

# LEAVING A LAKE LEGACY

## SAN FRANCISCO LAKES IN PERIL

November 18, 2002

By Kathleen Pilat  
Sponsored by  
the Neighborhood Parks Council

LEAVING A LAKE LEGACY:  
SAN FRANCISCO LAKES IN PERIL

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# ATTACHMENT A

“THE FULL REPORT”

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## **LIST OF ABBREVIATIONS**

ccf – hundred cubic feet  
CDS – Continuous Deflection System  
GGNPA – Golden Gate National Parks Association  
IPM – Integrated Pest Management  
JAMS – Judicial Arbitration and Mediation Services  
LMCMP – Lake Merced Comprehensive Management Plan  
LMTF – Lake Merced Task Force  
LS – Luhdorff & Scalmanini Consulting Engineers  
MMWD – Marin Municipal Water District  
msl – mean seal level  
NAVD 88 – North American Vertical Datum of 1988  
NGVD 29 – National Geodetic Vertical Datum of 1929  
NPS – National Park Service  
ppm – parts per million  
SFDPW – San Francisco Department of Public Works  
SFPUC – San Francisco Public Utilities Commission  
SFRPD – San Francisco Recreation & Park Department  
SNRAMP – Significant Natural Resource Areas Management Plan  
SPUR – San Francisco Planning and Urban Research Association  
T.R.E.E.S. – Trans-Agency Resources for Environmental and Economic Sustainability  
USFWS – United States Fish & Wildlife Service  
USGS – United States Geological Survey

## **LIST OF TERMS**

Allelopathic: producing and releasing toxins that prevent the growth of understory plants.

Anoxic: greatly deficient in oxygen.

Aquifer: an underground formation of permeable rock or loose material that can produce useful quantities of water when tapped by a well.

Aquifer recharge: the process by which aquifers are replenished with water from the surface.

Aquitard: a water-saturated sediment or rock whose permeability is so low it cannot transmit any useful amount of water.

Biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in water.

Chemical oxygen demand (COD): the amount of oxygen consumed by the chemical oxidation of compounds in water.

Cellular confinement mat: a polyethylene-based web or mat comprised of honeycomb-like cells that allow vegetation to grow through the void spaces used for erosion control.

Chloramine disinfection: a process in which chlorine is chemically combined with a small amount of ammonia to form a new disinfectant that does not form as many harmful by-products as are formed when chlorine reacts with organic and inorganic substances naturally present in the water.

Combined sewer overflow: the overflow of minimally treated sewage combined with stormwater runoff that occurs when the sewer system storage capacity is exceeded.

Drywell: an underground sump, usually either a pit filled with gravel or a perforated concrete tank, that stores runoff until it can infiltrate into the surrounding soil.

Evapotranspiration: loss of water through the combination of evaporation and transpiration by plants as a part of their metabolic processes.

Extraction / injection well: a well through which water can be either extracted from or injected into the ground.

Groundwater basin: area of groundwater separated from adjacent basins by geologic or hydrologic boundaries.

Jute mesh: a soil stabilization blanket or netting made of coarse, burlap-like plant material that is laid over bare soil to prevent erosion while vegetation becomes established.

Mechanical aeration: the addition of dissolved oxygen to water at the lake bottom. The proposed system will be partially solar-powered and will not be visible from the shore.

Non-potable: not suitable for drinking.

Nutrients: nitrogen and phosphorus that mainly come from fertilizers that are washed into the lake.

Potable: suitable for drinking.

Primary treatment: the first stage of wastewater treatment that removes settleable or floating solids only; generally removes 40% of the suspended solids and 30-40% of the BOD in the wastewater.

Riparian: occurring on the bank of a river or other body of water.

Runoff: rainwater that drains or flows off along the ground surface.

Secondary treatment: the process in which microorganisms digest or eat material that is dissolved or suspended in the water, and are then separated from the cleaned water. Secondary treatment for municipal wastewater is the minimum level of treatment required by the Clean Water Act.

Sedimentation: the deposition or accumulation of sediment.

Spreading: the application of water to the ground surface where it can enter the soil and percolate down to the water table for the purpose of artificial aquifer recharge.

State Endangered species: those species listed under the California Endangered Species Act.

Tertiary treatment: any level of treatment beyond secondary treatment, which could include filtration, nutrient removal, and removal of toxic chemicals or metals; also called “advanced treatment” when nutrient removal is included.

Total suspended solids: a laboratory measurement of the quantity of suspended solids present in wastewater or stormwater that is one of the main indicators of the quantity of pollutants present.

USFWS Species of Concern: status description under the federal Endangered Species Act of species that may be endangered or threatened, but about which there is not enough biological information to support listing on the Federal Register of species that are in danger of extinction.

Water recycling: the reuse of highly treated wastewater for subsequent, typically non-potable, uses before the water is discharged back to the environment.

Water table: the point below which the soil is saturated with groundwater, also the top of the uppermost aquifer.

Water year: the year beginning October 1<sup>st</sup> and ending September 30<sup>th</sup>. Example: the 2001 water year is from October 1, 2000, through September 30, 2001.

Watershed: all of the land area that drains toward a particular river or lake, also called the drainage basin.

## INTRODUCTION

Ask a San Francisco resident to tell you about some favorite places to enjoy the water in the city, and you'll probably hear about the shoreline -- Ocean and Baker Beaches, the dramatic cliffs along Land's End, or the views of the Bay. The idea of a lake in San Francisco is probably pretty far down on the list, if it made it at all, and if you ask about a favorite San Francisco creek, you'll probably get a blank look in response. Many of us have no idea that a creek once ran (and still sometimes runs!) under our house on Wawona Street, that springs still bubble up out of the ground in the Presidio, or that eight blocks of the Mission used to be under a freshwater lake. We know there's a Laguna Street exit off of 101 and that we pass Lake Street on our way to the Golden Gate Bridge, but we rarely stop to wonder "What lake?" or "Where's the lagoon?"

To most of us, the mention of a lake in San Francisco conjures up images similar to several of the lakes of Golden Gate Park -- small bodies of water with artificial bottoms and concrete edges that house ducks, seagulls, and remote control sailboats. More veteran explorers of San Francisco's urban open spaces know that San Francisco has other lakes besides the artificially-maintained lakes of Golden Gate Park. There are three natural lakes left in San Francisco -- Mountain Lake, Pine Lake, and Lake Merced -- whose present and future health is the subject of this study.

Before beginning any discussion on the current health the lakes, it is useful to have some frame of reference about the lakes and the natural hydrology of the area before the onset of the massive changes to the landscape that accompanied the creation of the city of San Francisco. When Spanish explorers first arrived at the San Francisco peninsula in the early 1770s, sand dunes extended from the ocean to the northeastern hills, and the central and southeastern areas were mainly grasslands. Lakes, creeks, and springs dotted landscape in all parts of city (Figure 1). At this time, the area extending from the San Francisco Peninsula south to Monterey Bay was inhabited by over 50 related tribal groups with a common linguistic and cultural background, known collectively today as the Ohlone. According to Andrew Brother Elk, professor at San Francisco State University in American Indian Studies, "The Ohlone and their Penutian speaking neighbors (the Miwok of Marin, the Patwin of Solano, the Maidu, Yokuts and Miwok of the Central Valley) tended to favor riverine and estuary sites as opposed to hill or upland sites. They can be considered the original and superior water lovers." Within the current borders of San Francisco, most of the known evidence of villages and seasonal camps is centered around coastal lakes and creeks (Figure 1).

**Figure 1. PRE-EUROPEAN SAN FRANCISCO WITH OHLONE SITES**

Source: Wild in the City (1992)

Just as the creeks and lakes determined where the Ohlone lived, they also played an important part in the development of the city of San Francisco. The Spanish missionaries established their settlement where Dolores Creek flowed into Dolores Lagoon because of the abundance of fresh water; Islais Creek wound its way across more than half of the southern part of the city; Hayes Creek, which has been called the mysterious underground creek, may have always flowed underground, and to this day causes continuous flooding of basements in the Civic Center area. These, along with at least 10 smaller creeks, were San Francisco's natural drainage system. They

collected rainfall from every part of the landscape, and emptied into the bay, the ocean, or to inland lakes (Figure 2).

**Figure 2. SAN FRANCISCO'S HISTORICAL LAKES AND CREEKS**  
Source: Adapted from Guide to San Francisco Bay Creeks, Christopher Richard, (<http://www.museumca.org/creeks/SFTopoCreeks.html>).  
Basemap courtesy of Histopo.  
Yellow label: still existing, tan label: filled or paved

There were also at least seven other natural lakes in San Francisco, besides the three that are still with us today (Figure 2). They included Dolores Lagoon, which once covered 5 to 10 blocks of the Mission District, according to early maps; Washerwoman's Lagoon at what is now the intersection of Octavia and Filbert Streets; Laguna Honda and Laguna Seca in the present-day neighborhoods of Forest Knolls and Haight/Ashbury, respectively; Geneva Lake in the Oceanside District near the current site of Balboa High School; Kelly's Pond at what is now the intersection of Palm and Euclid Avenues in the Richmond; and an unnamed lake in the northern corner of the Presidio.

Fast-forwarding to the present, all the creeks have been filled except Lobos Creek in the Presidio and a small remnant of the North Fork of Islais Creek in Glen Canyon. All the lakes have also been filled except Mountain Lake in the Presidio, Pine Lake tucked away in the west end of Stern Grove / Pine Lake Park, and Lake Merced in the southwest corner of the city (Figure 3). Laguna Honda still exists but is now part of the city's reservoir system; and the lakebed was paved with concrete in 1863 to prevent seepage (Figure 4).

**Figure 3. LOCATION OF SAN FRANCISCO'S MOUNTAIN LAKE, PINE LAKE, AND LAKE MERCED**  
Source: Wild in the City (1992)

**Figure 4. PAVING OF LAGUNA HONDA, 1863**  
Courtesy of Greg Gaar

It is an interesting mental exercise to compare maps such as Figures 1, 2, and 3 that show San Francisco's natural waterways juxtaposed with today's infrastructure, and imagine how things might have looked, neighborhood by neighborhood, if all the lakes and creeks had been preserved and incorporated into the fabric of the city. Anyone who has visited any of three remaining lakes, or has been lucky enough to walk along Lobos Creek,<sup>1</sup> knows what special places they are. The lakes are not only the jewels of the city park system and critical assets of San Francisco's urban ecosystem, but are rare along the entire West Coast. There are only five coastal lakes -- lakes within the "coastal zone" as designated by the California Coastal Commission -- on the entire California Coast (David Hayes, pers. comm.), and two of them, Mountain Lake and Lake Merced, are in the city of San Francisco! Pine Lake, while only about one mile from the coast, is technically outside of the "coastal zone."

<sup>1</sup> Lobos Creek is closed off to the public east of Lincoln Boulevard because it serves as the Presidio's water supply.

Even the lakes that suffer from adjacent traffic or other urban encroachment still provide habitat that is available in only a tiny fraction of the city. All three lakes have been named as Significant Natural Resource Areas as designated by the San Francisco Recreation & Park Commission in 1995 (SFRPD, 1995). They received this designation because they contain some of the last remaining fragments of the diverse and unique Franciscan landscape habitat that once extended from the Golden Gate Headlands to San Bruno Mountain (EIP, 2002).

Natural lakes with natural lakebeds and vegetated shorelines have the greatest potential to provide the complex combination of open water, freshwater marsh, riparian, and upland habitat that can support maximum wildlife diversity and richness. For example, over 50 species of birds nest at each of the lakes, and at least 10 bird species listed by the U.S. Fish and Wildlife Service (USFWS) as Species of Concern, including the State Endangered willow flycatcher, have been observed at the lakes. According to birder Dan Murphy of the Golden Gate Audubon Society, “There is seldom a time when you can’t find at least 40 species just wandering around the lake [Lake Merced]. This year we had 7 Great Blue Heron nests and about 125 Double-crested Cormorant nests.” Murphy later added that “Given the amount of marsh habitat [around the lake], I’d think Lake Merced is among the most significant bird habitats on coastal California” (Dan Murphy, pers. comm., 9/5/02 and 11/4/02). At Pine Lake, the taller trees provide potential nesting habitat for raptors and owls, while the shrubby understory and wetland vegetation provide nesting and foraging habitat for smaller birds (EIP, 2002, p. 6.7-3). At Mountain Lake, year-round residents and other commonly seen birds include ducks, gulls, grebes, hummingbirds, hawks, thrushes, kinglets, juncos, and phoebes (Presidio Trust, 2000). Rich invertebrate, reptile, amphibian, and plant communities at the lakes form the foundation of the biodiversity that the lakes support.

The lakes are also of regional and even international importance as elements of the Pacific Flyway on the coastal edge of the highly urbanized San Francisco peninsula. Coastal lakes, and particularly Lake Merced -- due to its size and proximity to protected habitat at nearby Fort Funston, serve as important stop-over points for migrating birds that follow the coastline (EIP, 2002, p. 6.1-6 and Dan Murphy, pers. comm., 11/4/02).

And with wildlife habitat comes educational opportunities for both students and the community to learn about and connect with nature. The California Academy of Science’s student water quality and wildlife monitoring project at Mountain Lake, going into its third year next fall, is one example. Numerous shoreline restoration projects at all three lakes that engage students and community members as volunteers are another way that people learn about and learn to care about the lakes. The lakes also provide us with unique open space, giving us places to walk, jog, bicycle, row, fish, or just enjoy a sunny afternoon away from the city’s concrete, traffic, and noise.

### The Neighborhood Parks Council Project

The preservation of Mountain Lake, Pine Lake, and Lake Merced – the focal points of three of San Francisco’s most stunning neighborhood parks – motivated the Neighborhood Parks Council to sponsor this assessment of the health and well-being of the city’s three remaining natural lakes.

The Neighborhood Parks Council framed the study with three questions:

1. Are any of San Francisco's lakes in peril resulting from human activity, or do their current conditions simply reflect the downside of natural cyclical phenomena?
2. What kinds of monitoring are being done to evaluate the health of these lakes, and have the best scientific and technical resources been used effectively to address the issues that are impacting them?
3. How effective is current public policy at protecting San Francisco's lakes, and what else can or should we be doing?

## MOUNTAIN LAKE

Mountain Lake lies at the southern edge of the Presidio (Figure 5). Its watershed, defined as all the land area that drains to the lake, is about 200 acres, including the Presidio Golf Course, some of the residential area south of the lake, and part of Park Presidio Boulevard. No creeks flow into or out of Mountain Lake. Its main source of inflow is from groundwater, and it also receives runoff from the watershed during the rainy season that results in some seasonal variation in the lake level. Historical maps indicate that Mountain Lake may once have overflowed into nearby Lobos Creek, but in its current state the lake level is never high enough to overtop Park Presidio Boulevard, which separates the lake and the creek.

**Figure 5. LOCATION OF MOUNTAIN LAKE IN THE PRESIDIO**

Courtesy of the SFRPD

Although there has been no evidence of inhabitation or other artifacts discovered around its shores, it is likely that the Ohlone used Mountain Lake in some way as a freshwater resource. The 1776 De Anza expedition camped along the shore of Mountain Lake and decided that the area had everything they needed to establish their fort including good water from Mountain Lake. Mountain Lake provided part of San Francisco's municipal water supply in the mid-1800s, and was the main water supply for the U.S. Army base from 1897 until about 1910 when it began to use Lobos Creek and groundwater instead. Historically, a combination of water pumped directly from Mountain Lake and from nearby wells was used to irrigate the Presidio Golf Course. Minimum lake level requirements were established for Mountain Lake after the water level was drawn so low in 1964 that children playing along the lake shore got stuck in the mud of the exposed lake bed (Allison, 1964) (Figure 6). The golf course continued to use both lake water and groundwater until the drought of the late 1980s brought the lake level low enough that they were forced to stop withdrawing from the lake in 1990 (Nolte & Associates, 1992). Since that time, the golf course has used water purchased from the city of San Francisco for irrigation. With lake extraction discontinued and the cessation of nearly all groundwater pumping in the vicinity of the lake in the early to mid-1990s, the lake level is now fairly stable from year to year (Michael Boland, pers. comm.).

**Figure 6. LOW WATER LEVELS AT MOUNTAIN LAKE, 1964**

Courtesy of the San Francisco Public Library

***QUESTION 1: Are any of San Francisco's lakes in peril resulting from human activity, or do their current conditions simply reflect the downside of natural cyclical phenomena?***

With its stable water levels and generally healthy appearance, Mountain Lake has been described as looking "deceptively wonderful" (Boland, 2002) (Figure 7). Although the lake looks beautiful, it has been severely impacted by human activity in the surrounding watershed over the last 200 years. Overgrazing, urbanization, road building, and invasive exotic trees and weeds in the surrounding watershed have contributed to the decline of the lake. Algae blooms, poisoned swans, and upland

habitats degraded by exotic weeds are the visible manifestations of the lake's ill health. The causes of Mountain Lake's ills are that it has become too shallow, its sediment is too rich in nutrients and contaminated by metals, and its adjacent upland areas are overgrown with exotic species like eucalyptus, that contribute to poor water quality and reduce habitat value.

