution" water quality improvements and native habitat creation, as analyzed by Psomas, with planned improvements to the L.A. River and with links to a regional bicycle transportation network.

Detailed regional and site analysis led to findings that support this site's suitability as a Regional River Access Hub which offers ample public parking, easy access via public transportation or bicycle, a direct connection to the Los Angeles River and many other project benefits. The project furthers the goals of the Los Angeles River Revitalization Master Plan as well as the City of Los Angeles 2010 Bicycle Plan and other regional plans to encourage multi-modal transportation alternatives.

A regional public access concept plan was developed for the L.A. River Natural Park to include the following multiple benefits. Off-site parking at the existing Public Parking Garage 500 yards downstream will allow visitors to easily reach the site via a short walk along an improved L.A. River Trail, while bicycle rentals and other bicycle amenities at the parking garage will provide easy bicycle access to the river trail and encourage bicycle usage. Visitors will be greeted at the project site with a signature gateway that clearly marks the Park entry and a river-themed Visitor Information Center. Cantilevered river terraces will provide views of the L.A. River, while bicycle corral and trail entrances will lead visitors both to the L.A. River Trail and into the site's natural habitat environment. Interpretive kiosks, signage and pedestrian paths through the site will allow visitors to experience the site's natural, habitat-oriented water quality improvement features. Signage and way finding will ensure a friendly and safe experience for visitors.

The public parking garage will be improved to be clearly visible and accessible from both Ventura Boulevard and the L.A. River, and the L.A. River Trail will be extended from the garage to Coldwater Canyon. A new pedestrian bridge crossing the L.A. River from the site will connect the L.A. River Natural Park to Ventura Boulevard and its many visitor-serving amenities.

As this Regional Public Access Feasibility Analysis demonstrates, the features and conditions existing at the Los Angeles River Natural Park site make it an ideal location for a regional hub and trailhead providing public access for people throughout the region to the Los Angeles River and its tributaries, as well as an ideal location for linking to regional bicycle networks.

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TABLE OF CONTENTS

LIST OF FIGURES

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PROJECT DESCRIPTION

NEED FOR REGIONAL PUBLIC ACCESS TO THE L.A. RIVER

The L.A. River Natural Park is a grand opportunity to provide a much needed regional gateway to the L.A. River. The lack of other such gateways has created a vast disconnect between the L.A. River and the City. This site has a unique potential to fill in that gap through a variety of different ways. Its close proximity to the public parking garage/bicycle hub, connections to numerous bus and Metro lines provides easy accessibility for its visitors. It will also have a positive impact on the environment by its capacity to naturally capture and clean polluted runoff and improve water quality in the L.A. River.

The Los Angeles River Natural Park is an opportunity to create a precedent-setting "smart", multi-benefit, river-oriented park on this last remaining, unprotected open space along the L.A. River in the San Fernando Valley. It includes development of regional public access to the L.A. River, riverfront preservation, water quality improvement, recreational opportunities and linkage to both public transit and regional bicycle transportation networks.

The project includes the 16-acre L.A. River Natural Park site in Studio City, a nearby public parking garage, and trail improvements along the L.A. River from the parking garage to Coldwater Canyon Blvd.

This report evaluates the feasibility of using the L.A. River Natural Park as a regional public access hub for the L.A. River. A site analysis was undertaken that looked at the site in its regional and local contexts and examined existing conditions and qualities of the site as well as opportunities and constraints. The regional analysis included the site's relationship to existing open space, public transit, City and County public transportation corridors, the City and County bicycle and trail networks, including both existing and proposed routes, adjacent zoning and amenities, issues with neighborhood compatibilities, the L.A. River Revitalization Master Plan and the L.A. River watershed, water quality and habitat. Prior studies were also consulted, including BlueGreen's Vision and Concept Design study and analysis and recommendations developed by Psomas' Hydrology, Hydraulic & Water Quality Components technical memorandum.

The L.A. River Natural Park integrates the creation of regional public access and a staging area for the L.A. River in the San Fernando Valley with the L.A. River Trail, important water quality improvements, habitat restoration, open space protection, active recreation (tennis & golf) and links to a regional bicycle transportation network. The project site would provide regional public access to the L.A. River for communities throughout the Valley and beyond, connect to upstream and downstream existing and planned river parks and trails, provide a centralized bicycle staging area and help to fulfill the goals of the City of Los Angeles L.A. River Revitalization Master Plan & recently-approved L.A. 2010 Bicycle Plan. The riverfront location for the project site would be maximized, would link to the existing L.A. River Trail system, expand regional transportation opportunities, provide a regional bicycle hub, and emphasize education about the L.A. River, the L.A. River watershed, water quality and habitat.

The increase in vehicular use in Los Angeles - an increase of 6500% since 1950 - correlates to urban sprawl, obesity, impersonal communities and increased greenhouse gas emissions, according to the Metropolitan Transportation Authority (Metro). Metro is engaged in an L.A. County mission-shift and is promoting alternative forms of travel as a strategy for congestion relief and climate protection. Recent relevant legislative and policy changes include:

- The Intermodal Surface Transportation Efficiency Act of 1991 that established funding and encouraged multiple modes of transportation, including bicycles and pedestrians
- California Complete Streets Act of 2008 (AB 1358), that requires that transportation facilities must be designed, planned, operated, and maintained for all users: bicyclists, pedestrians, transit vehicles and motorists
- U.S. Department of Transportation Policy on Bicycle and Pedestrian Accommodation 2010, which requires transportation agencies to plan, fund and implement improvements to walking and bicycling networks, including linkages to transit
- SB 375, Redesigning Communities to Reduce Greenhouse Gases 2009, which sets emission-reducing goals to support the development of sustainable communities.

The development of the L.A. River Natural Park site as an access point to the L.A. River and a hub that links trails and bicycle networks supports local and state efforts to promote alternative forms of movement, maximize mobility and build healthy communities.

There is a need for regional access to the L.A. River. As this feasibility analysis demonstrated, features and conditions exist in the proposed L.A. River Natural Park site that make it ideal for a regional hub and trailhead for public access to the L.A. River and its tributaries.

THE REGIONAL CONTEXT

THE L.A. RIVER

The Los Angeles River flows approximately 51 miles from its origin in the San Fernando Valley to Long Beach Harbor and the Pacific Ocean. The L.A. River runs east/southeast for 22 miles through the San Fernando Valley in the City of Los Angeles, along the cities of Burbank and Glendale, and then heads southward, flowing through the cities of Vernon, Commerce, Maywood, Bell, Bell Gardens, South Gate, Lynwood, Compton, Paramount, Carson, and Long Beach, where it enters San Pedro Bay.

THE L.A. RIVER IN THE SAN FERNANDO VALLEY

The L.A. River is a regional asset because it flows through many communities on its way through the Valley to San Pedro Bay. The river's headwaters are in Canoga Park at the confluence of Bell and Calabasas Creeks. It then flows through Reseda-West Van Nuys, Encino, and Tarzana, and through the Sepulveda Dam Recreational Area and Flood Control Basin. It continues through Van Nuys, Sherman Oaks, and Studio City, and then along the southern border of the City of Burbank and the northern border of Griffith Park, and through Elysian Valley, Lincoln Heights, Boyle Heights, and Downtown before flowing out of the City of Los Angeles.

Key tributaries of the L.A. River that include existing or renewed trail systems in the San Fernando Valley and in immediately adjacent areas include the Tujunga Wash, Pacoima Wash and the Arroyo Seco.

