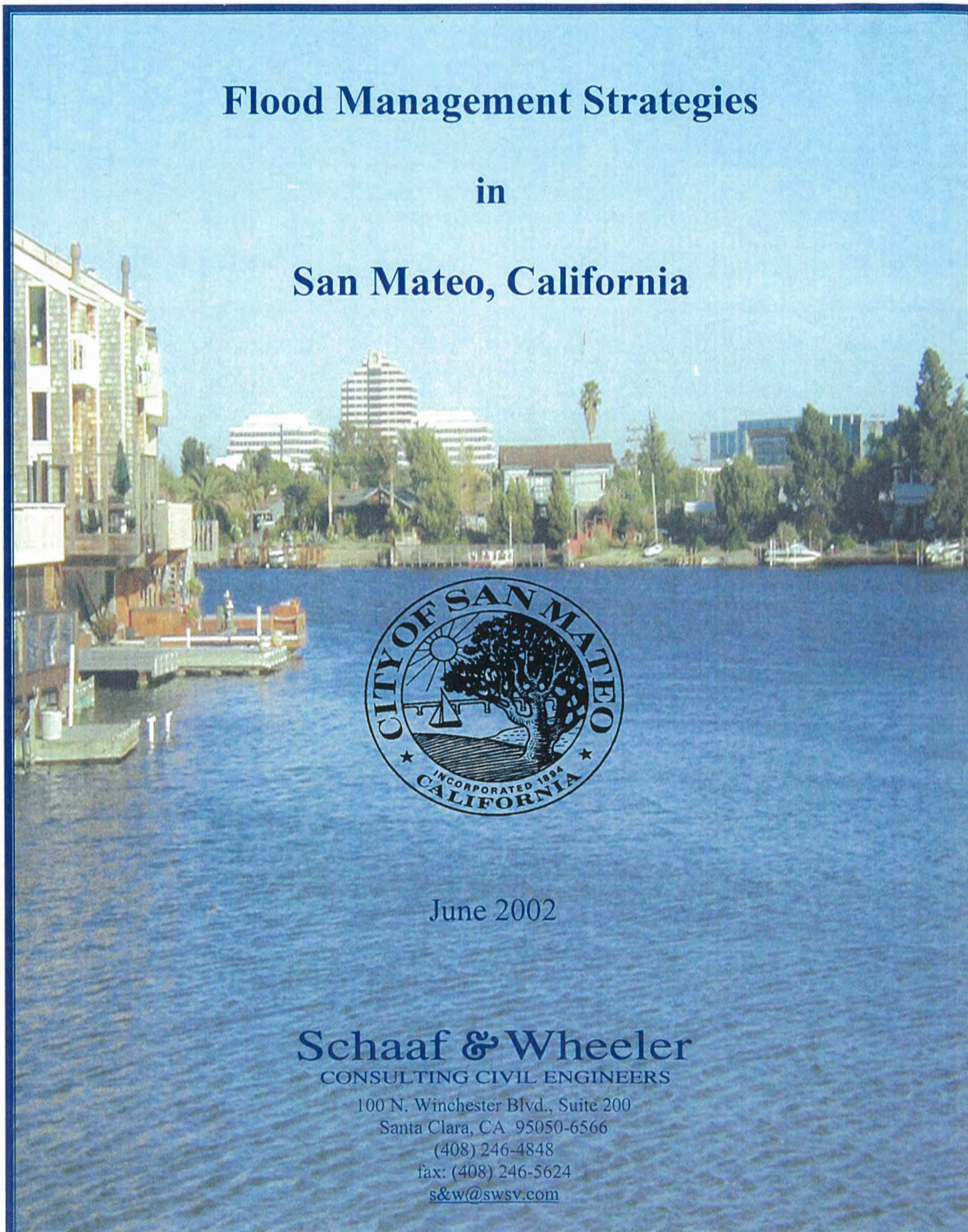
Flood Management Strategies

in

San Mateo, California



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CITY OF SAN MATEO
FLOOD MANAGEMENT STRATEGIES

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CHAPTER 1
STUDY OVERVIEW

This report provides technical information related to proposed flood management strategies for the City of San Mateo. Readers interested in more in-depth discussion are encouraged to read those chapters of interest.

STUDY OBJECTIVES

The basic objective of this flood management strategy study is to provide the information requested by FEMA necessary to complete the LOMR process and remove San Mateo from area of mapped special flood hazards. Specifically, this study identifies capital improvements needed to provide a level of flood protection consistent with the policies of the Federal Emergency Management Agency (FEMA) as administered through the National Flood Insurance Program (NFIP). Although the primary project objective is to identify capital improvements to removed mapped flood hazard areas north of Highway 92, this study has been expanded to include:

- An assessment of regulatory flood risk south of Highway 92;
- Identifying capital improvements to reduce that flood risk;
- An assessment of costs and benefits provided by proposed flood protection measures; and
- Alternative funding mechanisms to implement necessary capital projects.

SCOPE OF TECHNICAL REPORT

This study provides summaries and detailed discussions of hydrologic, hydraulic, and coastal analyses performed for the City of San Mateo in response to FEMA comments and questions. The body of technical work has been performed to NFIP standards and will serve as the basis for future floodplain map revisions. The work also can provide a foundation for more detailed capital improvement project design to reduce flood risks throughout the city.

BACKGROUND

Detailed study background including hydrologic and environmental settings, flood protection facilities, historic flooding and regulatory floodplain mapping efforts within the city are described in Chapter 2 of this report. A brief synopsis of the history behind this study is provided below.

San Mateo's Participation in the NFIP

The National Flood Insurance Act of 1968 allows FEMA to make flood insurance available only where the community has adopted adequate floodplain management regulations. The City of San Mateo joined the NFIP at the end of 1974, and has been a regular member of the program since 1981.

Historically, San Mateo was not designated as flood-prone. Studies completed in the 1980s, however, indicated that portions of San Mateo might be prone to flooding after all. In 1988 FEMA adopted new policies that changed the assessment of flood risks to those areas protected by levees.

New Flood Insurance Study

With new rules for levee evaluation, FEMA prepared a Flood Insurance Study (FIS) for San Mateo beginning in 1996. Although the scope of study was to include incorporated areas within the City of San Mateo, the limit of detailed study was established at Highway 92. (No information is available in city files to document how this limit was arrived at.) The FIS concentrated on flooding from San Mateo Creek, and indicated that the creek levees and the Bay levee at the north end of Coyote Point were not adequate and assumed to fail during a 100-year event.

San Mateo officials argued that the new preliminary maps were too conservative. The City and its consultants questioned the duration of high tides in San Francisco Bay, the operation of Crystal Springs Reservoirs, and available storage and pumping capacities within the Marina Lagoon.

FEMA responded to the City by concluding that most of the mapped flooding is due to 100-year tidal inundation rather than San Mateo Creek overflow. This technical report finds that in general, FEMA correctly applied their policies when mapping flood-prone areas north of Highway 92.

Map Appeals

The City filed a technical appeal of findings for the Preliminary FIS on June 7, 1999, asking FEMA to delay the publication of the new FIRM until the construction of additional flood protection facilities that would mitigate the Zone AE designation below elevation 7.0 feet NGVD. Identified projects included increased San Mateo Creek levee freeboard, additional bridge capacity at Norfolk Street, additional freeboard for the Coyote Point levees, increased pump capacity at the Poplar Avenue and Coyote Point pumping plants, median barriers along Highway 101 and a new culvert on San Mateo Creek.

FEMA denied the City's appeal, properly stating that the FIRM could not be delayed to incorporate flood protection provided by facilities not in place at the time of publication. However, many of the City's comments were incorporated into the revised FIRM for San Mateo Creek.

The Flood Insurance Rate Map became effective on October 19, 2001 (Figure 1-1). Changing the map will require the City to apply for a Letter of Map Revision (LOMR).

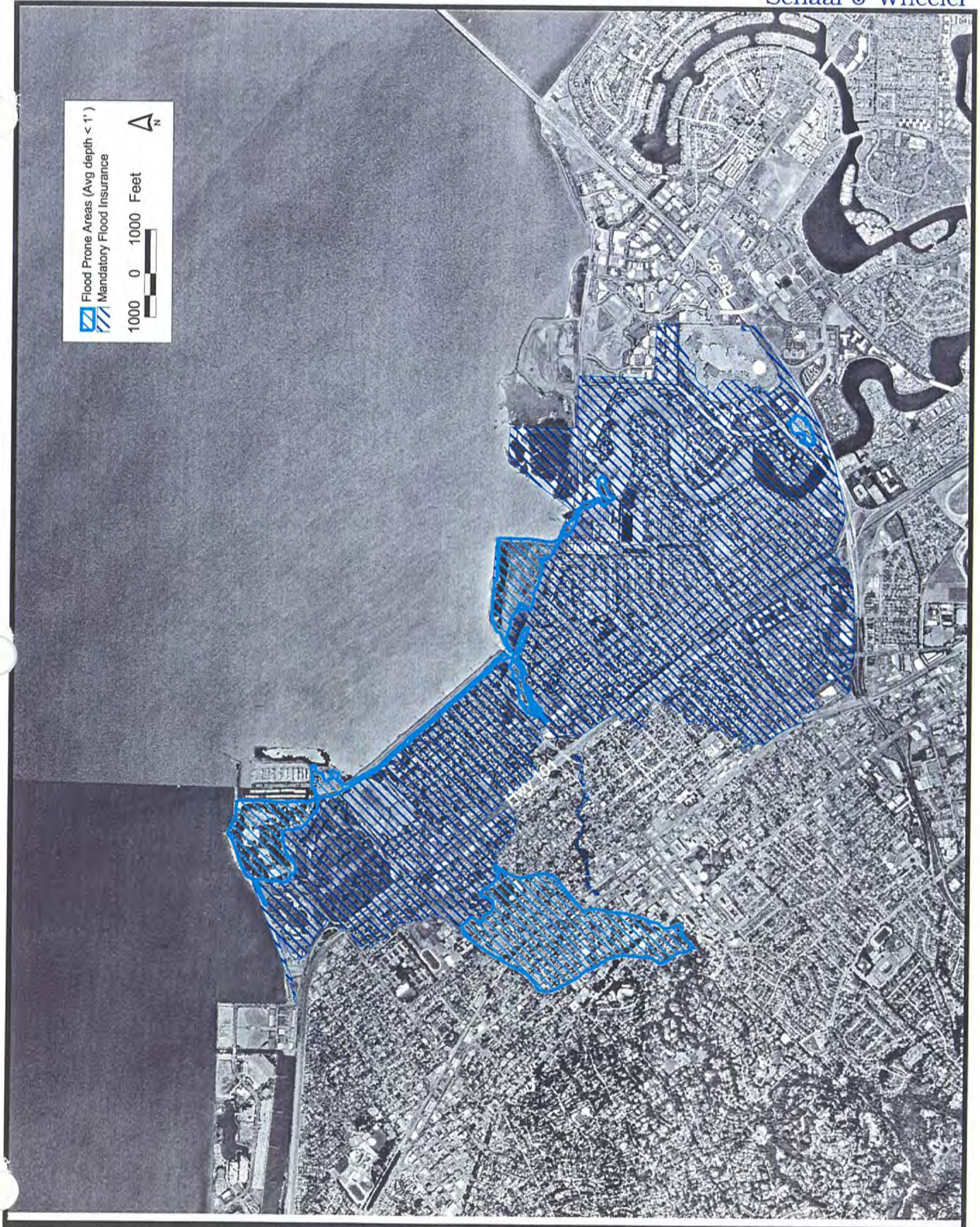


Figure 1-1 : Regulatory Flood Hazards in San Mateo

Revising the FIRM

The Letter of Map Revision Process, of which a Conditional Letter of Map Revision (CLOMR) is a part, is the only available means for the City and its residents to change the effective FIRM. In July 2000 the City formally requested a Conditional Letter of Map Revision for the San Mateo Creek South Bank Floodwall and Norfolk Bridge Replacement projects. FEMA responded to that request by asking for:

1. An official operations and maintenance plan for proposed San Mateo Creek levees.

2. A residual interior flooding analysis within the boundaries of the *current* (i.e. area north of Highway 92) Special Flood Hazard Area (SFHA) that would remain after the removal of the one-percent tidal flooding limits.

3. Documentation that the Marina Lagoon and Pumping Plant meet the requirements of the NFIP, including an operation and maintenance plan.

4. Certified work maps documenting the residual interior flooding analysis.

The City prepared operations and maintenance plans for the San Mateo Creek levees and Marina Lagoon facilities and forwarded that information to FEMA in October 2000. In response FEMA requested the following additional items:

1. Flood hazard analyses and mapping for 16th Avenue Drainage Channel, 19th Avenue Drainage Channel, and Laurel Creek.

2. Operation and maintenance plan for O'Neil Slough tidal gates demonstrating that they prevent inundation from coastal floodwater; and information demonstrating that coastal floodwater cannot overtop Belmont Slough and enter the City from the east.

Subsequent correspondence from FEMA clarified their position that only those areas within the identified flood hazard area required residual interior mapping, although hydrologic analysis for Marina Lagoon is necessary to establish backwater conditions for the 16th Avenue Drainage Channel.

However, FEMA encourages the City to identify flood hazards associated with all sources of flooding within its boundaries.

SOURCES OF FLOODING

San Mateo faces two distinct but interrelated sources of flooding: San Francisco Bay and interior runoff. Chapters 3 through 8 provide detailed evaluations of tidal and interior flood risks, and strategies to manage those risks. Figure 1-2 provides an overview of different flooding sources in the city.

San Francisco Bay

High tides can cause or exacerbate flooding in the low-lying areas between El Camino Real and the Bay. Without adequate levee protection, these areas would be directly exposed to saltwater inundation. Furthermore, interior flood protection systems discharge to the Bay, so high tides also serve to limit their effectiveness. That is, it is more difficult to discharge a given flowrate against a higher tide than a lower tide.

Three components of tidally influenced flooding — stillwater surge, wind-generated waves, and wave runup — must be evaluated to assess the flood risk posed by San Francisco Bay in San Mateo.

Interior Runoff

The original FIS for San Mateo concentrated on interior runoff from San Mateo Creek and the North Shoreview area. The present flood management study expands the examination of interior runoff to the Marina Lagoon system, which encompasses the 16th Avenue Drain, 19th Avenue Drain, and Laurel Creek tributaries. A hydrologic methodology similar to one described in the FIS is utilized to extend the study of interior runoff.

Local Drainage

After tidal inundation and residual interior runoff are eliminated for the base flood, the possibility of flood risk due to inadequate storm drainage facilities may remain. The new Storm Drain Master Plan will address this risk.

FLOOD RISKS IN SAN MATEO

San Mateo does confront substantial flood risks from both San Francisco Bay and interior runoff. Reducing the risk will involve capital improvement projects, continued maintenance, and political negotiation.

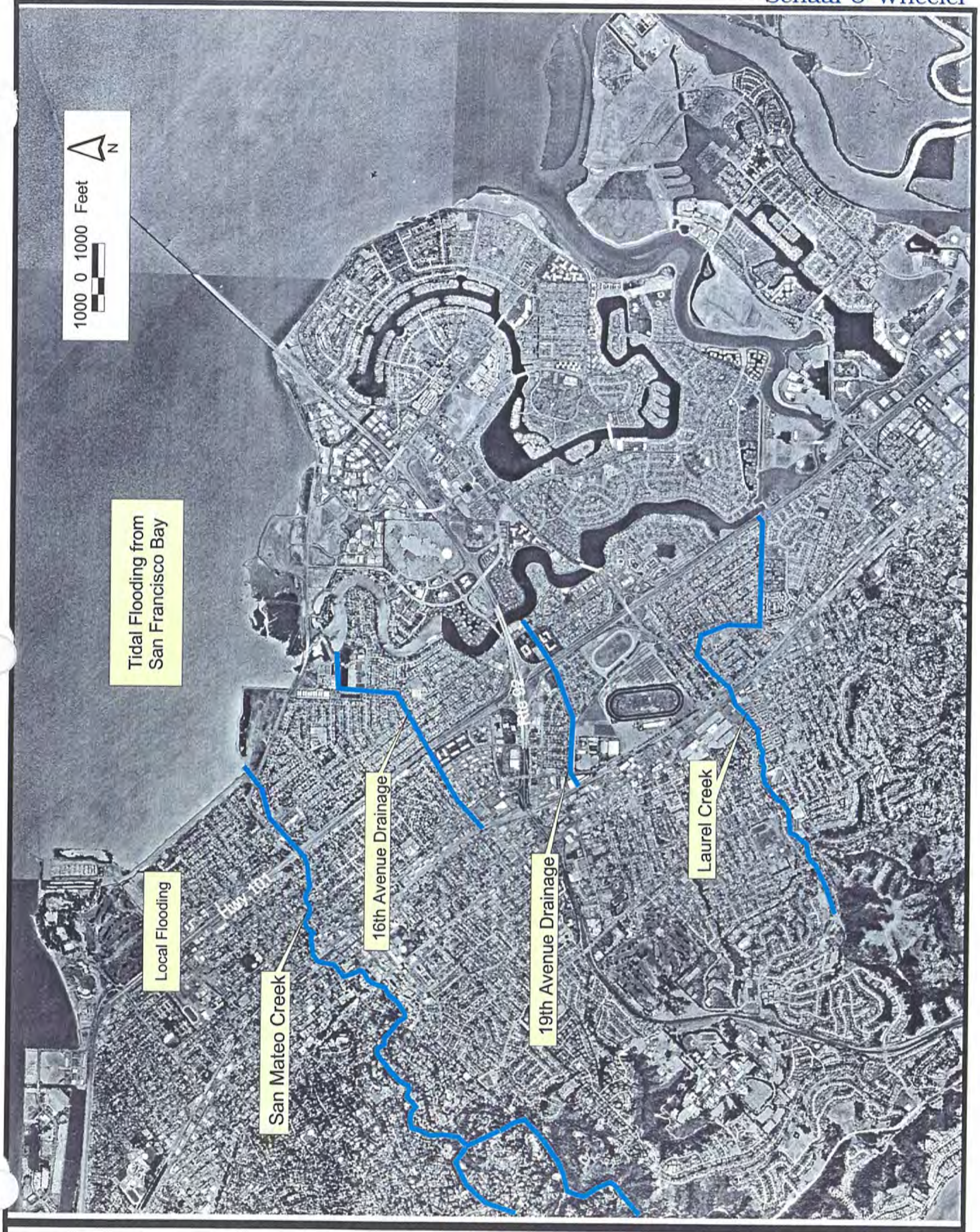


Figure 1-2 : Sources of Flood Risk in San Mateo

Tidal Flooding

A series of outboard levees protects San Mateo from San Francisco Bay tidal flooding. The city relies on levees located within San Mateo, Foster City, and Belmont. For FEMA to recognize the flood protection benefits of a levee:

- The levee must have adequate freeboard; and
- The levee must be certified.

Levee improvements that do not meet both standards are not included as flood protection facilities when FEMA prepares its flood insurance maps. In this case, San Francisco Bay is assumed to flood San Mateo as if the levee system were not in place. Thus the 100-year flood elevation in the city is equivalent to the 100-year stillwater tide elevation, or 7 feet NGVD. The effective FIRM covers areas north of Highway 92, but as Figure 1-3 demonstrates, there are significant areas south of Highway 92 subject to the same regulatory flood risk.

Analyses described in Chapter 4 have found that the following reaches of the outboard levee system do not provide freeboard meeting FEMA standards:

1. Shoreline from Burlingame to Coyote Point
2. Bayfront levee near Coyote Point
3. San Mateo Creek from Bay to Highway 101 ✓
4. Bayfront levee near Detroit Drive
5. O'Neil Slough Tide Gate levee from Foster City to Highway 101 ✓

Improvements to raise these levee reaches are necessary to meet FEMA freeboard criteria. (San Mateo Creek floodwall improvements are already partially complete.) Additional geotechnical and structural analyses will also be required to certify both the improved levee systems and existing levee systems that already meet freeboard requirements.

It may be noted that the Flood Insurance Rate Map for Foster City (effective January 19, 1995) indicates that Foster City is protected against 100-year flooding from San Francisco Bay by its levee system. From a regulatory perspective, Foster City's published floodplain map should mean that the O'Neil Slough tide gate and all of San Mateo's other levee systems are certified as well, since they protect Foster City from tidal flooding, just as Foster City's levees protect San Mateo.

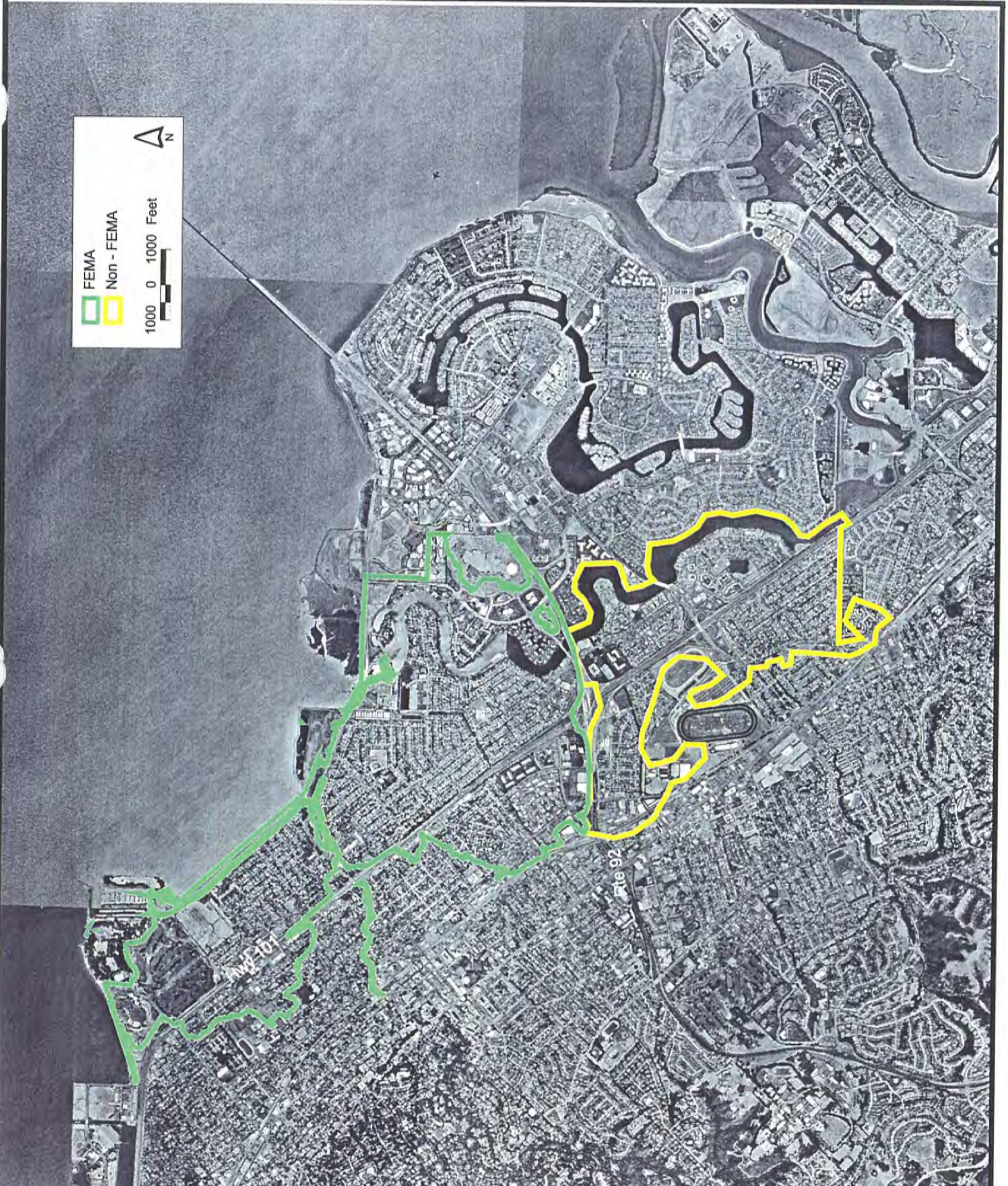


Figure 1-3 : Area Subject to Tidal Flooding

RESIDUAL INTERIOR FLOODING

To revise the effective Flood Insurance Rate Map replicated in Figure 1-1, it is necessary to evaluate the potential for residual flooding; that is, flooding from internal sources such as streams left once the tidal floodplain is unmasked. To remove Special Flood Hazard Areas from the effective Flood Insurance Rate Map, residual flooding north of Highway 92 must be specifically addressed. Analysis shows significant areas with residual flooding, almost to the point where the extent of mapped flooding will not significantly change without correcting the sources of residual flooding.

Figure 1-4 provides an overview of residual flooding in San Mateo. In areas labeled as "Zone A," mandatory flood insurance would remain in effect even after the identified outboard levee improvements are made. Major sources of residual flooding in northern San Mateo include:

- San Mateo Creek
- Area-wide runoff to the North Shoreview Neighborhood
- 16th Avenue Drain

San Mateo Creek

San Mateo Creek serves as the outlet to Lower Crystal Springs Reservoir, which has a large tributary area that includes the San Andreas Reservoir and Upper Crystal Springs Reservoir. Owned and operated by the San Francisco Water Department, the reservoir is part of a water supply system for the City of San Francisco. The reservoirs are not operated to provide flood protection per se.

Given the lack of a contractual flood storage pool, the FEMA analysis assumed that at the start of the 100-year design storm, each reservoir is full to its spillway elevation. Although some flood attenuation is provided, downstream channel and culvert capacities are not adequate to accommodate reservoir releases over the course of the design 10-day storm. The underground culvert through downtown cannot accept the flow, and spill at the El Camino Real entrance lasts for 52 hours, discharging 1,600 acre-feet to the streets of San Mateo. Once relieved of this flow, the creek has sufficient capacity downstream to San Francisco Bay if a proposed Caltrans culvert is constructed at Highway 101. Figure 1-5 provides a closer view of residual flooding from San Mateo Creek overtopping.