**Figure 7. MOUNTAIN LAKE, SPRING 2002**

### Lake Too Shallow

Although it was not the first offense in the string of abuses that have besieged Mountain Lake, the filling of approximately 40% of the lake area for the 1938-39 construction of Park Presidio Boulevard was arguably the most dramatic (Figure 8). About two acres of the lake were filled, reducing its surface area to about four acres. In addition to completely filling part of the lake, the road construction resulted in a massive influx of sediment to the bottom of the remaining open water area of the lake. Although sedimentation in lakes is a natural process, the artificial increase in sediment deposition jumped the lake forward on its evolutionary path, putting it centuries closer to its transition to becoming a marsh.

**Figure 8. AERIAL VIEW OF MOUNTAIN LAKE**  
Basemap: USGS aerial photograph from Terraserver

The lake was about 30 feet deep at the time of its formation about 1700 years ago as a wind-swept hollow in the dunes (Reidy, 2001). During the Ohlone era, the lake filled in with sediment at a rate of about 1 foot per 100 years, decreasing the lake depth to about 15 feet over 1,500 years by the time the Spanish arrived in 1775 (Reidy, 2001). The sedimentation rate may have increased slightly during Spanish occupation due to the effects of cattle grazing, but then it quintupled to about one foot every twenty years during army construction activities in the Presidio from the 1890s to the 1930s. With the construction of the Park Presidio Boulevard entrance to the Golden Gate Bridge, the rate jumped to at least 15 times higher than its natural rate, as 1 foot of sediment was added to the lake floor in the 7 years from 1938 to 1945. Since then, the sedimentation rate has stabilized, but at approximately 1 foot every 30 years, it is still 3 times higher than it was under pre-European conditions. Sediment sources today include runoff from Park Presidio Boulevard and from residential areas south of the lake, as well as erosion of the lake's east shoreline.

Mountain Lake now has an average depth of six to seven feet and is eight to nine feet deep at its deepest point (Horne, 2002). Much of the lake is now shallow enough that emergent vegetation could spread across and fill in the open water area (Presidio Trust, 2000). According to Dr. Alex Horne, a limnologist and ecological engineering professor from the University of California, Berkeley (UC Berkeley) who provided initial recommendations for the enhancement of Mountain Lake, a minimum water depth of about eight feet is needed to restrict the growth of marsh-type plants (Horne, 2000).

The sediment that filled the lake during roadway construction and other watershed development activities was primarily inorganic matter -- soil and sand particles. However, the rate of organic sedimentation in the lake has also been affected by human activity, in the form of eucalyptus trees that have been planted around Mountain Lake. For over a century, eucalyptus trees around the shoreline have dropped huge amounts of leaf and bark debris into the lake, which biodegrade much more slowly than other plant material because of the resins they contain. In addition to contributing to increased sedimentation rates, the leaves and debris contain tannins that stain the water, affecting various processes such as predator-prey relationships and submergent plant growth, which depend on a certain level of water clarity. Also, eucalyptus are allelopathic, which means that they produce and release toxins that prevent the growth of understory plants. With no understory, the eucalyptus-dominated eastern shoreline of the lake became vulnerable to erosion, which also contributed to sedimentation.

### Nutrient-Rich Sediment

The shallowness of the lake combines with another major impact of urbanization, the build-up of nutrients in the lake sediment, to cause algae blooms and fish kills at Mountain Lake. High concentrations of nitrogen and phosphorus, which serve as the food source for algae, have accumulated in the sediment of the lake bottom over the past hundred to two hundred years. In its original conditions, the lake was deep enough to be thermally stratified, with cooler, denser water at the bottom and warmer lighter water at the top. This temperature difference kept the nutrients that escaped from the sediment in the lower layer more or less separate from the algae in the upper, more sunlit layer. Today, the water temperature is fairly constant over the whole depth of the lake, so nutrients released from the sediment can easily mix with the algae. Additionally, the shallower depth creates warmer lake temperatures overall, which, combined with the excessive nutrients, allow the algae growth to explode. When the algae eventually die off, the decay of the plant matter uses a great deal of oxygen, resulting in the depletion of dissolved oxygen to levels that the fish cannot tolerate.

The nutrient enrichment of the lake began with manure from cattle grazing in the area, but most of the nutrient inflow in recent times can be attributed to fertilizers used on the golf course and possibly residential gardens and lawns. It has been estimated that generally about one-third of fertilizer gets washed away with runoff (Horne, 2002).

### Contaminants

The third major problem that degrades Mountain Lake's water quality and habitat is the accumulation of contaminants in the lake bottom sediment. These contaminants, mainly car-related heavy metal particulates such as lead, zinc, and copper, come from gasoline additives, and tire and brake dust. They are carried into the lake with runoff that flows directly from Park Presidio Boulevard through drainage culverts to the west shore of the lake. Because metals break down so slowly, they bioaccumulate in fish, birds, other lake wildlife. The necropsy report after the death of one of Mountain Lake's resident swans in 1996 indicated that it had a lead concentration of 44 parts per million (ppm) in its liver (Reidy, 2001). A concentration of 8 ppm is considered toxic (Dunker, 1996, as referenced in Reidy, 2001).

***QUESTION 2: What kinds of monitoring are being done to evaluate the health of the lakes, and have the best scientific and technical resources been used effectively to address the issues that are impacting the lakes?***

Students from nearby universities performed studies for various academic projects that yielded valuable data at Mountain Lake during the 1990s. These projects consisted mainly of water and sediment quality sampling. In particular, Liam Reidy's UC Berkeley Master's Thesis study played an important role in the increasing the understanding of the lake's early ecology as well as more recent contamination issues. Reidy's paleo-ecology project consisted of analyzing pollen samples from sediment cores collected from the lakebed. The pollen in sediment cores preserves an historical record of the plants that lived by lake throughout its history. The results of the study were used in the selection of plants for the shoreline revegetation program (discussed in greater detail in the section on Current Public Policy at Mountain Lake).

The California Academy of Sciences' Mountain Lake Research Project, which began in the fall of 2000, is an on-going education program focusing on Mountain Lake. In this program, students ranging from middle school to university measure water quality parameters such as water clarity, dissolved oxygen, and pH; and biological indicators such as zooplankton, bird, and reptile abundance.

Other monitoring efforts at Mountain Lake include groundwater monitoring at a well near Mountain Lake, which was conducted by the City of San Francisco from the 1988 through 1992. This monitoring was part of San Francisco's efforts to explore the potential to increase groundwater production throughout the city for potable or non-potable uses. Finally, numerous more general writings on the pre-history and history of San Francisco supplemented the knowledge about early Mountain Lake with descriptions of the lake, surrounding vegetation, geology, early uses, and other relevant topics.

Using the various data sources plus their own data on water quality, sediment quality, and biological, cultural, and historical resources, the Presidio Trust, Golden Gate National Parks Association (GGNPA), and National Park Service (NPS) have joined forces to provide the technical resources required in the effort to revitalize Mountain Lake. Through the Mountain Lake Enhancement Plan, this agency partnership has enlisted the expertise of agency staff, academia, and consultants to develop and implement a program that will address most of the identified issues affecting the lake, to the extent possible under current conditions.<sup>2</sup> Part of the initial planning phase for this project consisted of the formal consideration of 5 watershed controls and 17 in-lake treatments used by limnologists and lake managers to help effect change at a lake. In addition to professional resources, public input has played an important role in making improvements at Mountain Lake a reality. Members of the community have been heavily involved at various stages of the project, from participating in planning workshops to providing observational information on lake levels, to donating labor hours for restoration work.

The initial funding for the project was provided by a \$500,000 grant from the San Francisco International Airport, as part of the airport's off-site mitigation program. Additional funding is

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<sup>2</sup> For example, the lake's pre-highway area and depth could not be restored without removing Park Presidio Boulevard.

being sought to continue with subsequent phases of the project. The Mountain Lake Enhancement Plan will be discussed in further detail in the section on Current Public Policy at Mountain Lake.

***QUESTION 3: How effective is current public policy at protecting San Francisco’s lakes, and what else can or should we be doing?***

Because the majority of the area of Mountain Lake lies in the Presidio, the Presidio Trust has jurisdiction over most of lake and large portion of its watershed. A small corner of lake is on city property in Mountain Lake Park, and the San Francisco Recreation & Park Department (SFRPD) staff collaborate with the federal agencies in the management of the lake’s southern shoreline. There are several other local, state and federal agencies with some jurisdiction over the lake, listed in Appendix A-1.

The primary public policy action aimed at preserving and revitalizing Mountain Lake is the Mountain Lake Enhancement Plan (Enhancement Plan). The Enhancement Plan is a joint project of the Presidio Trust, GGNPA, and NPS.

Background

The motivation for the project began with concerns about health of the lake, in particular the algae blooms and fish kills, expressed by the community to the National Park Service. Planning efforts for the enhancement project began with “The Greening of the Presidio” design symposium in 1995, which focused on community education and concerns about the lake. According to Michael Boland, the Enhancement Plan’s GGNPA project manager, “The whole project has been a great example of public-private partnership. The community has been very dedicated and supportive, even about the removal of the eucalyptus trees along the east shore, because they understand that it is necessary to improve the health of the lake.”

Goals and Components

The three goals of the Mountain Lake Enhancement Plan are to improve the lake’s water quality, enhance habitat in and around the lake, and promote public access and interaction with the lake. The Enhancement Plan components can be broken down into the categories of watershed management: controlling the inflow of nutrients, sediment, and contaminants to the lake; and in-lake techniques: aeration and dredging (Figure 9). The project schedule includes two phases.

**Figure 9. MOUNTAIN LAKE ENHANCEMENT PLAN COMPONENTS**  
Courtesy of the Mountain Lake Enhancement Project

Phase 1 activities, which began in 2000, include:

- Elimination of the sources of sedimentation to the lake -- primarily eucalyptus debris and the erosion of bare slopes -- by removing eucalyptus from the east shore and revegetating with native plants that prevent erosion. The erosion control strategy also includes the construction of

a designated path down to the lake to discourage erosion-inducing informal trails in this location.

- Removal of nutrient-rich and contaminated sediment by dredging. The plan calls for the removal of four to five feet of sediment, which is basically all of the sediment that was deposited in the 1900s.
- Installation of a mechanical aeration system on the lake bottom. The system will likely be a short-term solution, to help bind nutrients that have been freed from the soil during dredging. The aeration system will be installed in the deepest part of the lake where it will help prevent the release of nutrients from the sediment that occurs when the water becomes oxygen-depleted. It will not be visible on the lake's surface and will likely not operate constantly, but may be activated by critical dissolved oxygen levels.

Eucalyptus removal on the east shore was completed and native plantings began in the fall of 2001. The bulk of the revegetation will be completed by the end of 2002, although there will be ongoing maintenance activities for an indefinite period of time. The dredging and aeration components have been delayed, because sediment cores collected as part of Liam Reidy's master's study and confirmed during Enhancement Plan sampling showed that contaminants in the sediment were at actionable levels, requiring sediment removal and disposal in accordance with toxics regulations. As a result, management of the dredging has been moved from the Enhancement Program to the Presidio Trust's Remediation Program. Dredging has been delayed until the California Department of Toxic Substances Control determines a responsible party who will pay for dredging and sediment disposal. The aeration component will also be delayed until after the dredging is completed.

Because of funds made available by the transfer of dredging from the Enhancement Program to the Remediation Program, Phase 2 may begin as early as 2003. Phase 2 activities include:

- Removal of the road that separates east arm of the lake from the main body of water. The road will be replaced by a bridge that will allow the free movement of water and wildlife between the lake and the east arm.
- Removal of eucalyptus trees along the east arm and establishment of native Arroyo willow and oak woodland to improve habitat, and freshwater wetlands to filter nutrients out of golf course runoff before it reaches the lake.

Outside of the scope of the Enhancement Plan, the Presidio Golf Course, which occupies a large part of Mountain Lake's watershed, is making efforts to reduce its contribution to the lake's nutrient input. The golf course has installed a new irrigation system and is beginning to experiment with new kinds of fertilizers. The irrigation system, installed in 1995, is activated only when sensors in the ground indicate that the soil needs water, thereby reducing runoff associated with overwatering. The golf course is also experimenting with foliar fertilizer. Unlike traditional granular pellets, which sit on the ground until they are dissolved by irrigation or rainwater, foliar fertilizers are sprayed as a liquid onto the grass leaves and therefore don't need irrigation to release nutrients to the grass. On the City of San Francisco side of the property line, no fertilizers or pesticides are used

on the turf or flowerbeds at Mountain Lake Park as part of the citywide commitment to integrated pest management (Candie Madson, pers. comm.).

### Outstanding Challenges

While the Mountain Lake Enhancement Plan is fairly comprehensive in addressing many of the causes and symptoms of the degradation of the lake, there remain some outstanding challenges. Currently, the Enhancement Plan does not address exotic fish and turtles in the lake. Originally, there were probably frogs and turtles in the lake, but no fish (Horne, 2000). People have introduced fish for fishing or dumped old pets (carp, striped bass, scrappy, red-eared slider and other turtles) into the lake. Once in the lake, the exotic fish can actually contribute to water quality problems and algae blooms by overgrazing the zooplankton that feed on algae (Horne, 2000). Carp also churn up the lake bottom, which causes nutrient release from the sediment and prevents the growth of emergent and submergent vegetation that, if present, would improve water quality through the uptake of nutrients. But eliminating exotic fish is a complicated issue and there is no guarantee that people wouldn't put them back into the lake. Therefore, the Enhancement Plan has focused on the watershed improvements, dredging, and aeration, and will follow up with monitoring for algae bloom activity. If poor water quality and algae blooms persist, the removal of exotic fish could be considered later as an adaptive management strategy.

The diversion of contaminated roadway runoff away from the lake is another outstanding challenge to Mountain Lake's enhancement. Because the stormwater contamination issue came to the forefront after the Enhancement Plan's Environmental Assessment was written, the re-routing of the storm drains away from the lake was not covered in the original plan. However, this issue, along with dredging, will be addressed in the planning process for remediation of the lake.

## PINE LAKE

Pine Lake also started life as a wind-formed sand dune hollow. It is located in the west end of Stern Grove / Pine Lake Park, about a half mile northeast of Lake Merced (Figure 10). The Spanish called it Laguna Puerca after the wild boar they saw bathing in its waters, according to legend. Under natural conditions, Pine Lake had a watershed area of about 650 acres, and runoff from the watershed was carried to the lake in a creek that began on the southwestern slopes of Mount Davidson.

There have been no formal studies into the early uses of Pine Lake, but there is evidence of an Ohlone seasonal camp southeast of Pine Lake (Figure 1). The canyon formed by Pine Lake's creek was settled by the Greene family in 1847. The Greenes started planting eucalyptus trees around the canyon's perimeter to serve as a windbreak in 1871 (Christianson, 1953). During the "Trocadero" days from the 1890s until the early 1920s, the area was a retreat for the elite, complete with ladies with parasols in rowboats. In 1931, Mrs. Sigmund Stern bought the property and deeded it to the city as a memorial to her late husband, with the provision that it forever be used for recreational purposes. Sometime prior to the inaugural season of the Stern Grove Festival's free summer concerts in 1938, a portion of the eastern end of the lake, perhaps as much as one-third of the original area, was filled (Figure 11). The filling, combined with the more recent lake level decline discussed below, have reduced the lake to its current surface area of about three acres. The creek was also filled sometime before 1938 to make more room for concert seating (Christianson, 1953). Much of Pine Lake's watershed was cut off by the construction of 19<sup>th</sup> Avenue, and the watershed is now only the western half (Pine Lake portion) of the park, with an area of about 35 acres.

### Figure 10. LOCATION OF PINE LAKE

Courtesy of the SFRPD

### Figure 11. HISTORICAL AND CURRENT AREA OF PINE LAKE

Source: Coast Survey (1852) – Historical map in brown with red lake edge; SFDPW (2001) – 2001 topographical map in black with blue lake area.

Since 1938, there have been no other deliberate modifications to the lake size or depth. However, Pine Lake is continually impacted by urbanization in the surrounding area, resulting in falling lake levels, the overgrowth of invasive aquatic weeds, and slope and bank erosion.

***QUESTION 1: Are any of San Francisco's lakes in peril resulting from human activity, or do their current conditions simply reflect the downside of natural cyclical phenomena?***

### Falling Lake Level

Based on interpretation of some early maps, Pine Lake was likely on the order of 20 feet deep up through the early 1900s (Figure 12).<sup>3</sup> Because it never served as a water supply, there is minimal historical information about Pine Lake's water level until the last five to six years. However, long-

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<sup>3</sup> With the current maximum depth of Pine Lake at 7 to 8 feet (SFDPW, 2001), an additional 12 feet of water -- from 28 to 40 feet (referenced to the San Francisco City Datum) -- would have produced a maximum lake depth of approximately 20 feet.

time residents remember that the lake rose high enough to cover the asphalt path at its eastern edge during heavy rainfall years in the 1970s and 1980s (Paul Scardina, Dylan Hayes, Shirley Selby, pers. comm.), which would have put the lake depth at around 16 feet. In May 2001, when the survey was performed for the Department of Public Works' (SFDPW) Stern Grove / Pine Lake Park Site Assessment (Site Assessment), the maximum depth of the lake was 7.5 to 8 feet (SFDPW, 2001).