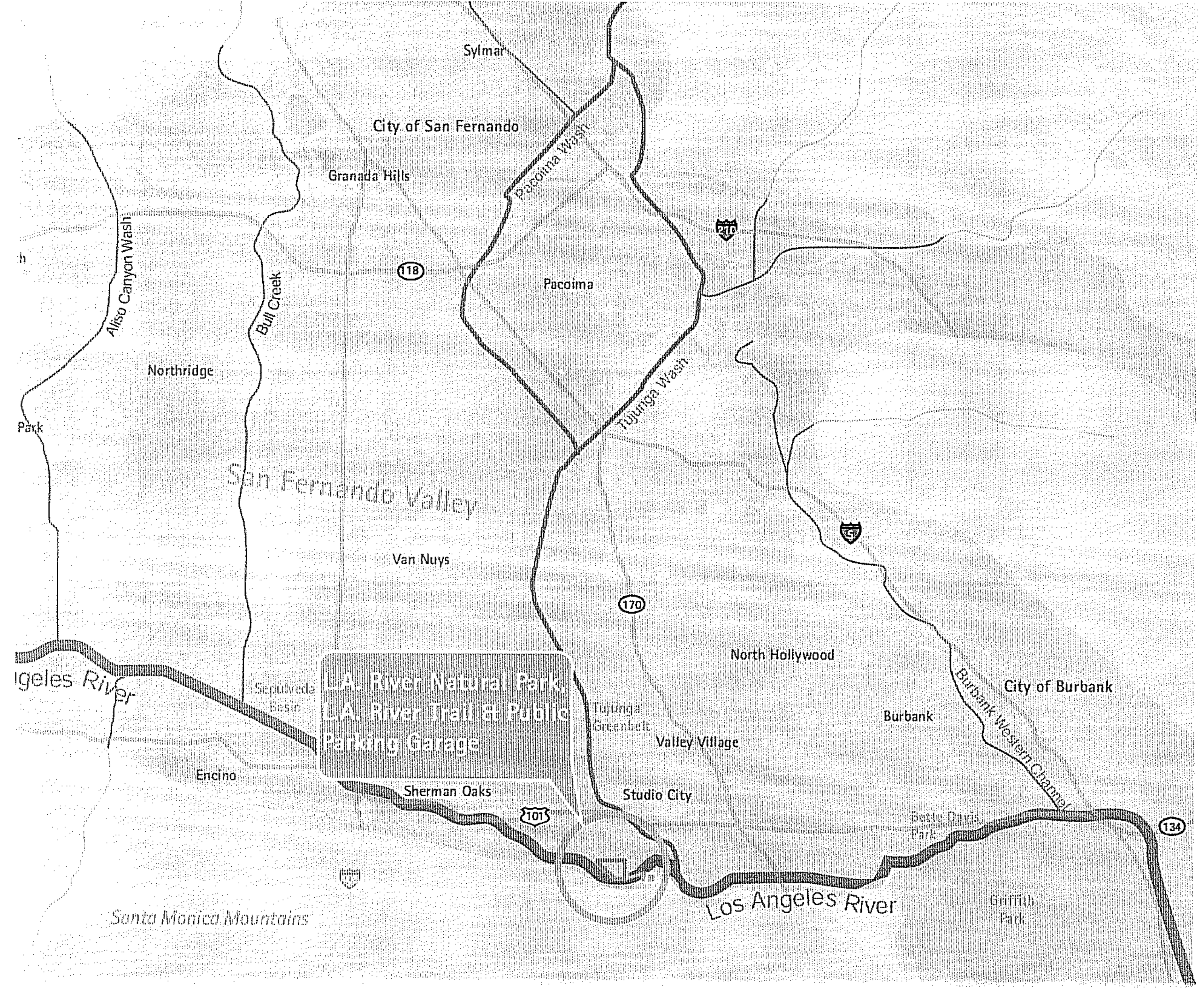
See Figure 1: Regional Context

Regional Bikeway Network

The L.A. River Natural Park, and the L.A. River Trail and Public Parking Garage that connect to the site, are located contiguous to a diversity of bicycle-friendly streets, lanes, paths, routes and transit stations as identified in the City of Los Angeles' 2010 Bicycle Plan. The 2010 Bicycle Plan identifies a network of 1,633 miles of continuous bikeways throughout the city, which will provide bicycle-friendly access to parks, schools, commercial areas and other key visitor destinations. The bike network will be comprised of off-street paths, routes, bicycle lanes and bicycle-friendly streets. As called for in the L.A. River Revitalization Master Plan, a continuous bicycle path will be installed along the south/west sides of the L.A. River. The L.A. River Natural Park has a bus stop and is near a number of bus lines.

In the area surrounding the project site, the 2010 Bicycle Plan identifies Laurel Canyon Blvd., Ventura Blvd., Valley Vista Blvd., Moorpark St., Riverside Dr., Colfax Ave., Tujunga Wash, Bellaire Ave., Hazeltine Ave., and the L.A. River Trails as part of either an existing regional bicycle network or segments to be improved or created.

VIEW OF LOS ANGELES RIVER FACING WEST
SOUTH SIDE OF THE LOS ANGELES RIVER ACROSS FROM PROJECT SITE



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THE PROJECT SITE

KEY ELEMENTS

The project site includes these three key elements:

- A 16-acre L.A. Riverfront parcel site
- An adjacent 391-space public parking garage and bicycle hub
- L.A. River Trail connections and improvements

The project site is a 16-acre parcel immediately adjacent to the L.A. River in Studio City between Whitsett Avenue and Coldwater Canyon Boulevard and is bordered on two sides by single family residential, on one side by multi-family residential and on one side by the L.A. River. Across the L.A. River are commercial/retail businesses along Ventura Blvd.

Currently privately-owned, the site has a 9-hole golf course, putting green, driving range, 16 tennis courts and club house and is utilized as a golf and regional tennis facility. The Los Angeles County Flood Control District owns and maintains the wide, unpaved rights-of-way along the L.A. River's edge along the property and across the river and the concrete flood channel.

A public parking garage owned by the City of Los Angeles is located 500 yards from the site, and is connected to the site via an existing L.A. River Trail and pedestrian bridge along a 1.5-mile stretch of improved river trail.

EXISTING CONDITIONS

LIMITED L.A. RIVER REGIONAL PUBLIC ACCESS IN THE SAN FERNANDO VALLEY

In the densely-developed San Fernando Valley, there are few places where the public can access the LA. River. Throughout the Valley, buildings exist up to the river right-of-way for nearly the entire length of the river, severely limiting opportunities for high-capacity public access. Adequate parking is necessary to create a trailhead and regional staging area for trails along the LA. River; currently there are no available large areas adjacent to the river for an appropriately-sized parking area.

While LA. River access for a large number of people could potentially be established at the Sepulveda Basin Recreation Area, this stretch of the LA. River is soft-bottom and is surrounded by important native habitat, making this site less than optimal for establishing a regional public access point.

Existing public access to the LA. River in the Valley is largely along busy streets, with no improved crossings, parking or other visitor-serving amenities. Two public parks do front the LA. River but do not have features that are key for the development of a regional hub. Bette Davis Picnic Area, part of Griffith Park and operated by the City of Los Angeles, is located in Glendale on the upstream end of the Glendale Narrows where Riverside Drive, Victory and Sonora meet, and is not conjoined with Griffith Park. It is small, unstaffed, has only limited on-street parking, and adjoins a walking/equestrian trail where bicycles are prohibited. It is 7.5 miles east of the proposed site of the LA. River Natural Park in a residential neighborhood with limited amenities and visitor-related services, and along with Griffith Park, services a different geographic sector.

See Figure 2: L.A. River Public Access Constraints

PARKING AND VEHICULAR ACCESS TO THE SITE

There are six freeways in the Valley (Interstate 405, U.S. Route 101, State Route 118, State Route 170, Interstate 210, and Interstate 5). Of these, the 101 (Hollywood/Ventura Freeway), 405 (San Diego Freeway) and 170 (Hollywood Freeway) are within a short distance of the project site, and two freeway exits are within one mile of the site.

A public parking garage owned by the City of Los Angeles with parking for 391 vehicles is located 500 yards from the site, within easy walking distance, and is connected to the site via an existing LA. River Trail and pedestrian bridge along a 1.5-mile stretch of improved river corridor. An existing trail is accessed from the rear of the parking structure via an ADA-compliant ramp that slopes down to the LA. River trail.

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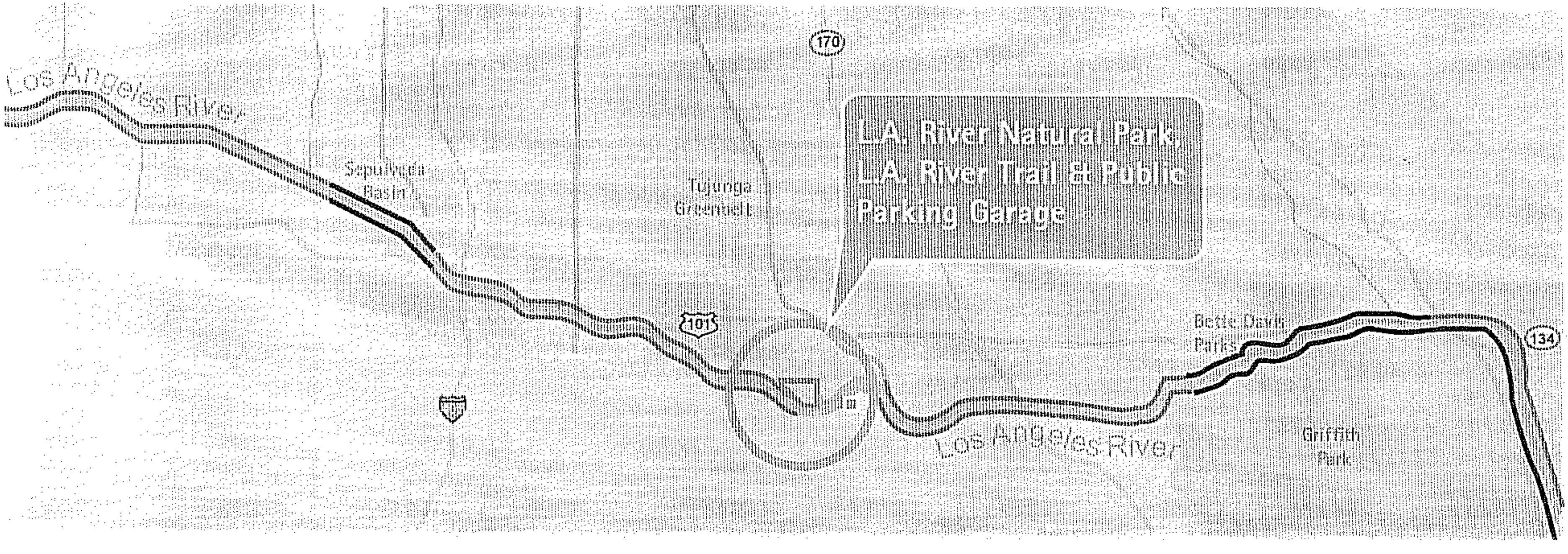
Aerial image of the project site



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L.A. RIVER TRAIL ACCESS

The existing multi-purpose L.A. River Trail extends from Whitsett downstream for 1.5 miles to Laurel Canyon and is used by pedestrians and bicyclists. The western end of the trail terminates at the pedestrian bridge that crosses the Los Angeles River and connects to Valleyheart Drive on the north.

BICYCLE ACCESS

Bikeways and Bicycle Access
There is currently no bicycle access to the project site, and no river trail connecting to the project site. The existing multi-purpose L.A. River Trail described above is part of the citywide bicycle network, and is a segment of a planned 51-mile contiguous bicycle path along the L.A. River. The existing 1.5 mile trail provides a pleasant, bicycle-friendly path along the river, completely separated from surrounding streets. Bicyclists must dismount and walk across Laurelgrove Ave., Colfax Ave., Whitsett Ave., and Laurel Canyon Blvd. There are no crosswalks at these trail crossings, and the streets are very busy.

A bicycle-friendly, ADA compliant ramp is located at the rear of the parking garage. The ramp connects to a pedestrian/bicycle-only bridge, which crosses the L.A. River at Laurelgrove Ave. and connects to Valleyheart Dr. The parking garage & connection to the L.A. River are not visible from Ventura Blvd.