Spills move toward the northwest, cross under the elevated railroad embankment at three locations (Poplar, Santa Inez, and Monte Diablo) and pond behind Highway 101. Fortunately the freeway sound wall and concrete median barriers are not continuous, and floodwaters may cross the highway between Poplar Ave. and Tilton Ave.

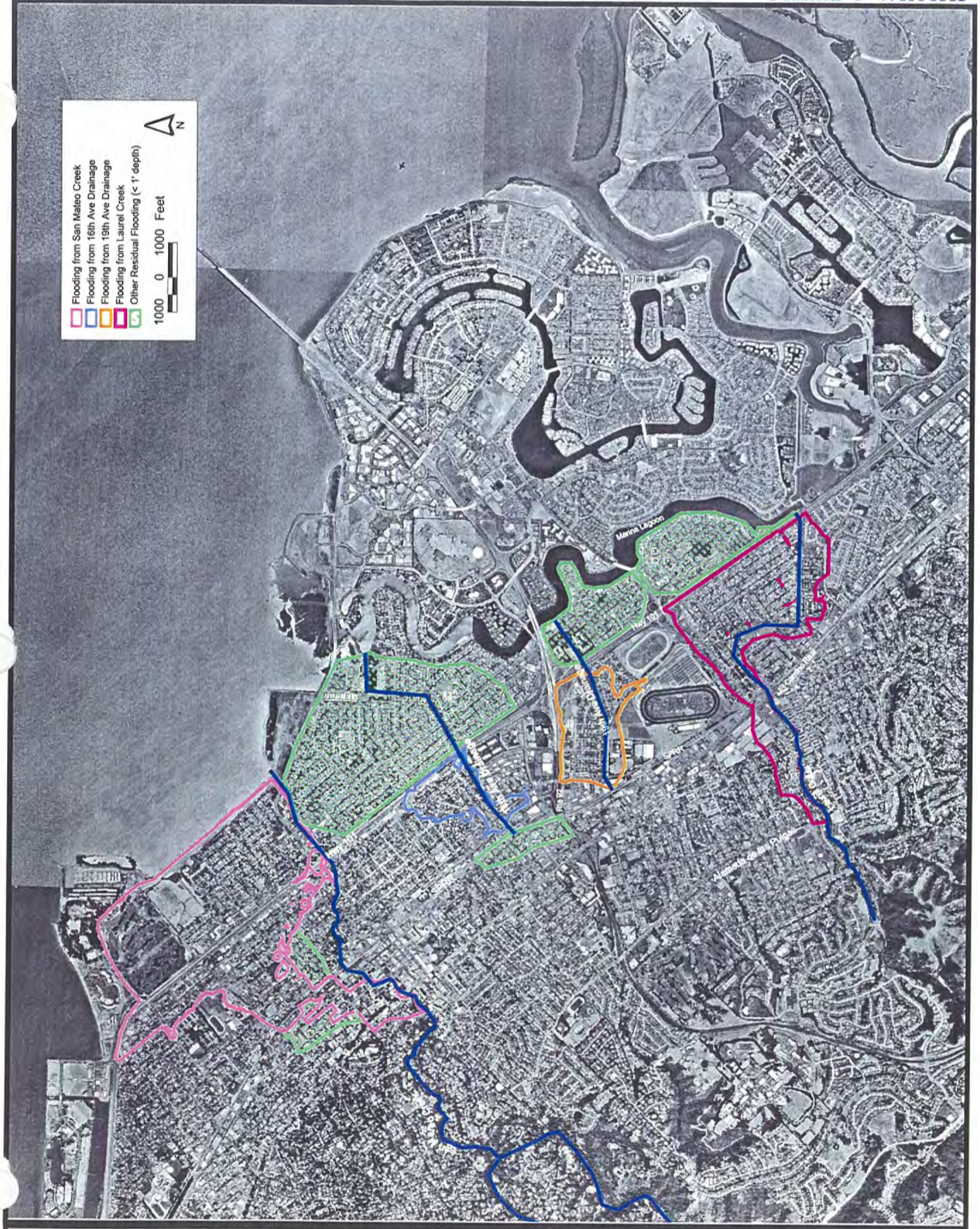


Figure 1-4: Residual Interior Flooding

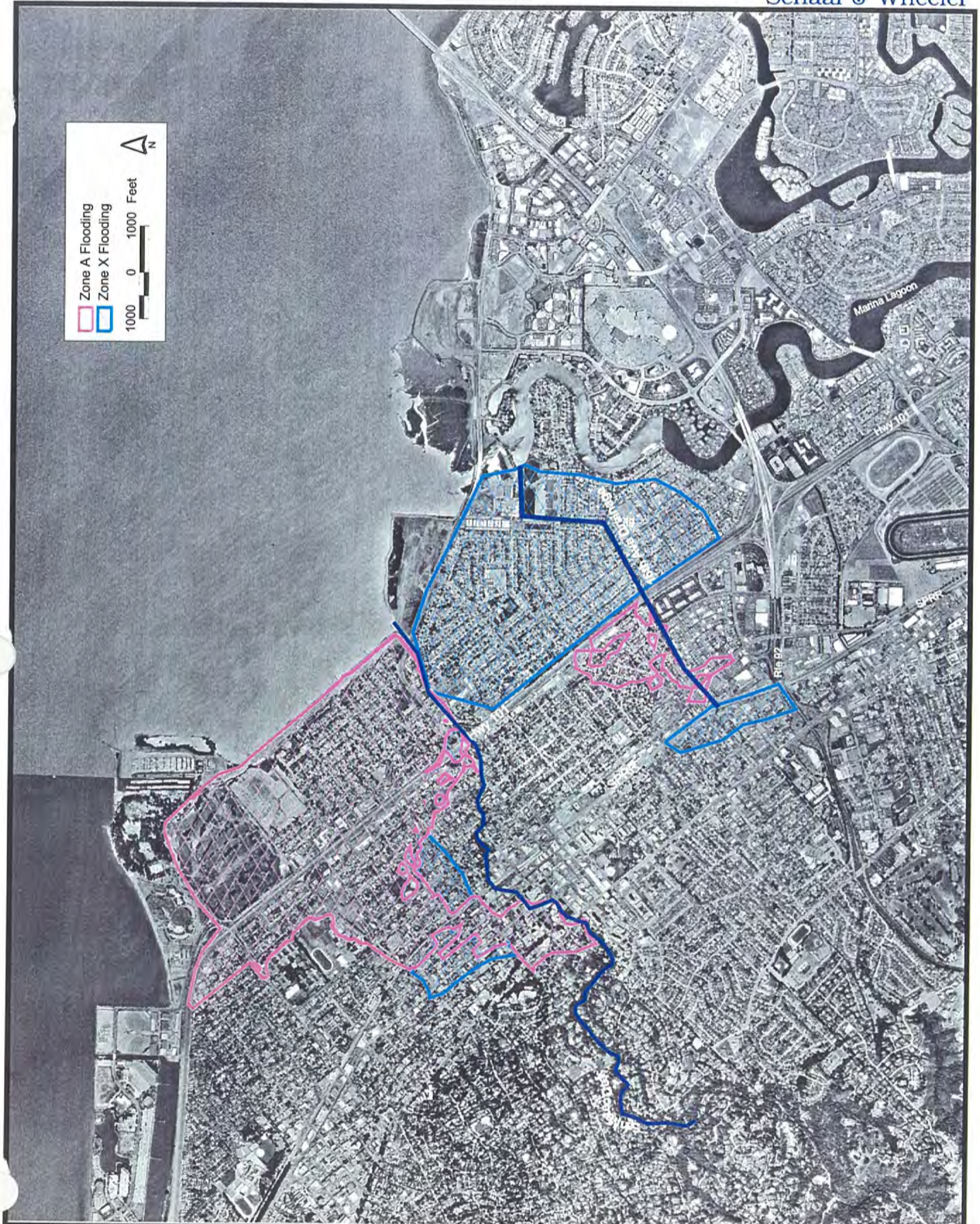


Figure 1-5 : Residual Interior Flooding in Northern San Mateo

It is imperative, however, that Caltrans does not close the gaps in either the sound wall or the freeway median to avoid drastically increasing the elevation of ponding. Floodwaters cross Bayshore Freeway and enter the North Shoreview area. As discussed later in this chapter, neither the Coyote Point nor Poplar Avenue pump stations are equipped with automatic emergency standby power. Without backup power, FEMA will not recognize the pumping facilities. Under this scenario, San Mateo Creek spills and local runoff are not pumped into the Bay and would pond to an approximate elevation of 8.7 feet NGVD (106.3 City), which is nearly two feet higher than the currently mapped limit of tidal inundation.

16th Avenue Drainage Channel

Urban storm water runoff generated between Crystal Springs Road and Highway 92 east of Alameda de las Pulgas is collected in the 16th Avenue Drainage Channel at the Southern Pacific Railroad. The 16th Avenue Drain is a fairly uniform, prismatic channel that conveys runoff into the Marina Lagoon for storage and pumping into San Francisco Bay. Major road crossings include Delaware Street, Grant Street, U.S. Highway 101, Norfolk Street, and Kehoe Street.

Minor surface flooding occurs just upstream of the SPRR culvert during a design 100-year runoff event, but more serious flooding happens as the result of undersized culverts at Delaware Street and particularly at Highway 101. Further downstream backwater from Marina Lagoon controls water surface elevations in the 16th Avenue Drain.

Mandatory flood insurance requirements would remain in effect as shown on Figure 1-5, even after tidal inundation is relieved. To remove the Zone A flooding, and prevent areas downstream of Highway 101 from being placed in Zone A once the upstream bottlenecks are removed, these projects are recommended to improve flood flow conveyance:

- Remove culvert at Delaware Street; replace with clear-span bridge
- Add (2) new 8' x 5' concrete box culverts at the Highway 101 crossing
- Construct floodwalls from Highway 101 to Delaware Street

19th Avenue Drainage Channel

Several upstream tributaries feed into the 19th Avenue Drainage Channel, which provides flood flow conveyance between the railroad and Marina Lagoon. However, its drainage area is larger than the 16th Avenue drain. Major crossings include the Southern Pacific Railroad, Delaware Street, Bermuda Drive, Highway 101, and Norfolk Street.

Constrictions at Delaware Street and Norfolk Street force floodwater out of the channel, and inundate areas between Delaware Street and Highway 101 to average depths of up to 1.5 feet as shown on Figure 1-6. Mandatory flood insurance requirements would remain in effect even after tidal inundation is relieved. To remove the Zone A flooding, and prevent areas downstream of Highway 101 from possibly being placed in Zone A once the upstream bottlenecks are removed, the projects listed below are recommended to improve flood flow conveyance:

- Replace double 13.5' x 5.4' RCB culvert with new clear span bridge at Delaware Street;
- Clean channel and repair slumped banks from Delaware Street to Bermuda Drive;
- Remove bridge at Norfolk Street and replace with new clear span bridge;
- Relocate utilities at Norfolk Street to eliminate blockage; and
- Construct concrete floodwalls from Bermuda to the SPRR

Laurel Creek

Laurel Creek drains the southern most part of San Mateo, including a portion within the City of Belmont. The creek channel has been modified over the years in an attempt to control flood events, and two detention facilities have been constructed in the headwaters of the watershed.

Many of these crossings are undersized to adequately convey Laurel Creek's discharge during extreme runoff events. Furthermore, the creek channel itself is very difficult to access in places, so vegetation removal, slope bank repairs, and other maintenance activities are nearly impossible. The limited access coupled with severe right-of-way limitations serve to prohibit significant channel improvements in many reaches. To prevent the addition of significant flood hazard areas shown on Figure 1-6, these projects are needed:

- Alameda de las Pulgas – Replace (E) double 8' x 4' RCB with triple 9' x 4' RCB
- Hacienda Street – Replace (E) 10' x 6' RCB with double 10' x 6' RCB
- Edison Street – Build parallel 10' x 6' underground culvert
- El Camino Real to Pacific Boulevard – Build new 12' x 5' concrete culvert bypass
- Enlarge channel within (E) right-of-way between Pacific Blvd. and George Hall School
- Curtiss Street – Replace (E) 10' x 5' culvert with 25' x 6' clear-span bridge
- Otay Avenue – Replace (E) double 7.5' x 4' RCB with 25' x 6' clear-span bridge
- George Hall School – Replace multi-pipe culvert with new 30' x 7' box culvert
- East 40th Avenue – Replace (E) triple 12' x 5.5' RCB with new 40' x 6' clear-span bridge
- Construct concrete floodwalls from Marina Lagoon to East 40th Street

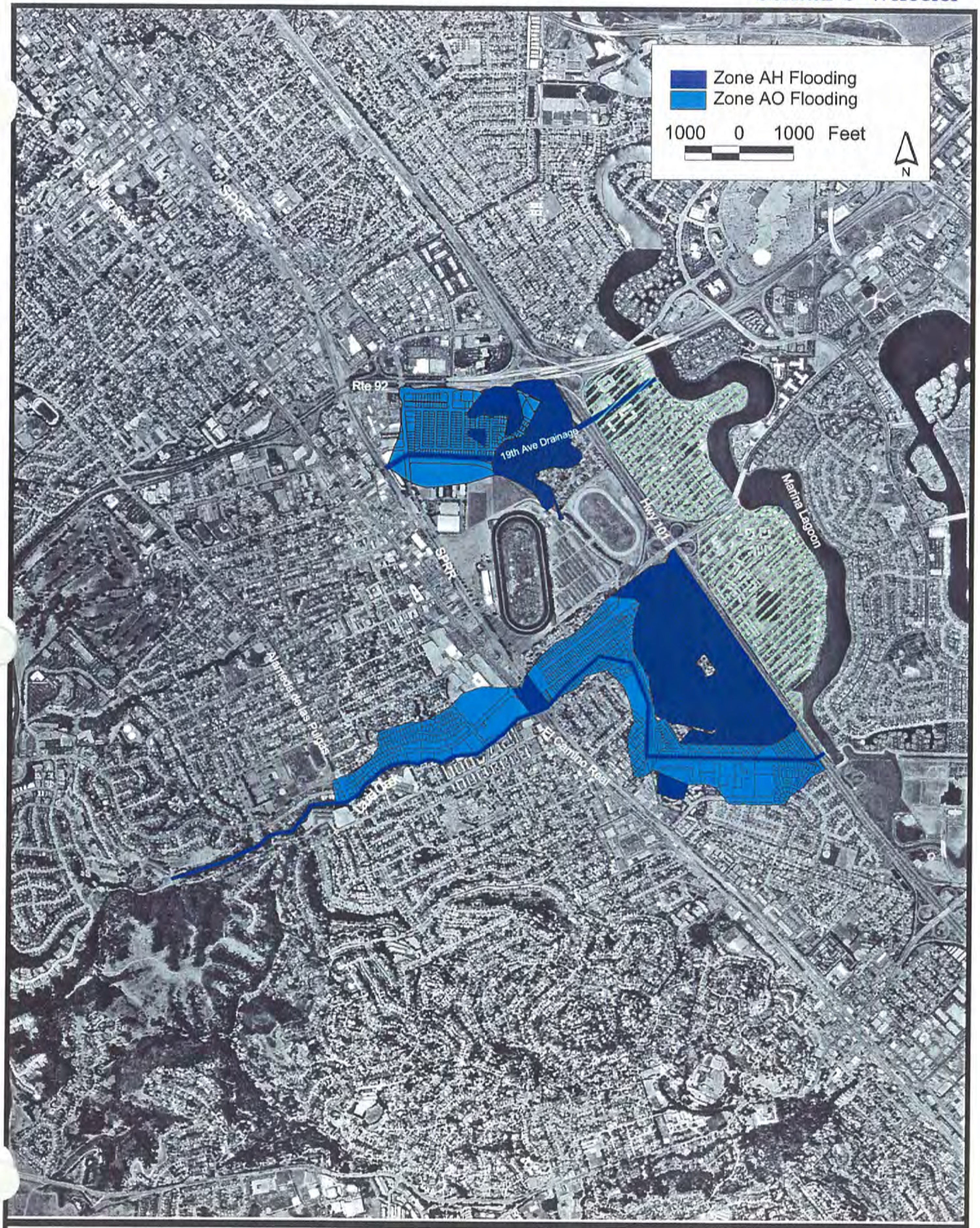


Figure 1-6 : Residual Interior Flooding in Southern San Mateo

Marina Lagoon

While Marina Lagoon's primary purpose is flood protection for bayside areas in San Mateo and Foster City; the facility also provides significant aesthetic and recreational benefits to residents, particularly those living along the lagoon's shoreline. Consequently the City has attempted to balance the flood protection and aesthetic functions of the Marina Lagoon; recognizing that during the winter flood season, public safety must take precedence over appearances.

Lagoon levels are regulated on a seasonal basis to optimize flood control, recreation, aesthetics, and ecological benefits. Currently during the winter, the operating level is lowered to elevation 95 feet (San Mateo datum) to reserve flood storage. During the summer, the water level is maintained at an elevation of 96.5 to provide optimal conditions for swimming, boating, and other recreational uses.

It is desirable to minimize maximum winter water levels in Marina Lagoon. Lower lagoon levels will improve hydraulic performance in the lower reaches of the three tributary channels, thereby minimizing the need for and height of floodwalls on 16th Avenue Drain, 19th Avenue Drain, and Laurel Creek. Iterative analyses of design water surface profiles in the lagoon's tributaries show that the optimal winter operating level should be an additional foot lower at elevation 94 feet. Further reductions in maximum lagoon levels are not warranted, because channel hydraulics does not change upstream. With this winter operating level, the lagoon and pump station have the capacity to prevent residual interior flooding from the lagoon during the design 100-year event.

COSTS AND BENEFITS

Capital projects are needed to provide the benefits of reduced flood risk and relief from mandatory flood insurance purchases. In some instances the benefit areas overlap. For instance, properties in the North Shoreview neighborhood benefit from both outboard levee projects and the rehabilitation of the local pump stations.

To avoid a complicated discussion, the sum total of each project component is assumed to benefit its entire benefit area. Although, for instance, upstream properties may not directly benefit from downstream capacity improvements; those downstream improvements allow upstream problems to be fixed without exceeding system capacity further downstream. This flood management strategy study considers two types of benefits:

1. The avoidance of flood damages; and
2. Eliminating the cost of purchasing flood insurance.

Flood damage prevention benefits could be assessed by calculating average annual flood damages assuming that capital improvement projects are not built; in other words, the no project alternative. Damage to property resulting from a flood consists of direct structural damage, the cost of evacuation, victim aid, emergency flood protection measures, business losses, and crop losses. This method of benefit calculation is not presented herein, primarily due to a lack of flood damage during more frequent events.

Elimination of flood insurance premiums is calculated as a benefit in lieu of average annual damages rather than in addition to average damages. The logic behind this approach is an assumption that flood insurance covers those average annual flood damages. Properties that are removed from a Special Flood Hazard Area, or are kept out of new regulatory flood hazard areas, receive a direct project benefit equivalent to their eliminated annual flood insurance premium.

Many parameters are used to calculate flood insurance premiums for each property owner. To simplify calculations, and provide for a conservative assessment of benefit-cost ratios, all individual benefits are calculated for the least expensive insurance possible. Table 1-1 provides a summary of project costs, the number of properties that benefit from that project, average annual benefits per parcel, and the benefit-cost ratio based on flood insurance premium avoidance. One might conclude that flood insurance is a good deal in every benefit zone other than the tidal flooding areas, although there are other valid reasons for providing actual flood protection instead of insurance coverage.

Table 1-1: Summary of Project Costs and Benefits

Flooding Source	Remediation Cost	Parcels Benefiting	Average Annual Assessment	B/C Ratio
FEMA Tidal Flooding[1]	$6,000,000	5,510	$40	5.8
All Tidal Flooding[1]	$6,000,000	8,130	$30	8.7
North Shoreview Drainage	$8,000,000	655	$1,100	0.5
16th Avenue Drainage	$10,500,000	490	$1,900	0.3
19th Avenue Drainage	$5,000,000	440	$1,000	0.6
Laurel Creek	$27,500,000	1,500	$1,600	0.4

[1]$2.5M assessment; $4.5M from other sources

FUNDING SOURCES

The City is operating under political and legal constraints to the raising of monies for public works projects. Residents in public forums have voiced their political concerns, and the City's attorney must work through the legal aspects of each type of potential funding mechanism. This study does not attempt to promulgate a detailed financing plan; rather, it provides a menu of possible capital sources for City leaders and residents to consider, including

- General funds
- Loans
- Grants
- Outside agency programs
- Special legislation
- Redevelopment agency money
- Taxation (Mello-Roos)
- Benefit-assessment districts

Benefit-assessment district formation appears to be viable only for projects that address coastal flooding hazards. City proposals to spread the burden of flood risk remediation throughout all of San Mateo are appealing because the entire city generates runoff, and thus contributes to the flood hazards. Reducing the risk of tidal flooding is, however, a local problem that has nothing to do with storm runoff. A nexus between project cost and benefit is easy to establish in this case.

STUDY FINDINGS

Several conclusions have been reached regarding San Mateo's regulatory flood risks, and methods to reduce that risk:

1. On the whole, FEMA appears to have properly mapped regulatory flood risks, where it has mapped those risks.

2. Limiting the examination of flood risk to areas north of Highway 92 is arbitrary, and does not provide property owners south of the limit of study with a reasonable understanding of their flood risks.

3. Substantial flood risks from interior residual flooding will remain even if regulatory tidal flooding is corrected.

4. Correcting coastal flooding hazards is very cost effective.

5. Benefit to cost ratios for remedial to reduce the risk of extreme residual interior flooding are less than unity.

RECOMMENDATIONS

Reducing regulatory flood risk remains a worthy goal despite some of the daunting economic information presented in this report. Other than funding a portion of the levee projects to address coastal flooding from San Francisco Bay, asking property owners to shoulder the entire burden of capital improvements to ameliorate flood risk is cost prohibitive. Therefore, the City should continue its efforts to identify other sources of funding, particularly through the Corps of Engineers Rehabilitation Program, which can provide 80 percent of a project's cost.

City officials have laid out a comprehensive long-term plan to address the regulatory flood risks identified in this study. One of the more important considerations in northern San Mateo is whether to address the floodplain in a piecemeal fashion, or in its entirety. Substantial reductions in mapped special flood hazard areas can be achieved by completing the identified capital improvement projects. The magnitude of risk reduction, as measured by the areal extent of floodplain mapping, generally follows this order:

1. Outboard levee improvements
2. Crystal Springs Reservoir spill mitigation
3. North Shoreview pump station rehabilitation and inboard levee system
4. 16^{th} Avenue Drainage Channel remediation

In southern San Mateo, citizens should be notified of this study's findings and proposed flood management strategies. Property owners should also be encouraged to purchase optional flood insurance at the less expensive pre-FIRM rates. Unfortunately it appears that resolving flood issues south of Highway 92 will be much more expensive and difficult to justify from a flood insurance perspective. Further risk-based studies could change the benefit-cost ratios in the south, but this is uncertain.

The City is also encouraged to prepare a comprehensive storm drain master plan and participate in the Community Rating System (CRS), whereby discounts of 5 to 45 percent on individual flood insurance premiums may be realized.

CHAPTER 2
STUDY BACKGROUND

This chapter provides a general background of flood management issues currently affecting the City of San Mateo. Hydrologic and environmental settings are described, along with flood protection facilities. Historic flooding and the timeline of regulatory floodplain mapping efforts within the city are described as well. Study objectives are outlined at the end of this chapter.

HYDROLOGIC AND ENVIRONMENTAL SETTINGS

San Mateo is situated between the Santa Cruz Mountains and San Francisco Bay along the eastern side of the San Francisco Peninsula approximately 12 miles south of San Francisco. Cities that border San Mateo include Burlingame to the north, Belmont to the south, Foster City to the east, and the Town of Hillsborough to the west. Figure 2-1 places San Mateo in its regional context, while Figure 2-2 delineates the City's five major watersheds:

1. North Shoreview District
2. San Mateo Creek
3. 16th Avenue Drain
4. 19th Avenue Drain
5. Laurel Creek

The first two watersheds drain directly to San Francisco Bay, either by gravity or pumping, while the latter three watersheds drain to the Marina Lagoon, whose water is pumped into the bay.

Climate

San Mateo's climate is moderate — some would say ideal — with an average summertime high temperature of 78°F, dropping to an average winter nighttime low temperature of 42°F. Mean average precipitation at City Hall is roughly 22 inches, with about 90 percent of that precipitation falling from November through March. Precipitation occurs entirely as rainfall. Snowmelt is not a hydrologic process that significantly affects runoff in the city.

Geology

Much of San Mateo was built over alluvium deposited from streams discharging from the Santa Cruz Mountain foothills to the west, and tidal flats adjacent to San Francisco Bay. The varied geologic settings affect the types of flood risk experienced throughout the city. Stream erosion and landslides are more prevalent in the upper watershed near the foothills. The center core of the city is more at risk from riverine flooding, and the bay front area is also prone to tidal flooding.