**Figure 12. CLOSE-UP OF PINE LAKE PARK SHOWING HISTORICAL AND CURRENT LAKE AREA**

Source: Coast Survey (1852) – Historical map in brown with red lake edge; SFDPW (2001) – 2001 topographical map in black with blue lake area.

While both Mountain Lake and Pine Lake are becoming shallower from the bottom up as they fill with sediment, Pine Lake's depth is also decreasing from the top down as the water level drops. The falling water level is mainly due to the depletion of the groundwater aquifer that supports the lake. The causes of aquifer depletion and the effect on lake levels are discussed in greater detail in the Lake Merced section on Reasons for Water Level Decline.

Aquatic Weed Overgrowth

Another problem affecting lake aesthetics as well as public safety is the massive overgrowth of an aquatic weed at Pine Lake (Figure 13). This weed, *ludwigia peploides* (commonly called "water primrose"), first appeared in Pine Lake in the mid-1990s and spread to cover the majority of the open water area of the lake within the span of a couple years. It is an aggressive and invasive aquatic plant that forms dense, sprawling, tangled mats of vegetation. It roots in areas of shallow water, and grows by creeping along the shoreline or floating on the water surface, and is very difficult to control once established. The SFRPD removed a large portion of the weed in 1996 when it covered nearly the whole lake, but it has come back and now covers the western two-thirds of the lake.

**Figure 13. WATER PRIMROSE COVERING PINE LAKE**

Source: SFRPD Planning Department

Besides impacting the beauty of what was once an open water lake, the weeds could potentially trap any people or dogs that may somehow become entangled in it. From a hydrologic perspective, the massive quantities of additional vegetation in the lake increase the overall evapotranspiration of lake water, which adds to the decline of the water level.

As pointed out in the 2001 Site Assessment, the abundance of water primrose in Pine Lake may be a contributing factor to the lake's generally good water quality because the vegetation filters excess nutrients out of the lake water. However, according to Dennis O'Rorke, the former SFRPD park superintendent for Stern Grove / Pine Lake Park, and Dylan Hayes, a long-time neighborhood resident who founded the Friends of Stern Grove / Pine Lake Park, there were never obvious water quality problems or overgrowth of algae before the primrose became established at Pine Lake

(Dennis O'Rourke, Dylan Hayes, pers. comm.). Hayes added that other native species such as knotweed likely performed the same nutrient uptake function before the primrose arrived.

### Slope and Bank Erosion

The lack of native vegetation on the slopes of the canyon and on the banks of Pine Lake make the sandy soils vulnerable to erosion, which contributes to rapid accumulation of sediment on the lake bottom, especially at the west end of the lake. According to the Site Assessment (SFDPW, 2001), a rough measurement of sediment build-up in the lake indicates that the thickness of the looser, newly deposited sediment ranged from 0 feet at the east end of the lake to 3.5 feet at the west end. An in depth study of the sedimentation rate at Pine Lake will likely be performed by Liam Reidy, a graduate student in the Geography Department at UC Berkeley. Reidy plans to conduct a pollen analysis of sediment cores from Pine Lake similar to the one that yielded important vegetation and sedimentation data at Mountain Lake (discussed in Question 2 of Mountain Lake section). Some of the causes of the denuded slopes and banks include heavy general use of the park, creation of informal paths, and sewer lines along the canyon slopes. Maintenance activities and rare but occasional overflows from the sewer lines destabilize the loose sandy slopes and cause small landslides, which wash sand and debris toward the lake (Figure 14).

**Figure 14. GULLY CAUSED BY SEWER LINE OVERFLOW ON NORTH SLOPE OF PINE LAKE PARK, WINTER 2001-2002**

***QUESTION 2: What kinds of monitoring are being done to evaluate the health of the lakes, and have the best scientific and technical resources been used effectively to address the issues that are impacting the lakes?***

In contrast with Mountain Lake, Pine Lake has been the subject of very little monitoring, both historically and currently. There have been no sustained efforts to track past changes in lake levels, and there is no long-term lake level monitoring planned for the future. A lake level gauge was installed in 1996 by the San Francisco Public Utilities Commission (SFPUC) in conjunction with monitoring efforts at Lake Merced, and a reading was taken at that time. There are no records of other measurements taken on this gauge.

Groundwater levels in Stern Grove (the eastern half of Stern Grove / Pine Lake Park) were measured on an occasional basis in the late 1980s, but their relationship with lake levels is unknown. The installation of a SFPUC monitoring well adjacent to Pine Lake in 1996 represented the first effort to correlate lake and groundwater levels. After groundwater level readings were taken in 1996, no new measurements were taken at this well until the fall of 2001, when a new shallower monitoring well was installed next to the 1996 well. Groundwater level measurements at this new well were included in a two-year semi-annual monitoring program as part of efforts to develop an integrated Westside Basin Groundwater Management Plan (see section on Monitoring and Utilization of Resources at Lake Merced).

Historically, there has also been very little water quality monitoring performed at Pine Lake. Following an overflow of the sewer vault at the west end of Pine Lake that caused sewage to back up into the lake in 1995, water quality samples have been taken once a month during the June through August when the summer camp at Pine Lake Park is in session (Lorraine Anderson, pers. comm.). The Pine Lake Pump Station was modified in 1998 to better handle wet weather flows and to eliminate future raw sewage overflows (Dale Posey, pers. comm.).

The SFRPD, which owns the park property including the lake, has contracted with the SFDPW and its consultants to design and implement a Stern Grove / Pine Lake Park Improvement Plan (Improvement Plan). Although the revitalization of Pine Lake is not the primary focus of the project as in the case of Mountain Lake, the lake is now getting more attention than it has received in the past several decades. The Improvement Plan process began with a Stern Grove / Pine Lake Park Site Assessment, produced by the SFDPW in 2001. This document provided a brief inventory of conditions at Pine Lake, but with so little monitoring data available, the development of recommendations did not go through as rigorous of a scientific process as that which occurred at Mountain Lake. However, public input was well-utilized as a resource in the planning process for the Improvement Plan, with public participation in prioritizing issues of concern to helping craft solutions to problems.

The Natural Areas Program, a division of the SFRPD, is also in the process of developing the Significant Natural Resource Areas Management Plan (SNRAMP) for all Significant Natural Resource Areas in San Francisco, including Pine Lake. This plan contains recommendations concerning public access around the lake that are more controversial with some members of the community, and in some cases are in conflict with the SFDPW's Improvement Plan. The SFDPW and the Natural Areas Program are in the process of resolving the remaining conflicts.

***QUESTION 3: How effective is current public policy at protecting San Francisco's lakes, and what else can or should we be doing?***

Pine Lake is under the primary jurisdiction of the SFRPD. The SFPUC has no involvement with this lake because it is not a water supply. Other local, state and federal agencies with some jurisdiction over the lake are listed in Appendix A-1.

Until 2001, public policy regarding Pine Lake consisted of occasionally filling the lake with water from the irrigation system, and removing the aquatic primrose in 1996 when it had spread to cover the entire lake. The independent development of two plans for improving Pine Lake, the SFDPW's Stern Grove / Pine Lake Park Improvement Plan and the SFRPD Natural Areas Program's SNRAMP, has been under way for the past two years. Inconsistencies have been found between some recommendations made by the two plans. The SFDPW and the Natural Areas Program are working to resolve conflicts and develop coordinated plan. The SFDPW's Improvement Plan addresses the lake's water level decline as well as habitat improvement and erosion control, while the SNRAMP's main focus is the protection and enhancement of native habitat.

**Stern Grove / Pine Lake Park Improvement Plan**

A request by the Stern Grove Festival Association for modernization and improvement of the concert area and facilities was the impetus for the Improvement Plan. This initiative was expanded by the SFRPD to a major renovation of the entire park, including making the park compliant with regulations of the Americans with Disabilities Act, as well as addressing community concerns ranging from the lake to traffic to tree management. The planning process included three public workshops in 2001 and early 2002 at which community members identified the improvement of Pine Lake as the most important issue in the park. The Improvement Plan team is working to complete a Master Plan for the park renovations, and a team of consultants dedicated to Pine Lake is currently making specific recommendations for improving the lake conditions.

The goals of the Improvement Plan's Pine Lake recommendations are to improve the health of the lake and improve visitor access to the lake. Although the official document containing recommendations for Pine Lake has not been finalized, the recommendations will include the following activities (Koa Pickering, pers. comm.) (Figure 15):

**Figure 15. PINE LAKE RECOMMENDATIONS FROM  
DRAFT STERN GROVE / PINE LAKE PARK  
IMPROVEMENT PLAN**

Source: Adapted from SFDPW

- Raising of the lake level by approximately four feet. Recommended sources of water include groundwater pumped from a well in the park, similar to the way water levels in the Golden Gate Park lakes are maintained, and recycled water, when it becomes available. The SFDPW received approval from the SFPUC to conduct a test to fill the lake using water from the existing well. This test will help determine an estimate of the amount of water required to maintain a desired lake level, and will likely take place in December 2002.
- Constructing a “water source.” Well water would be pumped below grade to the “water source” near the southeast corner of the lake, which would be made to look like a spring or grotto emerging from the hillside with the water flowing into the lake. An alternate recommendation will also be made for creating a watercourse (creek) through the length of the meadow, which could be developed at a later time if funding were not available initially.
- Removing the water primrose and implementing a regular maintenance program to prevent it from taking over the lake again. There will also be a recommendation to cut windows into the reeds on the north bank of the lake.
- Dredging a small amount of lakebed sediment from the west end of the lake to stop the advance of terrestrial vegetation that is filling in that end of the lake.
- Improving erosion control on the banks around the lake by creating designated lake access points and stabilizing the shoreline with native vegetation. Because the lake, its banks, some of the surrounding habitat area are designated as a Significant Natural Resource Area (EIP, 2002), the Improvement Plan will recommend that these areas be restricted to on-leash dog use.

- Improving erosion control on the steep canyon slopes through various methods, ranging from planting and jute mesh to cellular confinement mats. In some cases recommendations will be made for low stone retaining walls to buttress failing slopes.
- Using temporary vegetation establishment fencing between the path and the lake to allow damaged and erosive bank areas to become revegetated and stabilized.

### Significant Natural Resource Areas Management Plan – Pine Lake Recommendations

A Citizen's Task Force Draft of the Natural Areas Program's SNRAMP was released in June 2002. The SNRAMP is the planning document that will guide management activities in designated Significant Natural Resource Areas in San Francisco. As explained on the SFRPD's website, the SFRPD is mandated by the City's General Plan (Open Space Element, Policy 13) to protect and enhance the natural resources of Significant Natural Resource Areas through policies including restrictions on use and management practices such as invasive plant removal and plantings with native vegetation (SFRPD, 2002a). After the SNRAMP Draft is reviewed by a committee of citizens, a modified draft of the entire document, expected in December 2002 (SFRPD, 2002b), will be released to the public for review and comment.

The 8.5-acre Significant Natural Resource Area (Natural Area) of Pine Lake Park includes the lake itself and the wetlands and riparian willow communities around the lake. The SNRAMP recommendations for the Natural Area of Pine Lake Park include:

- Control, management, and in some cases eradication of certain invasive non-native plants
- A perimeter fence around Pine Lake to protect native vegetation and sensitive species in the shoreline areas
- Closure of the trail on either the north or south side of the lake
- A monitoring program for western pond turtles and periodic trapping and removal of non-native turtle species
- Removal and control of water primrose

There has been considerable public controversy surrounding the SNRAMP recommendations, centered around restriction of access to the lake and removal of eucalyptus. Objections from the community were further magnified by the fact that a grant proposal was submitted for a Pine Lake Trails Improvement Project in September 2002, including a revegetation element that was to be guided by the SNRAMP planting guidelines before any public review of the SNRAMP had taken place (SFRPD, 2002c). The grant proposal also included recommendations to "Improve paths and trails around Pine Lake" and for "Trailside erosion control and fencing" which, in light of the contradictions between the SFDPW Improvement Plan and SNRAMP concerning trail closure and fencing, raised concerns in the community.

As noted above, the SFDPW and the Natural Areas Program are in the process of working through the two Pine Lake plans to make consistent recommendations that meet the needs of both programs and incorporate community concerns. At the fourth SFDPW Stern Grove / Pine Lake Park Improvement Plan public workshop, held November 14, 2002, the SFDPW Improvement Plan Project Manager Judi Mosqueda announced that she had been working with Lisa Wayne, the

Natural Areas Program Director, to coordinate recommendations, and that they had agreed to the resolution of at least two controversial issues: (1) the fence around the lake will be temporary and will be removed after the vegetation became established, estimated at three to five years; and (2) the trail around the north side of Pine Lake will remain open and available to park users (Mosqueda, 2002).

### Outstanding Challenges

The Improvement Plan's Pine Lake recommendations address at least the symptoms all of the issues that have been identified as problems at Pine Lake. For example, the addition of water to the lake will be proposed to reverse the declining water level. However, the underlying cause of the decline, the depleted aquifer, is never addressed, perhaps because of the scale of that issue. Since aquifer depletion is largely responsible for the drop in the water level at Pine Lake, any efforts to improve aquifer conditions, particularly within the context of Lake Merced projects or negotiations, would likely be beneficial to Pine Lake as well. Strategies to increase groundwater levels and thereby improve the sustainability of a higher water level at both Pine Lake and Lake Merced are discussed in the section on Current Public Policy at Lake Merced.

Another issue that affects the eventual recommendations for Pine Lake is the need to find a balance between sometimes competing uses such as recreation and natural habitat within the small amount of open space left in San Francisco. At Pine Lake this has been evident in conflicts between the two Pine Lake management plans and in some park users' opposition to restriction of access around the lake, even if temporary, to facilitate the re-establishment of native habitat.

Finally, the full-time gardener position at Pine Lake Park has been vacant since the last gardener retired in 1999. Pine Lake would benefit from a regular gardener at the park simply through having a person there every day to notice changes in the lake conditions, to do plantings and be responsible for erosion control, and to perform regular maintenance around the lake (Joe Burnett, pers. comm.).

## LAKE MERCED

Lake Merced is located in the southwestern corner of San Francisco, about a half-mile from the Pacific Ocean. Its surface area is almost 100 times bigger than the other 2 lakes, at about 250 acres (Entrix, 1988). It was originally connected to the ocean through a channel that ran from the northwestern corner of North Lake to the current site of the San Francisco Zoo (Figure 16). This outlet was subsequently closed off by natural transport of beach and dune sands. The outlet was probably reopened intermittently during the last several hundred years under extraordinary circumstances such as high lake levels in unusually wet years, or during earthquakes.

Until 1895, Lake Merced was one continuous body of water. Now it is artificially separated into three lakes: North Lake, which is two main bodies of water connected by a narrow channel; South Lake, the largest of the lakes which contains more than two-thirds of the total volume of all three lakes; and Impound Lake, the smallest and southernmost lake (Figure 16). North and South Lake are separated from each other by the berm that supports the road to Harding Park. Although a culvert connects the two lakes, it is typically kept closed due to safety issues, and there is a consistent water level difference of about one foot between North and South Lake (LS, 2002a). A sand berm that has developed beneath a sewer line crossing separates South Lake from Impound Lake.

**Figure 16. LOCATION OF LAKE MERCED  
IN SAN FRANCISCO**

Courtesy of the SFRPD

Prior to urbanization, Lake Merced's watershed was approximately 6,000 acres in area. The diversion of stormwater away from the lake to protect its water quality in the late 1800s and the construction of stormwater collection systems throughout the surrounding area eventually reduced its watershed, excluding the lake itself, to its current 400 acres, of which about 150 are the Harding Park Municipal Golf Course (CDM, 1999). However, even prior to urbanization, little surface runoff reached Lake Merced (LS, 2002a). Instead, rainfall quickly infiltrated into the sandy soils surrounding the lake and arrived at the lake as groundwater inflow through springs or directly through the lakebed. The lake continues to be supported almost entirely by groundwater inflow to the present.

Lake Merced was an important place to the Ohlone, as evidenced by at least three seasonal camps and other artifacts found around its shores (Figure 1). It was also visited by several Spanish expeditions beginning in the 1770s and was later part of the *Rancho de la Merced* Mexican Land Grant. Lake Merced was part of the San Francisco urban water supply under the management of the Spring Valley Water Works, and became city property when San Francisco purchased the Spring Valley Water Company in 1930. Although direct pumping from the lake for municipal water supply ended in 1932 (LS, 2002a), the lake has been San Francisco's official emergency water supply, as designated in the San Francisco Bay Basin Water Quality Control Plan (Basin Plan) (RWQCB, 1995),<sup>4</sup> since that time. During the 1940s through the 1950s, the lake was

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<sup>4</sup> "Municipal and Domestic Supply" is listed as a Potential Beneficial Use in the 1995 San Francisco Bay Basin Water Quality Control Plan (Basin Plan). The Basin Plan lists Cold Freshwater Habitat, Water Contact Recreation,

managed as a “balancing reservoir,” meaning that it was used to absorb short-term fluctuations in supply and demand. The result of this type of use was that the lake was kept more or less full by the addition of Hetch Hetchy water during this period (Figure 17).