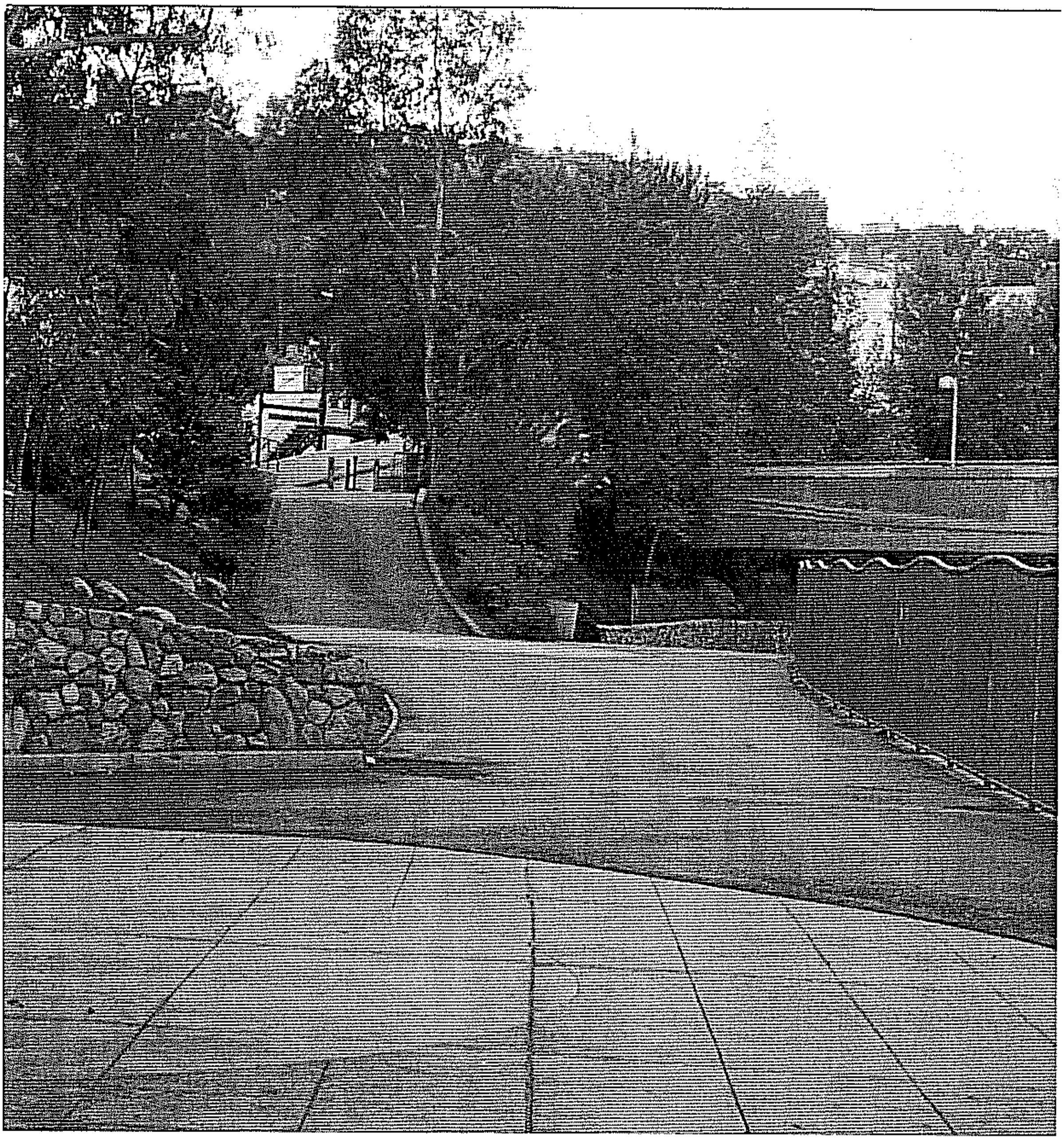
Bicycle lanes – painted lanes on existing streets – are located within one mile of the project site on Riverside Drive, and within two miles of the project site on Colfax Avenue and Chandler Blvd. A bicycle route along the MTA Orange Line exists within two miles of the site. No bicycle lanes or routes exist south of the site in the San Fernando Valley.

See Figures 3-4: 3.5 Mile Radius Bicycle Network Study
5 Mile Radius Bicycle Network Study

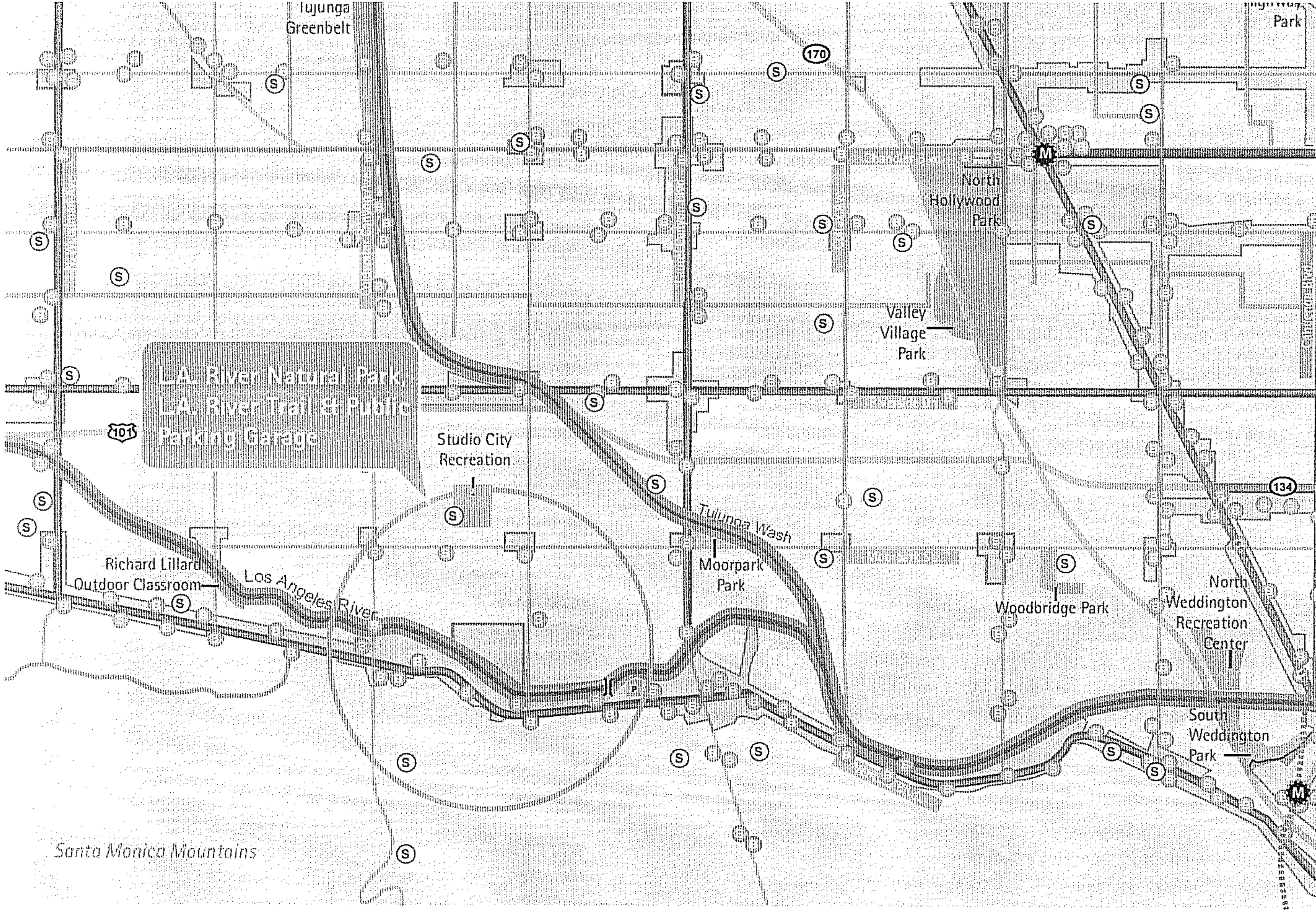
PUBLIC TRANSPORTATION AND PEDESTRIAN ACCESS

Public transportation is located in front of the project site and there is pedestrian access from Whitsett Avenue. Nearby, Ventura Blvd. provides visitor-serving amenities, including cafes, shops, dining, entertainment and farmers markets.

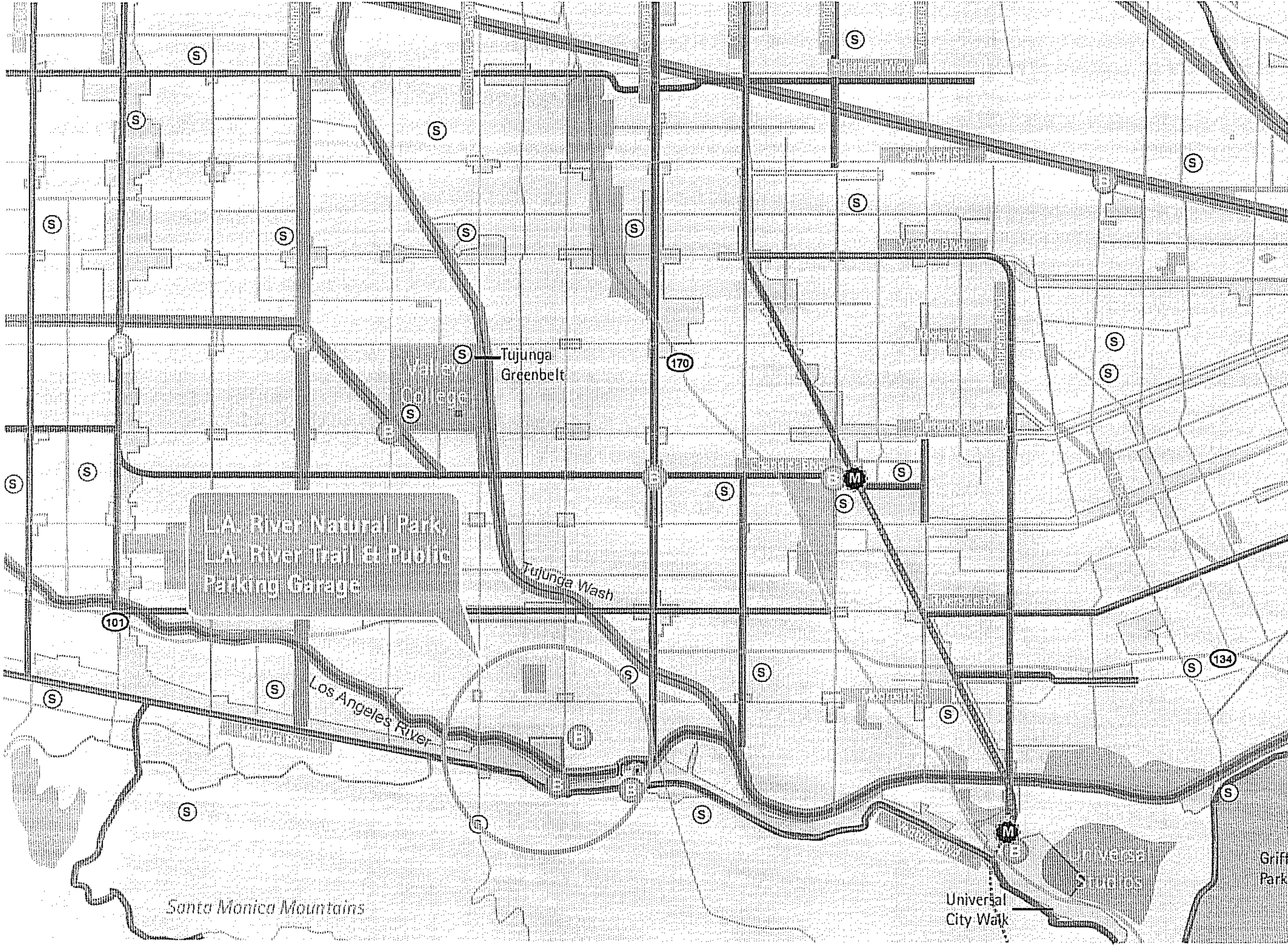
See Figure 5: Freeway, Streets, Transit + Walking Access