Figure 2-1 : Vicinity Map

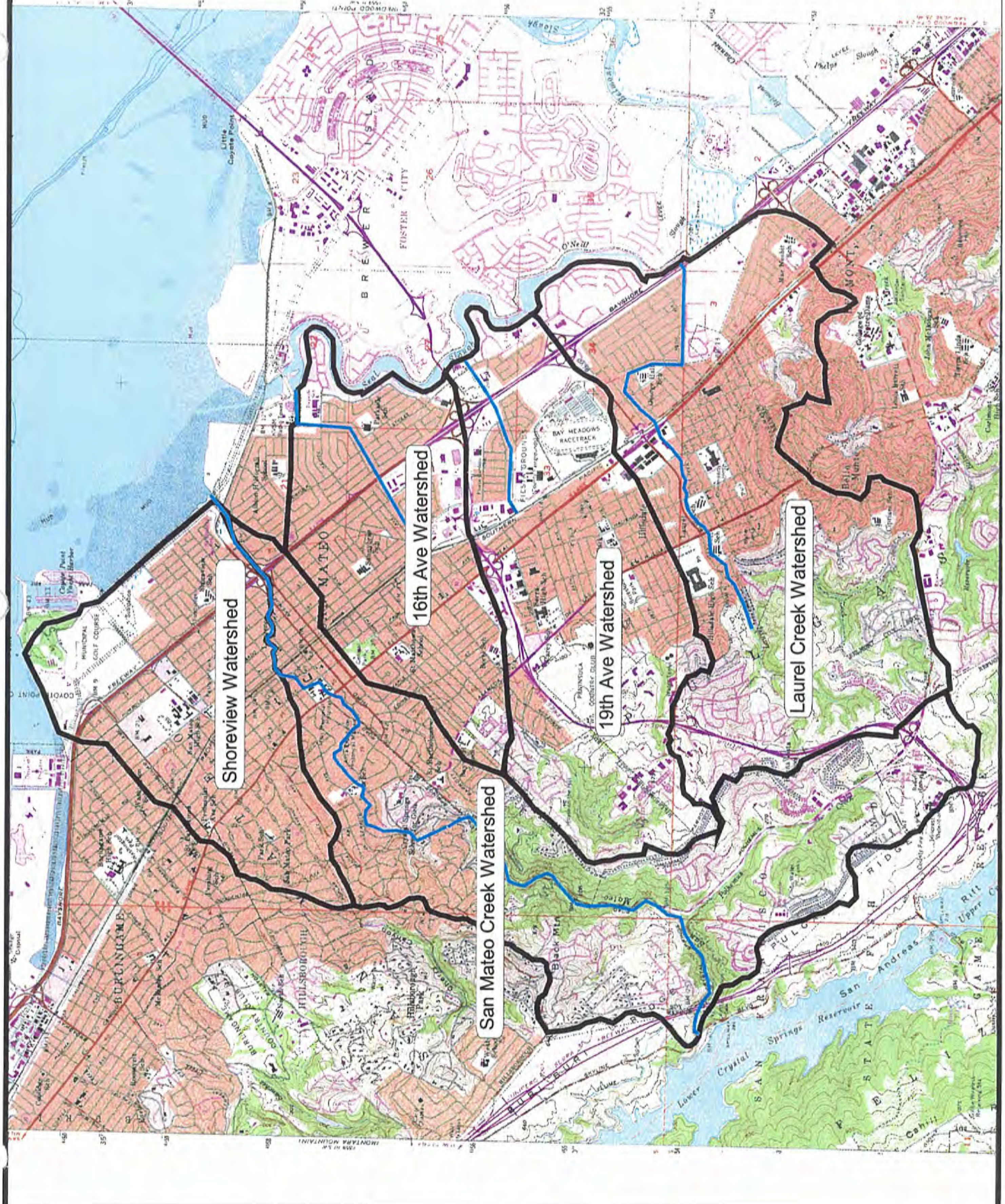


Figure 2-2: San Mateo Watersheds

Land Use

Although open space is scattered throughout the city, particularly in the foothills, the vast majority of San Mateo has been urbanized. The city has also matured to the point where redevelopment is the predominate form of new urbanization. For the most part, existing development is revitalized rather than having open space converted to more intense urban uses. Zoning within the city also appears to be stable, so with few exceptions land uses are not changing over time. (It may be noted that FEMA only considers existing land use conditions in its analyses and mapping.)

A fairly wide mix of land uses characterizes San Mateo. From protected watersheds and open space areas in the foothills, creeks flow through lower-density hillside residential areas through increasingly dense residential areas mixed with commercial and industrial uses. The city has been developed to the shores of San Francisco Bay. Most residential areas retain some open space in the form of lawns and gardens, and public parks are scattered throughout the city. Large open space areas include the Sugarloaf Mountain Open Space, Laurelwood Park, Peninsula Golf and Country Club, Beresford Park, Bay Meadows Race Course, Los Prados Park, Central Park, Joinville Park, Shoreline Park, and Coyote Point County Recreation Area and the Municipal Golf Course.

FLOOD PROTECTION FACILITIES

Flood protection is provided to developed portions of San Mateo by a series of levees that keep San Francisco Bay out, while storm drains and creeks convey storm-generated runoff into the bay. The two flood protection systems are distinct from one another, but the function of each system affects the other, and FEMA requires that both systems be analyzed together.

Outboard Levee System

San Mateo is protected from San Francisco Bay tidal flooding by a system of levees located within San Mateo, Foster City, and Belmont. Figure 2-3 shows the "outboard," or "bayfront," levee system that prevents tidal inundation from the bay. Chapter 4, "Tidal Flooding," presents a detailed description of the existing levee system and its ability to meet FEMA criteria for flood protection.

Contrary to the published Flood Insurance Rate Map for Foster City, there is no physical boundary between San Mateo and Foster City. The city limit boundary follows an arbitrary path through low-lying areas from the Marina Lagoon across Highway 92 to Mariner's Island Boulevard, East 3rd Avenue and the Bay. It must therefore be emphasized that both Foster City and San Mateo are protected by the same contiguous system of levees, particularly with regard to regulatory floodplain mapping. This issue is also discussed further in Chapter 4.

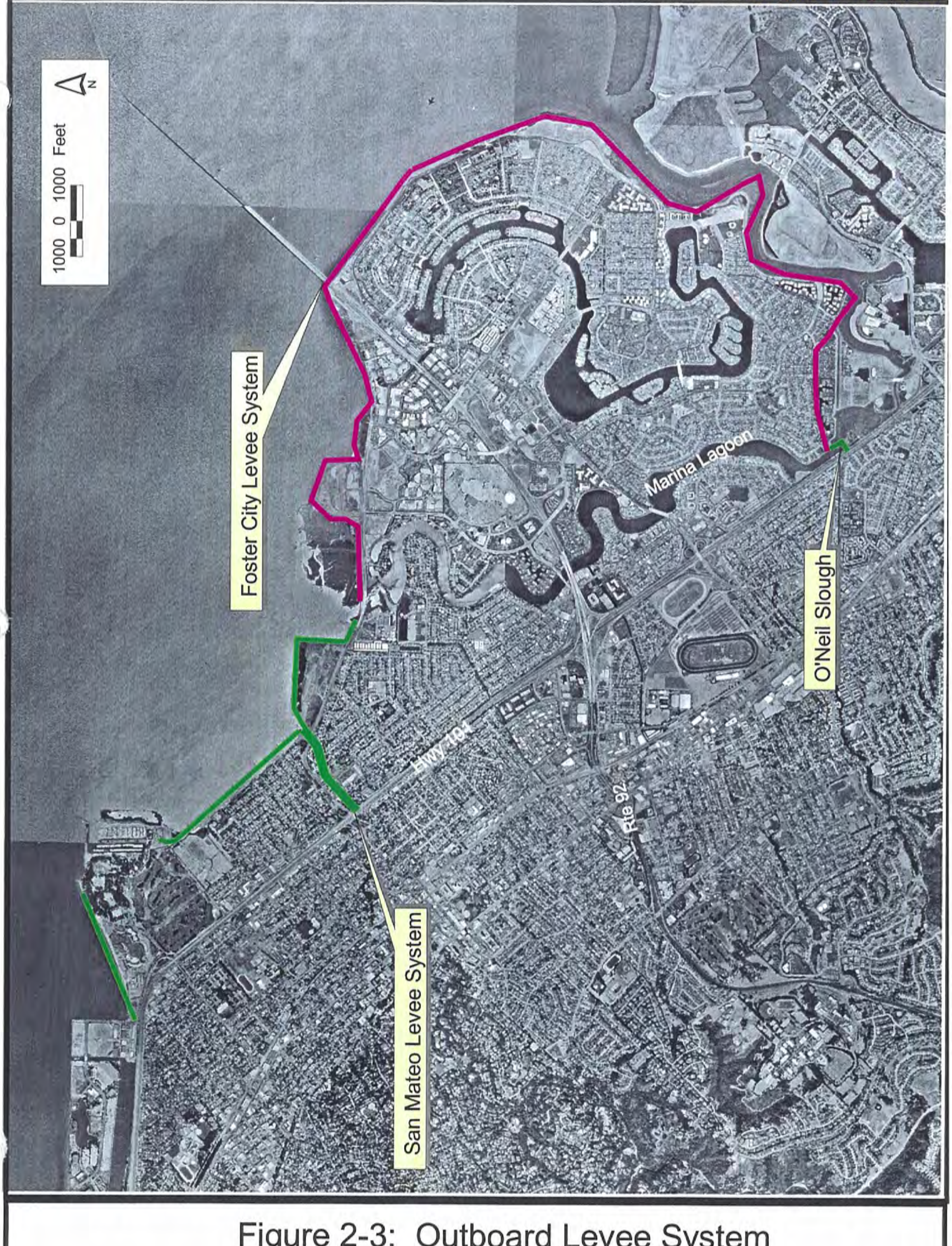


Figure 2-3: Outboard Levee System

Interior Flood Protection Facilities

FEMA makes a distinction between tidal flooding from San Francisco Bay and "interior" flooding landside of the levee system. Precipitation that falls on the land from the Santa Cruz Mountain foothills to the bayland area generates storm water runoff. This runoff flows downhill toward the bay and is conveyed in a number of natural and manmade flood protection systems:

North Shoreview Pump Stations	Chapter 5
San Mateo Creek	Chapter 5
16th Avenue Drain	Chapter 5
19th Avenue Drain	Chapter 6
Laurel Creek	Chapter 6
Marina Lagoon	Chapter 7

On the north end of San Mateo, pumping systems provide flood protection to low-lying areas in the North Shoreview Neighborhood and to the South Shoreview local drainage system. With the tidal floodplains walled off from San Francisco Bay by the outboard levee system, pump stations are required to discharge runoff that collects behind the levee. The Coyote Point and Poplar Avenue Pump Stations are evaluated in Chapter 5. The South Shoreview pumping facility will be evaluated in an upcoming storm drain master plan.

San Mateo Creek in the northern half of the city and Laurel Creek to the south represent natural channels that have been improved in various reaches to provide enhanced flood flow conveyance through more urbanized areas (Figure 2-2). The 16th Avenue Drainage Channel and 19th Avenue Drainage Channel are excavated channels that collect upstream runoff and convey it through fully urbanized areas to the Marina Lagoon, which is an artificial tidal lagoon that provides flood protection and other benefits as described in Chapter 7.

Storm runoff is delivered to the major flood protection facilities through a system of street gutters, pipes, ditches and pump stations. Although analyses of local storm drain performance are beyond the scope of this Flood Management Strategy Study, the City plans to update its Storm Drain Master Plan in the very near future. The last comprehensive storm drain planning study in San Mateo was completed in 1966.

As improvements are made to the major flood protection facilities throughout the city, a storm drain master plan is crucial to identify further potential for residual flooding caused by inadequacies in local drainage systems.

HISTORY OF FLOODING WITHIN SAN MATEO

Not every flooding event is recorded. However, it is useful to recount both published and anecdotal information about previous flooding episodes. Historic information can be valuable in highlighting areas of recurring problems, and gauging the relative severity of various flood events. Streamflow records at the nearest USGS gage (San Francisquito Creek at Stanford, which is about ten miles to the south of San Mateo's City Hall) have been examined for the ten largest runoff events on record (Table 2-1). The gage has recorded stream flows since 1932, with data missing from 1942 to 1950.

Table 2-1: Ten Largest Runoff Events on Record
(San Francisquito Creek at Stanford)

Event Date	Maximum Discharge (cfs)	Flood Frequency (years)
February 1998	7,200	80
December 1955	5,560	25
January 1982	5,220	20
April 1958	4,460	15
January 1967	4,000	10
February 2000	3,930	9
November 1950	3,650	8
February 1986	3,480	8
January 1983	3,420	7
January 1973	3,400	7

Each storm event has lead to a unique set of consequences. A sampling of published and anecdotal recollections of several storm events is presented below for historical perspective on the need for flood management in San Mateo. Recorded flood severity, unfortunately, often reflects individual newspaper reporters' writing styles as much as unbiased and reliable data. Individual storm events are recounted in chronological order, with an eye toward the effects felt in San Mateo.

February 1940

Heavy rainfall and high winds combined to cause extensive damage throughout San Mateo County, primarily from overblown trees and landslides. Power outages and road damage was common. San Mateo Creek threatened to overflow its banks, but there is no record that it did.

December 1955

The Christmas 1955 storm is considered to be the "storm of record" for Northern California by the Army Corps of Engineers, and its 72-hour rainfall pattern is used within this study as a basis for hydrologic analysis. Two days of heavy rainfall lead swollen creeks to overtop their banks throughout the Peninsula. Until the 1998 El Niño, the 1955 event represented the flood of record for San Francisquito Creek.

San Mateo City officials called the flooding a "one in a hundred year" event, but subsequent years of streamflow records have reduced the estimated magnitude of peak December 1955 runoff to the equivalent of a 25-year event. San Mateo Creek, Laurel Creek, and what is now the 19th Avenue Drain were reported to have overtopped their respective banks. San Mateo Creek flooded the basements of Mills Hospital, downtown businesses and the Shoreview neighborhood. Laurel Creek spills flooded El Camino Real from 25th Avenue south to Belmont. "Knee-deep" flooding resulted from spills from the 19th Avenue Drain. Storm drain inadequacies were blamed for the flooding of ground floor apartments at West 3rd Avenue and Eaton Road.

The worst reported flooding was in the South Shoreview neighborhood, where Norfolk, Newbridge, and Ocean View Avenues were full of water to the doorsteps of homes. Many homes were damaged, and evacuation was contemplated. Local flooding would have been much worse, but was at least partially mitigated by sandbagging efforts along the bayfront levee and San Mateo Bridge approaches.

April 1958

San Mateo and Laurel Creeks overflowed their banks primarily due to debris blocking bridges and culverts. Blocked storm drains also caused some local flooding. San Mateo Creek flooded the City of Paris department store and damaged merchandise. The City Library was also threatened but not flooded. In the Shoreview area and San Mateo Village, flooding was blamed on Laurel Creek blockages. Creek overflows flooded Santa Clara Street, Otay Circle, Branson Drive, 39th Avenue, 40th Avenue and Gatos Way, among others. Shoreview flooding was concentrated on Royal Avenue. Businesses along El Camino Real, Hillsdale Boulevard, and 25th Avenue also sustained flood damage.

January 1967

Minor street flooding due to the rains and a high tide was reported for low-lying areas along the bay. Serious flood damage was not reported.

January 1973

San Mateo County was hit by two combined storms and high tides within three days in the winter of 1973. The San Mateo Times reported high tides of 8.7 feet at the San Mateo Bridge for January 18, on what is believed to be the MLLW datum. (The 100-year tide at the bridge is 10.7 feet MLLW or 7.1 feet NGVD.) During this storm event, however, San Mateo City officials were pleased with the operation of the levees and the Marina Lagoon. On January 16, when rainfall was most intense, only minor intersection flooding was reported. On January 18, when the tides were highest, two feet of water was reported flowing over East 3rd Avenue.

As an aside, tides overtopped a levee along Belmont Slough in Foster City, and Beach Park Boulevard was closed from Shell Street to Foster City Boulevard. Apparently, no homes were damaged during this incident, however. A break in another Foster City levee threatened Redwood Shores.

January 1982

Record rainfall — nearly six inches in 24 hours at San Francisco International Airport — forced evacuations throughout the Peninsula during the January 4 storm. Most of the damage throughout the County was attributed to mudslides, but flooding in low-lying areas also contributed to the total damage figure. Damage was heavy and widespread, prompting Governor Jerry Brown and President Reagan to declare San Mateo County a disaster area on January 7. Four people lost their lives county-wide, and damages topped $30 million. The City contributed $300,000 in private property damage to that total, and $250,000 in public property damage. More than 100 homes were flooded with two to three feet of water in the Shoreview, San Mateo Village, and San Mateo Park areas.

January 1983

Reported high tides of 7 to 9 feet and a week of storms combined to cause widespread flooding along San Mateo County's bay front. Power outages, flooding, mudslides and road closures led County officials to declare a state of emergency on January 27. Areas along the bay shore suffered heavy damage caused by tidewaters, and high tides reduced storm drainage systems' abilities to handle high local runoff and overflowing creeks.

In San Mateo, nine-foot bay tides (MLLW, or about 5.5 feet NGVD) flooded intersections west of Bayshore Freeway near the Burlingame border. Saltwater lapped against East 3rd Avenue, and San Mateo Creek overflowed on January 28, also flooding 3rd Avenue. At the south end of the city, Highway 92 was nearly closed by floodwaters, and the El Camino Real underpasses at Hillsdale Boulevard and the Southern Pacific Railroad were closed because of hubcap-deep water.

February 1986

Ten days of steady rain and flooding in Northern California prompted a state of emergency for most of the region. By February 21, the storm system had produced as much as fifty percent of the average annual precipitation in some areas. While spared the severity of flooding along the Napa and Russian Rivers to the north, or in the Sacramento area, homes and businesses were flooded in several Peninsula cities, as high tides combined with heavy runoff to cause localized flooding.

In San Mateo, high tides caused sewer backups in the Shoreview area and southern San Mateo. Storm drain backups also flooded street intersections throughout the city. Marina Lagoon served the city well by storing excess storm runoff and relieving surcharged storm drain systems.

February 1998

Saturated ground conditions and heavy rainfall over a two-day period produced the flood of record on San Francisquito Creek coincident with high tides in San Francisco Bay. San Mateo was spared the heavy flood damage experienced by Palo Alto and East Palo Alto, but the storm forced uncontrolled releases from Crystal Springs Reservoir into San Mateo Creek. Spills from Crystal Springs caused some damage due to erosion and landslides, but the creek was never at "flood stage". San Mateo County was declared a federal disaster area, with over $40 million in losses countywide.

FEMA FLOOD INSURANCE STUDY

Typical insurance policies do not cover the potentially devastating consequences of flooding. Even after a catastrophic event wherein houses and businesses are completely destroyed, property owners remain liable for their mortgage balances without the equity to cover them. National flood insurance was created in 1968 for the expressed purpose of providing flood coverage even in the absence of a Presidential declaration of disaster. The intent of flood insurance is to proactively prepare for future flood damages on an equitable basis nation-wide, rather than relying upon Congressional relief after the fact.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) as administered by the Federal Emergency Management Agency (FEMA) allows property owners within participating communities to purchase insurance that protects against losses from flooding. Damages to structures and contents are covered by the flood insurance, which may be purchased through residential and commercial insurance agents. For San Mateo to participate in the NFIP, the City must adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas. In return, the Federal Government will make flood insurance available in the city.

San Mateo's Participation in the NFIP

The National Flood Insurance Act of 1968 allows FEMA to make flood insurance available only where the community has adopted adequate floodplain management regulations. The City of San Mateo joined the NFIP at the end of 1974, and has been a regular member of the program since 1981.

The first Special Flood Hazard Area map was produced in 1975 and rescinded in March 1981. At that time the entire city was mapped as a Special Hazard "Zone C," which essentially meant that the city was designated as non-floodprone. Lenders therefore would not have required flood insurance coverage on mortgages and business loans, although residents and businesses could have purchased optional flood insurance at fairly reasonable rates.

Further studies in the 1980s indicated that portions of San Mateo might be prone to flooding after all. Also, FEMA adopted new policies in 1988 that changed the assessment of flood risks to those areas protected by levees.

New Flood Insurance Study. Ensign & Buckley, a Sacramento consulting engineering firm, prepared a Flood Insurance Study (FIS) for San Mateo under contract to FEMA beginning in 1996. Although the scope of study was to include incorporated areas within the City of San Mateo, the limit of detailed study was established at Highway 92. No information is available in city files to document how this limit was arrived at. Ensign & Buckley's study concentrated on riverine flooding from San Mateo Creek, and indicated that the creek levees and the Bay levee at the north end of Coyote Point were not adequate and assumed to fail during a 100-year event.

Preliminary copies of the FIS and FIRM were provided to the City for review in 1998. Mr. Arch Perry, P.E., then the Director of Public Works, raised the concern that FEMA analyses were too conservative based on a review by Caltrans' Hydraulics Branch. Issues presented included the duration of high tides in San Francisco Bay, the operation of Crystal Springs Reservoirs, and available storage and pumping capacities within the Marina Lagoon. In October 1998, FEMA responded to each point of this letter and concluded that most of the mapped flooding is due to 100-year tidal flooding rather than San Mateo Creek spills. The findings of this Flood Management Study generally confirm FEMA's response to the Caltrans comments, primarily as they relate to FEMA mapping policies.

City Appeals New Flood Insurance Study. The City hired Church Water Consultants to review FEMA's study, and filed a technical appeal of findings for the Preliminary FIS on June 7, 1999. Essentially, the City asked FEMA to delay the publication of the new FIRM until the construction of additional flood protection facilities that would mitigate the Zone AE designation.

Identified projects included increased San Mateo Creek levee freeboard, additional bridge capacity at Norfolk Street, additional freeboard for the Coyote Point levees, and increased pump capacity at the Poplar Avenue and Coyote Point pumping plants. Mr. Church also provided a detailed assessment of the riverine hydraulic analysis for San Mateo Creek. A December 8, 1999 letter from the City to FEMA presented additional information regarding the Highway 101 median barriers as structural floodwalls, and a planned Caltrans culvert upgrade on San Mateo Creek. More precise topographic information north of San Mateo Creek was also furnished to FEMA.

FEMA Denies City Appeal. FEMA denied the City's appeal on July 10, 2000. In essence, FEMA stated that the FIRM could not be delayed to incorporate flood protection provided by facilities not in place at the time of publication. (The Letter of Map Revision process is the City's avenue to address the mapping of 100-year flood hazards.) However, many of Mr. Church's comments were incorporated into the revised FIRM for San Mateo Creek.

On August 1, 2000 the City responded to FEMA's July 10 appeal denial believing that the Technical Evaluation Contractor (TEC), Michael Baker Jr. of Fairfax, Virginia, did not clearly understand the basis of appeal. The City provided additional information regarding the use of traffic barriers as floodwalls, and photographic evidence in support of a revised Manning's roughness value for San Mateo Creek.

FEMA's formal response to the August 1 letter is dated February 26, 2001. FEMA indicated that they would review technical data submitted in support of the July 10, 2000 CLOMR request (discussed below). FEMA acknowledged that concrete traffic barriers meet NFIP regulations for floodwalls. The final FIRM was revised based on many of technical issues raised by the City. However, the Manning roughness value for San Mateo Creek was not revised, and flood protection facilities not completed at the time were not considered.

FEMA Issues Letter of Final Determination. After considering the City's technical appeal to its FIS, and several City requests for delays to address outstanding issues, FEMA issued a Letter of Final Determination on April 19, 2001 and ended the statutory 90-day appeal period. The final FIRM and base flood elevations become effective on October 19, 2001 (Figure 2-4).

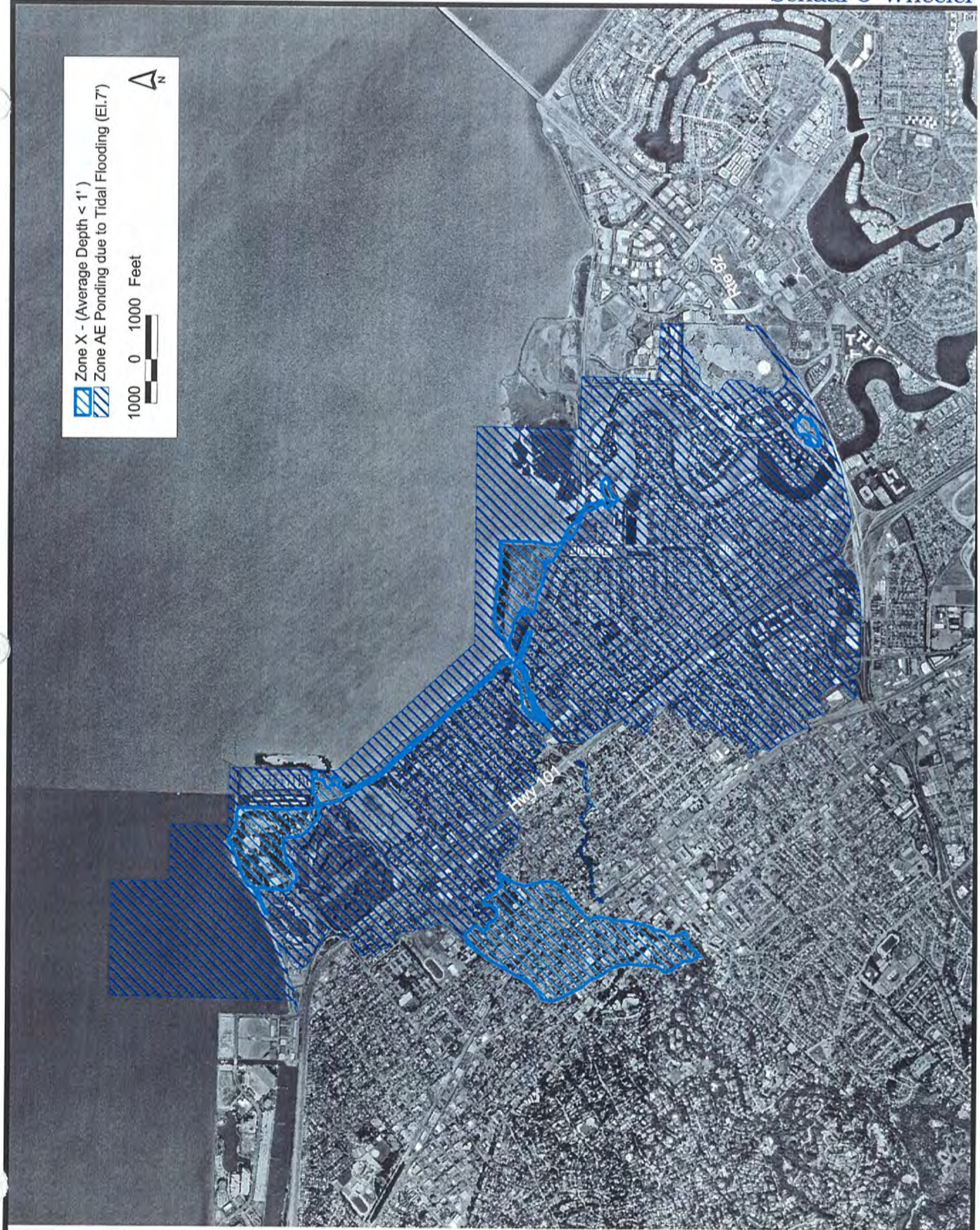


Figure 2-4 : Effective FEMA Flood Insurance Rate Map

<u>CLOMR Request.</u> The Letter of Map Revision Process, of which a Conditional Letter of Map Revision (CLOMR) is a part, is the only available means for the City and its residents to change the effective FIRM. On July 10, 2000 the City formally requested a Conditional Letter of Map Revision for the San Mateo Creek South Bank Floodwall and Norfolk Bridge Replacement projects. FEMA responded on July 27, 2000 by asking for:

1. An official operations and maintenance plan for proposed San Mateo Creek levees.

2. A residual interior flooding analysis within the boundaries of the *current* (i.e. area north of Highway 92) Special Flood Hazard Area (SFHA) that would remain after the removal of the one-percent tidal flooding limits.