**Figure 17. LAKE MERCED WATER LEVEL 1920s TO 2000s**  
 Source: SFPUC (water level), Western Regional Climate Center (rainfall at San Francisco International Airport station)

**QUESTION 1: Are any of San Francisco’s lakes in peril resulting from human activity, or do their current conditions simply reflect the downside of natural cyclical phenomena?**

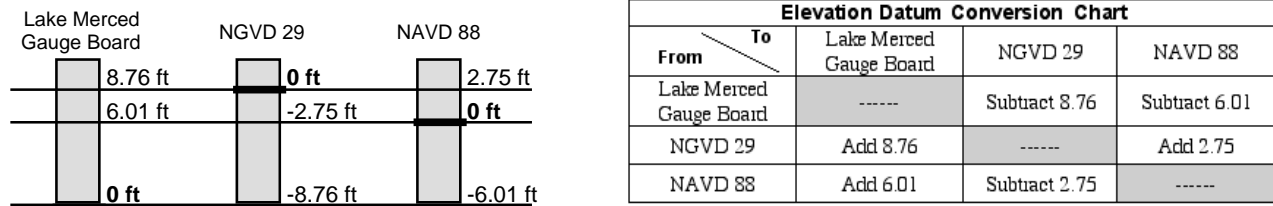
Declining Water Levels

Since the end of the “balancing reservoir” practice, water levels at Lake Merced have been slowly declining. From the 1960s through the mid-1980s the lake level varied by as much as 6 feet, but generally averaged about 25 feet as read from the original Lake Merced gauge board (Figure 17). For ease of comparison with historical water levels, all Lake Merced elevations in this study are referenced to the gauge board datum.<sup>5,6</sup> During the 1987-1992 drought, Lake Merced lost more than 9 feet of water, falling to a minimum water surface elevation of 13.9 feet in November of 1993 (Figure 18).<sup>7</sup> This drop resulted in the lowest lake level since the drought of the early 1930s, when water was pumped directly from the lake to supplement the city’s water supply.

Noncontact Water Recreation, Fish Spawning, And Warm Freshwater Habitat as Lake Merced’s Existing Beneficial Uses (RWQCB, 1995).

<sup>5</sup> The gauge board was formerly painted on the side of the Lake Merced Pump House adjacent to South Lake. A 1987 survey indicates that a gauge board reading of 20.5 feet corresponds to a depth of 23 feet in South Lake (Entrix, 1988).

<sup>6</sup> Other common reference datums used to report water levels at Lake Merced include feet above sea level referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) and feet above sea level referenced to the North American Vertical Datum as updated in 1988 (NAVD 88). Most previous studies that report water levels in feet above sea level are referenced to NGVD 1929. The PUC’s 2002 study (LS, 2002a) references mean sea level (msl) to NAVD 88. The following figure and chart show the datum conversions graphically:



Source: Adapted from LS (2002a), Figure I-2

<sup>7</sup> Even in the past 10 years, there has been some uncertainty about the accuracy of lake level measurements. The source of the November 27, 1993 water level of 13.91 feet (gauge board) was SFPUC data provided to Luhdorff & Scalmanini (LS) for their conceptual model study (LS, 2002a). However, the lake level plot in that report (LS, 2002a, Figure III-2) shows a minimum water level of approximately 7.2 feet msl (NAVD 88) or 13.2 feet (gauge board) in the fall of 1993. This plot represents a slightly different set of data that included adjustments to correct for occasional inexplicable shifts in the data (e.g. a water level drop of 1.53 feet from 9/30/94 to 10/1/94). According to Will Halligan of LS, after the report was released, LS “went back to review our initial corrections to the lake data and removed them as part of our current understanding of the history of the lake (artificial inflows, etc.)” (Will Halligan, pers. comm.). In addition to the data used by LS, a second dataset was transcribed from the Lake Merced Pump House notebooks by John Plummer of Friends of Lake Merced. This dataset contains a lake level of 12.93 feet (gauge board) for November 30, 1993 (John Plummer, pers. comm., 6/3/02).

**Figure 18. LAKE MERCED WATER LEVEL 1970 TO 2002**

Source: SFPUC (water level), Western Regional Climate Center (rainfall for San Francisco International Airport station)

With the help of several large additions of water that were pumped into South Lake in 1992, 1994, and 1995, and the El Nino rains in 1998, the lake regained about 4 feet and stabilized through the late-1990s at elevations ranging between spring highs of 20 feet and fall lows of 18 feet. Since the spring of 2000, however, the water level has been dropping at the rate of about one foot per year. The minimum lake level during the fall of 2001 was 16.4 feet. Data collected through September 2002 show that the lake level has dipped to 15.9 feet.

Effects of Water Level Drop

The falling water levels have had detrimental effects on several uses of Lake Merced. The shallowing of the lake has also exacerbated water quality problems, mainly by increasing the average water temperature. Warmer lake temperatures cannot hold as much dissolved oxygen and, as mentioned in the Mountain Lake section, also stimulate algae growth. As the algae die, their decomposition consumes oxygen, and the bottom layers of the lake water can become anoxic. The anoxic conditions cause the lakebed sediments to release nutrients into the water that stimulate algae growth and further exacerbate water quality problems.

Aquatic biodiversity at the lake has suffered as a result of the declining water levels. The warming of the lake and degraded water quality have all but eliminated the coldwater habitat that once existed in the deeper part of the lake. Trout and other coldwater species that once thrived in Lake Merced are now stunted due to reduced oxygen levels, which frequently fall below the 7.0 mg/liter stipulated in the Basin Plan (RWQCB, 1995) at the lake bottom. In general, lower lake levels decrease the total volume of the lake, which increases fish density and stresses the fish population by reducing available habitat and increasing competition for food (GRC, 1993).

Several recreational activities that once brought throngs of enthusiasts to Lake Merced have also been affected by the degraded state of the lake. In the 1950s and 1960s, thousands of people lined the banks of Lake Merced on the first day of fishing season; now only a handful of fishermen can be found at the lake on a given day, and the fish that people catch are said to taste like fertilizer (Stienstra, 1997a) or mud (Martin, 1999). The water level decline poses a safety concern for rowers who carry their boats down ramps that have been made steeper by the fallen lake level. Sailing, once a popular sport in Lake Merced's South Lake, disappeared when the water level dropped so low that the arms of the South Lake boat hoists hang over exposed lakebed covered with tules rather than open water (Figure 19). As of the summer of 2002, sailing has returned to Lake Merced with a new program on North Lake run by America True. Sailors put their boats in the water using a boat ramp rather than hoists.

**Figure 19. TULES IN FRONT OF BOAT HOISTS AT LAKE MERCED, JANUARY 2001**

Source: CalTrout (2001), Exhibit 28

Finally, because Lake Merced is San Francisco’s emergency water source, the water level decline has reduced the volume of water available for fire-fighting and emergency municipal supply in the event of a disaster that severed Hetch Hetchy supply lines. At the current elevation of 15.9 feet, the volume of South Lake, on which the pump house is located, is approximately 1,700 acre-feet (Entrix, 1988). This is slightly more than half of the roughly 3,200 acre-feet that South Lake contained from the 1960s through the mid-1980s when the water level averaged 25 feet. The primary use of water from Lake Merced in an emergency situation would be for fire-fighting and sanitary control. Because water from Lake Merced exceeds two primary drinking water standards, coliform bacteria and turbidity (GRC, 1993), the distribution of lake water for emergency potable use would be accompanied by a Boil Water Order and Unsafe Water Alert (SFPUC and SFRPD, 1998).

### Reasons for Water Level Decline

The primary reason for the declining water levels at Lake Merced is depletion of the aquifer, which has resulted in a lowering of the groundwater surface. Lake Merced, and in fact all three lakes, are “surface expressions of the underlying aquifers,” meaning that the lake and the groundwater aquifer are one continuous body of water. Where the land surface dips below the water table, a lake results.

Groundwater is present beneath the entire San Francisco peninsula, but it is not all connected. There are seven distinct groundwater basins underneath San Francisco, separated by bedrock ridges. Lake Merced and Pine Lake sit on top of and are fed by the Westside Basin aquifer, which extends from approximately Golden Gate Park in the north to south of San Francisco International Airport in the south, and is bound by the San Andreas fault to the west and San Bruno Mountain and hills of central San Francisco to the east (Figure 20). The Westside Basin aquifer is being depleted by intensive groundwater pumping and possibly by reduced aquifer recharge. In contrast, Mountain Lake is within Lobos Basin, where there is currently little to no pumping and somewhat greater recharge (Phillips et al., 1993, Table 15) due to less intense development, especially in the Presidio. Consequently, Mountain Lake’s water level shows no downward trend.

**Figure 20. GROUNDWATER BASINS OF THE SAN FRANCISCO PENINSULA**

Source: Adapted from SFWD (1996), Figure 2-4

The groundwater of the Westside Basin aquifer is pumped in Daly City, South San Francisco, Colma, and San Bruno for both municipal supply and irrigation of golf courses, cemeteries, and parks. It is also pumped in San Francisco for irrigation of Golden Gate Park and the San Francisco Zoo. According to data collected in 1998, the total volume of groundwater pumped from the Westside Basin is 11,370 acre-feet per year,<sup>8</sup> of which 4,036 acre-feet per year, or about 35% of the total, is used for irrigation (BE, 1998, Table 2.1). Table 1 provides a list of both groundwater and Hetch Hetchy water use for the various municipal and private facilities that operate pumps in the Westside Basin.

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<sup>8</sup> To get a sense of an acre-foot, imagine a football field, which is typically about an acre in area, covered with a foot of water. Put in terms of water usage, 11,370 acre-feet per year is enough water to supply about one-eighth of San Francisco’s total yearly water use. It is also common to see large volumes of water reported in millions of gallons; 1 million gallons = 3.07 acre-feet.

**Table 1. ANNUAL WATER USE IN THE WESTSIDE BASIN (1991-95)**

<b>Well Owner</b>	<b>Groundwater</b> (acre-feet per year)	<b>Surface Water</b> (acre-feet per year)	<b>Total</b> (acre-feet per year)
<b>MUNICIPAL</b>			
California Water Service Company	1,375	6,270	7,645
Daly City	4,045	3,977	8,022
San Bruno	1,914	2,253	4,167
San Francisco		15,065	15,065
<b>Subtotal</b>	<b>7,334</b>	<b>27,565</b>	<b>34,899</b>
<b>IRRIGATION AND PARKS</b>			
<i>San Francisco City Property</i>			
Alvord Park	70		70
Elk Glen	365		365
Golden Gate Park	881		881
Fleishhacker Zoo	18		18
<i>San Francisco Private Property</i>			
Edgewood School	10		10
<i>San Mateo County Golf Clubs</i>			
California Golf Club	264		264
Green Hills <sup>†</sup>	48		48
Lake Merced Golf Club*	454		454
Olympic Club*	401		401
San Francisco Golf Club*	192		192
<i>San Mateo County Cemeteries</i>			
Cypress Lawn	316		316
Eternal Home	90		90
Hills of Eternity	115		115
Holy Cross	268		268
Home of Peace	96		96
Italian Cemetery	76		76
Olivet	191		191
Woodlawn	182		182
<b>Subtotal</b>	<b>4,036</b>		<b>4,036</b>
<b>TOTAL</b>	<b>11,370</b>	<b>27,565</b>	<b>38,935</b>

Source: Bookman-Edmonston Engineering (1998), Table 2.1

<sup>†</sup> No longer pumping – well destroyed (Erdmann Rogge, pers. comm.)

\* Golf clubs that have signed recycled water contract with Daly City (see section on Current Public Policy at Lake Merced)

Until the early 1900s, groundwater elevations around Lake Merced were highest at the southeast corner of the lake, and decreased toward the northwest near the outlet to the coast. As with surface water, groundwater flows from high elevation to low, so the direction of flow was from southeast to northwest. Decades of intensive pumping south of the lake in San Mateo County have now effectively changed the direction of groundwater flow, causing it to flow from north to south (LS, 2002a). In addition to changing the groundwater flow direction, the pumping has also lowered groundwater levels in the vicinity of Lake Merced. According to the SFPUC's most recent study on the relationship between the lake and the aquifer, "The water table has declined some 8 feet on the south side of the lake as a result of induced ground-water flow toward the pumping depression to

the south/southeast; the lake has declined about the same amount over the past 50 years” (LS, 2002a, p. 46).

The situation of the Westside Basin aquifer is complicated by a horizontal clay layer, or aquitard, about 200 feet below the ground surface that dramatically slows down the vertical movement of water. The horizontal continuity and boundaries of the clay layer are not fully known, but there is evidence that the clay layer likely exists beneath Lake Merced. In this area, the clay layer separates the aquifer into two more or less distinct layers -- the shallow aquifer above the aquitard, and the deep aquifer below it. All major groundwater pumping south of Lake Merced is from a depth corresponding to that of the deep aquifer, while the lake is supported by the shallow aquifer (Figure 21). However, it is generally agreed that this clay layer becomes thinner and more discontinuous to the south of Lake Merced in the vicinity of the Daly City municipal production wells (LS, 2002a; Gus Yates, pers. comm., 4/1/02). Additionally, the material that makes up the clay layer has been described as “sandy silt” and “clayey sand,” (CH2M Hill, 1997a),<sup>9</sup> which does allow the passage of water through it, albeit at a very slow rate. Because the clay layer is not 100% impermeable, the depletion of groundwater in the deep aquifer induces shallow aquifer water to leak through the clay at a greater rate, and the water level of the shallow aquifer declines slowly in response (LS, 2002a, p. 44). Lake Merced and Pine Lake, the surface expressions of the shallow aquifer, are a visible demonstration of this decline.

**Figure 21. SIMPLIFIED ILLUSTRATION OF LAKE, AQUIFER LAYERS, CLAY AQUITARD, AND WELLS**

Because of the effects of the clay layer, it likely takes on the order of 15-20 years for a change in the lower aquifer to affect the upper aquifer in the vicinity of Lake Merced (Gus Yates, pers. comm., 9/9/02). Whether the relationship is labeled as “indirect” or “delayed,” pumping in the deep aquifer does ultimately affect the shallow aquifer and the lake. This delay is the reason the lake levels did not drop simultaneously with the deep aquifer levels as pumping increased dramatically from about 1950 to 1970. During this time, pumping in the whole Westside Basin doubled, and Daly City’s municipal pumping, with several wells located about one mile south of Lake Merced, increased 5-fold. The deep aquifer groundwater level at Daly City’s DC-1 well dropped from at or just below sea level in 1955 to about 140 feet below sea level by the 1980s, where it has remained since that time (LS, 2002a).

The SFPUC’s 2002 study (LS, 2002a) also lists the urbanization-related loss of area through which rainfall can recharge the aquifer as a significant cause of the decline of the Westside Basin. The report states that “the urbanization of the Lake Merced watershed and resulting reduction in [aquifer] recharge capacity has likely decreased ground-water inflow into Lake Merced and resulted in lower water levels” (LS, 2002a, p. 31). In their March 2002 presentation of the report, the SFPUC’s hydrology consultant concluded that because of the “essentially irreversible loss of ground-water recharge area” (LS, 2002a, p. 46), even if all pumping in the Westside Basin aquifer

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<sup>9</sup> However, the report also notes that “The drilling method used tends to remove fines from the drill cuttings, leading to a low estimates of the fines content” (CH2M Hill, 1997a, p. 11).

were stopped, we'd all be "dead and gone" (Scalmanini, 2002)<sup>10</sup> before we saw any improvement in water level of Lake Merced. However, according to other hydrologists, there is some uncertainty as to how aquifer recharge has changed from pre-European to current conditions.

Under natural conditions, all of the rainfall reached the soil. However, much of the ground surface of the Westside Basin area was likely vegetated, either with coastal scrub, similar to the plants that currently grow in the adjacent Fort Funston area (Figure 22), or with the perennial grasslands that covered the southern part of San Francisco (Figure 1) and San Mateo County. These plants may have used a large portion of the rainfall. Turner (1991), Miller and Pool (1979), and Hibbert et al. (1981) have shown that in many arid and semi-arid regions including Southern California coastal areas, upwards of 80% of the rainfall is consumed by evapotranspiration from plants (Gus Yates, pers. comm., 6/10/02).