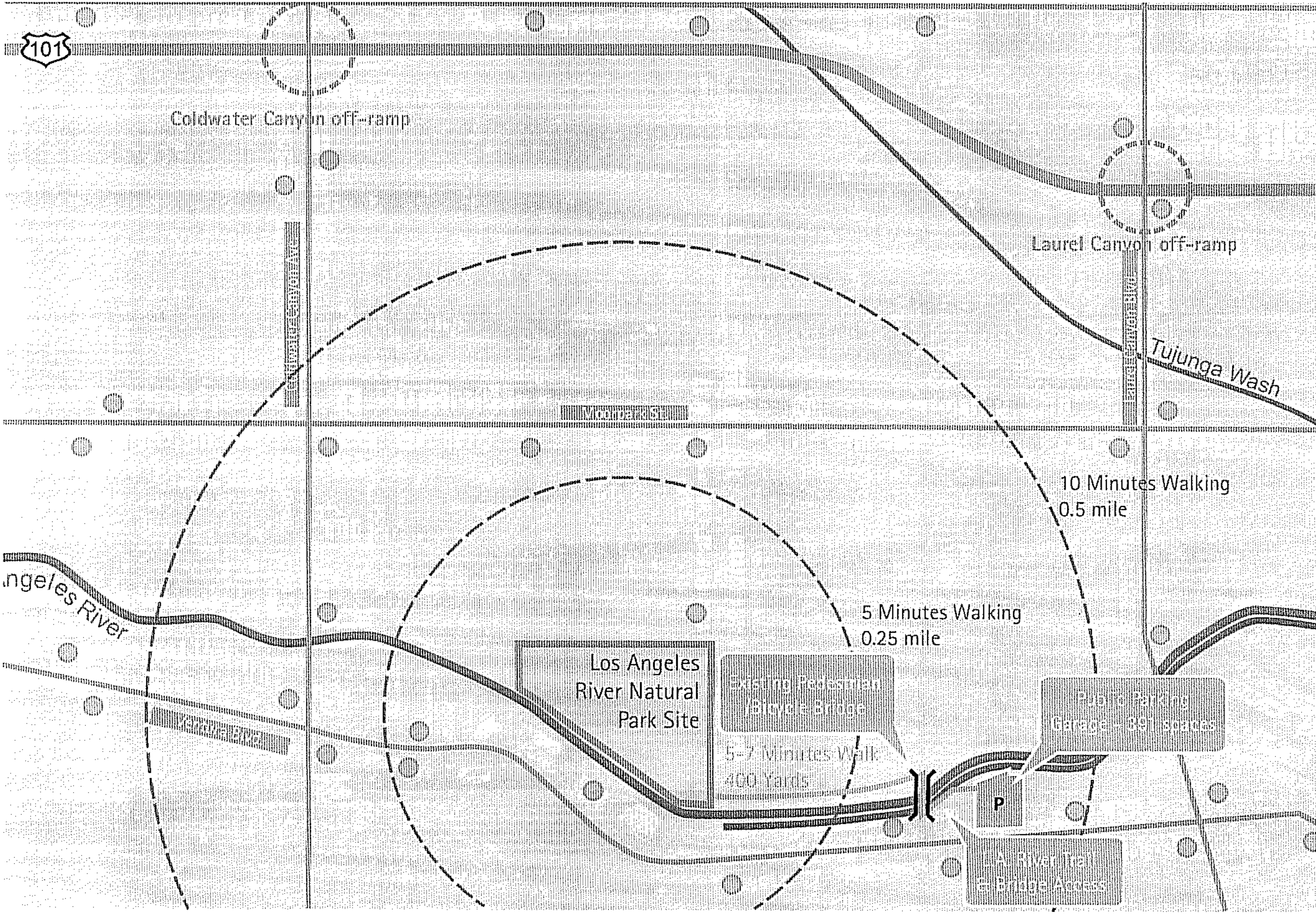
VIEW TOWARDS EXISTING PEDESTRIAN BRIDGE
WEST OF PARKING STRUCTURE



Tujunga Greenbelt
170
North Hollywood Park
Valley Village Park
L.A. River Natural Park
L.A. River Trail & Public Parking Garage
101
Studio City Recreation
134
Tujunga Wash
Moorpark Park
Woodbridge Park
North Weddington Recreation Center
South Weddington Park
Richard Lillard Outdoor Classroom
Los Angeles River
Santa Monica Mountains
Park



Tujunga Greenbelt
Valley College
170
L.A. River Natural Park
L.A. River Trail & Public Parking Garage
Tujunga Wash
101
Los Angeles River
134
Universal Studios
Universal City Walk
Santa Monica Mountains


101
Coldwater Canyon off-ramp
Laurel Canyon off-ramp
Tujunga Wash
10 Minutes Walking
0.5 mile
5 Minutes Walking
0.25 mile
Los Angeles
River Natural
Park Site
Existing Pedestrian
/Bicycle Bridge
5-7 Minutes Walk
400 Yards
Public Parking
Garage - 391 spaces
P
L.A. River Trail
& Bridge Access

THE VISION
L.A. RIVER REGIONAL PUBLIC ACCESS HUB & TRAILHEAD

WHAT IS AN L.A. RIVER 'REGIONAL PUBLIC ACCESS' HUB?

An LA. River regional public access hub must include these characteristics:

- Have easy access to the LA. River
- Be centrally located
- Have ample parking readily available
- Be bicycle-friendly and connect to a regional bikeway network
- Easily accessible by public transit
- Be a regional destination that attracts visitors
- Have established visitor-serving infrastructure and amenities
- Have potential for connection to other river trails
- Be accessible via multiple modes of transportation, including mass transit, bicycle and walking

The project site includes all of the above characteristics and is well-positioned to serve as a regional public access hub and trailhead for the LA. River in the San Fernando Valley and to provide a key bicycle staging area linking to regional bicycle networks. Development of this project site will create a regional trailhead/staging area for public access to the entire 51-mile LA. River Trail and other river parks and trails, including Tujunga, Pacoima and Arroyo Seco.

There is an opportunity to connect to river parks and trails on the 51-mile Los Angeles River and its tributaries, in particular to Coldwater Canyon Boulevard as part of this project and to the planned LA. River Trail improvements that include trails on both sides of the river. Other LA. River tributaries that already have river trails in place or are in planning stages and can be connected to the project site include the Tujunga Wash, Pacoima Wash and the Arroyo Seco.

OPPORTUNITIES

This project offers all of the attributes of an LA. River Regional Public Access Hub and includes additional amenities that contribute to regional public access.

1. LA. Riverfront location and central San Fernando Valley location

The project site is adjacent to the Los Angeles River and is centrally located in the San Fernando Valley with easy access from major streets and nearby freeways. In addition to vehicular access, there are multiple bus lines that stop either at or adjacent to the project site providing easy access via public transportation. There is also easy pedestrian and bike access. The site is located in an area with both residential and commercial land uses, and is one block from the Ventura Boulevard commercial corridor. Improving neighborhood walkability and wayfinding will benefit both local neighborhoods and regional visitors. In addition to Ventura Blvd., there are multiple destination points that can be accessed from the L.A. River Natural Park site, including regional parks and recreation facilities, metro lines, bus stops and schools. Universal Studios is located on the L.A. River, three miles from the project site. The L.A. River Natural Park will serve as a hub linking visitors to all of these destinations.

2. Parking

The multi-level, L.A. City-owned public parking garage that can accommodate 391 vehicles is immediately adjacent to the improved L.A. River Trail and is 500 yards from the project site. There is an existing ADA-compliant ramp that connects the parking garage to the existing L.A. River Trail. The parking garage is easily accessed from Ventura Boulevard, Coldwater Canyon Boulevard, and Laurel Canyon Boulevard and is close to two freeway off-ramps. The garage connects to an existing pedestrian bridge which crosses the L.A. River, providing access to both sides of the L.A. River and to the project site. This high-capacity parking garage is also an excellent location for a centralized bicycle hub, storage, and bicycle rental program to serve this project site as well as the rest of the L.A. River Trail system. It can provide an essential staging area to enhance the viability of a regional bicycle transportation network and to encourage bicycle use.

3. Connections to L.A. River Trail

The existing adjacent 1.5 mile L.A. River Trail connects the project site to the parking garage via a pedestrian bridge that links to the river trail and adjoining commercial/retail destinations on Ventura Boulevard.

4. Potential for easy connection to other river trails, existing and planned, including Tujunga Wash, Pacoima Wash and the Arroyo Seco.

5. Access to numerous regional destinations and visitor-serving amenities, including regional parks, recreation facilities, metro lines, bus stops, schools and commercial corridors.

6. Bicycle access and link to Regional Bike Transportation Network

The project site can be an important link with regional bicycle transportation networks by providing bicycle staging, parking, storage and some bicycle services.