3. Documentation that the Marina Lagoon and Pumping Plant meet the requirements of NFIP §65.10, including an operation and maintenance plan.

4. Certified work maps documenting the residual interior flooding analysis.

The City prepared operations and maintenance plans for the San Mateo Creek levees and Marina Lagoon facilities. This information was forwarded to FEMA on October 26, 2000. On January 31, 2001 FEMA provided a formal response to the July 10, 2000 CLOMR request and subsequent October 26, 2000 letter. The following additional items were requested.

1. Flood hazard analyses and mapping for 16th Avenue Drainage Channel, 19th Avenue Drainage Channel, and Laurel Creek.

2. Operation and maintenance plan for O'Neil Slough tidal gates demonstrating that they prevent inundation from coastal floodwater; and information demonstrating that coastal floodwater cannot overtop Belmont Slough and enter the City from the east.

FEMA's first request regarding flood hazard analyses for all of Marina Lagoon's tributaries was in direct conflict with their July 27, 2000 letter asking for residual floodplain mapping only within the *current* SFHA. Correspondence between the City and FEMA in 2001 discusses this last point. An August 27, 2001 letter from FEMA to the City resolves this issue by stating that while all three tributaries must be evaluated for their discharge to Marina Lagoon, only the 16th Avenue Drainage Channel must be analyzed and mapped. However, FEMA encourages the City to identify flood hazards associated with all sources of flooding within its boundaries.

STUDY OBJECTIVES

The basic objective of this flood management strategy study is to provide the information requested by FEMA necessary to complete the LOMR process and remove San Mateo from area of mapped special flood hazards. Specifically, this study identifies capital improvements needed to provide a level of flood protection consistent with the policies of the Federal Emergency Management Agency (FEMA) as administered through the National Flood Insurance Program (NFIP).

NFIP regulations define the "base flood" as a flood magnitude having a one percent chance of being equaled or exceeded in any given year. Often this is referred to as a "one-percent" or "100-year" flood. This level of risk, however, should not be confused with a flood that *will* occur once every one hundred years, but one that might occur once every one hundred years or so *on the average* over a very long period of time. In fact, over the life of a 30-year mortgage, there is a 26 percent chance of experiencing a flood equal or greater in magnitude than the base flood as demonstrated by Table 2-2, which provides an interesting perspective on flood risk.

Table 2-2: Relative Risk of Various Flood Events

	10-year	25-year	100-year
Annual risk of event	10%	4%	1%
Risk of at least one event in 5 years	41%	18%	5%
Risk of at least one event in 10 years	65%	34%	10%
Risk of at least one event in 30 years	96%	71%	26%
Risk of at least one event in 50 years	99%	87%	39%
Risk of at least one event in 100 years	99.997%	98%	63%

Although the primary project objective is to identify capital improvements to removed mapped flood hazard areas north of Highway 92, this study has been expanded to include:

- An assessment of regulatory flood risk south of Highway 92;
- Identifying capital improvements to reduce that flood risk;
- An assessment of costs and benefits provided by proposed flood protection measures; and
- Alternative funding mechanisms to implement necessary capital projects.

CHAPTER 3
FLOODING SOURCES

As described in Chapter 2, flooding in San Mateo has two distinct but interrelated sources: San Francisco Bay and interior runoff. This chapter describes each source of flooding and the methodologies used for analysis. Chapter 3 serves as a prelude to Chapters 4 through 8, which provide detailed evaluations of tidal and interior flood risks, and strategies to manage those risks.

SAN FRANCISCO BAY

Flood risk in San Mateo is influenced by the tides in San Francisco Bay. High tides can cause or exacerbate flooding in the low-lying areas between El Camino Real and the Bay. Without adequate levee protection, these areas would be directly exposed to saltwater inundation. Furthermore, interior flood protection systems discharge to the Bay, so high tides also serve to limit their effectiveness. That is, it is more difficult to discharge a given flowrate against a higher tide than a lower tide.

Three components of tidally influenced flooding — stillwater surge, wind-generated waves, and wave runup — must be evaluated to assess the flood risk posed by San Francisco Bay in San Mateo, as shown schematically by Figure 3-1.

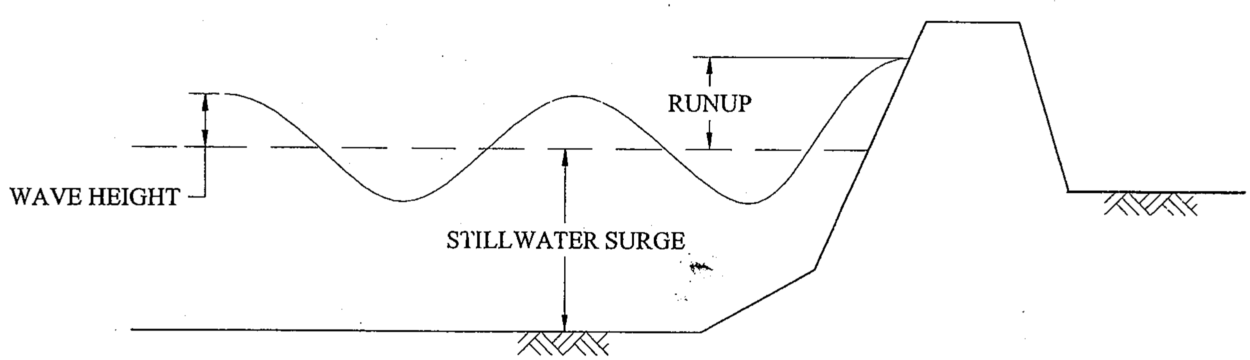


Figure 3-1: Tidal Flooding Nomenclature

Stillwater Surge

The U.S. Army Corps of Engineers has established a *19-year mean tide cycle* for San Francisco Bay and other geographical locations on the West Coast. This cycle represents average tide heights over a specific period known as the tidal epoch, which spans the 19 years it takes for every possible combination of relative positions for the sun, moon and earth to occur. A mixed tide cycle predominates on the West Coast of the United States. This cycle consists of two high tides (one higher than the other) and two low tides (one lower than the other) each lunar day. The tide cycle points are known as high-high (HH), high (H), low (L) and low-low (LL).

Based on calculations for these relative celestial positions, it is possible to predict tides for any day of the year at any time of the day. *Astronomic tides,* created by the gravitational forces of the moon and sun acting on earth's oceans, are provided in tide prediction calendars. The mean tide cycle is simply the long-term average of astronomic tides. *Observed tides*, on the other hand, are actual tidal elevations recorded by National Oceanic and Atmospheric Administration (NOAA) gauging stations located throughout coastal areas. Observed tides reflect not only the astronomic influence of the moon and sun, but also the influence of low-pressure systems that often accompany storm systems.

From observed historical data, it appears that storm-related forces induce higher tides during rainfall events, and by extension, runoff events. This phenomenon may be due to a number of meteorological or hydrologic factors. NOAA refers to the term "inverse barometer effect," and defines it as higher tides that are caused by lower barometric pressures associated with winter storm systems. References to "storm surges," whereby the meteorological effects of low barometric pressures and/or strong southerly winds are also found in the literature. Observed tide data provides what is often referred to as the "stillwater surge".

Flood risks posed by stillwater surge on San Francisco Bay are evaluated by examining the statistical frequency at which certain tide elevations are reached over time. A 1984 study by the USACE is used to establish the one-percent (100-year) exceedance tide elevation as summarized by Table 3-1. Tide elevations are presented in feet on the 1929 National Geodetic Vertical Datum (NGVD) and City of San Mateo Datum (City) at the location indicated. The currently effective FIRM has adopted a consistent one-percent tide elevation of 7 feet NGVD for the entire mapped portion of San Mateo.

Although Bay tides fluctuate in a diurnal cycle as discussed above, FEMA maps the tidal floodplain as if it is equivalent to a constant high tide, or more specifically, the 100-year tide. FEMA's approach is discussed in Chapter 4.

Table 3-1: Stillwater Surge for San Francisco Bay at San Mateo
(Source: USACE)

Location	MHHW (NGVD)	100-year Tide (NGVD)	100-year Tide (City)
Coyote Point Marina (Station 4449)	3.9	6.9	104.5
San Mateo Bridge (Station 4458)	4.0	7.1	104.7
Mouth of Belmont Slough (Station 4483)	4.0	7.0	104.6

Wind-Generated Waves

In addition to astronomic and barometric tidal considerations, the effects of wind-generated waves must also be considered to assess the level of protection afforded by the outboard levee system. Wind generated waves are not measured by the various tide stations around the Bay, and are therefore not incorporated into the stillwater surge analysis reported above.

Wave heights are a function of wind velocity and duration, as well as the fetch, or the distance over water that the wind is blowing against any particular shoreline. Various wind exposures from north to east have been analyzed, with fetch lengths between 47,500 feet and 70,000 feet as indicated in Table 3-2. Figures 3-2 and 3-3 show the fetches for the Bay Front and Marina Lagoon levee systems.

Table 3-2: Fetch Characteristics for Wind-Driven Waves

Location	Fetch	Length (feet)	Average Depth[1] (feet)
Bay Front Levee	North	70,000	23.2
	North-Northeast	53,500	21.9
	Northeast	54,000	19.3
	East-Northeast	50,000	19.1
	East	47,500	22.0
Mouth of Marina Lagoon	North-Northeast	53,700	21.3

[1]Above 100-year stillwater surge

Figure 3-2: Fetch Distances for Bay Front Levee

Figure 3-3: Fetch for Marina Lagoon Levees

Table 3-3: Wind Speed and Direction at SFO

Wind Direction	Average Yearly 2 min. Maximum (mph)	Average Yearly Maximum Wind (mph)
North	25	30
North-Northeast	20	30
Northeast	18	21
East-Northeast	18	21
East	18	21

For wind-driven waves to develop on the Bay with the indicated fetch lengths, about one to two hours of sustained wind speed are required. Using the Shore Protection Manual (USACE, 1984) to convert the two-minute wind to one-hour and two-hour winds yields 21.9 mph and 20.9 mph, respectively, for northerly gusts. A wind speed of 25 mph is used to estimate wave heights to be consistent with a recent study of Coyote Point (Noble, 1999) that used 25.6 mph for one-hour wind, and 24.6 mph for two-hour wind.

Wave heights and periods are then estimated using the Shore Protection Manual. For comparison, at the Bay Front levee, a 25 mph wind and average depth of 25 feet produce waves with a height of 2.8 feet, and a period of 3.5 seconds. Noble's study, which used a slightly different depth averaging methodology, yielded a 3.2-foot wave with a 4.1 second period for the same wind and depth conditions. Wave heights for each reach of the levee system subject to wind-generated waves are provided in Chapter 4.

Wave Runup

As a wave reaches a confining barrier such as the shore, the energy in the wave is converted to a "runup" that increases the overall water surface elevation. The magnitude of runup depends upon wave height, wavelength (period), and slope of the embankment. Wave runup generally applies to the more moderate slopes of shores and embankments such as levees. FEMA's RUNUP2 software program is used to estimate the wave runup on levees. Different transects along the levee system have been analyzed for wave runup in Chapter 4.

INTERIOR RUNOFF

When Ensign & Buckley prepared the Flood Insurance Study (FIS) for San Mateo, they concentrated on interior runoff from San Mateo Creek and the North Shoreview area. The present study expands the examination of interior runoff to the Marina Lagoon system, which encompasses the 16th Avenue Drain, 19th Avenue Drain, and Laurel Creek tributaries. A hydrologic methodology similar to one described in the FIS is utilized to extend the study of interior runoff as discussed herein. Hydraulic models for each of the flood protection systems not previously analyzed by FEMA have also been prepared as detailed in Appendix D.

Analytical Methods

To improve estimates of one-percent discharge for FEMA mapping, the following procedure has been used to calibrate watershed models using a flood frequency analysis of recorded streamflow gage data for nearby San Francisquito Creek.

1. Perform a statistical analysis of streamflow data at the nearby USGS gage on San Francisquito Creek at Stanford.

2. Prepare a rainfall-runoff model for the watershed tributary to the San Francisquito Creek gage, which is hydrologically similar to San Mateo.

3. Using the design 100-year rainfall pattern, calibrate the San Francisquito Creek model to replicate 100-year flood frequencies for peak discharge and runoff volume.

4. Construct detailed rainfall-runoff models for each San Mateo watershed using a unit hydrograph procedure similar to the FIS, applying the calibrated rainfall pattern.

Design Storm

Unit hydrograph methods are used to estimate runoff from precipitation through a process known as convolution. As stated in Chapter 2, the three-day rainfall event of December 1955 is still considered to be the "storm of record" for Northern California. Figure 3-4 shows the Christmas 1955 storm pattern, normalized as a percentage of total precipitation depth.

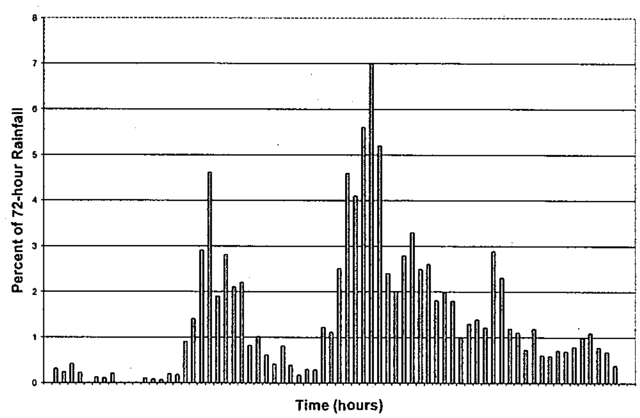


Figure 3-4: USACE 72-hour Storm Pattern

For this study, however, the Christmas 1955 precipitation pattern has been adjusted to preserve local rainfall statistics for the area compiled by the Santa Clara Valley Water District (SCVWD). The peak one-, three-, six-, 12-, and 24-hour precipitation depths in the adjusted storm pattern will match local depth-duration-frequency statistics. Appendix C shows how this statistical balancing is performed, which results in the adjusted rainfall pattern presented as Figure 3-5.

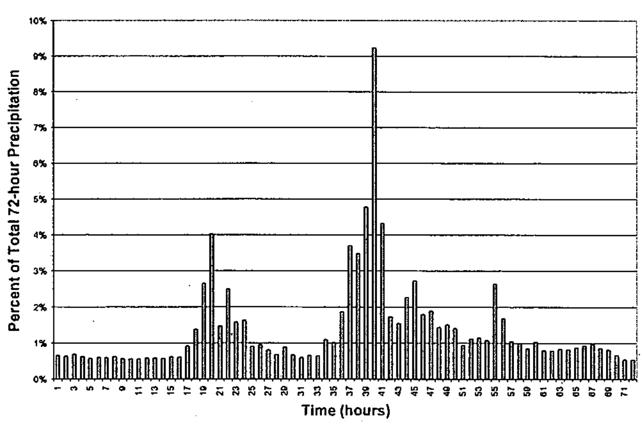


Figure 3-5: Balanced 72-hour Storm Pattern

This approach allows a particular balanced precipitation pattern to be calibrated to stream gage frequency analyses by matching antecedent moisture conditions, and bases watershed modeling on factual data. As long as this procedure is followed, the actual storm duration and pattern are not important; the calibration ensures that local runoff frequencies are matched for peak discharge. Since the depth-duration relationships depend only upon mean annual precipitation (MAP) at any particular location, the statistically balanced rainfall pattern may be applied to different watersheds simply by changing the total 72-hour rainfall depth as a function of MAP. A similar procedure is used to produce balanced storm patterns for the 10-year and 25-year events.

Unit Hydrographs

A unit hydrograph is a numerical representation of the time response of catchment runoff caused by one inch of excess rainfall applied uniformly over a unit of time. Many different techniques are available to estimate unit hydrographs for rainfall-runoff convolution. The San Francisco District Corps of Engineers "S-Graph" is used in this study. This methodology provides an estimate of basin lag, which is the time from the beginning of excess rainfall (i.e. direct runoff) to the point in time when fifty percent of the runoff has passed the catch point. The USACE equation for basin lag is:

$$t_{lag} = 24n\left(\frac{L L_c}{\sqrt{S}}\right)^{0.38}$$

where

- t_{lag} is defined above (hours)
- n is a function of basin urbanization (dimensionless)
- L is the length of flow from the highest point in a catchment to its outlet (mi)
- L_c is the length from a point perpendicular with the basin centroid to its outlet (mi)
- S is the average basin slope in (ft/mi)

Basin parameters and the resulting 15-minute unit hydrographs are provided in Appendix C. This unit hydrograph duration is short enough to prevent any numerical attenuation of flood peaks for smaller catchments with short basin lags.

Infiltration and Other Losses

Direct runoff is estimated by subtracting soil infiltration and other losses from the rate of rainfall. The Curve Number (CN) method is an empirical methodology derived by the Soil Conservation Service (SCS). The Curve Number is an abstraction that reflects the potential loss for a given soil and cover complex. In this methodology, which was used by Ensign & Buckley for the FIS, an initial abstraction must be satisfied before there will be any direct overland runoff. This abstraction represents rainfall that is absorbed by tree cover, depressions, and soil. After satisfying the initial abstraction, the soil becomes saturated at a certain rate so that a higher percentage of the accumulated rainfall becomes converted into runoff.

Estimates of the CN are made based on the soil types and cover within a drainage basin. The number varies from 0 to 100, and represents the relative runoff potential for a given soil-cover complex for given antecedent moisture conditions (that is, how wet is was prior to any precipitation event). Curve numbers for the calibration of antecedent moisture and application to the San Mateo watershed models are based on published CN tables and Hydrologic Soil Groups established on maps prepared by the SCS. Soil cover and land uses are based on aerial photographs, USGS Quadrangle maps, and field reconnaissance. As stated previously, the antecedent moisture condition (AMC) is calibrated to the results of flood frequency analyses for San Francisquito Creek. AMC is characterized by the SCS as:

AMC I	soils are dry
AMC II	average conditions
AMC III	heavy rainfall, or light rainfall with low temperatures; saturated soil

Calibration of AMC

Antecedent moisture conditions are established for each storm pattern used in this study. Schaaf & Wheeler developed curve numbers and other basin parameters for the San Francisquito Creek basin. (Schaaf & Wheeler, 2001) Appendix C contains a frequency plot for San Francisquito Creek at Stanford following procedures outlined in USGS Bulletin #17B (USGS, 1982). Summarizing the calibration (Table 3-4):

<u>San Francisquito Creek at USGS Gaging Station</u>

Area = 37 mi^2
SCS Curve No. 68 (AMC II)
Percent Impervious = 5
Mean Annual Precipitation = 31 inches
100-year, 72-hour Depth = 13.24 inches

"n" = 0.08 (USACE)
L = 63,800 feet = 12.08 mi
L_C = 28,000 feet = 5.30 mi
S = 0.016 = 84 ft/mi
t_{lag} = 4 hours

Table 3-4: Calibration of AMC for Watershed Modeling

Return Period	Peak Discharge (cfs)	Calibrated AMC	AMC Used
10-year (10%)	4,100	1.2	I¼
25-year (4%)	5,300	1.3	I¼
100-year (1%)	7,700	1.4	I½

San Mateo Watershed Models

Using statistical rainfall data from the Santa Clara Valley Water District, the design storm patterns, and calibrated AMC values, runoff hydrographs for individual catchments are derived and combined to produce discharge estimates at points of interest. Flood hydrographs are routed downstream using the Muskingum-Cunge method, which provides for both the translation and attenuation of hydrographs depending upon the size, shape, slope and roughness of the main routing channel. Hydrologic modeling results are summarized in Chapters 5 and 6. Appendix C provides more modeling detail.

Hydraulic Models

To evaluate the flood protection provided by natural channels and manmade facilities in San Mateo, a series of hydraulic models have been prepared. Water surface elevations for various design flows within flood protection facilities are estimated using a one-dimensional steady state flow backwater analysis via the HEC-RAS public domain program. Establishing water surface elevations provides the basis for FEMA floodplain mapping, indicates where flood protection facilities are inadequate, and suggests the likely frequency of flooding in certain areas.

To perform hydraulic capacity and floodplain mapping analyses, each of the major flood flow conveyances have been modeled. Ensign & Buckley previously modeled San Mateo Creek for the FIS, and included topographic changes suggested by Church Water Consultants. The models for 16th Avenue Drain, 19th Avenue Drain, Laurel Creek, and the Marina Lagoon are based on field surveys provided by Mark Thomas & Company, supplemented with additional field work as needed. Other topographic information necessary to map creek overflows has been obtained from the USGS 10 meter Digital Elevation Model; storm drain and sanitary sewer rim information provided by the City; aerial topography from the Shoreline Parks Master Plan; FEMA work maps (2 foot contours); and record drawings of Joinville Park and Marina Lagoon.

CHAPTER 4
TIDAL FLOODING

The most significant impact of the effective Flood Insurance Rate Map for San Mateo is the need for mandatory flood insurance purchases to 5,300 parcels affected by tidal flooding. This chapter provides an assessment of the existing outboard levee system, discusses tidal flood risks in San Mateo, and proposes projects that could eliminate the regulatory tidal floodplain.

FEMA CRITERIA

A "levee" is defined by NFIP regulations as any manmade structure designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water to provide protection from temporary flooding. Levees usually refer to earthen embankments, but the regulatory term applies to structural floodwalls as well. A series of outboard levees protects San Mateo from San Francisco Bay tidal flooding. The city relies on levees located within San Mateo, Foster City, and Belmont. For FEMA to recognize the flood protection benefits of a levee:

- The levee must have adequate freeboard; and
- The levee must be certified.

Levee improvements that do not meet both standards are not included as flood protection facilities when FEMA prepares its flood insurance maps. In this case, San Francisco Bay is assumed to flood San Mateo as if the levee system were not in place. Thus the 100-year flood elevation in the city is equivalent to the 100-year stillwater tide elevation, or 7 feet NGVD.

Freeboard

To meet FEMA standards, the top of levee elevation must be at least the maximum of the 100-year stillwater surge elevation:

- plus 2 feet; or
- plus the wind-driven wave height plus one foot; or
- plus the wave-runup plus one foot.

Certification

Levees must be analyzed and certified by a Registered Civil or Geotechnical Engineer as to their structural, seismic and geotechnical stability. Consulting geotechnical engineers will generally use methodologies authored by the Corps of Engineers to complete this analysis, since FEMA will accept levee certification from a federal agency such as the Corps.

REQUIRED FREEBOARD IMPROVEMENTS TO THE LEVEE SYSTEMS

Photo 4-1 shows a portion of the bay front levee, which closes the gap between high ground at Coyote Point (Photo 4-2) and Seal Point (Photo 4-3). The bay front levee is fairly typical of the outboard levee system. The beach at Coyote Point Recreation Area is exposed to direct tidal action (Photo 4-2).