**Figure 22. COASTAL SCRUB AT FORT FUNSTON, BEHIND RANGER STATION**

Courtesy of GGNPA

Under current conditions, rain that falls on roads, rooftops, and other impervious surfaces, which cover 70-80% of the land surface in many parts of the Westside Basin area, is captured by the sewer system and never reaches the aquifer. But in this case, several factors inherent in modern water use and infrastructure increase recharge to the extent that it may equal or exceed what natural recharge may have been. For example, summer irrigation contributes to recharge both as the water itself percolates into the ground, and also by pre-wetting the soil column before winter rains start, which significantly increases the percentage of rainfall that becomes recharge. Also, a very high percentage of any rooftop or pavement runoff that drains to yards or gardens becomes recharge because the rainfall is effectively concentrated on a smaller area with less evaporation or uptake by plants. Leakage from pipes and other impervious areas also contribute to groundwater recharge, as shown by studies of San Francisco's water system that estimate the leakage rate of water supply pipes at 4% (Yates et al., 1990). Sewer pipes likely leak at about the same rate.<sup>11</sup>

The conclusion that recharge has been decreased by urbanization is therefore not as obvious as it might seem. According to hydrologist Gus Yates, who has been involved in modeling of the Westside Basin aquifer since the early United States Geological Survey (USGS) studies in the late 1980s and is currently consulting for Daly City, "the net effect of the pre-development vs. post-development recharge is strongly influenced by numerous assumptions that are difficult to verify for lack of data." He added that "assumptions about the percentage of total watershed area that is impervious, depression storage on impervious surfaces, leakiness of impervious surfaces, and the

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<sup>10</sup> Joe Scalmanini, March 20, 2002, presentation at the PUC office. This was a general statement based on LS's conceptual model, rather than on the numerical modeling that would be required for a more specific prediction. The GRC (1993) model indicates that changes to deep aquifer likely take about 15-20 years to affect shallow aquifer water levels.

<sup>11</sup> For example, the total municipal water use for the part of San Francisco in the Westside Basin area is approximately 15,000 acre-feet per year (BE, 1998), and annual sewer flow is about 98% of total water use (Yates et al., 1990) or 14,700 acre-feet per year, for a total pipe flow of 29,700 acre-feet per year. With a leakage rate of about 4%, pipe leakage contributes about 1,190 acre-feet per year to groundwater recharge in this area.

percent of total impervious area that is connected to the storm drain system are variables that have considerable influence on the calculated net recharge.” If the reduction of recharge is called into question, so then are the conclusions that reduced recharge shares the blame for the fallen aquifer and lake levels, and that the loss of recharge would overshadow the aquifer improvements that could be gained by reduced pumping.

### Water Quality Degradation

According to the Lake Merced Watershed Sanitary Survey (CDM, 1999), there are several significant potential and existing sources of water quality deterioration at Lake Merced. Terrestrial soil and aquatic sediment have been contaminated with lead at the Pacific Rod & Gun Club on the western shore of South Lake. It is estimated that approximately 100 tons of lead shot remain in the lake, although a 1990 study concluded that the lead pellets did not significantly affect lake water quality (Crosby and Overton, 1990 as referenced in CDM, 1999). Illegal dumping of used batteries, oil and paint containers, tires, large appliances and even automobiles around the lake is described as a constant problem. Although the SFRPD’s Integrated Pest Management (IPM) approach significantly reduced the amount of herbicides and fungicides that are used at Harding Park Municipal Golf Course, there were still 9,200 pounds of fertilizers per year applied to the golf course as of 1999. According to the SFRPD’s IPM manager Phil Rossi, the new plan for the golf course after its current renovation is completed will rely more heavily on an organic approach to reduce the use of sulfur-coated slow release fertilizers (Phil Rossi, pers. comm.).

Another major potential source of water quality degradation identified in the CDM (1999) Watershed Sanitary Survey is the possibility of damage to the large capacity sewer line “viaduct” that traverses Lake Merced between South Lake and Impound Lake. In early 1998, heavy storms caused the stormwater to overflow from Daly City’s Vista Grande stormwater conveyance canal, which runs along the western side of South Lake. The resultant flooding washed out part of John Muir Drive and came within a few feet of destabilizing the sewer line. “Had this sewer become separated at this location, the sanitary sewage and stormwater within the viaduct would have been washed into the lake” (CDM, 1999, p. 3-5). Finally, according to the CDM study, there are 31 storm drain inlets that are assumed to discharge roadway runoff to the lake. Of these, three inlets have been fitted with devices to treat runoff before it enters the lake. The main pollutants of concern from stormwater runoff include microbes, suspended sediment, metals, and hydrocarbons from oils and greases.

***QUESTION 2: What kinds of monitoring are being done to evaluate the health of the lakes, and have the best scientific and technical resources been used effectively to address the issues that are impacting the lakes?***

Because it was once a key component in the city’s water supply system, and more recently because of the dramatic, visible decline in the lake’s water levels, Lake Merced has been the subject of a great deal of monitoring and study. Daily measurements of the water level in South Lake have been taken since the mid-1920s. They were recorded by hand in a notebook until 1988, and from 1988 to the present by an automated gauge that records the data electronically. Automated gauges were also installed in North and Impound Lakes in 2001 to determine differences in water levels between the three lakes as part of the 2002 SFPUC study.

There has been sporadic groundwater monitoring in the Lake Merced vicinity since the late 1980s, and it has become more regular in the past two to three years. Larger one-time monitoring efforts connected with past studies have been performed, first to explore the potential for increasing San Francisco's groundwater production and later to help model the relationship between Lake Merced and the Westside Basin aquifer. Some groundwater levels collected for past studies included a systematic error caused by incorrect well-head elevations. This problem was corrected in the SFPUC's most recent study (LS, 2002a).

Quarterly water quality monitoring of various parameters including water clarity, dissolved oxygen, and temperature has been performed by SFPUC staff since September of 1997. Field visits and a review of existing reports were conducted as part of the Lake Merced Watershed Sanitary Survey (CDM, 1999). This study identified potential pollutant sources that might affect lake water quality and made watershed management recommendations to improve water quality. A natural resources inventory that documented existing plant, wildlife, and fish species was also performed in the summer of 1998. However, this study did not accomplish the stated purpose of the project, which was to "assess the impact of changing lake level on the natural resources and to recommend a range of lake levels consistent with beneficial uses" (SFPUC and SFRPD, 1998, p. WRS 2).

A major category of data that is lacking in the effort to understand the effects of groundwater decline is seawater intrusion data. The SFPUC's most recent study (LS, 2002a) asserts that the geology of the San Mateo County and southern San Francisco coastline forms a barrier that prevents seawater from entering the aquifer, even in the Daly City area where groundwater levels of the deep aquifer are well below sea level. However, in response to the fact that these conclusions are based on somewhat sparse geological data,<sup>12</sup> Daly City is conducting further research into the potential for seawater intrusion. The study includes the installation of two additional monitoring wells to collect more data on the geology of the Daly City coastline, and the establishment of these wells along with two existing wells as dedicated monitoring sites for seawater intrusion from both the ocean and the bay. This monitoring is part of a larger project funded by California Department of Water Resources AB 303 Local Groundwater Assistance grant funds.

While the SFPUC maintains primary responsibility for the lake, several other organizations have contributed various technical resources in the effort to understand the trend of declining water levels at Lake Merced. In roughly chronological order, these organizations include:

- U.S. Geological Survey (USGS) - performed two early studies that began the process of modeling the interaction between Lake Merced and the Westside Basin aquifer.

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<sup>12</sup> Tentative correlations depicting angled clay layers were drawn in LS (2002a). These correlations connected clays that were identified in well and borehole drilling logs with clays found in the exposed Merced Formation on the beach cliffs between Fort Funston and Thornton Beach. LS (2002a) first suggests (p. 13) and later asserts (p. 39) that these angled clay layers form a geologic barrier that isolates the aquifers from ocean water. However, the USGS monitoring well at Fort Funston is the only well log available from the area of the angled Merced Formation, and the soil information from its drilling log is neither labeled nor incorporated into the tentative correlations shown in Figure II-6. As part of their AB 303 grant project, Daly City has selected locations for proposed seawater intrusion sentinel wells "in hopes of resolving some of the uncertainty regarding the effectiveness of the Merced Formation barrier" (Gus Yates, pers. comm.).

- Daly City Department of Water and Wastewater Resources – sponsored early modeling studies to evaluate the severity of overdraft of the aquifer in the Daly City area. Their current efforts are focused on the development of a more accurate numerical model of the entire Westside Basin aquifer.
- SFPUC – sponsored major studies by three different consultants (Geo/Resource Consultants in 1993, CH2M Hill in 1997, and Luhdorff & Scalmanini in 2002) with the objectives of determining the cause of the lake’s decline and evaluating the effectiveness of potential management strategies to raise the lake level. They also co-authored a Lake Merced Comprehensive Management Plan with the SFRPD. A revised draft of the plan was released in 1998, but was never adopted in any formal capacity (CalTrout, 2001). The SFPUC is currently involved in a second effort to characterize the impacts of raising the lake level to existing habitat in and around the lake.
- Westside Basin Partners - brought together four local water agencies in the Westside Basin region to develop the Westside Basin Proposed Groundwater Management Plan, a voluntary integrated management plan for the aquifer.
- Lake Merced Task Force (LMTF) - brought together stakeholders including community groups, city agencies, groundwater users, and other interested parties, with the goal of creating a long-term sustainable stewardship program for Lake Merced.

Despite or perhaps because of the numerous efforts to study lake-aquifer interactions, several of which contradicted each other, there has historically been a lack of consensus about the causes of Lake Merced’s falling water levels and the strategies that should be used to remedy the situation. To a large extent, new studies did not build upon past efforts, as was the case when CH2M Hill developed a new model in a different modeling code from that which was used in the 1993 Geo/Resources model, rendering a comparison of results extremely difficult. Also, the findings of peer reviews commissioned by the SFPUC and City of Daly City in 2000 were never used to contribute to the process of improving the models. Currently, Daly City consultants are working on improving a numerical model of the whole Westside Basin, while SFPUC consultants, who are working on a conceptual model of the basin, have indicated that they may be conducting numerical modeling as well. At the present time no specific arrangements have been made to coordinate these modeling activities.

Although scientific consensus does not guarantee the necessary resources and political will to move forward, the lack of consensus regarding how best to achieve and maintain higher lake levels has hindered efforts to develop a comprehensive and binding master plan for the long-term management and stewardship of Lake Merced. Two attempts have been made to develop such a plan. A revised draft of the Lake Merced Comprehensive Management Plan (LMCMP), which was co-authored by the SFPUC and the SFRPD and involved many hours of public discussion, was released in April 1998. However, it was never submitted to the commissions of either department due to opposition from community activists (Michael Carlin, pers. comm., 9/19/02). Tom Stienstra of the San Francisco Chronicle called the LMCMP “one of the biggest disappointments in the lake's 120-year history, a precious opportunity that is being squandered” (Stienstra, 1997b). Although certain recommendations have since been implemented, the plan as a whole has faded into history. A second attempt, the Lake Merced Stewardship Proposal written by the LMTF in January 2001, outlined a new set of recommendations that incorporated many of the ideas outlined in the LMCMP. Like the LMCMP, it was criticized for being too general, and it lacked backing from any

city agency with the authority, resources, and commitment to develop the proposal into a plan for action.

The SFPUC charges that the community must reach consensus on a vision for the lake and take ownership of the development of any comprehensive management plan. According to Michael Carlin, the SFPUC's Chief of Planning, the LMTF should take the lead role in developing the details of these general recommendations, working through budgets and timelines by directing the appropriate public agency members (i.e. SFPUC, SFRPD, or Daly City Department of Water and Wastewater Resources staff) to provide presentations with the necessary technical information. Carlin maintains that this approach would produce a plan with built-in community support as well as technical expertise, rather than the status quo, in which SFPUC plans lack community support or LMTF recommendations contain requirements that the city considers unrealistic due to operational and regulatory constraints (Michael Carlin, pers. comm., 9/19/02).

John Plummer of Friends of Lake Merced, a long-time advocate and watchdog for the health of the lake, contends that the SFPUC failed to incorporate the public input generated at both the LMCMP and WBGMP public workshops (John Plummer, pers. comm., 9/2/02). He added that the meetings were not workshops, but instead public hearings with a uni-directional exchange of information. Plummer also cites a lack of response to community offers to provide free technical support, ranging from maintaining a database of groundwater data to reviewing the groundwater model, as evidence of city agency reluctance to work with the public (FoLM, 2002).<sup>13</sup> The SFPUC has been a member of the LMTF and a participant in the Water sub-committee since the LMTF's formation in 1999. However, communications between the SFPUC and community members within the LMTF, especially in the Water sub-committee, have not improved. For example, when the LMTF helped to secure a \$150,000 allocation from the Board of Supervisors earmarked for studies at Lake Merced, the SFPUC made no response to a proposal written by members of the LMTF for the development of these studies. The SFPUC later discharged the funds on studies that the LMTF did not have the opportunity to review.<sup>14</sup>

In general, community members have been frustrated by the SFPUC's slowness to act to increase lake levels. Lake Merced Task Force member Dick Morten of the San Francisco Planning and Urban Research Association (SPUR) laments, "Through years of inaction, the SFPUC allowed Lake Merced's lake level to decline, water quality to deteriorate, and habitat to change without any environmental review. Now, efforts to reverse years of neglect require hundreds of thousands of

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<sup>13</sup> Friends of Lake Merced offered in letters to San Mateo County Supervisor Mike Nevin (11/10/99) and Daly City DWWR director Patrick Sweetland (12/7/99) to summarize and report groundwater data collected for the Westside Basin Groundwater Management Plan (FoLM, 2002). Retired USGS hydrogeologist David Dawdy offered to assist in refinements CH2M Hill groundwater model on a pro-bono basis in 6/27/00, 9/20/00, and 10/5/00 letters to Joan Ryan of the PUC's Planning Bureau (David Dawdy, pers. comm.).

<sup>14</sup> Jessica Ring, who was a co-chair of the LMTF development committee and aide to District 7 Supervisor Mabel Teng, wrote the motion that the Board of Supervisors passed in July 2000, allocating \$150,000 to the PUC that was earmarked for Lake Merced. The money was to be used to perform (1) an assessment of varying lake levels on the beneficial uses of Lake Merced and (2) a study to develop a model of the relationship between the aquifer and the lake level at Lake Merced. Nine members of the LMTF Water and Nature sub-committees submitted a proposal to the SFPUC in December 2000 for the use of that money, to which the SFPUC made no response. In fall 2001 and fall 2002, respectively, the SFPUC dispersed \$75,000 to LS for the installation of 7 new shallow monitoring wells around Lake Merced and \$75,000 to EDAW, Inc. for a baseline habitat study. There was no public or LMTF review of the LS contract, and opportunity for only minimal review of the EDAW scope of work after it was essentially completed.

dollars to be spent on environmental analysis and potentially on mitigation measures to improve the current deteriorated condition of the lake.”

***QUESTION 3: How effective is current public policy at protecting San Francisco’s lakes, and what else can or should we be doing?***

Two city agencies -- the SFPUC and the SFRPD -- share management responsibilities at Lake Merced. Because of Lake Merced’s connection to San Francisco’s water supply system, the SFPUC owns the lake and surrounding property, and has primary responsibility for maintaining the lake as alternative water resource. The SFRPD manages the recreational facilities at the lake and provides stewardship of the shoreline and park area around the lake. The SFRPD received the “right to occupy, use, and improve for park and recreational purposes” the lands surrounding the lake through the 1950 SFPUC resolution No. 10,435 under the conditions that “the Park and Recreation Commission agrees that the primary purpose of the Lake Merced Tract is to supply potable water to the water consumers in San Francisco,” and “in no instance shall the water level be drawn below 27 feet on the gauge.” At the state level, the State Water Resources Control Board “has the primary jurisdiction to assure the reasonable and beneficial use of the public waters of Lake Merced and the Westside Basin” (CalTrout, 2001, p. 5). There are several other local, state and federal agencies with some jurisdiction over the lake, listed in Appendix A-1.

Background

Despite the long history of groundwater use for domestic and agricultural water supply statewide and the fact that it provides 60% of all water supplied to Californians (California Water Association, n.d.), groundwater jurisdiction has very little institutional or legal history. While surface water use is governed by the California State Water Code, groundwater use is essentially unregulated, unless disputed rights are settled in court. A new method of groundwater management, known as the AB 3030 legislation, was added to the California Water Code in 1992. The AB 3030 legislation provides a framework for local agencies to develop groundwater management plans. In 1996, the cities of San Francisco, Daly City, and San Bruno, and the California Water Service Company formed a partnership called the Westside Basin Partners to develop an AB 3030 groundwater management plan for the Westside Basin. The Westside Basin Partners completed the Westside Basin Proposed Groundwater Master Plan in 1999.

For at least the past 15 years, public policy for Lake Merced has consisted primarily of a lot of studying (see section above on Monitoring and Utilization of Resources at Lake Merced). In addition to the studies, which were aimed at shaping long-term policy regarding the lake level, some emergency measures have been taken to help keep water in the lake. For example, in 1990, with lake levels plummeting to their lowest elevation in almost 60 years, the city ended its practice of drawing water directly from Lake Merced to irrigate the Harding Park Golf Course and to fill street-cleaning trucks (GRC, 1993).<sup>15</sup> Ending this direct drain on the lake, in combination with sizable water additions to Lake Merced for one- to two-month periods in 1992, 1994, and 1995,<sup>16</sup>

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<sup>15</sup> Yates et al. (1990) reported pre-1990 annual water extraction estimates for Harding Park irrigation and street-cleaning trucks as 250 acre-feet per year and 9.5 acre-feet per year, respectively.