The project site is positioned to contribute substantially to the implementation of the City of Los Angeles 2010 Bicycle Plan, approved March 2011, given its adjacency to the Neighborhood Bikeway, Green Bikeway and Backbone Bikeway Networks as detailed in that plan. It also achieves multiple goals set forth by the Southern California Association of Governments (SCAG) Non-Motorized Transportation Plan and Metropolitan Transportation Authority's Bicycle Transportation Strategic Plan. Los Angeles County's Plan of Bikeways, a sub-element to the L.A. County General Plan, covers bicycling issues in unincorporated areas of the County of Los Angeles and studies the potential for new and improved bike paths along flood control facilities – rivers, creeks, arroyos, washes and drains. Unincorporated areas in L.A. County are commonly non-contiguous but comprise over 2,600 square miles; this is an opportunity to support both the City and County's efforts and would serve as a link and connector for both City and County bike networks.

The project site can provide a regional bicycle hub and can be an important component of providing safe, accessible non-motorized opportunities to people throughout the San Fernando Valley and beyond. The site can contribute to a regional bicycle transportation network by providing bicycle-friendly access to the L.A. River, safe connections to planned bicycle routes along surrounding streets, and a regional bicycle staging area in the public parking garage. The parking garage can provide important bicycle amenities that facilitate bicycle access to the river and nearby visitor destinations, and that help encourage regional bicycle use and reduction of car trips.

Extensions to the L.A. River Trail can create a contiguous, off-street bicycle path for riders of all ages, providing recreation, commuting opportunities, and connections to parks, other cities, the commercial corridor along Ventura Blvd., and other regional destinations.

OTHER PROJECT BENEFITS

This project offers all of the attributes of an L.A. River Regional Public Access Hub and includes additional amenities that contribute to regional public access.

1. Further the goals of the L.A. River Revitalization Master Plan

   The Los Angeles River Revitalization Master Plan, adopted by the City of Los Angeles in 2005, outlines a series of goals for the L.A. River, neighborhoods along the river and the region. These goals include water quality treatment, the development of the L.A. River as a linear greenway to serve the entire region, connecting neighborhoods to the river and making it a focus of activity, and value for the residents of greater Los Angeles.

2. Further the goals of the Los Angeles 2010 Bicycle Plan

   The Los Angeles 2010 Bicycle Plan, adopted by the City of Los Angeles in March 2011, aims to "create an environment that increases, improves and enhances bicycling in the City as a safe, healthy, and enjoyable means of transportation and recreation for bicyclists..." The Plan's goals focus on making the City a bicycle-friendly community through creation of a citywide bikeway system that will encourage use of this healthy transportation alternative by all City residents; the Plan includes creating a wide diversity of bicycle-serving amenities, regional and neighborhood bikeways, and links with public transit and visitor-serving destinations. The City's 2010 Bicycle Plan is consistent with the L.A. City General Plan, the Southern California Association of Governments (SCAG) Non-Motorized Transportation Program, and Metropolitan Transportation Authority's Bicycle Transportation Strategic Plan.

   The L.A. River Natural Park project will help further these goals by 1) providing a central, easily-accessible public garage for parking and bicycle staging that connects to the L.A. River Trail and to many miles of city bikeways around the project site, and which includes bicycle parking, bicycle rental, and other key bicycle services; 2) establishing a site for regional public access to the L.A. River Trail system; and 3) creating new bicycle trails along the L.A. River that connect to city streets and planned bikeways. All of these improvements will enhance public access to the L.A. River Trail and connecting bikeway networks for residents throughout the Valley and beyond, and will provide access to nearby commercial areas, parks, Valley College, and public transit.

The Los Angeles 2010 Bicycle Plan incorporates the recommendation of the LA. River Revitalization Master Plan to provide a continuous bicycle path along the LA. River.

The LA. River Natural Park project's bicycle hub, bicycle-friendly features, trail linkages and connections to bikeway networks and surface transportation will forward regional goals for reducing car trips, maximizing mobility, encouraging use of bicycles to reach commercial, school, park and other visitor-serving destinations.

3. Help the City meet mandated air quality goals

By providing a regional bicycle hub and staging site, bicycle parking, new bike trails and links to a regional bikeway network, the project will encourage bicycle use and will help reduce the number of vehicle trips. This will help the City meet state-mandated air quality improvement and sustainability goals outlined by Assembly Bill 32, the Global Warming Solutions Act, Senate Bill 375 (aimed at reducing greenhouse gas emissions), and the Complete Streets Act of 2008.

4. Environmental and water quality improvement

Environmental benefits include natural treatment of stormwater and urban runoff to improve water quality in the LA. River, using creation of a complex of riparian and related native habitats. Polluted runoff will be captured from 200 acres of surrounding urban areas and naturally treated on-site. Stored water will be reused for irrigation. Restored habitat will provide nesting and foraging sites for numerous resident and migratory bird species.

5. Preserve L.A. Riverfront open space

The Los Angeles Neighborhood Land Trusts reports that LA. ranks last among major cities in per capita open space. The project will preserve the last remaining unprotected open space along 22 miles of the LA. River in the San Fernando Valley.

6. Improved signage and wayfinding

Development of way-finding and signage will benefit both local and regional visitors.

7. Community benefits

Community benefits include preserving and enhancing precious open space, the potential to incorporate mature trees, traffic calming and control, enhancing site and neighborhood security with perimeter fencing, addressing local flooding problems and improving drainage, preserving historic recreation, developing off-site parking, bike parking and public access, improving walking opportunities, strengthening connectivity to Ventura Boulevard, other commercial corridors, schools, parks, bus stops and metro lines, developing an educational/interpretive component and improving health and the quality of life in the San Fernando Valley.

The project will help address the open space deficit in the Valley, and will provide a critically-needed public access point to the L.A. River to serve residents from communities throughout the San Fernando Valley. Links to public transit will make the L.A. River easily accessible to a wide diversity of visitors. The site will provide a vital link that over time will connect to other river greenways, trails and parks in the Valley and beyond.

CONSTRAINTS

1. Lack of project site visibility

   The project site is screened from view from the site entrance on Whitsett Avenue. An existing berm and numerous palm trees prevent views of the site from the L.A. River.

2. Limited project site access and entry

   The entrance to the site is limited to Whitsett Avenue, and is constrained by the existing fire station at the southern corner. Neighborhoods on Valley Spring Lane and Bellaire Avenue preclude public access from these streets. There is currently no access from the L.A. River to the project site and there is a grade differential. However, there is a current plan sponsored and funded by the County that will develop the trail system.

3. No access between project site and Ventura Boulevard.

   There is no direct connection across the L.A. River to the adjacent commercial corridor located on Ventura Boulevard.

4. Traffic

   Whitsett Avenue is a busy street with no pedestrian crossings near the project entry, which is located mid-block, and no pedestrian crossing connecting to the L.A. River.

5. The parking garage is not visible from Ventura Boulevard nor from L.A. River

   The public parking garage is set back from Ventura Boulevard and there is no signage to properly identify the garage and clearly define the entrance, both from Ventura Boulevard and the L.A. River. The garage is not visually connected to the river because of the grade change between the garage and the river.

6. L.A. River Trail connectivity

There is currently no existing L.A. River Trail at the project site. Connection to the existing L.A. River Trail immediately downstream is via Valleyheart. Limited space would make a crossing under-grade below Whitsett Avenue difficult. Connecting from the planned L.A. River Trail extension to the project site would require coming up to street level and crossing Whitsett. The existing pedestrian bridge which connects the public parking garage to the existing L.A. River Trail crosses the river and connects to Valleyheart.

7. No bicycle amenities

The project site and L.A. River Trail connections are not bicycle-friendly. There are major gaps in the L.A. River Trail and in existing bicycle networks (bike lanes and streets) around the project site. No current bicycle connections to public transit or arterial streets exist at the project site, so Valley College and the heavily-used visitor destinations along Ventura Blvd. are not easily or safely accessible by bike. There is no place to park and unload bicycles in order to access the existing bike trail along the L.A. River. There are no bicycle crosswalks where the L.A. River Trail crosses the busy streets of Laurelgrove Ave. and Colfax Ave., nor at Whitsett Ave. where the project site is located.

CONCEPT PLAN
A REGIONAL GATEWAY TO THE L.A. RIVER

A natural, L.A. River-oriented park that is a regional gateway to the L.A. River, providing easy access for people through the region to the L.A. River Trail and to regional bicycle transportation networks.

See Figure 6: L.A. River Regional Public Access Concept Plan

THE VISION: L.A. RIVER REGIONAL PUBLIC ACCESS & BICYCLE HUB

The L.A. River Natural Park will be a regional gateway to the L.A. River that provides easy access, welcoming visitors from throughout the region. The nearby public parking garage/bicycle hub links visitors to the site via the L.A. River Trail, provides ample parking as well as bicycle staging, storage, repairs and rentals to connect to a regional bicycle network and increases non-motorized mobility. Connections to numerous bus lines and nearby Metro lines make the site easily accessible by public transit. Trail improvements along the L.A. River will extend the river trail to Coldwater Canyon Boulevard along both sides of the river from the parking garage and bicycle hub on Ventura Boulevard. A system of constructed, designed wetlands and natural habitat will naturally capture and clean polluted runoff, improving water quality in the L.A. River and creating a green oasis in the heart of the San Fernando Valley. Regional tennis courts, a driving range and putting green will be part of the park.

CONCEPT PLAN: A REGIONAL GATEWAY TO THE L.A. RIVER

This concept vision for the L.A. River Natural Park focuses on the proposed regional public access, regional bicycle network and public transit connection components of the project site, public parking garage and adjacent L.A. River Trails. The overall concept for the site also includes creation of habitat and green space to help naturally capture and treat urban runoff to improve water quality, related water storage, and active recreation (regional tennis, driving range and putting green).

The L.A. River Natural Park will be a regional hub for public access to the L.A. River, drawing visitors in and easily connecting to the nearby public parking garage and bicycle hub, public transit, river trails, citywide and neighborhood bicycle networks, schools, Valley College and the commercial corridor along Ventura Blvd.

1. PROJECT SITE

The site will feature an L.A. River Entry Plaza, Visitor Information Center, picnic areas and ample bicycle parking. The Entry Plaza fronts Whitsett Avenue with a signature gateway that clearly marks the L.A. River Natural Park entrance and invites visitors into the project site. A pedestrian crosswalk along Whitsett reinforces the entrance and promotes visitor safety. Through the gateway, the visitor is drawn in by a river-themed water feature, shade structure with interpretive kiosks integrated with the Visitor Information Center and bicycle parking. The Visitor Information Center sets the tone for the L.A. River Natural Park as an L.A. River regional public access hub and trailhead integrated with the site's showcase water quality improvement features, natural habitat, walking trails, links to regional bicycle networks and active recreation.