Photo 4-1: Bay Front Levee

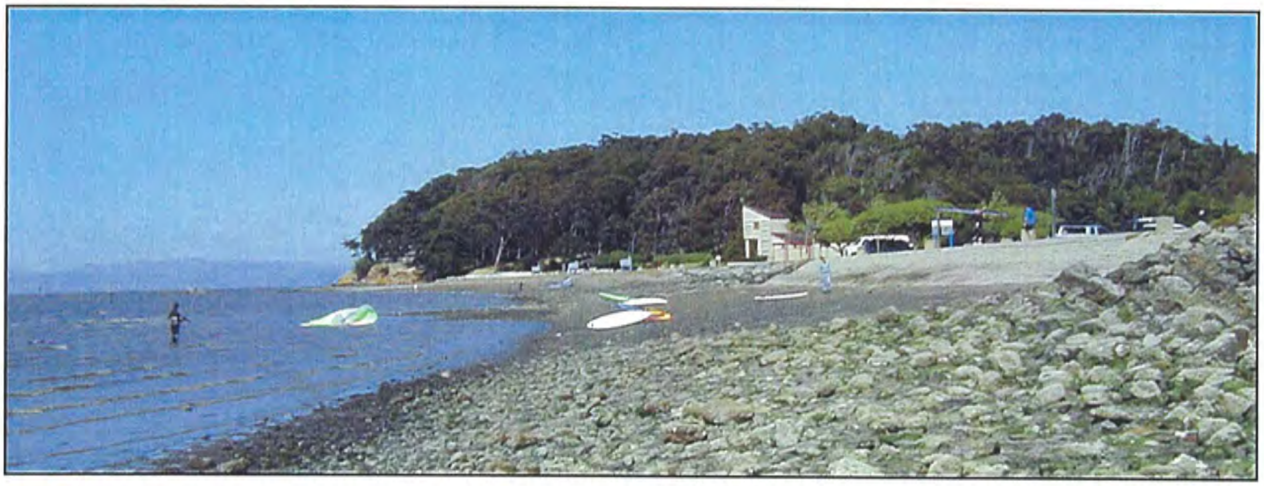


Photo 4-2: Beach at Coyote Point Recreation Area

Photo 4-3: Seal Point Landfill

Photo 4-4: Setback Levees at Marina Lagoon Mouth

At the mouth of Marina Lagoon, setback levees in Joinville Park and the pump station outfall structure protect the lagoon from tidal inundation (Photo 4-4). To the east of the lagoon mouth, San Mateo's outboard levees join Foster City's outboard levee system. FEMA wants the City to demonstrate that coastal floodwater cannot overtop Belmont Slough and enter the City from the east, specifically meaning Foster City and Belmont. The O'Neil Slough tide gate facility is operated and maintained by the City of San Mateo.

However, in the Flood Insurance Rate Map for Foster City (effective January 19, 1995), FEMA indicates that Foster City is protected against 100-year flooding from San Francisco Bay by its levee system. The City of San Mateo has elected to take the federal agency at its word, so in essence, the Foster City levees are already certified for flood protection to the national standard.

(From a regulatory perspective, Foster City's published floodplain map should mean that the O'Neil Slough tide gate and all of San Mateo's other levee systems are certified as well, since they protect Foster City from tidal flooding, just as Foster City's levees protect San Mateo.)

Figure 4-1 shows the results of levee freeboard analyses for the complete San Mateo system, except previously certified Foster City levees, which are assumed to be adequate. Analytical methodologies are detailed in Chapter 3. The levee system has been broken into several defined segments for analysis and proposed remedial work as shown and listed in Table 4-1. Reaches shown in red on Figure 4-1 will require improvements to meet FEMA freeboard criteria. Reaches coded in green have adequate freeboard, but will need to be checked for structural and geotechnical stability to obtain FEMA certification.

To be consistent with available levee topography, all elevations in this report are given in feet on the City of San Mateo's vertical datum. Mean sea level datum (NGVD 1929) may be calculated by subtracting 97.6 feet from the City datum.

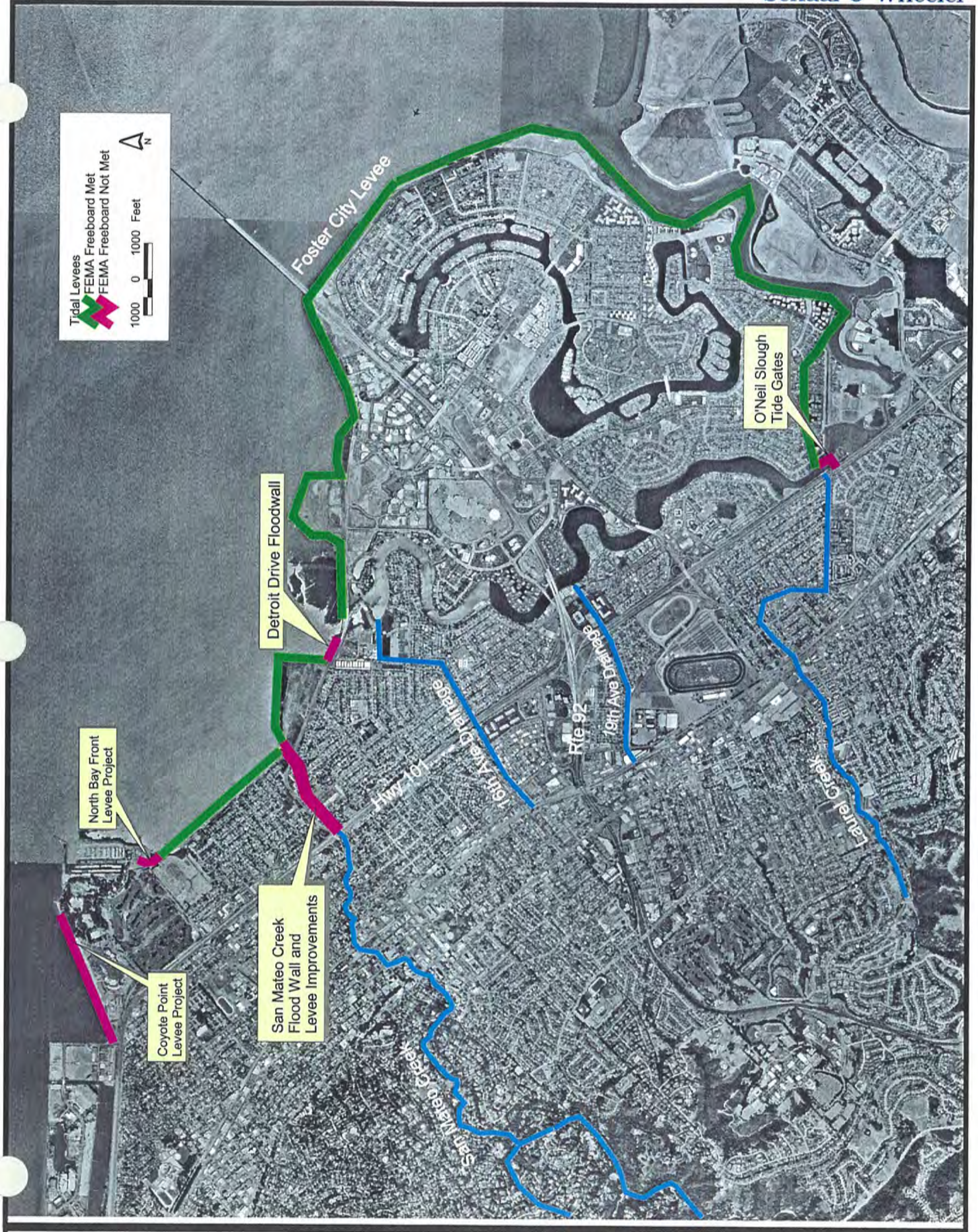


Fig 4-1 : Outboard Levee Projects to meet FEMA Criteria

Table 4-1: Outboard Levee Evaluation in San Mateo
(Elevations Given on City Datum)

Segment	Begins at	Ends at	Minimum Existing Elevation	Required Elevation
Coyote Point	Airport Boulevard	Coyote Point	105.7	110.9
Bay Front	Coyote Point	San Mateo Creek	107.3	108.5
San Mateo Creek	San Francisco Bay	Highway 101	Varies[1]	Varies[1]
Detroit Drive	Seal Point Landfill	Marina Lagoon	104.3	108.0
East End	Marina Lagoon	Foster City Limit	108.5	108.0
O'Neil Slough	Foster City Limit	Highway 101	105.0	106.5

[1]See section below and Chapter 5 for more discussion

Coyote Point Segment

In the published FIS for San Mateo, FEMA identified lower elevations along the shoreline between Burlingame and Coyote Point as the reason for the Special Flood Hazard Area in San Mateo mapped to elevation 7 feet NGVD. As explained in Chapter 3, once a segment of levee is determined not to meet FEMA criteria, that segment is "failed" to natural ground, and the flood plain is mapped as if the levee did not exist. FEMA has therefore mapped the Zone AE in San Mateo assuming that the gap at Coyote Point lets San Francisco Bay in. This is the correct regulatory approach.

Subsequent to the issuance of the Preliminary FIRM, the City contracted with Noble Consultants, Inc. (through Church Water Consultants) to assess the potential for coastal flooding along this shoreline. Noble concluded that the existing shoreline does not meet FEMA criteria, and that the easterly and central sections of the shoreline along the beach would be overtopped during the 100-year tidal event. While overtopping does not occur along the western portion of the beach, sufficient freeboard is not available. Their results are based on the following:

<u>Western Third of Shoreline</u>

Fetch Distance	69,300 feet
Wind Speed	27 mph (North)
Maximum Wave Height	3.0 feet (4.0 sec period)
Maximum Wave Runup	2.7 feet
Storm Surge Elevation	104.5 feet
Controlling Elevation	107.5 feet (storm surge plus wave)

The appropriate freeboard in this case is one foot, and the top of levee elevation needs to be 108.5 feet on the City datum. The existing top of levee elevation is about 107.8, so nearly one foot needs to be added to the existing levee that passes by the Coyote Point Pump Station. The pedestrian path would be raised to achieve required freeboard, beginning at Airport Boulevard at Burlingame, running east for approximately 1,000 feet.

Photo 4-5: Western Portion of Coyote Point Levee

<u>Eastern Two-Thirds of Shoreline</u>

Fetch Distance	69,300 feet
Wind Speed	27 mph (North)
Maximum Wave Height	3.0 feet (4.0 sec period)
Maximum Wave Runup	5.4 feet
Storm Surge	104.5 feet
Controlling Elevation	109.9 feet (storm surge plus wave runup)

The appropriate freeboard in this case is again one foot, and the top of levee elevation needs to be 110.9 feet on the City datum. The existing crest along the shoreline is about 105.7; so over five feet of levee would need to be added along the beachfront area shown in Photo 4-2. Such an "improvement" would not complement the views afforded to Coyote Point's visitors, which stretch to San Francisco and the East Bay:

Scott Noble and Dave Church have both suggested that a small berm or wall could be placed around the landward perimeter of the Coyote Point parking lot in lieu of a stepped seawall between the parking lot and beach. This would allow waves to break within the parking lot, but the coastal floodwater would be contained, and this particular source of tidal inundation would be resolved. This appears to be a reasonable general approach.

Rather than constructing a wall or berm around the parking lot, however, it may be more aesthetically and functionally pleasing to simply "connect the dots" between the areas of high ground already found throughout the park, tying into the aforementioned levee on the west, and high ground at Coyote Point to the east. Pending a detailed geotechnical investigation, the grassed mounds already located within the picnic area could be used to contain the wave runup. Using broad landscape features is appealing from a stability standpoint, and this would lessen the appearance of an artificial perimeter. Several photographs explore this possibility below:

At left, the Bay Trail could be raised to match the Coyote Point Levee (Western Reach), tying into a landscape berm or textured wall at the rear of the parking lot beyond the fence. Mature trees would be saved.

At right, landscape mounds could be connected with lower berms and/or walls (perhaps with benches or other amenities). Entrance roads would need to be regarded to provide containment, and efforts would be made to blend the perimeter into its surroundings.

Bay Front Levee Segment

Based on shoreline topography, only 500 feet at the northern end of this levee segment need to be raised by about one foot to elevation 108.3 for wave freeboard:

Fetch Distance	53,500 feet
Wind Speed	25 mph (NNE)
Maximum Wave Height	2.8 feet (3.5 sec period)
Maximum Wave Runup	2.1 feet
Storm Surge Elevation	104.5 feet
Controlling Elevation	107.3 feet (storm surge plus wave)

San Mateo Creek

Tidal action influences water surface elevations in San Mateo Creek where the creek drains into the Bay. (The hydraulic interaction is described more fully within Chapter 5.) Even without creek discharge, however, coastal floodwater can enter San Mateo over the banks of the creek. At the mouth of San Mateo Creek, the shoreline is subjected to the same fetch and wind conditions as the Bay Front Levee. Therefore, the required freeboard elevation is 108.3 feet.

Where the levees meet each bank of San Mateo Creek near J. Hart Clinton Drive, the pedestrian/bicycle path is between six-inches and one-foot shy of meeting freeboard requirements. The proposed remediation project would raise the pedestrian/bicycle path on each bank by one foot for 300 feet toward the Bay. This project will be within the Shoreline Parks Master Plan area.

Proposed projects that address tidally influenced flood elevations near the mouth of San Mateo Creek will also, in effect, divide San Mateo into two tidal flooding zones. Tidal flooding in areas to the north of the creek would not be affected by outboard levee projects south of the creek, and vice versa; however, to avoid complexity, tidal projects are considered to benefit properties in the tidal floodplain as a whole regardless of where the specific project is located relative to San Mateo Creek.

Detroit Drive

Near the Detroit Drive / East Third Avenue intersection, shoreline characteristics are:

Fetch Distance	53,700 feet
Wind Speed	20 mph (NNE)
Maximum Wave Height	2.5 feet (3.2 sec period)
Maximum Wave Runup	2.1 feet
Storm Surge Elevation	104.5 feet
Controlling Elevation	107.0 feet (storm surge plus wave)

At some discontinuities in the levee system, the existing ground is less than elevation 104.4 feet. The 100-year stillwater surge would overtopping the ground at this elevation, and wind-generated waves could significantly overtop the ground at this location. Wave generated water could flow down Detroit Drive toward the wastewater treatment plant (Photo 4-9). To remedy this problem, a floodwall built to FEMA criteria is recommended to provide required freeboard.

Photo 4-9: Detroit Drive Levee

A wall may be easier to build than an earthen levee; due to a relative lack of space for the levee footprint, potentially weak bay mud soil as a foundation; and BCDC permitting requirements. Obtaining the necessary four-foot levee height while avoiding excessive settlement due to the weight of fill over the bay mud may be problematic. The details of this levee or floodwall system remain to be resolved with input from a geotechnical engineer, and those involved with the Shoreline Parks Master Plan. Options remain open, and a practical and cost-effective solution will be sought.

East End Levee

Record drawings for Joinville Park and the Marina Lagoon Pump Station indicate that sufficient freeboard is provided for the fetch and wind conditions experienced, which are the same as the Detroit Drive area.

O'Neil Slough Tide Gate

Photo 4-10 provides a perspective of the O'Neil Slough Tide Gate structure, which provides for tidal inflow at the south limit of Marina Lagoon through the gates pictured, while providing for protection against stillwater surge from Belmont Slough. The facility is located within a City maintenance easement, but within the city limits of Belmont. At the O'Neil Slough tide gate, four 24-inch openings allow the controlled entry of tidal water from Belmont Slough into Marina Lagoon for circulation.

Figure 4-10: O'Neil Slough Tide Gate and Outboard Levee

Based on field surveys from established control points on the City datum, the levee on either side of the tide gate does not provide two feet of freeboard for the 100-year stillwater surge. In fact at the levee's lowest point just east of Highway 101, the 100-year stillwater surge is not contained. Approximately 600 feet of levee need to be raised to elevation 106.5 (City datum) between the end of Foster City's levee and Highway 101. The average increase in levee elevation is between one and 1.5 feet. Pavement elevations on northbound Highway 101 appear to be above the 100-year tide. Due to age and condition, the existing tide gate structure will also be rebuilt (to the required freeboard) as part of this project.

COST OF OUTBOARD LEVEE IMPROVEMENTS

Estimated capital costs to complete the recommended freeboard improvements are detailed in Chapter 8 of this report.

CHAPTER 5
RESIDUAL FLOODING IN NORTH SAN MATEO

Once adequate freeboard is provided as detailed in Chapter 4, and all outboard levee systems are certified to FEMA standards, residual flooding "unmasked" by the removal of tidal inundation must be addressed. To remove Special Flood Hazard Areas from the effective Flood Insurance Rate Map, residual flooding north of Highway 92 must be addressed. As described in this chapter, there are significant areas with residual flooding, almost to the point where the extent of mapped flooding will not significantly change without correcting the sources of residual flooding.

Major sources of residual flooding in northern San Mateo include:

- San Mateo Creek
- Area-wide runoff to the North Shoreview Neighborhood
- 16^{th} Avenue Drain

SAN MATEO CREEK

San Mateo Creek serves as the outlet to Lower Crystal Springs Reservoir, which has a large tributary area (almost 30 mi^2) that includes the San Andreas Reservoir and Upper Crystal Springs Reservoir. Owned and operated by the San Francisco Water Department, the reservoir is part of a water supply system for the City of San Francisco. The Hetch-Hetchy Aqueduct brings water from Yosemite National Park, across the Central Valley, around the south end of San Fransisco Bay, and through the Pulgas Tunnel; terminating at the Pulgas Water Temple at Upper Crystal Springs Reservoir. As water supply storage facilities, Upper and Lower Crystal Springs Reservoirs are not operated to provide flood protection per se.

San Mateo Creek drains another four square miles below Crystal Springs Dam (Figure 2-2), including areas tributary to Polhemus Creek. FEMA studied the entire San Mateo Creek watershed to produce the currently effective Flood Insurance Rate Map. Figure 5-1 illustrates the San Mateo Creek system.

From the reservoir outlet (Photo 5-1), San Mateo Creek parallels Crystal Springs Road in a relatively deep and narrow canyon for about two miles to the base of the foothills, where the canyon opens out into an alluvial fan. The creek remains in a natural state downstream to El Camino Real, where it enters an underground culvert at Mills Hospital (Photo 5-2). The creek is confined to the culvert through downtown, re-emerging as a natural urban channel at B Street near the Caltrain Depot (Photo 5-3), and continuing to San Francisco Bay in various states of improvement.

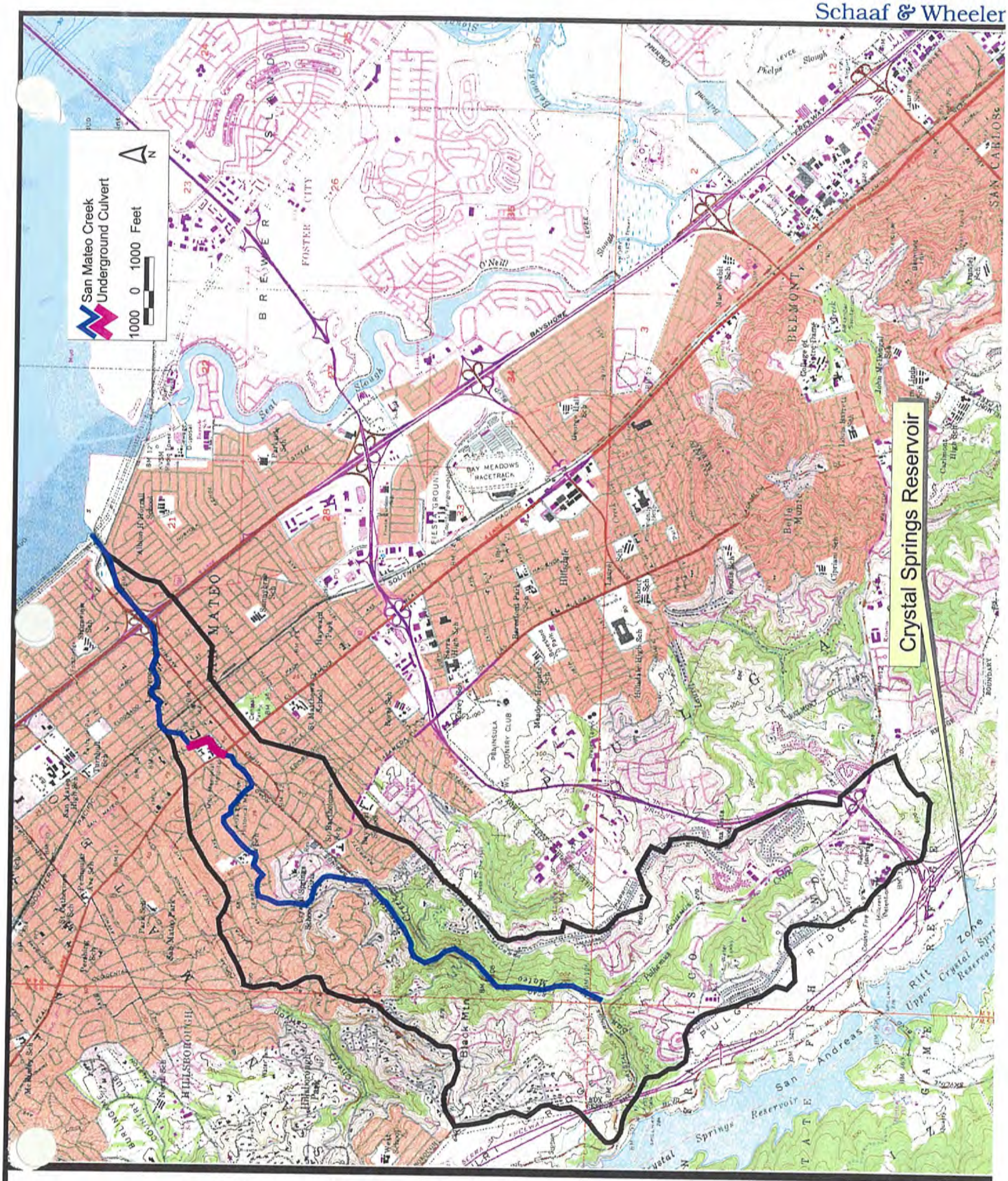


Figure 5-1 : San Mateo Creek System

Photo 5-1: Crystal Springs Dam and Outlet to San Mateo Creek. Without a contractual flood control function, FEMA assumes that the reservoir is ready to spill at the beginning of the design storm.

Photo 5-2: Entrance to San Mateo Creek Culvert at El Camino Real. Reservoir releases cause floodwater to leave the channel banks in this location.

Photo 5-3: Re-emergence of San Mateo Creek near Caltrain Depot downstream of B Street.

From Highway 101 downstream to J. Hart Clinton Drive, a concrete floodwall (Photo 5-4) has been constructed along the south bank to contain floodwaters during extreme runoff events when high tide conditions are often prevalent in San Francisco Bay. A similar floodwall for the north bank is currently in design. Caltrans is also designing improvements to the creek culvert at the Bayshore Freeway to increase the design capacity from 1,200 cfs to 1,500 cfs, accommodating full design flow downstream of the downtown culvert restriction.

Photo 5-4: New Floodwall on South Bank of San Mateo Creek.

(The Gap at Norfolk Avenue will be closed during construction of the bridge.)

Downstream Floodwall Evaluation

To complete part of the CLOMR request for San Mateo Creek improvements, the impact of channel roughness on required floodwall elevations for both banks of San Mateo Creek, with and without additional channel discharge resulting from improvements to the Caltrans culvert. FEMA's effective HEC-RAS model uses a Manning's roughness coefficient of 0.035; in earlier work, Church Water Consultants proposed a roughness coefficient of 0.030 for this reach of San Mateo Creek. The HEC-RAS model used for the July 10, 2000 CLOMR application for the "San Mateo Creek South Bank Floodwall and Norfolk Bridge Replacement" project is the basis for this evaluation.

The geometry file has been modified only as needed for compatibility with HEC-RAS Version 3.1, and run with n values of 0.030 and 0.035, with channel discharges of 1,200 cfs and 1,500 cfs. The latter discharge represents the downstream effect of future Caltrans culvert improvements at Highway 101.

With the present design discharge of 1,200 cfs, the constructed south bank floodwall would contain the one-percent discharge with freeboard meeting FEMA standards, with either roughness coefficient.

Once the Caltrans culvert improvements are completed, however, and creek discharge increases to 1,500 cfs, FEMA freeboard would not be provided within limited reaches for either roughness coefficient. If FEMA were to adopt the City's n of 0.030, the south bank floodwall needs to be increased in elevation by about 6 inches for 200 feet downstream of the Caltrans sound wall at the 3rd Avenue off-ramp from Highway 101. (Water surface profiles are provided in Appendix D.)

If FEMA maintains its previously adopted Manning roughness coefficient of 0.035, the floodwall downstream of Highway 101 needs to be raised by about one foot over its existing elevation. In addition, the floodwall needs to be raised by six inches for 100 feet upstream of the Norfolk Avenue Bridge.

Recommendation: To minimize argument with FEMA, the north bank and south bank floodwall elevations should be set based on a roughness coefficient of 0.035 and a discharge of 1,500 cfs. This action has the most impact to the south bank floodwall. Without high water marks and measured discharges, the selection of an n value is subjective. (Based on a formula published by the Corps of Engineers, the standard deviation for FEMA=s base n value of 0.035 is 0.009, so n values between 0.025 and 0.045 are generally considered reasonable. In other words, one could argue for either n value and be "right". However, FEMA has no compelling reason to change their mind.)

Spills that Cause Residual Flooding

The capacity of the 1,850-foot long culvert underneath downtown causes 630 cfs to spill out of the creek to the west at El Camino Real during the design ten-day, 100-year storm with Crystal Springs Reservoir assumed to be filled to its spillway elevation of 283.5 at the beginning of the storm. Under the operating assumption FEMA made, the reservoir releases and the spill at El Camino lasts for 52 hours, discharging 1,600 acre-feet to the streets of San Mateo. Once relieved of this flow, the creek has sufficient capacity downstream to San Francisco Bay if the proposed Caltrans culvert is constructed at Highway 101.

Flow in excess of culvert capacity spills to the north through residential properties upstream of El Camino Real. FEMA's recent work map depicts this spill as broad shallow flow with average depths less than one foot. The FIRM zone designation is "Shaded X" and mandatory flood insurance is not required. The study contractor cut cross-sections through the shallow flooding area and analyzed the flow using a backwater model with a Manning's roughness coefficient of 0.1 to reflect urbanization.