<sup>16</sup> Water additions to Lake Merced in 1992 and 1994 were 840 acre-feet and 920 acre-feet, respectively (LS, 2002a). Water was also added to Lake Merced from July 31 to August 29, 1995, as part of a study to record the effect of water

undoubtedly helped stabilize the lake levels during the mid to late 1990s. But the continued decline of the lake after 2000 demonstrates that stopping the Harding Park extraction was not enough and that piecemeal water addition provides no long-term benefit to the lake. The lake is part of a much larger body of water -- the aquifer, and if the lake level is raised above the aquifer level, water slowly leaks out of the lake through the lakebed until the two water levels equalize.

From the beginning of the lake's dramatic decline in 1987 until 2001, no coordinated, long-term actions were taken to reverse the downward trend of the water level at Lake Merced. It was this lack of action<sup>17</sup> that prompted California Trout (CalTrout) to file a petition in January 2001 with the State Water Resources Control Board and seven other local and state agencies. Their petition requested that the State "adopt and implement limitations on groundwater pumping as necessary to halt the continuing decline of Lake Merced and as expeditiously as practical, restore and maintain the historic level of 18.25 feet MSL" (CalTrout, 2001). However, in August 2001, CalTrout requested that the State place the petition on inactive status to allow a series of voluntary, confidential negotiations between the golf courses, Daly City, and SFPUC to proceed. The negotiations, which are still on-going, are mediated by William Cahill, a retired San Francisco Superior Court judge now with a nationwide firm of mediation experts called Judicial Arbitration and Mediation Services (JAMS), who provide alternative, out-of-court dispute resolution services. It has been through these negotiations that the first real movement toward long-term solutions aimed at reducing pumping, including both the Daly City recycled water and conjunctive use agreements, began to happen.

### Projects In-Progress

Due to the combination of attention brought to the issue by very active community members and the CalTrout petition, and the cooperation between San Francisco, Daly City, and three private groundwater users resulting from the JAMS negotiations, substantial efforts are now under way to improve aquifer conditions and add water to lake. Four main projects have been sponsored in various combinations by Daly City and the SFPUC.

The first of these efforts is the long-awaited signing of a recycled water agreement between Daly City and three golf courses just south of Lake Merced -- Olympic Club, San Francisco Golf Club, and Lake Merced Country Club (Figure 23). The 50-year contract stipulates that Daly City will build a tertiary treatment facility at their North San Mateo County Sanitation District's Westlake Plant and sell tertiary-treated recycled water to the golf courses, who will use the recycled water for a minimum of 70% of their total irrigation needs. Recycled water from the plant will also be used for irrigation of several Daly City parks. The SFPUC will contribute \$1 million to the estimated total cost of approximately \$6 million for the construction of the plant in exchange for easements

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additions to the lake on water levels in nearby wells (CH2M Hill, 1997a). The volume of water added was not reported, but it can be estimated at about 300 acre-feet through a comparison with water level changes that occurred during 1994 water additions. Lake level plots in Appendix A-3 show periods of water addition, indicated by a dramatic increase in lake level during periods with no rainfall.

<sup>17</sup> "CalTrout acknowledges the good will and hard work of the Westside Basin Partners in proposing to adopt and AB 3030 plan for the Westside Basin. We acknowledge that the San Francisco PUC has proposed a management plan for Lake Merced. We bring this Petition in the face of a history of delay in the on-the-ground action" (CalTrout, 2001, p. 18).

allowing them to build one extraction / injection well at each golf course.<sup>18</sup> The target date for the commencement of tertiary recycled water delivery to the golf courses is January 1, 2004. The agreement is a milestone because it represents the first conversion of irrigation infrastructure from groundwater to recycled water in San Francisco and San Mateo Counties. It is also significant because the pumping at the golf courses wells, located so close to the lake, has a more exaggerated effect on the lake and shallow aquifer levels than the effects of more distant wells (GRC, 1993). In sum, the wells at these 3 golf courses currently pump about 1,000 acre-feet per year, or about 25% of all pumping for irrigation from the Westside Basin.

**Figure 23. AERIAL PHOTO OF LAKE  
MERCED SHOWING GOLF COURSES  
AND VISTA GRANDE CANAL**

Basemap: USGS aerial photograph from Terraserver

The SFPUC also has plans for a recycled water program, with the goal of replacing Hetch Hetchy water and groundwater with recycled water for appropriate non-potable uses. The new recycled water program will not be the first use of recycled water in San Francisco, however. The McQueen wastewater treatment plant in Golden Gate Park produced secondary-treated recycled water that was used for irrigation, lakes, and streams and Golden Gate Park beginning in 1932. The plant was closed down in 1982, when new State Department of Health Services regulations, enacted in 1978, required tertiary treatment for recycled water use in the park (MW, 1995).

The new Recycled Water Program, included in the SFPUC's proposed Capital Improvements Program as a project in the Local Water portion of the November 2002 water bond, is the latest step in the on-going efforts to realize recycled water use in San Francisco. The efforts began with two companion recycled water ordinances (Ordinances 390-91 and 391-91) passed by the San Francisco Board of Supervisors in October 1991, directing the San Francisco Water Department (since incorporated into the SFPUC) and Department of Public Works to develop a coordinated long-term plan to expand groundwater and recycled water use. Draft Recycled Water Master Plans were released in 1992 and 1995, but were never approved and implemented. For the current update of the plan, scheduled to be completed in July 2003, the SFPUC is working on a proposal for a decentralized approach, which would consist of small regional "package plants," or water recycling hubs based on customer location. This approach would minimize the distribution pipe network, which is a very costly part of any water project. The three potential hubs on west side of the city include the San Francisco Zoo/Harding Park, Golden Gate Park, and Lincoln Park. The three locations proposed for east side are McLaren Park/Hunter's Point, Mission Bay, and the Presidio/Marina Green. Environmental review could begin by early 2003, and money will be available for starting projects by April of 2003. Recycled water could be available as early as 2005 (Michael Carlin, pers. comm., 6/5/02). Patricia Martel, the SFPUC's general manager, has stated that the SFPUC is "committed to using recycled water for all irrigation in the city," and added that "public opinion seems to be extremely positive about recycled water" (Patricia Martel, pers. comm.).

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<sup>18</sup> The easements to build extraction / injection wells on the golf course properties would provide the PUC with locations to recharge the groundwater through injection of Hetch Hetchy system water to the deep aquifer, as discussed below in the section on conjunctive use of surface water and groundwater supplies. The extraction / injection wells would not be part of the recycled water distribution system for golf course irrigation.

The SFPUC's recycled water program could affect water levels at Lake Merced, as well as Pine Lake, in three ways. First, recycled water could be added to the lakes to raise water levels, and in fact the SFPUC's Michael Carlin stated that "we will be factoring in recycled water for recharge of Lake Merced in our proposal" (Michael Carlin, pers. comm., 6/17/02). Second, recycled water is intended to replace groundwater used for irrigation, although the main groundwater use near Lake Merced is for the San Francisco Zoo,<sup>19</sup> since neither Harding Park, San Francisco State University, nor Stern Grove / Pine Lake Park use groundwater for irrigation. In general, the availability of recycled water for irrigation will reduce the incentive to pump from the aquifer. Third, as an alternative to adding recycled water directly to the lake, recycled water could also potentially be injected into the shallow aquifer to build up the water table south of the lake, which could be effective in maintaining higher lake levels. A thorough examination of public health issues involved with this concept would be required before it could be implemented.

The third project consists of a group of two-year experimental "conjunctive use" agreements between the SFPUC, as operator of the Hetch Hetchy system, and the three municipal water purveyors pumping from the Westside Basin -- Daly City, San Bruno, and California Water Service Company. Under these agreements, the water purveyors will reduce their pumping for municipal supply<sup>20</sup> by up to 80% to 100%, depending on the purveyor, and instead purchase "supplemental" Hetch Hetchy water<sup>21</sup> from the SFPUC at a reduced rate<sup>22</sup> when available. The goal of the project is to monitor how the aquifer responds to significantly reduced pumping. The contract with Daly City is particularly important to achieving this goal, as Daly City is the largest single user and pumps over one-third of all groundwater extracted from the Westside Basin. The agreement with Daly City was signed in the spring of 2002. The agreements with the California Water Service Company and San Bruno are currently pending approval at the San Francisco Board of Supervisors (SFPUC, 2002b). Supplemental water deliveries to Daly City are scheduled to begin in the winter of 2002-2003.

A strategy to help decrease the adverse impacts of municipal pumping on groundwater levels is critical, because over two-thirds of all groundwater pumped from the Westside Basin is used for potable municipal supply, which unlike water used for irrigation, cannot easily be replaced with recycled water. The concept of conjunctive use, or integrated management of groundwater and surface water supplies, can be thought of as banking water in the aquifer. During normal and wet years, water suppliers would use more imported surface water and less groundwater, allowing

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<sup>19</sup> According to SFRPD Chief Stationary Engineer Leon Smith, water pumped from the zoo well is used for animal pools (seal pool drained and filled once a week), zoo grounds irrigation and washdown, and Great Highway irrigation (at night). Only the irrigation and washdown could potentially be converted to recycled water since water for the animal pools must be groundwater (even Hetch Hetchy water cannot be used without dechlorination). (Leon Smith, pers. comm.)

<sup>20</sup> Currently at approximately 4,000 acre-feet per year, 1,900 acre-feet per year, and 620 acre-feet per year for Daly City, San Bruno, and Cal Water, respectively (LS, 2002a).

<sup>21</sup> "Supplemental" Hetch Hetchy water is water that currently flows out of the O'Shaughnessy Reservoir and fills New Don Pedro reservoir, which is used by the Modesto and Turlock irrigation districts. Once this water goes to the New Don Pedro, the PUC can't get it back, but the PUC benefits in that they can pre-deliver part of their contractual water allocation to Modesto and Turlock and can then use more PUC storage space for Hetch Hetchy customers. (Michael Carlin, pers. comm., 6/5/02)

<sup>22</sup> For example, Daly City will pay \$0.35 per 100 cubic feet (ccf) of supplemental water under the conjunctive use plan, compared to their regular rate of \$0.88/ccf in its regular contract with the PUC (Verrinder, 2002).

aquifer storage to increase through passive recharge, also called “in-lieu” recharge. During dry years, the groundwater that has been “banked” would be pumped more heavily to make up for surface water shortages. According to hydrologist Gus Yates, “An incidental advantage of conjunctive use of the deep zone (assuming water is first stored and then withdrawn) is that long-term-average groundwater levels would be higher than they are under present management. Even though deep-zone water levels would be drawn back down to present levels during droughts, the shallow zone would respond beneficially to the higher average water levels” (Gus Yates, pers. comm., 6/10/02). Yates added that “The real Achille's heel of existing management as well as conjunctive use is the risk of seawater intrusion, and we are working on improving our understanding of that risk.”

The SFPUC is also considering a plan for active recharge of the aquifer, in which Hetch Hetchy water would be injected into the deep aquifer through the extraction / injection wells on the golf course properties, with the same goal of building up the aquifer and storing groundwater for later use. These wells could also potentially be used for injecting recycled water into the shallow aquifer as discussed above.

In the end, the success of a concept such as conjunctive use depends on how much supplemental water is available to substitute for groundwater in the long-term. The average total groundwater extraction used by Daly City, Cal Water, San Bruno for municipal supply is 7,300 acre-feet per year. According to Michael Carlin, “‘surplus’ water has been available primarily in the October to March period in 12 of the years between 1975-95. During this period was also the 89-93 drought when no ‘surplus’ water was available. The quantities vary from a few hundred acre-feet to hundreds of thousands of acre-feet” (Michael Carlin, pers. comm., 7/25/02).

Finally, Daly City is building another project that it hopes will both benefit Lake Merced and alleviate flooding problems in Daly City. Construction is under way for a pilot project that will eventually divert to Lake Merced part of the stormwater that currently flows through the Vista Grande Canal. The Vista Grande Canal collects stormwater from about two square miles of Daly City and unincorporated San Mateo County and carries it to Vista Grande Tunnel, which empties into the Pacific Ocean through an outfall one-half mile offshore (Figure 23). Currently, large storms cause stormwater to back up where the canal meets the lower-capacity tunnel. Destructive flooding across John Muir Blvd into Lake Merced, such as that which occurred during the winters of 1998 and 2001, as well as flooding in Daly City are the result. Unlike San Francisco’s combined sewer system, Daly City has separate sewer and storm drain systems, which make the stormwater diversion project feasible from an infrastructure perspective.

Pollutants that are picked up as runoff flows across street surfaces will be removed from the stormwater using a treatment process called a Continuous Deflection System, or CDS. This system passes stormwater through a chamber that produces a vortex-like effect, from which solids settle to a sump, and floatables, such as oils and greases, remain in the separation chamber. It effectively removes oil, grease, and grit, but has fairly low nutrient and coliform removal capabilities. Constructed treatment wetlands along southwestern shoreline of South Lake are also a potential part of the overall stormwater treatment plan. The wetlands would remove total suspended solids, biological and chemical oxygen demand, and nutrients before the stormwater reaches the lake. According to Patrick Sweetland, the director of Daly City’s Department of Water and Wastewater

Resources, the process for determining the necessary treatment for adding stormwater to the lake will be very iterative, and wetlands will be used if necessary (Patrick Sweetland, pers. comm.).

The pilot CDS units are in place for the 2002-2003 rainy season, during which stormwater will be diverted, treated, tested, and then returned to the canal. If the results that indicate the water quality of the treated stormwater is compatible with that of Lake Merced waters, Vista Grande stormwater could be diverted to Lake Merced by the winter of 2003-2004. Estimates of the volume of water that the Vista Grande diversion would add to the lake on an annual basis range from 63 to 94 million gallons per year (CH2M Hill, 1998; GRC, 1993).<sup>23</sup>

These projects, all designed to reduce aquifer pumping or return runoff to the lake, are a good start in the slow process of increasing lake levels, improving aquifer conditions, and moving toward more sustainable water use policies on the San Francisco peninsula. But they won't be completed for at least two to three years if they stay on schedule, and, as discussed above, experts estimate that it would take on the order of two decades for improvements in deep aquifer to effect the water level of the shallow aquifer.

In the mean-time, Lake Merced's water levels are dropping about a foot per year. In response, the SFPUC started adding dechlorinated Hetch Hetchy water to Lake Merced during the week of October 16, 2002, at a rate of 10 million gallons per day for 30 days (SFPUC, 2002c). This water addition program, which was initiated by the community and is endorsed by the California Department of Fish and Game and the Golden Gate Audubon Society, is expected to result in a lake level rise of approximately 1.5 feet. The goal of the water addition is the short-term stabilization of the lake, intended to prevent further decline, rather than to actually increase the water level. To avoid any negative impacts on the existing natural habitat in and around the lake, water will be added to the lake according to the following schedule: (1) water added to the lake between July 15, 2002 and February 15, 2003, will not raise the lake more than one foot above its July 15, 2002, level; (2) water added between February 15 and April 15, 2003, will not raise the lake more than six inches above its February 15, 2002, level; and (3) no water will be added to the lake between April 15 and July 15, 2003, without the concurrence of the California Department of Fish and Game and the Golden Gate Audubon Society (SFPUC, 2002b).

After the water additions stop, the water levels will begin to fall back to their former level, as the levels of the lake and aquifer, which are part of the same body of water, equalize. The addition of water to the lake, without concurrent efforts to raise the aquifer levels, can therefore only be a long-term strategy to maintain higher lake levels if it is designed to continue indefinitely. And indefinite water addition is part of the SFPUC's proposed plan. While the SFPUC does support recycled water and conjunctive use programs that will reduce groundwater pumping, they also advocate a strategy of separate management of the lake and aquifer, in which groundwater users can continue

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<sup>23</sup> 63 to 94 million gallons per year translates to 190 to 280 acre-feet per year, which when divided by the total 250-acre area of the lake yields about 1 vertical foot of lake rise per year. However, with constant seepage out of the lake bottom, the actual effect would be significantly less. Depending on the source, estimates of water level rise resulting from diversion of Vista Grande stormwater into Lake Merced range from 0.3 to 0.6 feet per year, from GRC (1993) and CH2M Hill (1998) respectively.

to pump as necessary,<sup>24</sup> and that lake levels will be managed through perpetual water addition (Scalmanini, 2002). Currently, the proposed target lake level, based on a 1993 beneficial use assessment (GRC, 1993), is 26 feet as measured on the Lake Merced gauge board. The SFPUC has made a preliminary estimate that if the lake levels were increased to 26 feet, approximately 1 million gallons per day, or about 1,100 acre-feet per year, would be required on a permanent basis to maintain the lake at this level (LS, 2002b).