The public interface at the street transitions to an L.A. River Viewing Terrace, which features an observation deck and views of the L.A. River, picnic areas, seating and an entrance to the L.A. River Natural Park's walking trails. A walkway from the L.A. River Viewing Terrace brings visitors to a cantilevered deck over the L.A. River and connects to the L.A. River's bicycle and pedestrian trails. These L.A. River Trails connect visitors to the parking garage 500 yards downstream, and, via a new pedestrian/bicycle-only bridge upstream of the site, to cafes, restaurants and shopping on Ventura Boulevard.

2. L.A. RIVER PARKING GARAGE AND BIKE RENTAL

The L.A. City-owned and operated existing multi-level parking garage with 391 parking spaces that is located within 500 yards of the project site gives the site great advantage, and provides an opportunity to develop a regional bicycle hub with various visitor-serving bicycle amenities. The parking garage connects to the project site via an existing L.A. River Trail and pedestrian/bicycle bridge. The L.A. River Trail is accessed from the rear of the structure with an ADA-compliant ramp that slopes down to the trail. There is ample space to develop and house bicycle rental, storage and repair.

3. L.A. RIVER TRAIL IMPROVEMENTS: PARKING GARAGE TO COLDWATER CANYON

The access road along the north side of the L.A. River from the existing pedestrian/bicycle bridge to Coldwater Canyon would be improved to provide a continuous pedestrian and bicycle trail. This L.A. River Trail would include landscaping with native plants, signage, seating and solar panels to offset electrical usage at the site. The City of Los Angeles is currently developing L.A. River Trail improvements on the south side of the river from Whitsett Blvd. to Coldwater Canyon, including trail enhancements, seating, slope stabilization and landscaping.

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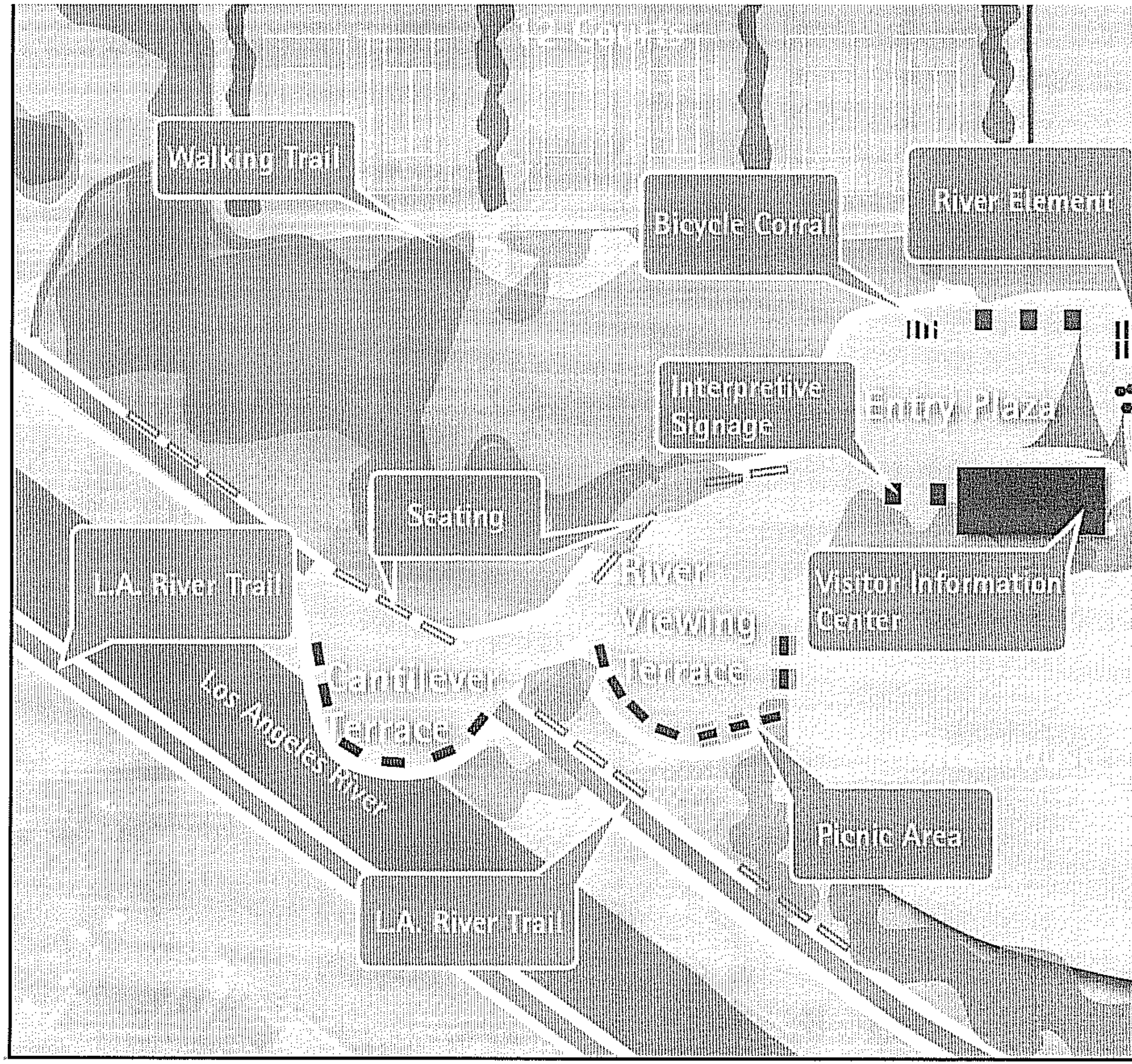

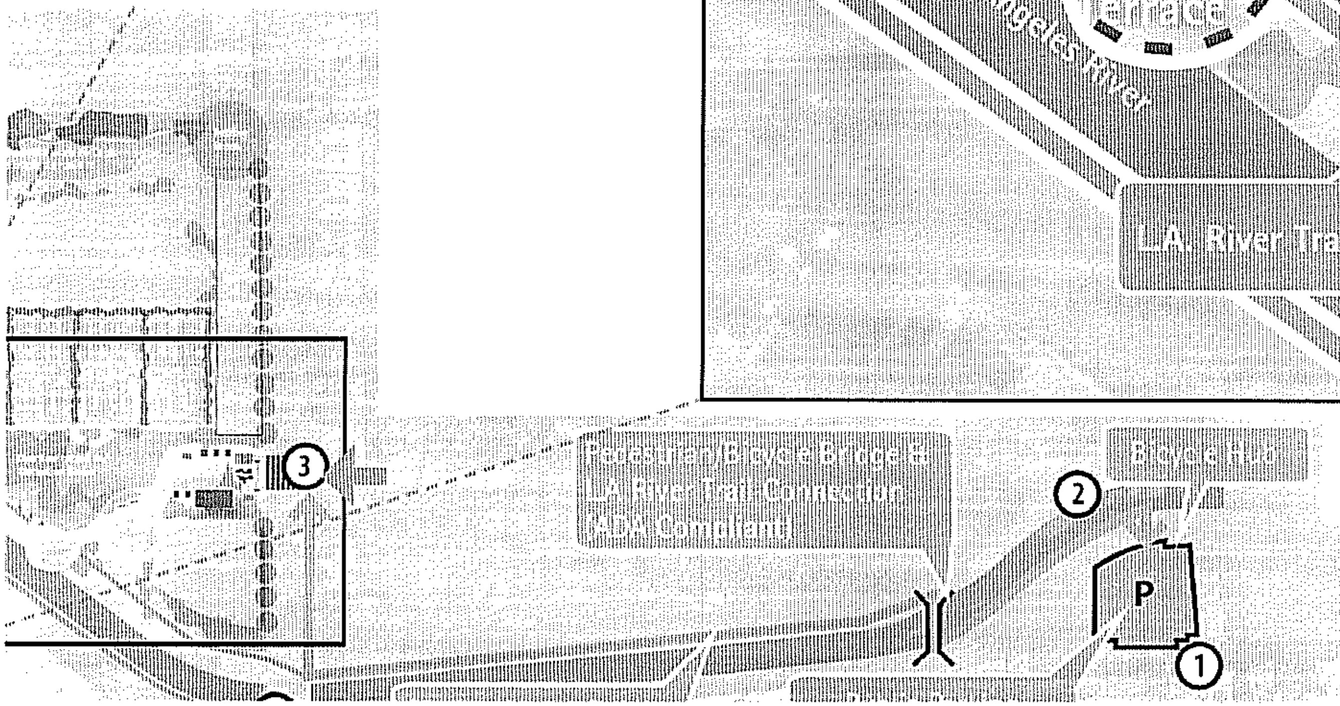

L.A. RIVER REGIONAL PUBLIC ACCESS CONCEPT VISION

The Los Angeles River Natural Park features the following program components:

1. L.A. RIVER GATEWAY
   - Crosswalk and traffic calming at entrance access point
   - Enhanced street buffer along Whitsett Avenue
   - Entry Plaza: Public greeting area
   - Visitor information center
   - Shade structure
   - Information and interpretive kiosks
   - Bicycle corral
   - River-themed water feature
   - L.A. River Viewing Terrace
     - Picnic areas
     - Observation deck
     - Seating
     - Trailhead to site Natural Park walking paths
   - L.A. River Terrace at river's edge
     - Seating, observation

2. L.A. RIVER PUBLIC PARKING GARAGE AND BICYCLE RENTAL
   - Off-site parking in existing public garage on the L.A. River 500 yards downstream
   - Easy connection to L.A. River Trail and pedestrian/bicycle bridge (existing)
   - Development of bicycle hub with bicycle amenities linked to regional bicycle network
     - Wayfaring signage to L.A. River Trail, regional bicycle network and destinations
     - Bicycle rental signage
     - Bicycle staging, parking and storage
     - Bicycle rental program
     - Light bicycle repair