This may be a flawed analysis given the multitude of flow obstructions from buildings and fences on each property. To account for the severe flow blockage, the effective roughness coefficient may be adjusted upward (Hejl, 1977). When applied to the San Mateo Creek spill, the adjusted roughness coefficient is 0.4, which would significantly increase the average depth of flow.

A more precise way to calculate flow depths is to trace the spill as it moves down individual street rights-of-way, splitting at intersections according to street widths and slopes. A diagram on the next page shows the results of this analysis, indicating discharge splits and flow depths in each street. While the area of inundation is very similar to the published FIRM, average depths of flooding could be up to two feet in some locations, requiring mandatory insurance for some adjacent properties. (When discussing this issue, however, it is important to remember the extended release from Crystal Springs Reservoir in FEMA's analysis.)

With a spill of long duration, there is little flow attenuation in the streets. Spills move toward the northwest, cross under the elevated railroad embankment at three locations (Poplar, Santa Inez, and Monte Diablo) and pond behind Highway 101. Fortunately the freeway sound wall and concrete median barriers are not continuous, and floodwaters may cross the highway between Poplar Ave. and Tilton Ave.

It is imperative, however, that Caltrans does not close the gaps in either the soundwall or the freeway median. To do so could drastically increase the elevation of ponding.

In the FEMA condition, floodwaters cross Bayshore Freeway and enter the North Shoreview area. As discussed later in this chapter, neither the Coyote Point nor Poplar Avenue pump stations are equipped with automatic emergency standby power. Without backup power, FEMA will not recognize the pumping facilities. Under this scenario, San Mateo Creek spills and local runoff are not pumped into the Bay and would pond to an approximate elevation of:

8.7 feet NGVD (106.3 City)

This elevation is nearly two feet higher than the currently mapped limit of tidal inundation. (It may be noted, however, that FEMA's hydrology model does include the effect of pumping.) Figure 5-2 shows the limits of residual flooding due to San Mateo Creek spills in conjunction with the absence of standby power in the North Shoreview area.

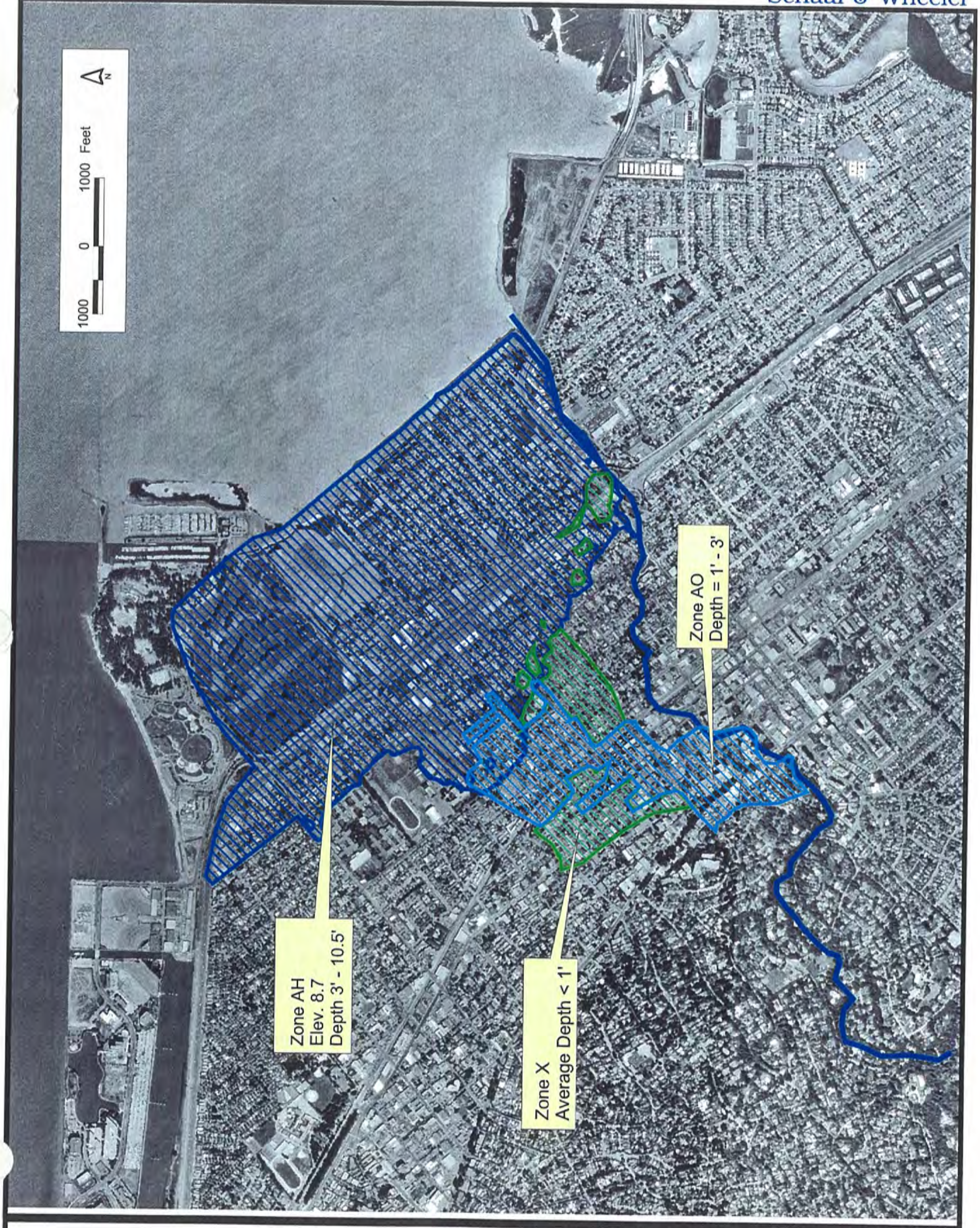


Figure 5-2 : San Mateo Creek Spills

Remediation of San Mateo Creek Spill

Further analysis indicates that by adding standby power generation and automatic transfer switches to the existing pumping facilities FEMA would consider the benefit provided by each of the 70,000 gpm pump stations, and the mapped ponding elevation in Shoreview could be reduced to:

4.4 feet NGVD (102.0 City)

Presently, only manual power transfer capability for portable engine-generator units is provided. The transfer of power must be automatic to meet FEMA standards. The addition of standby power is discussed with pump rehabilitation. However, the mapped floodplain of Figure 5-2 between El Camino Real and Highway 101 would be unchanged.

Furthermore, if the volume of San Mateo Creek spill predicted under FEMA's reservoir operation assumption is not reduced or eliminated, there is no practical way to resolve the residual flooding problem in North Shoreview. Therefore, eliminating the mapped spill from San Mateo Creek at El Camino Real is imperative to flood mitigation strategies for the city. Two alternatives have been identified to deal with this problem.

Bypass Option. An expensive solution, driven primarily by regulatory issues rather than current reservoir operation, is to build an underground bypass from El Camino Real to San Francisco Bay. Several routes are possible, but the most direct one to the bay travels approximately 10,000 feet down Baywood and Baldwin Avenues, San Mateo Drive and Monte Diablo Avenue (Figure 5-3). The size of the bypass would range from an 8-foot by 8-foot box culvert in the steeper reaches where the bypass is not surcharged, to a 12-foot by 8-foot box culvert further downstream where the available energy gradient is less and high tides surcharge the facility. (Against the 100-year tide, surcharge conditions extend upstream to San Mateo Drive.) Avoiding an outfall to the Bay by discharging into the North Shoreview detention area is not considered practical due to the difficulty and expense of substantially increasing pump station capacity. Constructing the underground bypass without new pumping capacity is expected to cost on the order of $65 million.

Crystal Springs Option. According to San Francisco Water Department staff, Crystal Springs Reservoir is routinely operated with a reserve winter pool of 2 billion gallons (6,000 acre-feet) below the spillway elevation. The desired maximum winter operating elevation is 278.5, which is five feet below the crest. If this is the adopted operating plan, there is no 100-year spill from San Mateo Creek above El Camino Real. Figure 5-4 shows residual flooding for this alternative.

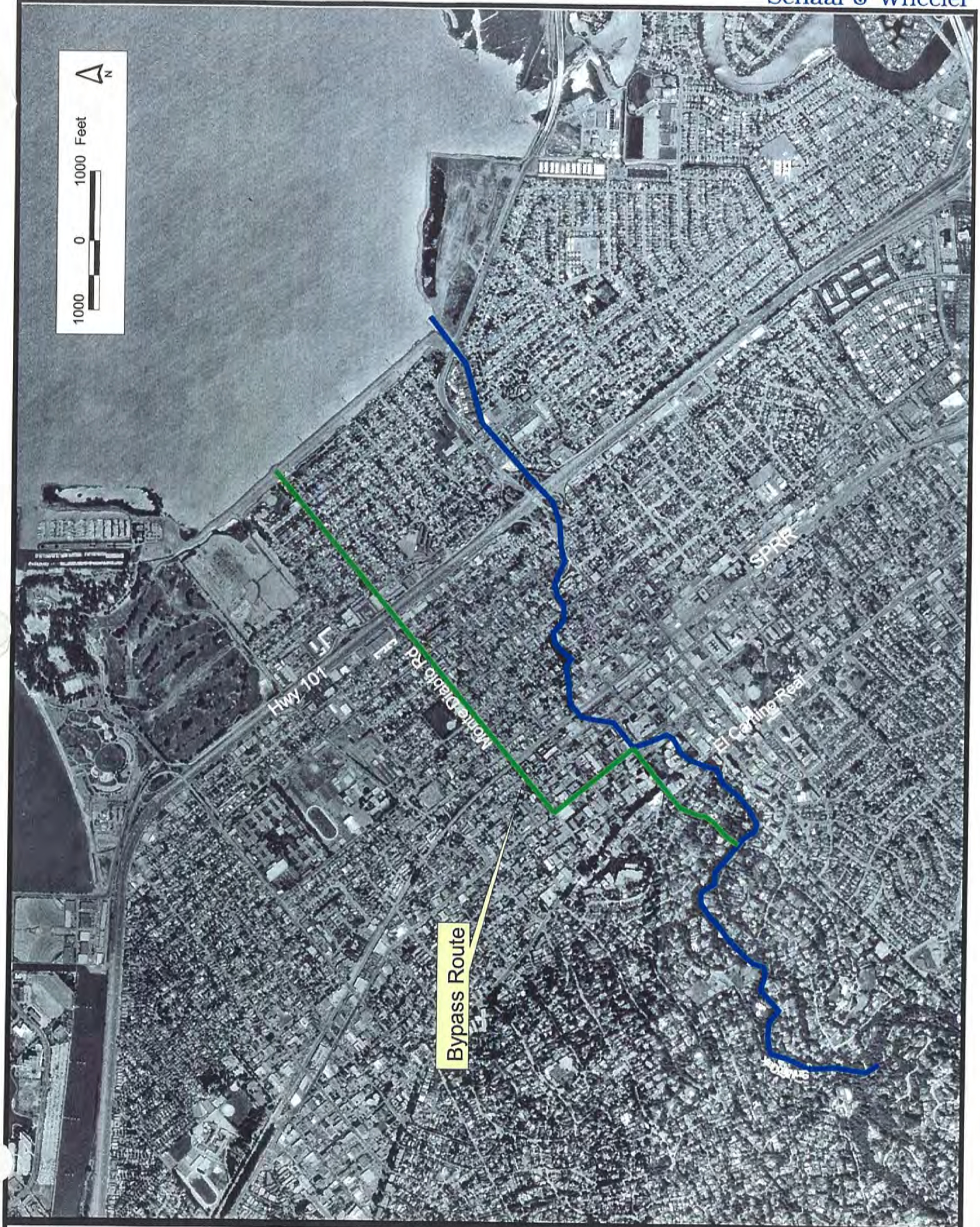


Figure 5-3: Bypass Alternative

Figure 5-4 : Crystal Springs Reservoir Mitigation

San Francisco Water has resisted signing a contract to provide a permanent flood pool in Crystal Springs Reservoir. They prefer not to give up storage flexibility needed in the wake of decreases in available storage at other facilities such as Calaveras Reservoir. However, they are concerned about their liability for downstream damages caused by large spills, which is why the routinely keep the reserve pool in Crystal Springs.

Recommendation. Although it is difficult to directly estimate the value or cost of providing a permanent flood pool that FEMA would recognize, the City should reopen negotiations with the Water Department. As long as the value of stored water remains below about $950 per acre-foot, this alternative remains more cost-effective than the bypass option discussed above.

NORTH SHOREVIEW FLOODING

With the tidal floodplains of San Mateo walled off from San Francisco Bay by the outboard levee systems evaluated in Chapter 4, a series of pump stations is required to discharge runoff that collects behind the levee. Approximately 2.4 square miles drain from the hills and flatlands into the North Shoreview area as shown on Figure 2-2. Runoff crosses the Bayshore Freeway and drains through a series of ditches to two pumping facilities:

1. Coyote Point Pump Station
2. Poplar Avenue Pump Station

Each of these facilities pumps storm water directly into San Francisco Bay. Station locations are provided on Figure 5-5, which also outlines the low-lying area south of the municipal golf course, which is used to detain storm water runoff prior to pumping at the Poplar Avenue station.

Figure 5-5 : North Shoreview Area Facilities

Storage Near Shoreline Park

The Poplar Avenue Pump Station is situated against the bay front levee, which protects the Shoreview area from tidal flooding. The station's intake is connected to a series of feeder channels that drain the golf course, areas to the west and areas to the south through the Shoreline Park. Photo 5-5 shows the storage area immediately to the west of the Poplar station intake. (The PG&E substation in the background is located on higher ground above the limit of ponding.)

Photo 5-5: Storage at Poplar Avenue Station

A Shoreline Park master plan proposes enhancements and modifications to existing wetlands and watercourses, and the creation of additional wetland areas. Flood control channels passing through the shoreline open space site will be modified to increase tidal flows into the channel, thereby increasing its salinity and recreating a natural slough habitat. It is important, however, to remember the flood control function already provided by this facility.

One master plan element of potential concern is an existing 12-inch diameter pipe at the mouth of San Mateo Creek that allows saltwater inflow to periodically flush the southern end of the Shoreline channel system. Inflow from this source is entirely dependent upon the elevations of Bay tides, and marine water that enters the system can only exit the system via the Poplar Avenue Pump Station.

Without regulation, the existing pipe can discharge 7 cfs (3,100 gpm) at mean higher high tide (MHHW). While this is a relatively minor flow compared to the pump station's capacity, the Shoreline Master Plan proposes features that will regulate marine inflow without manual intervention. The only other recommendation from a flood management perspective is to add a manual shutoff valve to combat slightly higher flows during more extreme tides if necessary.

Poplar Avenue Pump Station

As shown in Photo 5-6 to the right, the Poplar Avenue station is located adjacent to the Bay Front Levee, and pumps directly from the storage area to the west (right in the photo). Storm water is discharged into San Francisco Bay through three 30-inch diameter steel pipes, which are badly corroded and missing flap gates (Photo 5-7).

Photo 5-6: Poplar Avenue Pump Station

Photo 5-7: Poplar Avenue PS Outfall Pipes to Bay

Information about the pumping equipment is summarized below. Total nominal station capacity is 72,400 gallons per minute (gpm), or about 160 cubic feet per second (cfs). A manual transfer switch with mechanical interlock (Kirk key) is provided so that a portable engine-generator set can be connected for standby power. Photo 5-8 shows the pump station interior.

Pump	Model	rpm	hp	gpm
1	30" Cascade	580	140	18,700
2	30" Cascade	580	140	18,700
3	30" Allis-Chalmers	585	250	35,000
				72,400

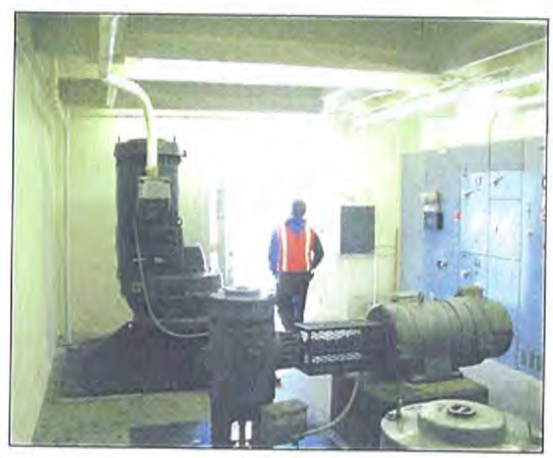


Photo 5-8: Poplar Avenue PS Interior

Coyote Point Pump Station

Near the Burlingame city limit, the Coyote Point Pump Station was also built next to a bay front levee. This facility receives storm water runoff from an open ditch that parallels Airport Boulevard beginning at Peninsula Avenue. The pumps discharge through the levee into San Francisco Bay through two 20-inch and two 36-inch diameter outfalls onto a concrete apron.

Photo 5-9: Coyote Point Pump Station

Photo 5-10: Coyote Point PS Outfall to Beach (Note Coyote Point Levee)

Photo 5-11: Coyote Point PS Interior

Information about the pumping equipment is summarized below. Total nominal station capacity is 70,000 gpm, or about 155 cfs. Provisions for manual standby power are similar to the Poplar Avenue Station. Photo 5-11 shows the pump station interior.

Pump	Model	rpm	hp	gpm
1	36" Johnston	585	125	25,000
2	20" Fairbanks-Morse	880	40	10,000
3	20" Fairbanks-Morse	880	40	10,000
4	36" Johnston	585	125	25,000
				70,000

Remedial Work in North Shoreview Area

Both pump stations have reached an age where serious consideration must be given to equipment replacement. In particular, the electrical controls are outdated and difficult to service and repair. At the Coyote Pump Station, the pad-mounted transformer is located far too close to the building. Several structural deficiencies are noted at each facility. Roof diaphragms are not properly tied to the walls, so each facility is vulnerable to seismic events. Most importantly, automatic standby power is not available although the most pressing issue, according to operations personnel, is the lack of a reliable source of power from PG&E. However, to provide manual standby power, personnel often have to stand in knee-deep water or higher to plug in the generator. This is an obvious safety hazard.

For FEMA to recognize the impact of pumping at Coyote Point and Poplar Avenue, automatic standby power must be provided. With upstream spill from San Mateo Creek eliminated, residual ponding could be reduced to the limits shown on Figure 5-6 (at an approximate elevation of 1.1 feet NGVD or 99 feet on the City datum), if existing pump station capacity is maintained while adding standby power. Unfortunately, as the figure shows, several low-lying residences would still be subject to 100-year inundation.

Furthermore, due to limited capacity within the ditch feeding the Coyote Point Pump Station (Photo 5-12 to the right), much of the influent flow cannot reach that facility and will spill from Peninsula Drive across the golf course toward the Poplar Avenue station. This situation wastes the full beneficial effect of both pump stations.

Photo 5-12: Ditch Into Coyote Point PS
(This is not a City Facility.)

__Recommendations.__ Figure 5-7 shows recommended projects in the North Shoreview area. Some of these projects lie within the limits of the Shoreline Parks Master Plan, and coordination will be needed. In summary the following capital projects are proposed:

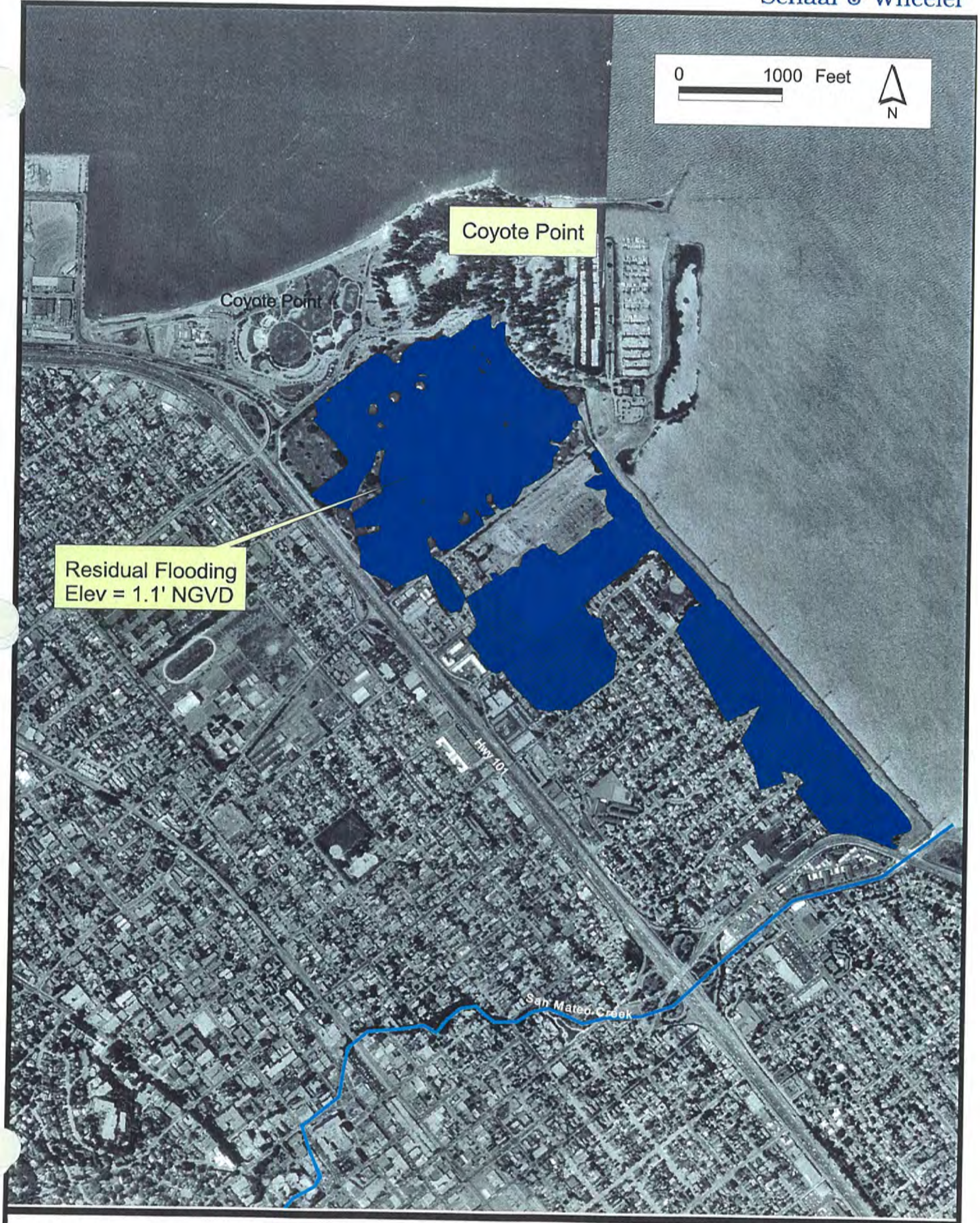


Figure 5-6 : North Shoreview Flooding with Standby Power

Figure 5-7 : Projects to Mitigate North Shoreview Flooding

Poplar Avenue Pump Station Rehabilitation (Figure 5-8)

- Three (3) new axial flow pumps rated at 34,500 gpm each (station capacity = 225 cfs)
- New vertical 150 hp electric motors
- Small submersible low-flow pump (not shown)
- Replace electrical equipment and transformer
- Seismic retrofit of existing building
- Extended wetwell divider walls and reconstructed inlet for better hydraulic performance
- Diesel engine-generator set with automatic transfer switch
- Three (3) new 48-inch diameter outfalls to San Francisco Bay

To minimize the disturbance of surrounding habitat (H.T. Harvey, 2002), the existing pump station footprint will be utilized as much as possible. Some mitigation may be required for temporal and permanent disturbance within the wetland area at the pump station's intake, but this appears to be minimal.

Coyote Point Pump Station Rehabilitation (Figure 5-9)

- Three (3) new axial flow pumps rated at 34,500 gpm each (station capacity = 225 cfs)
- New vertical 150 hp electric motors
- Small submersible low-flow pump (not shown)
- Replace electrical equipment and transformer
- Seismic retrofit of existing building
- Reconfigured wetwell divider walls and enlarged inlet for better hydraulic performance
- Diesel engine-generator set in acoustic enclosure over new wetwell approach
- Automatic transfer switch
- Three (3) new 48-inch diameter outfalls to San Francisco Bay
- New underground 10' x 6' RCB in Airport Boulevard from Peninsula Avenue with overflow to golf course

To fully utilize the rehabilitated Coyote Point station, it is necessary to provide a maintainable conveyance from Peninsula Avenue into the station. A concrete box culvert to convey 225 cfs is proposed for Airport Boulevard. A storm drainage easement will be required. Hydrologic calculations in Appendix C indicate that the 100-year flow at Peninsula Avenue and Highway 101 is approximately 400 cfs, so roughly 175 cfs is expected to spill at Coyote Point Drive, and will be safely directed to the golf course. The natural gradient will deliver this excess runoff to the Poplar Avenue Pump Station storage system.