Hetch Hetchy water will only be available for addition to Lake Merced until sometime in early 2004, when the SFPUC expects to complete its conversion from a chlorine to a chloramine disinfection system. This conversion would make Hetch Hetchy water unsuitable for direct addition to lakes. While the SFPUC has generally identified that a combination of recycled water and treated Vista Grande stormwater will be used to provide this water in the long-term, they have also stated that there is significant uncertainty regarding the regulatory approval of adding recycled water to add to the lake.<sup>25</sup>

Another issue that must be considered in the ultimate plans to raise lake levels is the impact to existing habitat, primarily wetland habitat that has grown up along the fringes of the lakes on the now-exposed former lake bottom. Although there is as yet no community consensus regarding the precise optimal lake level -- with some wildlife advocates wanting more assurances that existing habitat won't be destroyed, while some recreation advocates are more eager to return to previous higher levels -- there does exist a broad consensus among diverse groups such as the Sierra Club, boating clubs, the Golden Gate Audubon Society, the Committee to Save Lake Merced, Friends of Lake Merced, and SPUR, that the decline must be halted as soon as possible, that the level must be increased, and that habitat and hydrological studies are needed (Ruth Gravanis, pers. comm.). The SFPUC has contracted with a consultant to perform an assessment of the environmental impacts of raising the lake level. A second task included in this study will be to develop a roadmap to identify environmental, regulatory, and operational issues that will need to be addressed in order to add recycled water or treated stormwater to the lake.

### Other Ways to Improve Lake Merced Water Levels

#### **Greater Pumping Reduction**

While it may be appropriate and necessary to continue pumping from the aquifer, at least for municipal supply, the water recycling and conjunctive use projects listed above indicate that it is also appropriate and necessary to reduce pumping in situations where alternative water sources are available. These projects, and any other efforts that reduce pumping or increase groundwater levels, will help create a way to maintain higher lake levels that is more natural and sustainable than the addition of imported water to the lake. Additionally, by restoring higher groundwater levels, these

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<sup>24</sup> “There is a range of opportunities for integrated management of the basin to provide ongoing water supply, whether on a continuous (as has been the case) or intermittent (as might be desired in some form of conjunctive use scenario) basis” (LS, 2002a, p. 47).

<sup>25</sup> “Approach: The proposed plan will rely on existing environmental conditions to anticipate the likely environmental and regulatory requirements that will guide the discharge of recycled water and/or stormwater to Lake Merced. (Note: there is no regulatory precedent in California for the discharge of recycled water into a water body designated as a ‘potential municipal and domestic supply.’)” (SFPUC, 2002a)

projects would also reduce the potential for seawater intrusion into the aquifer. Given the lack of data supporting the existence of a uniformly impermeable geological barrier, and the fact that the Westside Basin aquifer lies between two bodies of saltwater, a solution that provides greater insurance against seawater intrusion by restoring the balance between extraction and recharge seems well warranted.

The three projects described above (Daly City water recycling, SFPUC water recycling, and Daly City conjunctive use), however, do not represent the sum of all that can be done to reduce pumping. Using the recycled water agreement between Daly City and the golf courses as a model, one way to further reduce pumping is to convert the remaining groundwater-based irrigation systems in the Westside Basin area to recycled water. San Francisco and San Mateo Counties are included among only 10 of California's 58 counties in which there is no recycled water use, and are the only metropolitan counties in California without recycled water. Until last year, when Daly City began taking concrete actions toward building infrastructure to produce recycled water, both counties were operating under paradigm in which all water is treated to potable standards regardless of its eventual use, used once, and then disposed of. With the establishment of water recycling programs, they will begin to move toward a paradigm, already adopted by much of the state, in which water is used multiple times before it is discharged. In this system, water is treated to a quality appropriate for its specific use.

The use of recycled water in California is not new or experimental. The California Code of Regulations regarding recycled water use has been developed over decades of monitoring the effects of recycled water use on public health, and is considered to be among the most stringent in the world (Bontoux, 1997). The code requires different categories of treatment for various uses of recycled water. Most irrigation applications require tertiary treatment, which means advanced treatment beyond primary and secondary treatment, and usually involves filtration and disinfection. California requires the same level of treatment for irrigating parks, schoolyards, and other unrestricted landscaped areas, as it does for irrigating food crops, including edible root crops. (See <http://www.calregs.com> California Code of Regulations, Title 22, Division 4, Chapter 3 for more information on Water Recycling Criteria.)

But even after the Daly City and San Francisco recycled water programs come on-line, there will still be two golf courses and eight cemeteries in San Mateo County that have no plans to convert their irrigation systems to recycled water, because there is no supply available (Figure 24). These golf courses and cemeteries, which currently use on the order of 3,000 acre-feet of groundwater per year, lie between Daly City's North San Mateo County Sanitation District plant and the South San Francisco Water Quality Control Plant. The tertiary treatment facilities being constructed at Daly City's plant will only have the capacity to provide recycled water for their contracted customers, the three Lake Merced area golf courses; and the South San Francisco plant has no plans at this time to add tertiary treatment to their existing facility.<sup>26</sup> According to Ken Navarre, the Assistant Superintendent of the plant, "The addition of tertiary treatment facilities and a recycled water distribution system would be a huge expense and the rate payers will need to be convinced that it is in their best interest to fund the project. As the public becomes more aware of the beneficial uses of

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<sup>26</sup> However, the South San Francisco City Council recently approved study to examine the prospect of using reclaimed water within South San Francisco (Ken Navarre, pers. comm., 7/10/02).

recycled water [...] they will probably be more receptive to funding such a project” (Ken Navarre, pers. comm., 4/26/02).

**Figure 24. SAN MATEO COUNTY IRRIGATORS  
THAT USE WESTSIDE BASIN GROUNDWATER**

Source: Adapted from CalTrout (2001), Exhibit 4

Many communities are finding out that it does pay to use recycled water. Bay Area examples of recycled water use for irrigation include Marin and Sonoma Counties, the cities of Livermore, Palo Alto, and regional projects, such as the South Bay Water Recycling Program that serves San Jose, Milpitas, and Santa Clara. Within San Francisco, the Presidio is building its own water recycling plant to provide recycled water for landscape irrigation that meets the construction timeline of the new Lucas Digital Arts Center. The new treatment plant will also serve several other sites in the Presidio.

In the majority of these locations, recycled water is used primarily for irrigation applications ranging from highway median vegetation, golf courses, cemeteries, parks, and commercial landscaping to agricultural irrigation for farming and vineyards. But the Marin Municipal Water District (MMWD), which has been producing tertiary-treated recycled water since 1981, has been a leader in expanding the use of recycled water to more innovative applications. With its slightly wetter climate and greater portion of wild or natural vegetation, landscaping in Marin doesn't require as much irrigation as is needed in drier, more heavily landscaped areas such as the East Bay and South Bay. The MMWD was the first in state to use recycled water for commercial laundries and car washes, and currently supplies eight dual-plumbed buildings that use recycled water for toilet flushing, more than in any other county in the California (Bob Castle, pers. comm.). As would be the case in built-up San Francisco, Marin's recycled water program focuses on retrofitting existing facilities rather than on new development, and has retrofit 310 facilities for recycled water use to date.

Southern California, which imports the majority of its water supply from the State Water Project and from the Colorado River, began to understand how severely overdrafted its aquifers were decades ago and has since developed recycled water uses even more extensively. A recent article in the San Francisco Chronicle contrasted Los Angeles and San Francisco County's irrigation water sources, saying “Golden Gate Park is still irrigated each day with about 2 million gallons of drinkable water. By comparison, Los Angeles County's parks and golf courses use about 6 million gallons of recycled water every day” (Finnie and Sward, 2002). Besides irrigation, applications of recycled water use in Southern California include recreational lakes and wildlife refuges, industrial processes such as carpet dyeing and concrete mixing, groundwater recharge by spreading, and groundwater injection to provide a saltwater intrusion barrier (SWRCB, 2000a). Some of these programs, including groundwater recharge in Los Angeles County, have been operating successfully for as long as 40 years (WateReuse, 2001).

## Better Use of Rainwater

While reducing pumping will undeniably improve groundwater levels, manipulating withdrawal from the aquifer is only half of the equation. The other side of the equation is recharge. Large volumes of rainwater that could be used to recharge the lakes and aquifer are captured by the city's combined sewer system, mixed with sewage, treated by the city's water pollution control plants, and discharged to the ocean or bay. This rainfall is treated as waste product instead of a resource in a region where the imported water supply is insufficient to meet the projected future demand and parts of the aquifer have been overdrafted for decades. In addition to the loss of potential lake and aquifer recharge water, the capture of storm runoff by the sewer system can lead to another detrimental effect on the environment. Several times a year, large rain storms overload sewer system and cause combined sewer overflows, in which the essentially raw sewage and stormwater mixture spills out into bay or ocean from overflow points all along San Francisco's coastline.

Regardless of whether aquifer recharge has decreased since the early 1900s or not, the depressed groundwater levels of both the shallow and deep aquifer indicate that extraction exceeds recharge, and the water levels of Lake Merced and Pine Lake continue to fall as a result. Getting more rainwater out of sewers and into the ground would both help balance current demands on the aquifer and reduce combined sewer overflows.

To get a sense of the volume of rainwater involved, San Francisco and northern San Mateo County receive an average of 20 inches of rainfall a year. The area of the Westside Basin is about 40 square miles or about 26,000 acres, and it receives a total rainfall volume of about 43,000 acre-feet of water per year. For comparison, the total water use (including both groundwater and Hetch Hetchy water) in the entire Westside Basin is about 40,000 acre-feet per year. CH2M Hill (1997b) estimates current aquifer recharge in the entire Westside Basin, including percolation of precipitation and irrigation water, seepage from lakes, and leakage from pipes, at about 13,400 acre-feet per year.

Of course, it is not realistic or even possible to capture and put to use 100% of the rainfall. Remaining vegetation uses part of the total rainfall, some of it evaporates, and some of it becomes polluted with roadway contaminants. However, about 5,100 acre-feet of stormwater were processed by San Francisco's western watershed (Oceanside Water Pollution Control Plant) during the 2001-2002 water year (Nathan Brennan, pers. comm.). If 25% of this runoff, about 1,300 acre-feet per year, could be captured and used for aquifer recharge, that would represent an increase in inflow to the aquifer on the order of 10%. This increase would be an excellent example to set for the other municipalities that sit atop the Westside Basin, and would be a significant achievement on its own.

There are many emerging stormwater management techniques that can increase the amount of rainwater that infiltrates into the ground, where it could eventually help maintain higher water levels in Lake Merced and Pine Lake. One method that many cities are beginning to explore is the idea of disconnecting rooftop downspouts from the sewer system. Unlike roadway runoff that picks up contaminants, as is case at Mountain Lake, rooftop water is fairly clean and free of sediment. Once

### **Figure 25. DOWNSPOUT DISCONNECTION**

Source: Adapted from City of Portland Bureau of Environmental Services downspout disconnection literature

they are disconnected from the sewers, rooftop downspouts can direct runoff to unpaved areas such as yards or gardens, or to drywells (Figure 25).

If rooftop rainwater is simply directed to a yard or other unpaved area, the amount of the runoff the ground can absorb depends on the permeability of the soil of the yard. The sandy soils of western San Francisco, once covered with shifting dunes, allow infiltration rates as high as 20 inches per hour (SCS, 1991).

Rooftop runoff can also be directed to a drywell, which is basically an underground sump, usually either a pit filled with gravel or a perforated concrete tank, that stores runoff for short periods of time until it can infiltrate into the surrounding soil. Drywells are useful in settings where unpaved area is limited because they can actually be built underneath pavement, such as driveways or patios. While they are the preferred option in many cases for this reason, they are more expensive and complicated to build, and in other cities they typically require more rigorous inspection and a city permit. Appendix A-2 provides a chart used by the city of Portland, Oregon to correlate rooftop area with recommended drywell size. It should be noted that the chart is included as an example only. The values contained in the chart are specific to rainfall typical for Portland and would not apply to San Francisco.

Rooftop disconnection was a key technique for a demonstration house in the Los Angeles area that was retrofit to capture 100% of a 2-inch storm. The house was part of the Trans-Agency Resources for Environmental and Economic Sustainability (T.R.E.E.S.) project, sponsored by an organization called TreePeople. The goal of the project was to demonstrate how the design of the property could “work with nature's cycles of flood and drought (not to fight them) and to heal the damage we have done to our environment and to ourselves by paving the earth with concrete and asphalt” (TreePeople, n.d.). The site maximizes the storage of rainwater on the lot and was specifically designed to require little to no maintenance.

Programs encouraging downspout disconnection are also beginning to be adopted on a city-wide level in cities across the country, including Portland OR, Vancouver BC, Milwaukee WI, St. Paul MN, and Skokie IL. Portland, Milwaukee, and Vancouver offer financial compensation ranging from \$50 to \$100 per home for residents who do the work themselves. Portland also offers to do the work for free with volunteer crews from local organizations that earn money from the city with each downspout they disconnect.

The goals behind these programs range from reducing flooding and erosion in creeks to reducing sewer overflows to increasing aquifer recharge. However, getting rainwater into the ground rather than into sewer pipes allows them all to take advantage of the natural storage and filtration that aquifers provide. Portland, whose disconnection campaign began in 1996, reports that to date “16,130 total homes have participated removing 323 million gallons/year [of stormwater] from the combined sewer” (Barbara George, pers. comm.). For reference, 323 million gallons is about 1,000 acre-feet, approximately equal to the total annual pumping of the three golf courses around Lake Merced.

San Francisco is also preparing to take advantage of the benefits of removing rooftop runoff from the city sewer system, along with other innovative stormwater management practices. The SFPUC

is currently seeking funding sources for a demonstration project to investigate reducing combined sewer overflows from the Westside Basin area of the city using techniques such as downspout disconnection.

But before we all take a hacksaw to our downspouts, we should know that current San Francisco Health and Safety code requires that rooftop downspouts be connected to the sewer system. This kind of law is fairly common in cities with both combined and separate storm sewers as a protection against the unpleasant effects that can result from poor handling of runoff, such as flooding the neighbor's yard, flooding the foundations of one's own house, or creating standing water. In fact, many of the cities with downspout disconnection programs perform free inspections and offer in-person technical advice to individual residents specifically to help avoid these kinds of situations. Cities that are faced with codes requiring connection to the sewers have overcome legal constraints by enacting ordinances to allow disconnection. For example, Milwaukee passed such an ordinance in December 2001 and has been promoting its downspout disconnection program this spring.

For more information on rooftop disconnection programs, see these websites:

<http://www.treepeople.org/trees/demo.htm>

<http://www.cityfarmer.org/downspout96.html>

<http://www.myportlandneighborhood.org/programs/civic%20involvement%20center/Downspout/downspout.html>

[http://www.cleanrivers-pdx.org/get\\_involved/downspout\\_disconnection.htm](http://www.cleanrivers-pdx.org/get_involved/downspout_disconnection.htm)

<http://www.volws.bc.ca/projects/2001/downspoutweb/pilot.html>

A second method for increasing rainwater infiltration into the ground is the use of pervious pavements, which let rainfall pass through the paving material to the soil beneath (Figure 26). Pervious pavements are divided into three main categories: (1) porous concrete or asphalt, (2) individual blocks laid together with built-in open spaces called unit pavers, and (3) granular material such as gravel (Figure 27). They are appropriate for low traffic areas with minimal underground utilities, such as parking lots, parking lanes, or even some lower traffic streets. Various pervious pavement techniques have been widely used in Europe since the 1950s, and porous concrete in particular has been used in Florida for the past twenty years with no durability problems or significant loss of permeability. Maintenance requirements for porous concrete vary by site, depending mainly on how much sediment is carried onto the site by runoff from adjacent unpaved areas. In most cases quarterly to yearly vacuuming, pressure-washing, or cleaning with a standard street-cleaner is sufficient to maintain 80 to 90% of the pavement's original permeability (GCPA, 2002).

**Figure 26. POROUS CONCRETE**

Source: California-Nevada Cement Council

**Figure 27. THREE TYPES OF PERVIOUS PAVEMENTS**

Source: (1) porous concrete – California-Nevada Cement Council, (2) unit pavers – North Carolina State University, (3) gravel – Jay Cross, <http://www.jaycross.com/jayhoo/javart.htm>

Numerous pervious pavement applications for both new and retrofit projects have been built all over the country from Connecticut to Nevada and Florida to Washington state. California is somewhat of a late arrival to the use of pervious pavements, according to Andy Youngs of the California-Nevada Cement Council. However, there are a few parking lot applications, such as the use of unit pavers at the Rio Vista Water Treatment Plant in Santa Clarita and porous concrete at

Bannister Park in the Sacramento area town of Fair Oaks. The Fair Oaks Recreation and Park District will also be using porous concrete on two other parks parking lots.

Porous concrete can pass 3 to 5 gallons per minute per square foot, or in other words 270 to 450 inches of rain per hour. Therefore, the rate at which rainfall can be absorbed through pervious pavements is limited not by the pavement, but by the permeability of the soil beneath it. Again, with the high natural infiltration rates of its sandy soils, San Francisco would be an ideal location for pervious pavements.