3. L.A. RIVER TRAIL IMPROVEMENTS
   - Multi-use river trail, fencing and native landscaping from parking garage/bicycle hub to Coldwater Canyon
   - Pedestrian/bicycle bridge at parking garage/bicycle hub
   - L.A. River Trail improved from parking garage/bicycle hub, across Whitsett Avenue to Coldwater Canyon Boulevard, including linkages to project site
   - L.A. River Trail improved from Whitsett Avenue to Coldwater Canyon Boulevard across river from site
   - New pedestrian bridge from project site to connect to Ventura Boulevard

See Figures 7-10: Illustration #1: L.A. River Parking Garage & Bicycle Hub
Illustration #2: Parking Garage, L.A. River Trail & L.A. River Access
Illustration #3: L.A. River Gateway & Entry Plaza
Illustration #4: L.A. River Viewing Terrace & River Trail

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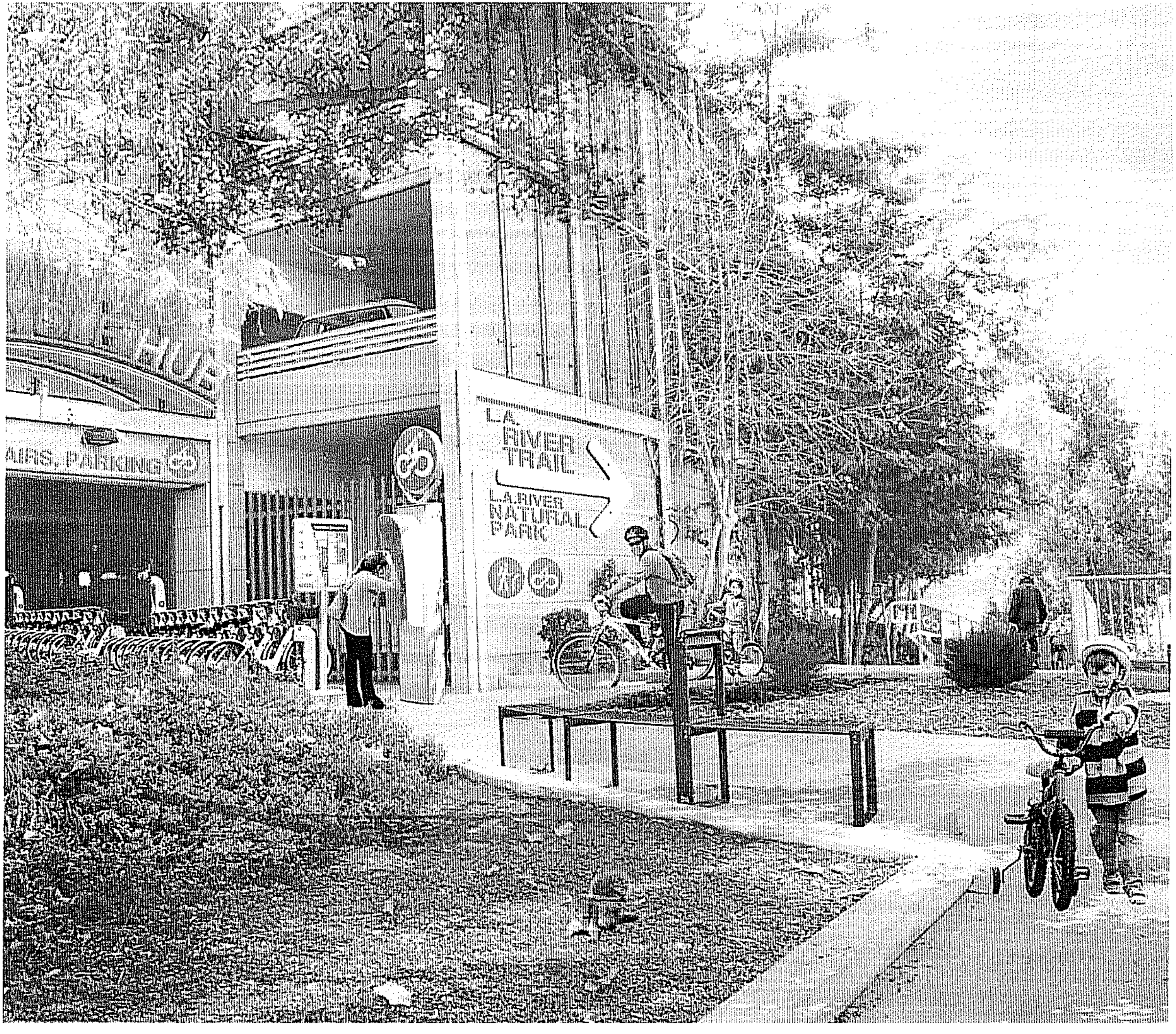
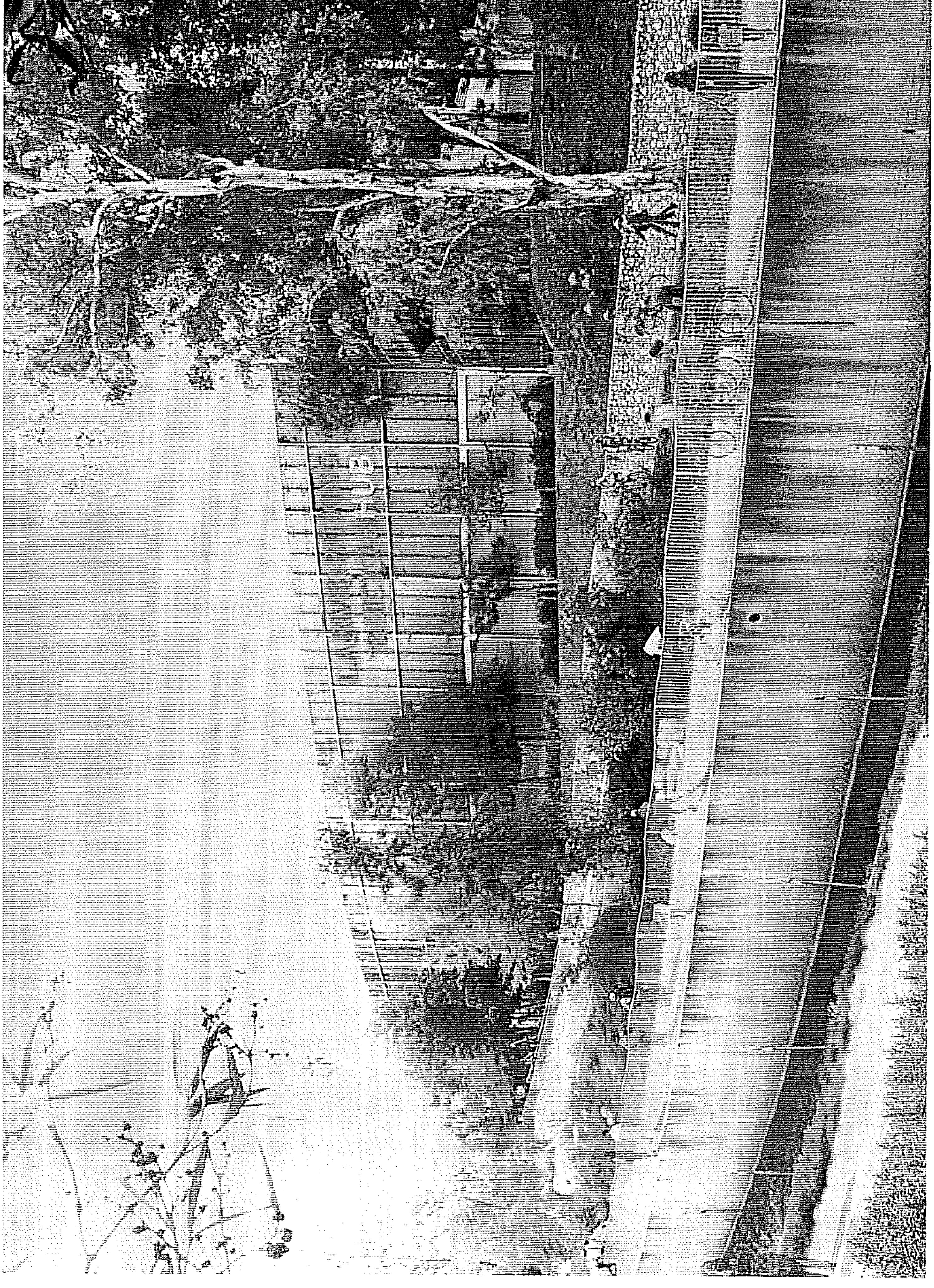
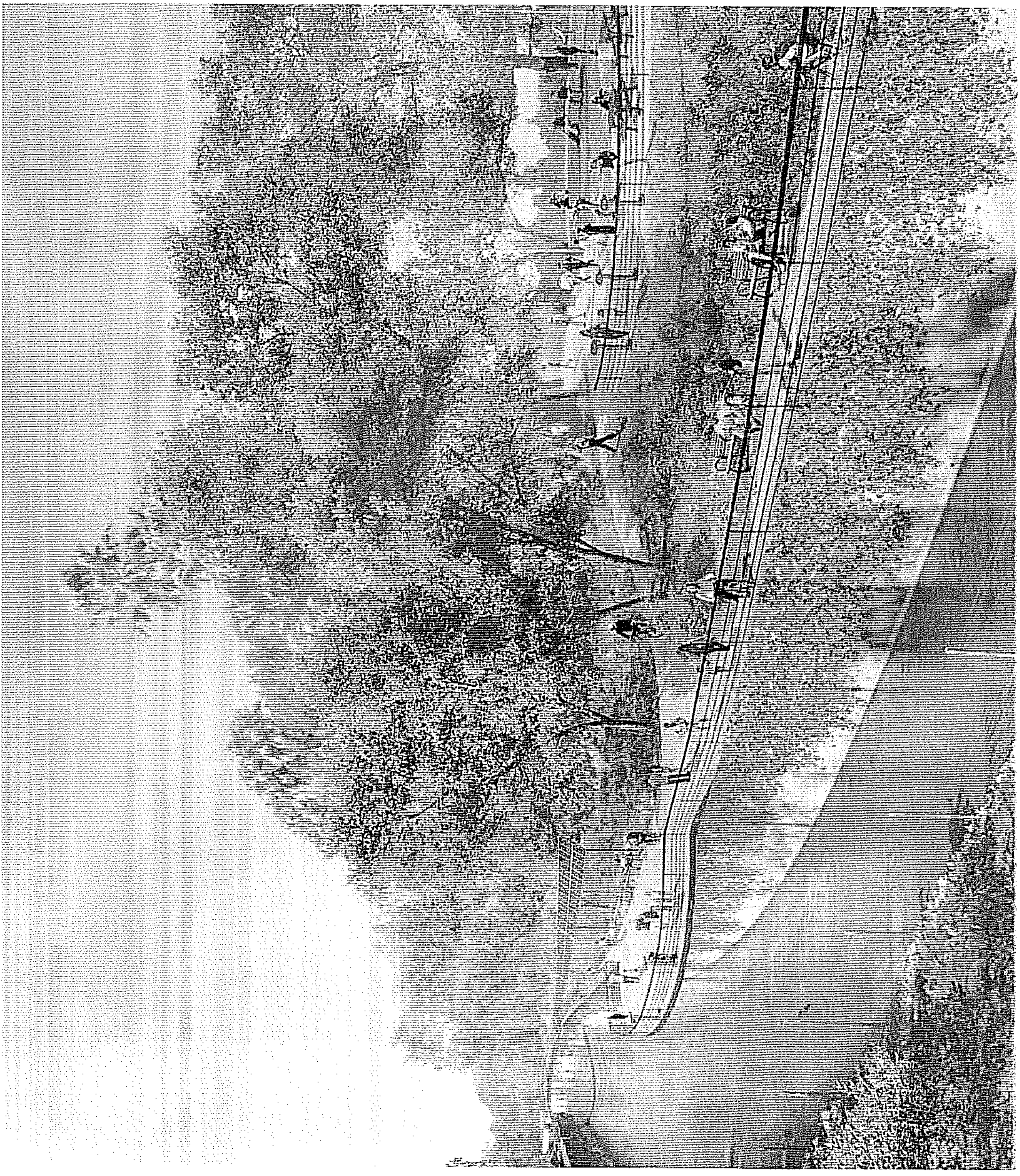