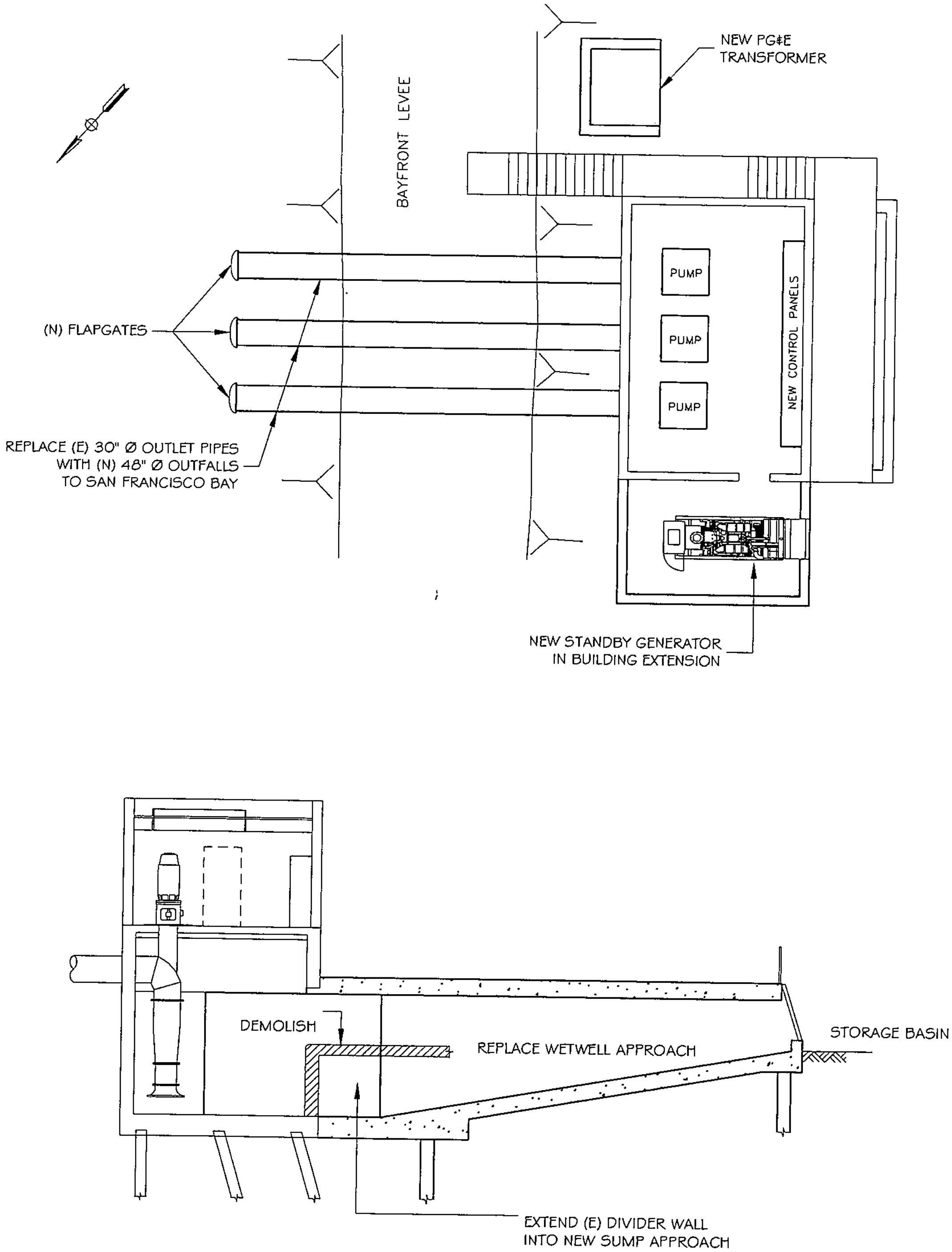
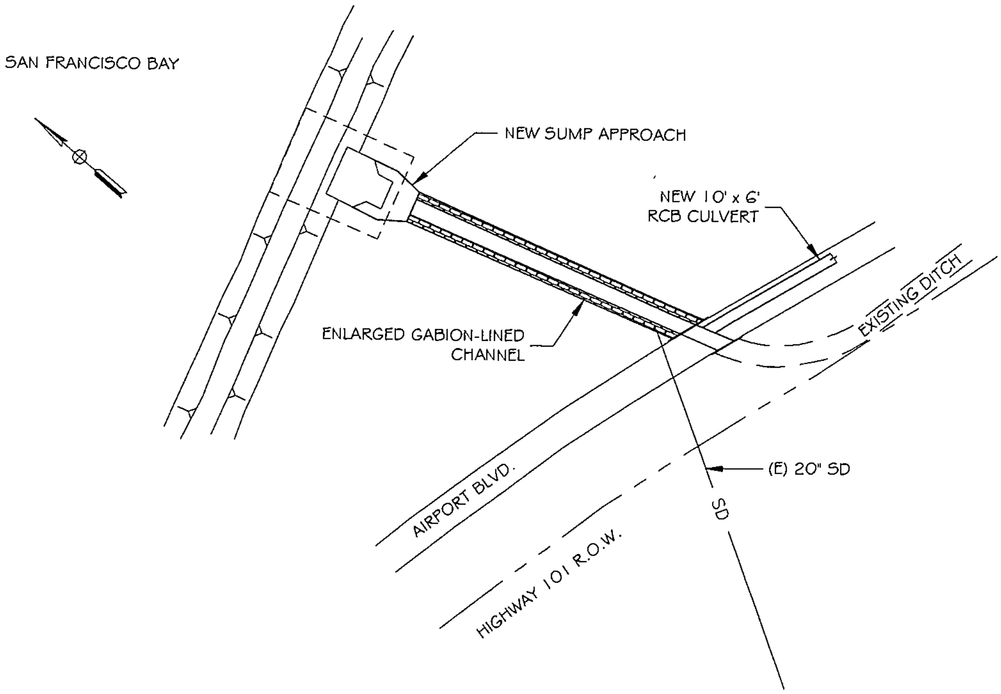


Figure 5-8: Poplar Avenue Pump Station Rehabilitation



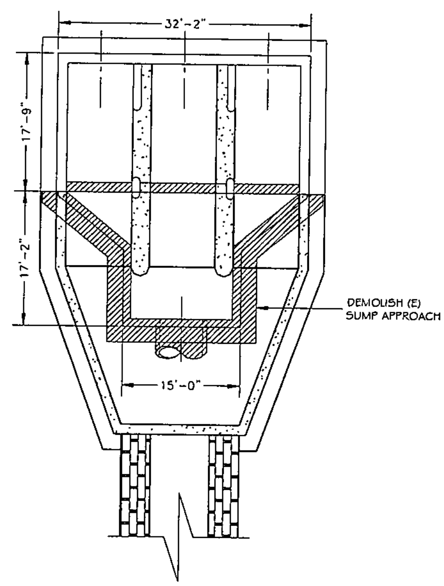


Figure 5-9: Coyote Point Pump Station Rehabilitation

Inboard Levee/Floodwall System

To prevent the inundation of low-lying residential parcels adjacent to the Shoreline Park, the maximum level of ponded water must be reduced to an approximate elevation of:

0 feet NGVD (97.6 City)

At this elevation, only a handful of parcels are partially inundated. Since this area is very flat, inaccuracies in survey data could have a significant impact on the extent of inundation. Therefore, a low protective berm or floodwall adjacent to residential properties is recommended (Figure 5-6). The volume of storage lost by cutting off areas on the landward side of the new levees is more than made up for by the increase in pumping capacity through rehabilitation, and the estimated 100-year post-project ponding elevation is 0.8 foot NGVD (98.4 City).

To protect low-lying residential areas against local flooding during extreme storm runoff events, a system of levees and/or floodwalls would be constructed along the landward property line of Shoreview Park. The top of levee/floodwall elevation would be approximately 102 feet (City of San Mateo datum) or 4.4 feet NGVD (mean sea level), providing FEMA freeboard. The levees or walls would be up to about four feet in height. At this time, a floodwall system is the more likely alternative since a floodwall's footprint is less extensive than that of a levee.

The proposed levee/floodwall system would begin at J. Hart Clinton Drive, follow the north bank of San Mateo Creek for 300 feet to the edge of Shoreline Park, then parallel San Francisco Bay's shoreline for roughly 3,500 feet to the northwest. At this point the levee/floodwall system will turn 90 degrees to the southwest and continue outside of the Shoreline Park Master Plan Area to the property line north of Cavanaugh Street, thence to Poplar Avenue and on to higher ground at Bayshore Freeway.

(Sensitivity analyses demonstrate that increasing the combined pumping capacity is not as cost-effective as the containment system. To shrink the residual floodplain sufficiently to eliminate the need for a barrier, total pumping capacity must exceed 700 cfs. It would not be practical to upsize the pump stations to this degree within their established footprints. The scope of compensatory mitigation would likely increase dramatically.)

16th AVENUE DRAIN

Urban storm water runoff generated between Crystal Springs Road and Highway 92 east of Alameda de las Pulgas is collected in the 16th Avenue Drainage Channel at the Southern Pacific Railroad (Photo 5-13). The 16th Avenue Drain is a fairly uniform, prismatic channel that conveys runoff into the Marina Lagoon for storage and pumping into San Francisco Bay. Major road crossings include Delaware Street, Grant Street, U.S. Highway 101, Norfolk Street, and Kehoe Street.

Photo 5-13: Headwaters of 16th Avenue Drain at Southern Pacific Railroad

The SPRR culvert cannot pass the estimated 100-year discharge. However, the duration of excess flow is on the order of an hour, and water would spread out behind the railroad without exceeding one foot in depth. This is mapped as a Shaded X zone on Figure 5-10.

View of 16th Avenue Drain Downstream from SPRR (Typical of this Channel)

Further downstream backwater from Marina Lagoon controls water surface elevations in the 16th Avenue Drain. Tailwater on the channel crossing structures has a cumulative impact on upstream water surface elevations, due to hydraulic losses through bridges and culverts. As demonstrated below, crossings at Delaware Street and Highway 101 are particularly constrained.

Delaware Street Crossing

Highway 101 Culvert

The hydraulic constrictions at Delaware Street and Highway 101 force floodwater out of the channel. Ponded elevations exceed one foot in depth, and would be mapped as Zone AH as shown on Figure 5-9. The worst of the ponding is upstream of Highway 101 with an elevation of 3.2 feet NGVD (100.8 City datum) and depths of nearly three feet.

Downstream of 101 the channel can pass the remaining discharge with little spill. Based on available topography, the average depth of ponding to the Marina Lagoon berm appears to be less than one-foot. This residual flood plain is mapped as Shaded Zone X.

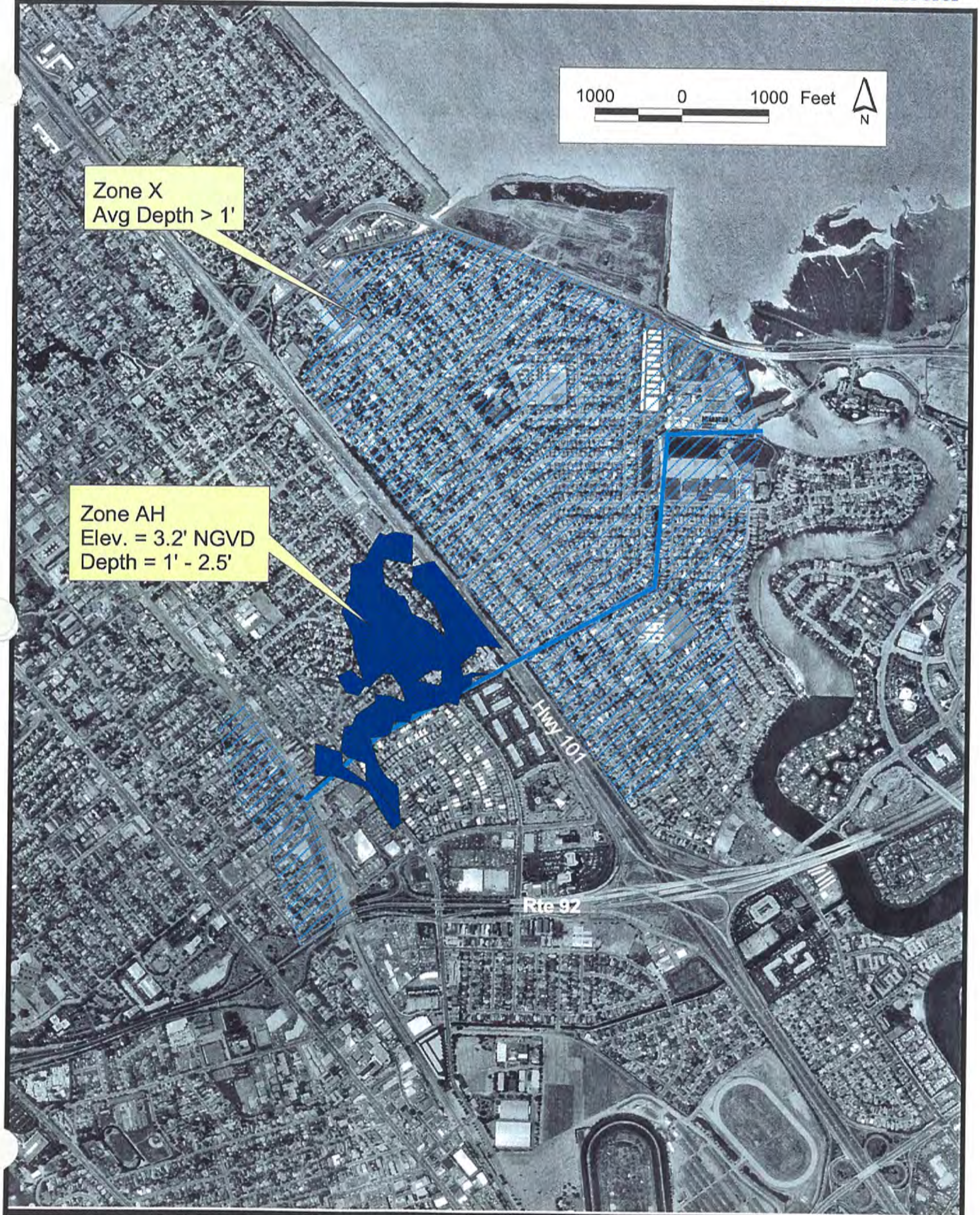


Figure 5-10 : Flooding Near 16th Avenue Drainage Channel

Table 5-1 summarizes the results of hydrologic analysis for the 16th Avenue drainage facility, and gives estimated design discharges for the 10-year, 25-year, and 100-year return periods. While the NFIP is only concerned with 100-year base flood elevations, it is instructive to examine other return periods to sense the relative magnitude of flood risk for this facility. Discharge values in red indicate that the existing channel banks are overtopped during the indicated frequency of flooding. Design discharge values in Table 5-1 have not been adjusted for upstream spills.

Table 5-1: Design Discharges for 16th Avenue Drainage Channel
(All Discharge Values in cfs)

Location	10-year Discharge	25-year Discharge	100-year Discharge
Southern Pacific Railroad	320	380	490
Highway 101	530	620	800
Marina Lagoon	620	760	980

Projects to Mitigate 16th Avenue Flooding

Mandatory flood insurance requirements would remain in effect within the dark blue area on Figure 5-10, even after tidal inundation is relieved. To remove the Zone A flooding, and prevent areas downstream of Highway 101 from being placed in Zone A once the upstream bottlenecks are removed (i.e. for the design discharge of Table 5-1), the projects shown on Figure 5-11 and listed below are recommended to improve flood flow conveyance:

- Remove culvert at Delaware Street; replace with clear-span bridge
- Add (2) new 8' x 5' concrete box culverts at the Highway 101 crossing
- Construct floodwalls from Highway 101 to Delaware Street as shown on Figure 5-10

Replacing the existing 10' x 5' RCB culvert at Highway 101 with a clear-span bridge is not feasible due to heavy traffic. It is assumed that the new precast RCB culverts would be bored and jacked or tunneled through the freeway.

Based on surveyed cross sections, bank-full capacity under inlet control conditions at Highway 101 is only 420 cfs. This is the most critical problem for the 16th Avenue Drainage Channel.

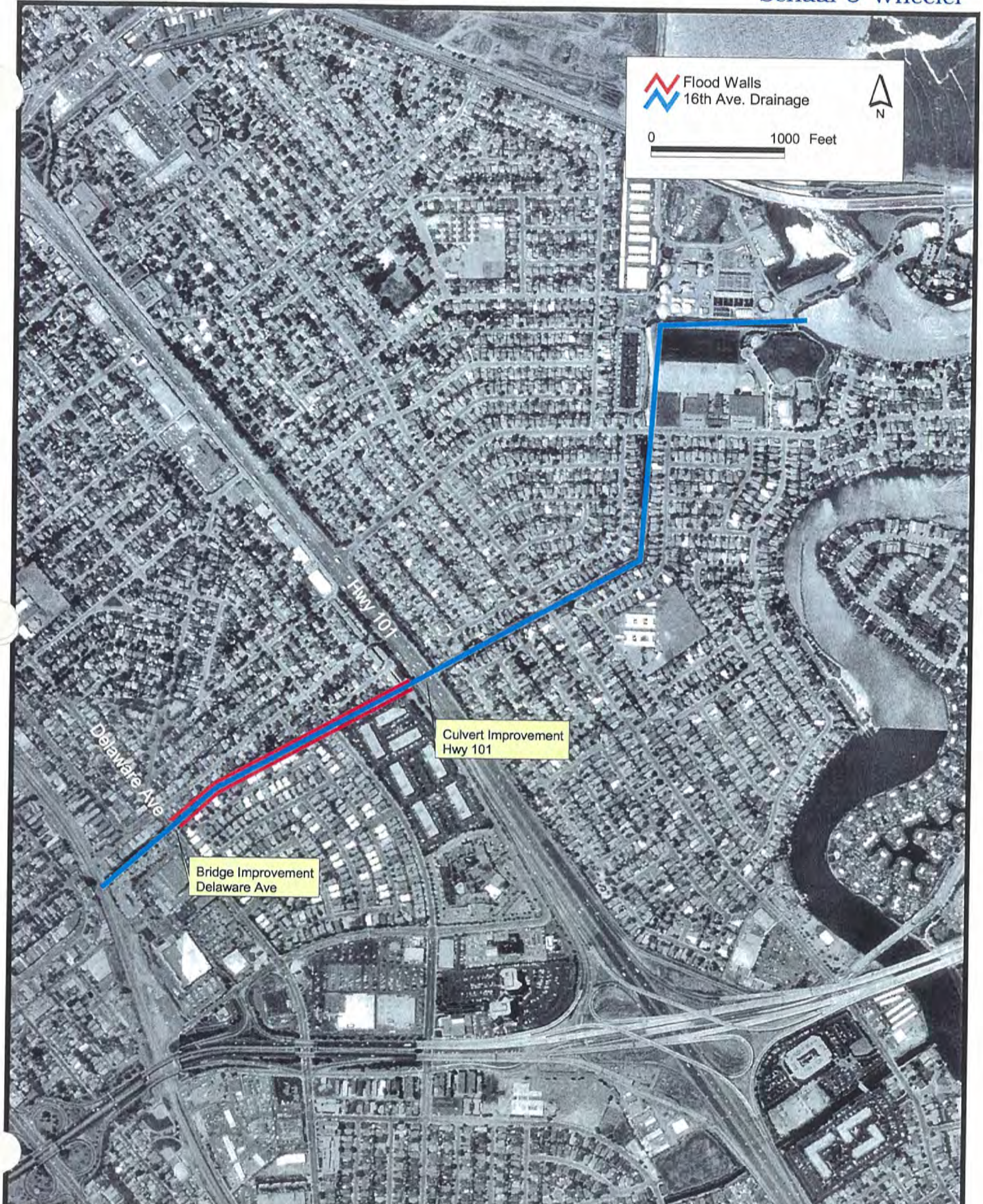


Figure 5-11: Projects to Mitigate 16th Ave Drainage Channel Flooding

CHAPTER 6
RESIDUAL FLOODING IN SOUTH SAN MATEO

Although FEMA has not asked the City to address residual interior flooding south of Highway 92, the City wants to understand flood risks throughout San Mateo. As is the case to the north, significant areas of residual flooding have been identified in the southern parts of the city.

Major sources of residual flooding in southern San Mateo include:

- 19^{th} Avenue Drain
- Laurel Creek

19^{th} AVENUE DRAIN

Several upstream tributaries feed into the 19^{th} Avenue Drainage Channel, which is similar to the 16^{th} Avenue Drain, and provides flood flow conveyance between the railroad and Marina Lagoon. However, its drainage area is larger than the 16^{th} Avenue drain (3 square miles compared to 2 mi^2). The 19^{th} Avenue channel drains runoff from Parrott Drive to the Lagoon as shown on Figure 2-2. Major crossings include the Southern Pacific Railroad, Delaware Street, Bermuda Drive, Highway 101, and Norfolk Street.

Delaware Street Crossing

Norfolk Street Crossing

Constrictions at Delaware Street and Norfolk Street force floodwater out of the channel, and inundate areas shown on Figure 6-1, which provides FEMA SFHA designations. Between Delaware Street and Highway 101, sheet flow and ponding depths are one foot to 1.5 feet on average.

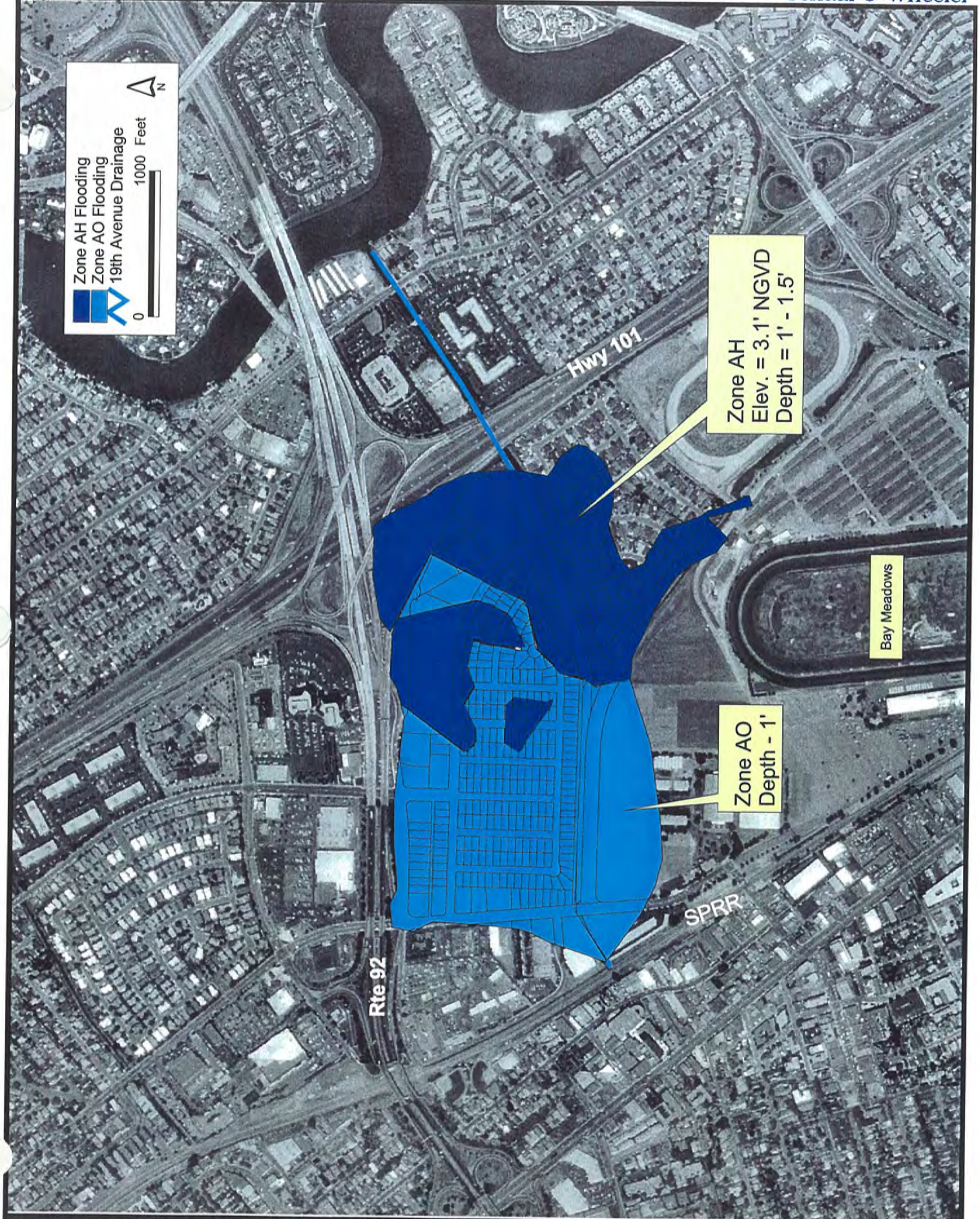


Figure 6-1 : Flooding Near 19th Avenue Drainage Channel

Photo 6-3: Most of the 19th Avenue Drainage Channel appears to be well maintained, although some floodwall improvements will be necessary to contain 100-year flood flows with adequate freeboard. The photograph shows a typical reach of the 19th Avenue Drainage Channel upstream of Bermuda Drive.

Table 6-1 summarizes the results of hydrologic analysis for the 19th Avenue drainage facility, and gives estimated design discharges for the 10-year, 25-year, and 100-year return periods similar to the analysis performed for 16th Avenue Drain. Discharge values in red indicate that the existing channel banks are overtopped during the indicated frequency of flooding.

Table 6-1: Design Discharges for 19th Avenue Drainage Channel
(All Discharge Values in cfs)

Location	**10-year Discharge**	**25-year Discharge**	**100-year Discharge**
Southern Pacific Railroad	830	1,000	1,310
Delaware Street	840	1,015	1,330
Bermuda Drive	900	1,110	1,450
Highway 101	920	1,140	1,490
Norfolk Street	960	1,180	1,530

Figure 6-2 shows capital projects needed to provide 100-year flood protection that meets FEMA standards.