The cost of using pervious pavements can range from 50% to as much as five times higher than standard asphalt (LID, 2002),<sup>27</sup> but proponents argue that pervious pavement projects usually more than pay for themselves through savings in smaller or even eliminated drainage infrastructure and decreased stormwater loads on combined sewers. The pavement itself, as well as the subgrade and soil below it, are part of the drainage system, acting as both a reservoir and a filter. Monitoring studies to date indicate that if properly designed and maintained, the use of pervious pavements for residential areas and commercial parking areas poses very little risk of groundwater contamination, as surface contaminants are generally retained in the pervious pavement structure (Dierkes et al., 1999; Legret et al., 1999 as referenced in Field et al, 2000).<sup>28</sup> However, for applications such as parking lots where car-related pollutants would be present, trial installations accompanied by monitoring prior to larger-scale use of pervious pavement would be a conservative and location-specific way to determine the degree to which surface contaminants would pass through the pavement and into the soils below.

For more information on pervious pavements, see these websites:

<http://www.lid-stormwater.net/intro/sitemap.htm>

[http://www.coolcommunities.org/cool\\_pavements.htm](http://www.coolcommunities.org/cool_pavements.htm)

[http://courses.ncsu.edu/classes-a/bae/cont\\_ed/pavement\\_course/index.htm](http://courses.ncsu.edu/classes-a/bae/cont_ed/pavement_course/index.htm)

<http://www.stormwatercenter.net/> (Fact Sheets † Better Site Design or Stormwater Mgt.)

<http://www.epa.gov/owm/mtb/mtbfact.htm> (Stormwater † Porous Pavement)

[http://www.forester.net/sw\\_0103\\_porous.html](http://www.forester.net/sw_0103_porous.html)

Returning to the idea that we'll all be "dead and gone" before improvements in groundwater levels translate into visible improvements in lake levels, the fact that only our children's children will see the improvement in lake levels does not mean that we shouldn't start investing now in more effective, environmentally more compatible, and in the end more economical infrastructure. Of course, it would be very expensive to convert the whole city to disconnected rooftops and pervious pavements all at once. But if the conversion were done in the context of regular maintenance and repair, it could be accomplished incrementally, and with multiple benefits. As mentioned above, many cities are finding creative ways to reduce cost by giving the community incentives to participate in this transformation. A new way of thinking is becoming manifest in the civic

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<sup>27</sup> The in-place cost for large-scale projects using porous concrete in California ranges from \$3.00 to \$3.20 per square foot. For smaller projects such as driveways and sidewalks, the cost ranges from \$3.00 to \$5.00 per square foot (Andy Youngs, pers. comm.).

<sup>28</sup> In general, surface infiltration poses less contamination risk than injection of stormwater directly into groundwater. Rich organic soil provides more pollutant removal than sandy soil. Pervious pavement should not be used near critical source areas such as storage areas, heavy equipment yards, bus barns, loading docks, gas stations, auto service facilities, and car washes. Some localities require a certain depth of soil above the seasonally high water table to use pervious pavement (Dr. Robert Pitt, pers. comm.).

consciousness of many cities, an understanding that environmental restoration, rather than being an added burden to be considered only after “essential” or “regular” infrastructure projects are finished, is an integral part of any improvements to a city’s infrastructure.

## CONCLUSIONS

The ecological health and sustainability of Mountain Lake, Pine Lake, and Lake Merced have deteriorated in response to decades and even centuries of increasing urbanization of the areas surrounding the lakes. Until as recently as 5 to 10 years ago, when public concern about the growing degradation of all three lakes began to increase, the job of protecting and preserving San Francisco's three remaining natural lakes was mainly left to Mother Nature. As the impacts have become more dramatic, including algae blooms, overgrowth of aquatic weeds, and declining water levels, the need for restorative management of these lakes has become more compelling. Agencies responsible for the lakes' maintenance, along with concerned community members, have begun to engage in the development of improvement plans that will be required to halt and then reverse the negative trends seen at the lakes, as well as long-term management plans to prevent deterioration in the future. The strategies that are being proposed to improve lake conditions fall into three broad categories: watershed management; groundwater basin management -- both of which seek to effect change in the lakes through modification of conditions on or below the lands surrounding the lakes; and in-lake techniques, through which the lake itself is altered in some way, such as through dredging, aeration, or water addition.

Many factors affect the success of efforts to improve conditions at the lakes. These include but are not limited to: (1) the geographic scale and political complexity of the issues that are impacting them, (2) funding and staff availability of responsible agencies, and (3) the degree and quality of community involvement, including agency commitment to building a plan with community rather than seeking only their approval, the ability of the community to work together to provide constructive input to agency staff, and the maintaining of open lines of communications between the agencies and the community.

The existence of lake improvement plans and community task forces show that we are beginning to recognize and attempt to amend some of the harm that our development choices have wrought on these rare habitat and natural heritage resources. But the fact that we are still struggling to reach consensus on lake management alternatives, primarily because we are constrained by a system of economic evaluation that gives no value to environment, indicates that we are not fully ready to make the choices that will enable us to protect and preserve the lakes in a manner that is as sustainable and holistic as possible.

To continue the work that has been started, Neighborhood Parks Council supports the following actions to help preserve the lakes:

### Water quality

- Shoreline and watershed stabilization with appropriate planting, designated paths, and other restoration techniques to reduce sediment accumulation caused by erosion. *Shoreline - all lakes, watershed - Pine Lake*
- Treatment of all stormwater runoff prior to discharge into the lakes. This could include structural techniques, wetlands, or other methods on a case-specific basis - **Mountain Lake, Lake Merced**

- Watershed management that reduces the use of fertilizers and pesticides to the maximum extent possible – **golf courses at Lake Merced, Mountain Lake**. Pesticide and fertilizer use in city parks is rare, and is used only as a last resort.
- Temporary use of aeration systems to improve water quality - **Mountain Lake, Lake Merced**

### Water levels

#### Restoration of higher lake levels - **Pine Lake, Lake Merced**

Long-term program should focus on aquifer rehabilitation through:

- Development of recycled water programs for all remaining San Mateo irrigators;
- On-schedule development of the SFPUC recycled water program with broadest possible customer list and ability to increase recycled water production as new non-potable uses develop;
- Prioritization of the determination on whether or not recycled water can be added to the lakes or injected into the shallow aquifer (for a discussion of the shallow and deep layers of the Westside Basin aquifer, see the Lake Merced section of Attachment A);
- Establishment of long-term conjunctive use agreements with Daly City, California Water Service Company, and San Bruno, if 2-year trials yield positive results; and
- Development of downspout disconnection programs and use of pervious pavement to increase aquifer recharge (and reduce combined sewer overflows) in the Westside Basin area.

Opportunities to reconnect watershed runoff with the lakes should be investigated and implemented wherever possible, including:

- Diversion of treated stormwater from Daly City’s Vista Grande Canal to **Lake Merced** if pilot project results indicate acceptable water quality after treatment;
- Redirection of runoff from Stern Grove and possibly east of 19<sup>th</sup> Avenue to **Pine Lake**; and
- Recreation of creek channel and riparian corridor to convey watershed runoff to **Pine Lake**.

Water addition should be used to stabilize lake levels in the short- to medium-term, until long-term policies take effect.

### Habitat

- Water level and water quality improvements that will improve aquatic habitat – **all lakes**
- Improvement of degraded shoreline and adjacent uplands through a variety of erosion control mechanisms including plantings, jute mesh, and cellular confinement mats, and other methods - **all lakes**

- Feasibility evaluation of recontouring the shoreline to create more wetland habitat at **Lake Merced**, if habitat studies indicate that raising water levels would result in a loss of wetland habitat

### Aesthetics and Recreation

Maximization of open water area through:

- Removal of east arm roadway berm - **Mountain Lake**;
- Removal and maintenance program to control aquatic weeds - **Pine Lake**;
- Realignment of the sewer crossing that separates South Lake and Impound Lake - **Lake Merced**; and
- Restoration of higher lake levels - **Pine Lake, Lake Merced**.

### Lake Management

- The San Francisco Public Utilities Commission should take the lead role in developing a **Lake Merced** management plan or provide resources to community groups such as the Lake Merced Task Force, Committee to Save lake Merced, Friends of Lake Merced, and others to produce the plan. Federal and city agency teams provided leadership and resources for the development of the Mountain Lake Enhancement Plan and Stern Grove / Pine Lake Park Improvement Plan, respectively. An all-volunteer organization such as the Lake Merced Task Force cannot develop detailed action items for large complex projects, even with technical presentations by agency staff.
- Community participation in the development of management and stewardship plans is essential to any successful effort to preserve the lakes. Proactive inclusion of the community in the planning process will help to (1) ensure that community interests are incorporated into the plan, (2) deliver broad-based support necessary for funding and implementation of any major project, and (3) educate the community about the issues facing the lakes and the opportunities and constraints that may affect lake improvement efforts.

## OUR LEGACY

Archaeological evidence points to the existence of First Nations people in the Bay Area for a remarkably long and uninterrupted time, from at least 11,000 years ago to the present. The Penutian-speaking Yelamu Ohlone arrived in San Francisco roughly 3,500 years ago. Their culture was centered around waterways, as is evident from the clusters of villages and seasonal camps around Lake Merced and Dolores Lagoon. Their legacy to those who followed them was an environment filled with thriving and intact watersheds, creeks, and lakes.

The founders and builders of modern-day San Francisco have given us a city filled with skyscrapers, bridges, roadways, water and sewer systems, and all the things that make up a major metropolitan city. But in doing so, they filled and destroyed most of the city's lakes and creeks in just 200 years.

What will our legacy to future San Franciscans be? Will we allow our lakes to shrink as we continue to overdraft the groundwater? Will we continue to let roadway runoff foul our lakes until they no longer support wildlife? Or will we preserve and revitalize the three natural lakes we have left?

### *What you as a citizen of San Francisco can do:*

- Be informed - understand consequences of paving over yards, and of using groundwater for irrigation
- Find ways to undo damage in your own yards, especially in the Westside Basin area: when San Francisco is ready to move forward with a downspout disconnection program or with pervious pavement use, volunteer to have your house retrofitted to increase rainwater infiltration into the ground
- Be vocal - tell your Supervisor that saving the lakes, using recycled water, and developing better use of stormwater are important
- Volunteer for restoration projects
- Go visit the lakes - see why they're worth saving!

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**APPENDIX A-1:  
Agencies with Jurisdiction over Lakes**

Agency	Mountain Lake	Pine Lake	Lake Merced	Area of authority
<b>City and County of San Francisco</b>				
Department of Public Health	X	X	X	Protects public health. Reviews compliance with Underground Storage Tank regulations, hazardous material management. <sup>a</sup>
Department of Public Works	X	X	X	Provides engineering services and maintains city infrastructure on lands surrounding lakes. <sup>b</sup>
Natural Areas Program (branch of Recreation and Park Department)	X	X	X	Restores and enhances Significant Natural Resources Areas, develops community-based site stewardship. <sup>c</sup>
Planning Department	X	X	X	Administers CEQA review for actions on lands within city jurisdiction. <sup>d</sup>
Public Utilities Commission			X	Manages Lake Merced as an alternative water resource. <sup>b</sup> Responsible for maintaining lake level and water quality.
Recreation and Park Department	X	X	X	Manages city park lands around lakes including erosion control, public signage and education, and facilities maintenance. <sup>a</sup> Has primary authority for management of Pine Lake, secondary authority for Lake Merced and Mountain Lake.
<b>State of California</b>				
California Coastal Commission	X		X	Regulates development in the coastal zone and coastal waters to ensure conformity with the policies of the Coastal Act. <sup>b</sup>
California Dept of Fish & Game	X	X	X	Protects wildlife resources in state of California including administration of State Endangered Species Act. Gives input to CEQA process for projects that impact natural resources. <sup>a</sup> Issues Streambed Alteration Agreements when project activities have the potential to impact intermittent and perennial streams, rivers, or lakes. <sup>c</sup> Stocks fish at Lake Merced. <sup>a</sup>
California Dept of Health Services	X	X	X	Protects water quality of drinking water sources. Would be involved in approval process for putting recycled water into Lake Merced or shallow aquifer.
California Department of Toxic Substance Control	X	X	X	Regulates hazardous materials and hazardous waste. <sup>a</sup> Will oversee Mountain Lake dredging program. <sup>d</sup>
Regional Water Quality Control Board (regional branch of State Water Resources Control Board)	X	X	X	Regulates surface and groundwater quality. Enforces mandate of Clean Water Act. Enforcement power to issue permits with water quality requirements. Issues NPDES permits, CWA Section 401 Water Quality Certification (state review of any project requiring federal permit). <sup>e</sup> Will be involved in Mountain Lake remediation program. Would be involved in approval process for putting recycled water into Lake Merced or shallow aquifer. Administers Beneficial Use designation, Impaired Water Body list (Clean Water Act section 303d list).
State Water Resources Control Board	X	X	X	Assures reasonable and beneficial use of the public waters of Lake Merced and the Westside Basin. Has evolved to the charge of comprehensive planning and allocation of waters. Has authority to investigate alleged water misuse and give particular consideration to the use of reclaimed water. <sup>f</sup>
State Lands Commission (SLC)			X	Owns western portion of the Lake Merced bottom. Comments on CEQA process, reviews Army Corps of Engineers permit applications for SLC lands. <sup>a</sup>
<b>Federal</b>				
U.S. Army Corps of Engineers	X	X	X	Administers Clean Water Act permits including Section 10 (navigable waters), CWA Section 404 (dredge and fill). <sup>d</sup>
EPA			X	Implements and oversees federal legislation including Clean Water Act. <sup>b</sup>
U.S. Fish & Wildlife Service	X	X	X	Protects wildlife resources in United States including administration of Federal Endangered Species Act.
Presidio Trust	X			Administers Presidio Area B (within which Mountain Lake lies). <sup>d</sup>

Sources:

<sup>a</sup> CDM, 1999, p. 5-2

<sup>b</sup> SFPUC and SFRPD, 1998, Table 1

<sup>c</sup> EIP, 2002

<sup>d</sup> Presidio Trust, 2000

<sup>e</sup> SWRCB, 2000b

<sup>f</sup> CalTrout, 2001

## APPENDIX A-2:

### Portland Bureau of Environmental Services Drywell Sizing Chart

# DRY WELL SIZING CHART

For Horizontally Projected Areas of Roofs or Other Impervious Surfaces

#### FOR DRY WELLS USING 28 INCH INSIDE DIAMETER RINGS:

**28" ID Rings:** For each additional 200 square feet of area or portion thereof, add one (1) foot to DRY WELL VERTICAL DIMENSION column in table below. The dry well must have a minimum vertical dimension of five (5) feet.

AREA OF ROOF OR IMPERVIOUS SURFACE	DRY WELL INSIDE DIAMETER	DRY WELL VERTICAL DIMENSION
1,000 square feet	28 inches	5 feet
2,000 square feet	28 inches	10 feet
3,000 square feet	28 inches	15 feet
4,000 square feet	28 inches	20 feet

#### FOR DRY WELLS USING 4 FOOT INSIDE DIAMETER RINGS:

**4' ID Rings:** For each additional 600 square feet of area or portion thereof, add one (1) foot to DRY WELL VERTICAL DIMENSION column in table below. The dry well must have a minimum vertical dimension of five (5) feet.

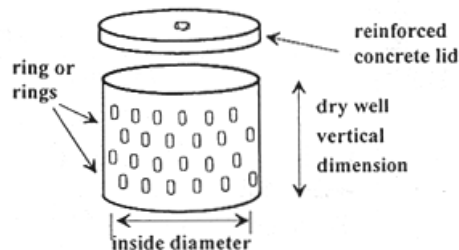
AREA OF ROOF OR IMPERVIOUS SURFACE	DRY WELL INSIDE DIAMETER	DRY WELL VERTICAL DIMENSION
3,000 square feet	4 feet	5 feet
6,000 square feet	4 feet	10 feet
9,000 square feet	4 feet	15 feet
12,000 square feet	4 feet	20 feet

#### FOR DRY WELLS USING 5 FOOT INSIDE DIAMETER RINGS:

**5' ID Rings:** For each additional 945 square feet of area or portion thereof, add one (1) foot to DRY WELL VERTICAL DIMENSION column in table below. The dry well must have a minimum vertical dimension of five (5) feet.

AREA OF ROOF OR IMPERVIOUS SURFACE	DRY WELL INSIDE DIAMETER	DRY WELL VERTICAL DIMENSION
4,720 square feet	5 feet	5 feet
9,440 square feet	5 feet	10 feet
14,160 square feet	5 feet	15 feet
19,000 square feet	5 feet	20 feet

Typical Dry Well



### APPENDIX A-3:

#### Lake Level Plots Showing Addition of Water to Lake Merced, 1994 and 1995

Periods of water addition to Lake Merced: most of April 1994, most of August 1994, and most of August 1995, as evidenced by a sharp increase in water level with little or no concurrent rainfall. Note also the water level drop of 1.53 feet from 9/30/94 to 10/1/94. This is an example of the occasional inexplicable shifts that occur in the Lake Merced water level data.