L.A.
RIVER
TRAIL
L.A.RIVER
NATURAL
PARK




LOS ANGELES RIVER NATURAL PARK



RECOMMENDATIONS

1. DEVELOP PROJECT SITE AS L.A. RIVER REGIONAL PUBLIC ACCESS PROTOTYPE

The L.A. River Natural Park site has unique features that make it particularly suitable as a regional access hub, but it can be a developed as a prototype that showcases how to provide a centralized, easily accessible regional public gateway to the L.A. River Trail system and to a regional bicycle transportation network. Elements of this project can be applied to other sites along the L.A. River and in other cities looking to make similar connections to their rivers. Prototype elements include parking facilities, links to river trails and bicycle networks, linkages to heavily-used commercial/restaurant areas, the bike rental program, educational components, water management, and solutions for issues of compatibility with adjacent neighborhoods.

2. DEVELOP PEDESTRIAN AND BICYCLE-FRIENDLY CROSSING AND TRAFFIC CALMING STRATEGIES

Access from the L.A. River Trail to the project site entrance requires a pedestrian crosswalk and traffic calming, as Whitsett Avenue is a busy street and crossing Whitsett either on foot or on bicycle can be dangerous. Traffic calming measures such as a stop light or stop sign, bulb outs, and enhanced paving are all methods of slowing or stopping traffic to allow for safe crossing.

3. DEVELOP SITE SIGNAGE AND WAYFINDING

Signage and improved wayfinding can be developed to ensure park visitors a friendly and safe experience. Directional signage and wayfinding should clearly identify the public parking garage/bicycle hub and link it to the L.A. River Trail and to the project site. Signage along the L.A. River Trail should easily guide visitors to the site and to nearby visitor-serving amenities.

4. IMPROVE CONNECTIONS TO PARKING GARAGE/BICYCLE HUB

Physical and visual connections to the parking garage from Ventura Boulevard need to be developed. Signage needs to be improved and a visual connection made to draw people in from the street. This parking garage can serve as a connection to the L.A. River Trail and from the River Trail to the garage, and from the site to the parking garage.

5. DEVELOP L.A. RIVER BICYCLE STAGING AND RENTAL PROGRAM

Develop a user-friendly bicycle rental and storage program in the parking garage, and enhance connections to the existing multi-purpose LA. River Trail. Improvements include signage, parking and off-loading for cars with bikes, development of the garage as a regional bicycle hub with services that cyclists would appreciate (e.g., maps, tire repair).

There is an opportunity to provide bicycle rental, storage and repairs in the parking structure as it adjoins the existing multi-purpose LA. River Trail. In addition to existing river trails, many trails are in the planning stages for the LA. River throughout the San Fernando Valley and beyond. The ability to connect to existing Los Angeles River trails and to provide this much parking is unique to this site. In the San Fernando Valley buildings were constructed almost up to the river right of way for most of the length of the river. While access for a large number of people can be found at the Sepulveda Basin Recreation Area the river is in its natural state there and direct access to the river or the creation of trails immediately adjacent to the river will endanger habitat.

6. DEVELOP LINK TO REGIONAL BICYCLE NETWORK

Develop site and parking garage as a key regional access node in regional bicycle networks to maximize mobility throughout the San Fernando Valley. Develop wayfinding and signage that links bicycle routes and paths and other elements of the regional bicycle network throughout the San Fernando Valley to the parking garage/bicycle hub, the project site, the LA. River Trail and surrounding destinations. Utilize the LA. River Natural Park and parking garage/bicycle hub to encourage bicycle access to Ventura Boulevard and other commercial areas, schools, parks and visitor-serving destinations. River trails and bicycle routes exist and are being planned for key tributaries that connect to the project site and the LA. River Trail, including the Tujunga Wash, Pacoima Wash, and the Arroyo Seco. The LA. River Natural Park and parking garage/bicycle hub should be improved to maximize these regional connections for bicycle use, and to provide linkages to existing and planned elements of a regional bikeway network.

7. ENHANCE SECURITY

Develop wayfinding to the project site as well as to river trails and other local destinations. Develop environmentally-sensitive site lighting along the LA. River Trail and at the parking garage/bicycle hub. Increase visibility into the site. Address security and public safety through the CEPTED (Crime Prevention Through Environmental Design) approach: perimeter fencing that secures the project site night, screening areas with active recreation protects the privacy of adjacent homes.

8. DEVELOP EDUCATIONAL AND INTERPRETIVE COMPONENTS

Provide educational and interpretive information on the LA. River watershed, habitat, native plants, water management and water quality improvements.

9. UNDERTAKE ADDITIONAL TECHNICAL STUDIES AND ANALYSIS

NEXT DESIGN/PROCESS STEPS

- Move forward with site design
  - Contract with landscape architect to develop a site plan
  - Develop signage program with graphic designer
  - Develop site lighting with lighting consultant
  - Develop visitor center with architect
  - Develop bike staging/rental program
  - Develop connection to parking garage/bicycle hub

RECOMMENDED TECHNICAL STUDIES

The following technical studies and/or analyses should be undertaken during the pre-design phase for integration of hydrologic and habitat restoration elements with public access design goals:

- Topographic/civil survey
- Structural evaluation for wall and cantilevered deck over river
- Geotechnical reports for soil structure and fertility
- Arborist evaluation of health of trees
- Biological assessment and plant community mapping
- Detailed vegetation plan for native habitat restoration/creation
- Bicycle amenities planning for parking garage
  - Rental
  - Storage
- Design of improvements to parking garage
- River Trail Planning:
  - Survey
  - Right-of-Way evaluation
  - Trail width evaluation
  - Signage and connections to existing trails and destinations
- Street crossings

Agency coordination will be required with the U.S. Army Corps of Engineers, Los Angeles County Flood Control District and the City of Los Angeles Bureau of Engineering, River Office

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OPINION OF PROBABLE COSTS

LA River Natural Park

Opinion of Probable Costs

ITEM	QTY	unit price	unit	TOTAL
Site Demolition	3,970	$40.00	sf	$158,800.00
Earthwork	3,970	$10.00	sf	$39,700.00
Pedestrian Trail	430	$6.00	sf	$2,580.00
Multi Purpose Trail	1240	$25.00	lf	$31,000.00
Seating	10	$1,500.00	ea	$15,000.00
Bike Corral	24	$500.00	lf	$12,000.00
Interpretive Signage	12	$1,500.00	ea	$9,000.00
Visitor Center	1	$2,000,000.00	ea	$2,000,000.00
Picnic Tables	5	$1,200.00	sf	$6,000.00
Traffic Calming Crossing	3700	$3.00	sf	$11,100.00
River Element	1	$150,000.00	ea	$150,000.00
Signage at Public Parking	1	$35,000.00	ea	$35,000.00
Pedestrian Bridge	1	$1,000,000.00	ea	$1,000,000.00
River Viewing Terrace	15000	$15.00	sf	$225,000.00
River Cantilever Terrace	6200	$40.00	sf	$248,000.00
Shade Structure	1	$100,000.00	lf	$100,000.00
Enhanced Street Buffer	4000	$5.00	sf	$20,000.00
Irrigation	63500	$2.00	ls	$127,000.00
River Trail Improvements	1	$500,000.00	ea	$500,000.00
Parking Garage Improvements	1	$500,000.00	ea	$500,000.00
Planting	63500	$1.50	ea	$95,250.00
subtotal 1				$5,285,430.00
Estimating Contingency - 20% of subtotal 1	20%			$1,057,086.00
subtotal 2				$6,342,516.00
Mobilization - 7% of subtotal 2	7%			$443,976.12
Permits - 2% of Subtotal 2	2%			$126,850.32
Allowances - 5% of Subtotal 2	5%			$317,125.80
subtotal 3				$7,230,468.24
Construction Contingency - 10% of subtotal 3	10%			$723,046.82
TOTAL, HARD COSTS				$7,953,515.06

SOFT COSTS	
Design Fees Entry Area and River Edge	$1,184,140.00
Topographical Survey	$10,000.00
Structural evaluation	$20,000.00
Arborist Report	$5,000.00
Biological Assessment	$15,000.00
Vegetation Plan	$5,000.00
Parking Garage Improvements Design	$125,000.00
Structural engineering bridge and terraces	$175,000.00
TOTAL, SOFT COSTS	$1,539,140.00

TOTAL, ALL $9,492,655.06