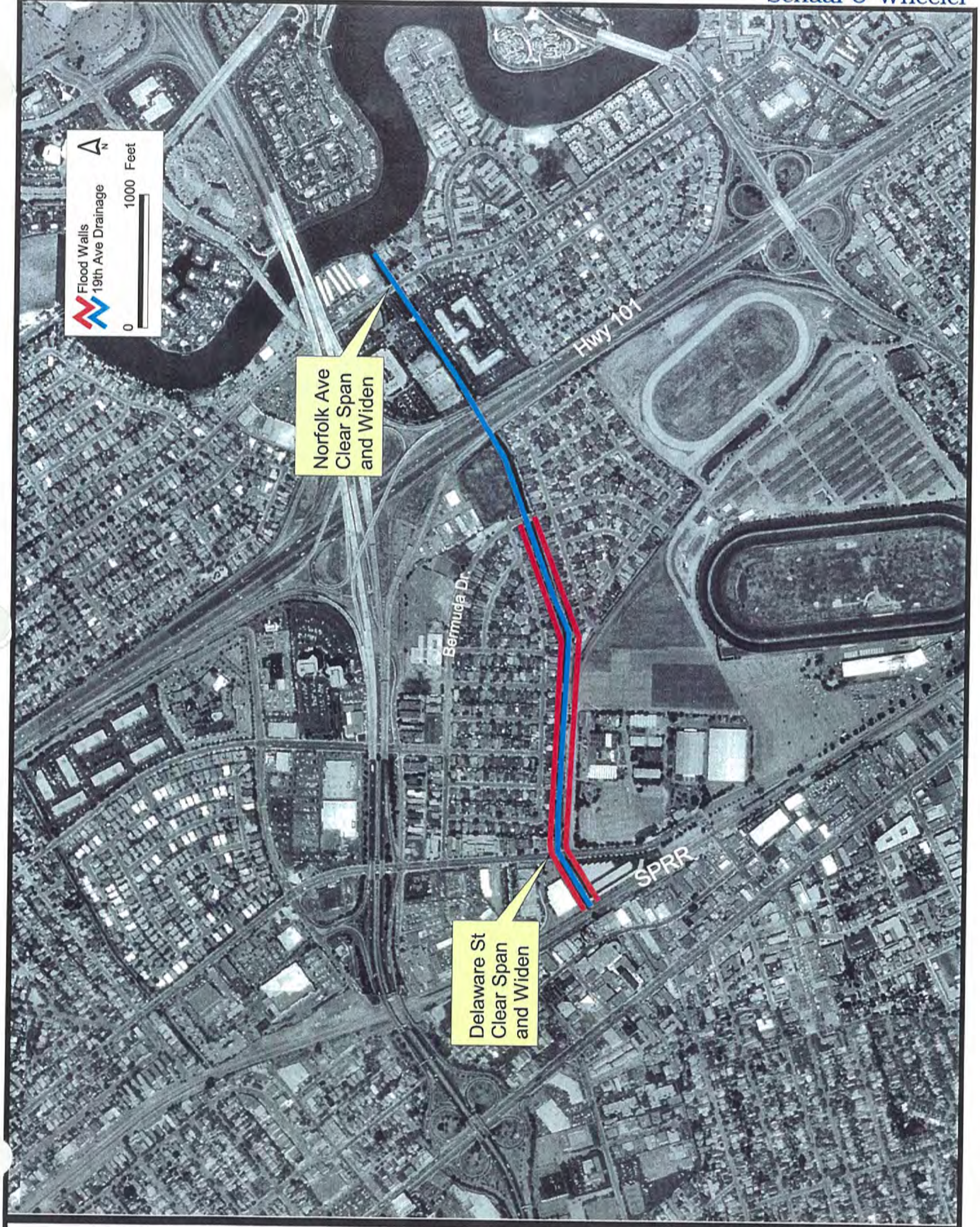


Figure 6-2 : 19th Avenue Remediation Projects

Projects to Mitigate 19th Avenue Flooding

Mandatory flood insurance requirements would remain in effect within the dark blue area on Figure 6-1, even after tidal inundation is relieved. To remove the Zone A flooding, and prevent areas downstream of Highway 101 from possibly being placed in Zone A once the upstream bottlenecks are removed (i.e. for the design discharge of Table 6-1), the projects shown on Figure 6-2 and listed below are recommended to improve flood flow conveyance:

- Replace double 13.5' x 5.4' RCB culvert with new clear span bridge at Delaware Street;
- Clean channel and repair slumped banks from Delaware Street to Bermuda Drive;
- Remove bridge at Norfolk Street and replace with new clear span bridge;
- Relocate utilities at Norfolk Street to eliminate blockage; and
- Construct concrete floodwalls from Bermuda to the railroad as shown on Figure 6-2

LAUREL CREEK

Laurel Creek drains the southern most part of San Mateo, including a portion within the City of Belmont (Figure 2-2). The creek channel has been modified over the years in an attempt to control flood events. Two detention facilities have been constructed in the headwaters of the watershed, shown in Figure 6-3.

Photo 6-4: Laurel Creek Dam is located at the upstream end of Laurelwood Drive.

Photo 6-5: The East Laurel Creek Dam controls a little more than one square mile on East Laurel Creek, which is tributary to Laurel Creek at Fernwood Street.

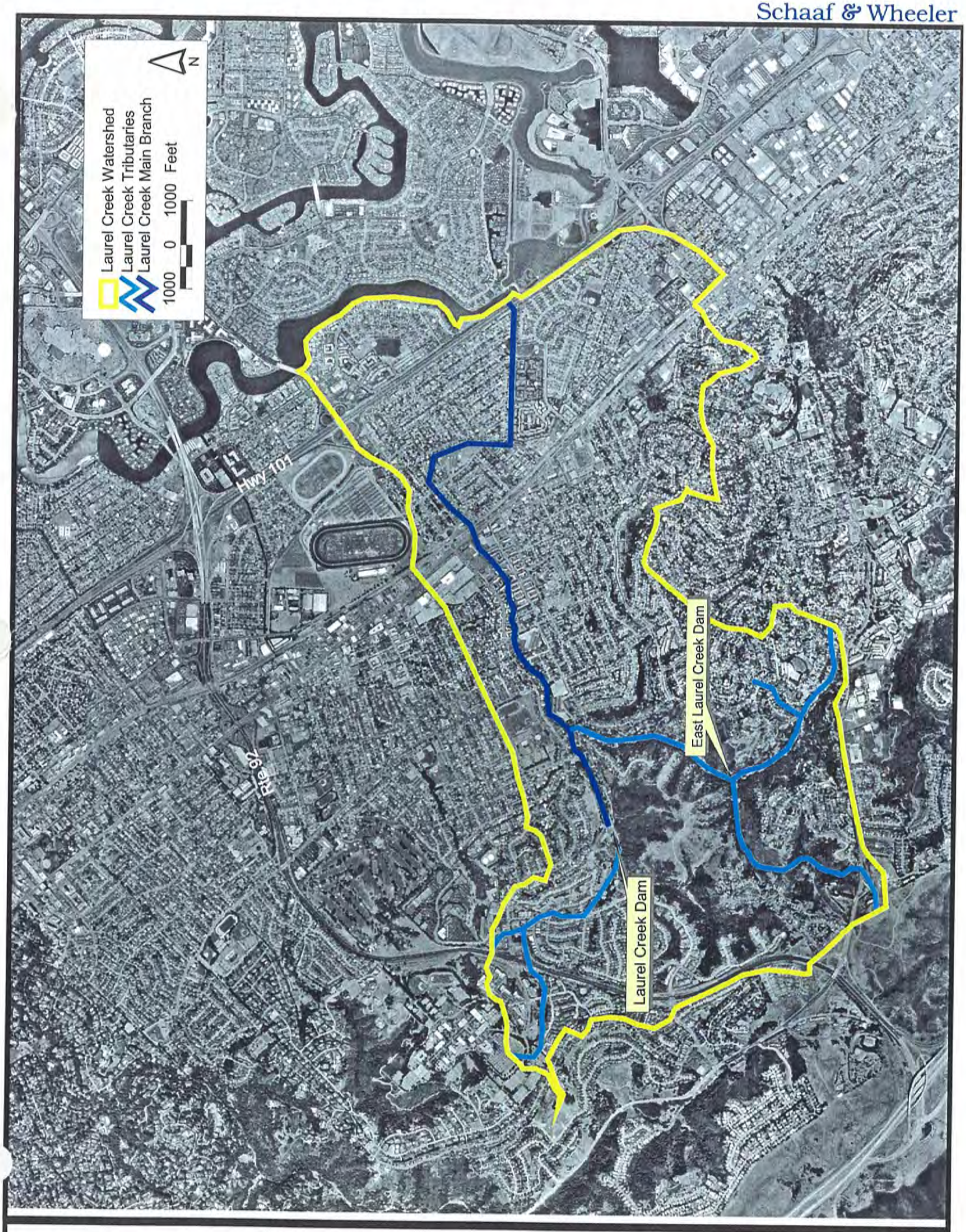


Figure 6-3 : Laurel Creek

Each of these facilities performs differently during runoff events as tabulated below. The Laurel Creek Dam (94 acre-feet of capacity at spill elevation) appears to be somewhat underutilized since the maximum one-percent elevation in the reservoir is nearly 13 feet below the morning glory spillway. On the other hand, East Laurel Creek Dam, which stores 31 acre-feet of runoff at its release elevation, spills during extreme storms. Each dam is subject to licensure by the State Division of Dam Safety, and this flood management study does not address the risk of dam failure or downstream inundation from catastrophic dam failure.

Table 6-2: Laurel Creek Detention Facilities

Facility	**Trib. Area** (mi^2)	**Spillway Elevation** (feet)	**Inflow** (cfs)			**Maximum Release** (cfs)			**Maximum Elevation** (feet)		
			10 year	**25 year**	**100 year**	**10 year**	**25 year**	**100 year**	**10 year**	**25 year**	**100 year**
Laurel Creek Dam	0.8	167	300	380	520	130	145	170	144.3	147.7	154.3
East Laurel Creek Dam	1.1	126	460	570	770	170	315	640	126.6	127.6	129.1

Laurel Creek Channel

On its journey from the Laurel Creek Dam to Marina Lagoon, Laurel Creek crosses:

- East Laurel Creek Drive
- Fernwood Street
- Alameda de las Pulgas
- Hacienda Street
- Edison Street
- El Camino Real
- Southern Pacific Railroad
- Pacific Boulevard
- Curtiss Street
- Otay Avenue
- East 40th Avenue
- Orinda Drive
- Highway 101

Many of these crossings are undersized to adequately convey Laurel Creek's discharge during extreme runoff events. Furthermore, the creek channel itself is very difficult to access in places, so vegetation removal, slope bank repairs, and other maintenance activities are nearly impossible. The limited access coupled with severe right-of-way limitations serve to prohibit significant channel improvements in many reaches.

Photo 6-6: From the dam outlet, Laurel Creek flows in a quasi-natural state through single-family residential areas on a relatively steep slope. The channel itself has bank-full capacity for even the 100-year design discharge because of the slope.

Photo 6-7: Unfortunately, between the dam outlet and Edison Street, the creek right-of-way is severely restricted and often encroached by private development. The only practical means of improving capacity involves culvert replacements at Alameda de las Pulgas and Hacienda Street, where existing constrictions force floodwater out of the creek. The resulting one to two feet deep floodplain that parallels Hillsdale Boulevard is shown in Figure 6-3.

One important concept is that as upstream improvements are made, downstream facilities often require enlargement to handle increased flow in the channel. This is indeed true for Laurel Creek, although many downstream improvements are needed regardless of upstream fixes.

Photo 6-8: The natural creek disappears into an underground culvert beneath apartment buildings at Edison Street. Protecting the apartments and Hillsdale Shopping Center will require an additional underground culvert bypass.

Photo 6-9: After emerging from the Edison Street culvert, the creek makes its way to El Camino Real in an engineered open channel alongside the Hillsdale Shopping Center.

Laurel Creek crosses El Camino Real and the Southern Pacific Railroad in three undersized box culverts. Between El Camino and the railroad, there is a brief stretch of open channel (Photo 6-10). Culvert dimensions change again through Pacific Boulevard downstream of the railroad as shown in Photo 6-11. The three culverts combine to force floodwater out of the creek onto El Camino Real and toward the Hillsdale Boulevard underpass, which is drained only be a small local pump station. Once the pumping equipment is overwhelmed, the level of ponded water could be quite significant.

Photo 6-10: Laurel Creek Between El Camino Real and Southern Pacific Railroad

Photo 6-11: Discharge from Pacific Blvd. Culvert

Even with proposed culvert replacements at Curtiss Street and Otay Avenue, additional channel enlargement work is required between Pacific Boulevard and the George Hall School property. As seen in the photograph below, in places the vegetation growth and slumping banks have lessened bank-full channel capacity. To minimize the construction of structural floodwalls or levees, which also disrupts local drainage patterns, one method of providing increased flow conveyance would be to enlarge using more stable and more vertical banks. Planted gabion baskets have provided an aesthetic way to achieve this for other urban creek settings on the Peninsula and South Bay. Channel improvements would also tend to help facilitate regular maintenance.

Photo 6-12: Laurel Creek downstream of Otay Avenue. Some form of channel enlargement is desirable in this reach.

Photo 6-12: At George Hall School the creek enters a multi-pipe underground culvert. Energy losses in this underground structure, and particularly at the odd geometric entrance cause upstream overbanking. A new underground bypass is needed.

Laurel Creek exits the underground culvert upstream of East 40th Avenue and continues toward Highway 101 in a clean, well-maintained channel through Casanova and Laurie Meadows Park. The creek empties into Marina Lagoon just on the other side of the Bayshore Freeway (Highway 101). The freeway culvert is adequate to pass the 100-year design discharge without excessive head loss. Figure 6-4 shows the cumulative impact of channel and culvert restrictions for Laurel Creek.

Photo 6-13: Concrete-lined channel below 39th Street.

Photo 6-14: Footbridge over Laurel Creek Between Casanova and Laurie Meadows Parks

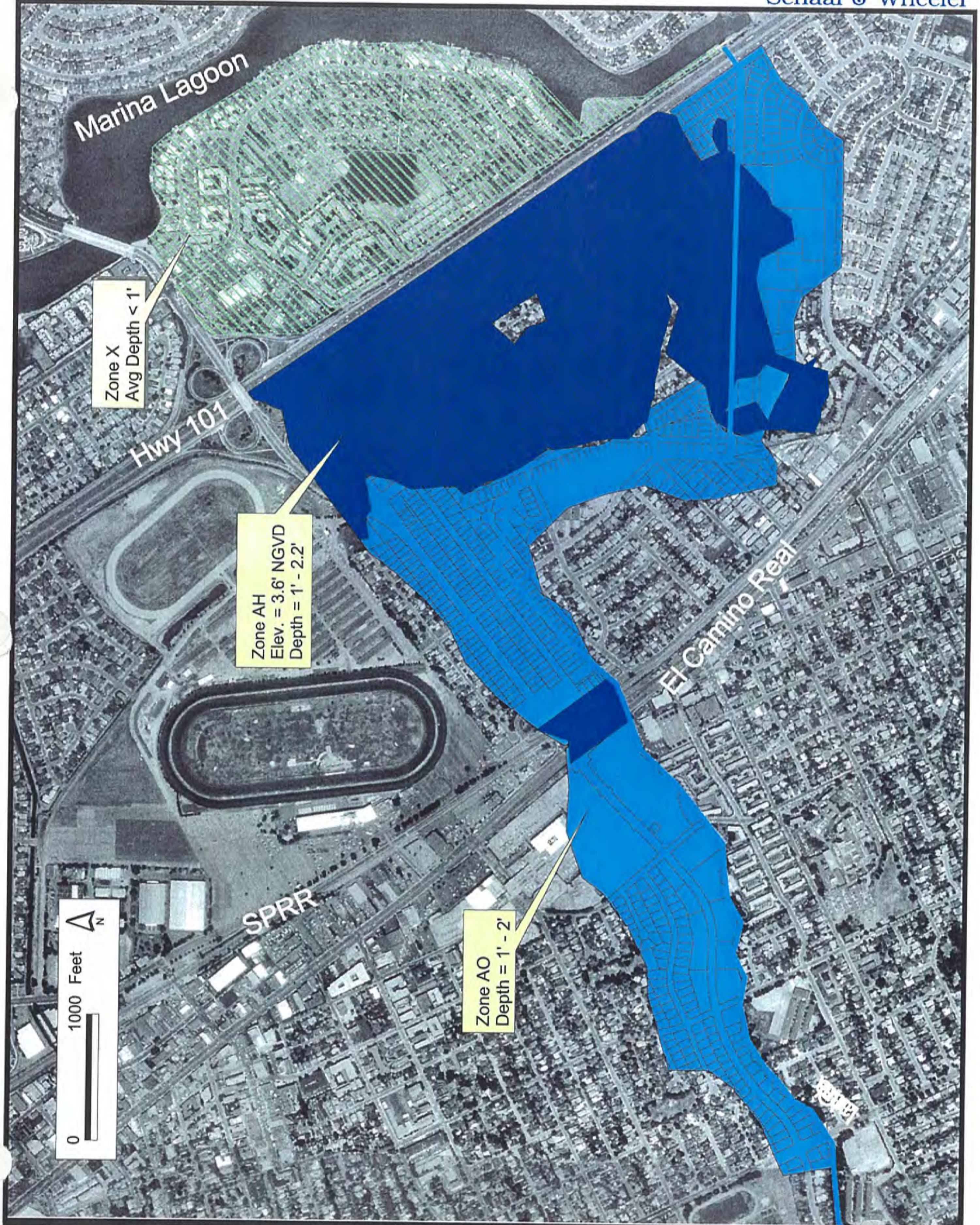


Figure 6-4 : Flooding Along Laurel Creek

Table 6-3 summarizes the results of hydrologic analysis for Laurel Creek, similar to the analyses performed for 16th Avenue and 19th Avenue Drains. Discharge values in red indicate that the existing channel banks are overtopped during the indicated frequency of flooding.

Table 6-3: Design Discharges for Laurel Creek
(All Discharge Values in cfs)

Location	10-year Discharge	25-year Discharge	100-year Discharge
Laurel Creek Dam	130	145	170
Alameda de las Pulgas	360	535	960
El Camino Real	560	670	1,140
George Hall School	800	960	1,490
Highway 101	1,070	1,300	1,950

Projects to Mitigate Laurel Creek Flooding

Figure 6-5 lists identified projects to relieve flooding along Laurel Creek, and prevent the possible imposition of mandatory flood insurance in this area. Projects are also listed below beginning at the upstream end. (It may be noted that a further restriction of flow at Laurel Creek Dam would not significantly reduce the scope of remedial work to the creek.)

- Alameda de las Pulgas – Replace (E) double 8' x 4' RCB with triple 9' x 4' RCB
- Hacienda Street – Replace (E) 10' x 6' RCB with double 10' x 6' RCB
- Edison Street – Build parallel 10' x 6' underground culvert
- El Camino Real to Pacific Boulevard – Build new 12' x 5' concrete culvert bypass
- Enlarge channel within (E) right-of-way between Pacific Blvd. and George Hall School
- Curtiss Street – Replace (E) 10' x 5' culvert with 25' x 6' clear-span bridge
- Otay Avenue – Replace (E) double 7.5' x 4' RCB with 25' x 6' clear-span bridge
- George Hall School – Replace multi-pipe culvert with new 30' x 7' box culvert
- East 40th Avenue – Replace (E) triple 12' x 5.5' RCB with new 40' x 6' clear-span bridge
- Construct concrete floodwalls as shown on Figure 6-5

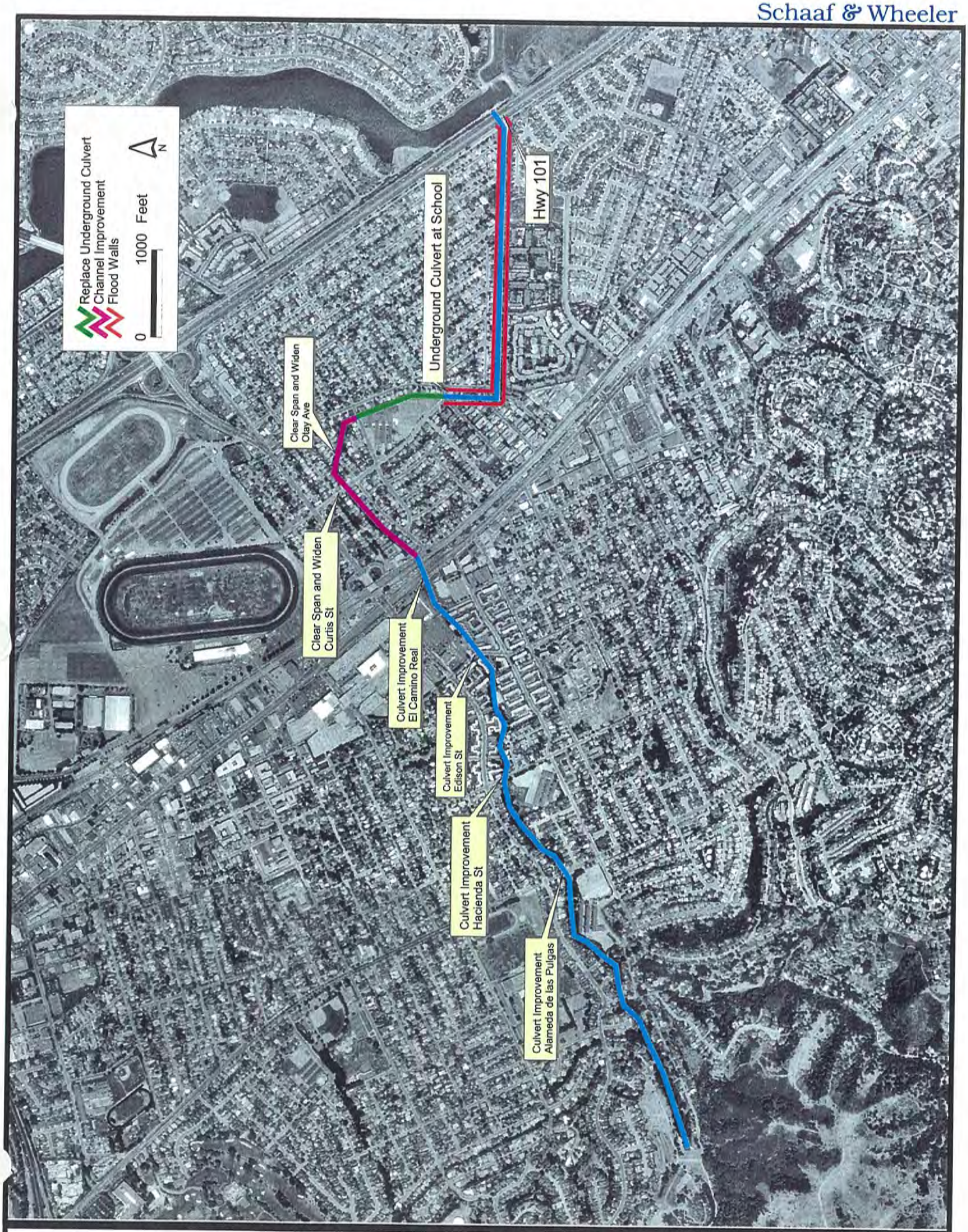


Figure 6-5: Laurel Creek Remediation Projects

CHAPTER 7
MARINA LAGOON

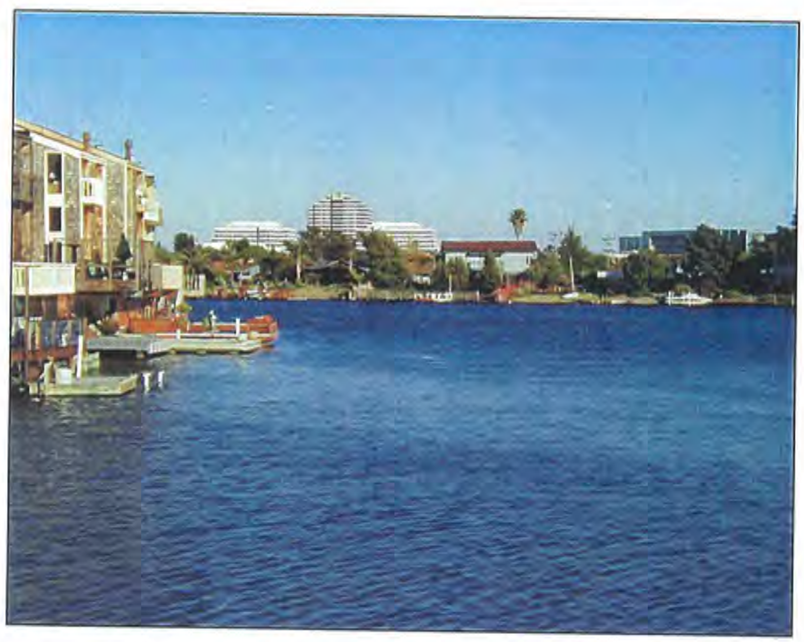
As discussed in the previous two chapters, 16th Avenue Drain, 19th Avenue Drain, and Laurel Creek all discharge to the Marina Lagoon. A small local drainage basin in the South Shoreview area discharges via a pump station to the mouth of the Marina Lagoon, but the outfall is downstream of the Marina Lagoon Pump Station. FEMA has specifically asked the City to prepare an operations and maintenance manual for the Marina Lagoon and address the potential for residual interior flooding due to storm water inflow.

THE FACILITIES

This 1,400 acre-foot storage facility was created from remnants of O'Neil Slough and Seal Slough; dredged and leveed to provide flood protection, recreation opportunities, an aesthetic amenity and ecological resource. The facility serves as the terminus for 16th Avenue Drainage Channel, 19th Avenue Drainage Channel, and Laurel Creek. The three tributaries provide a source of fresh water runoff during the winter. The runoff is stored in the lagoon and pumped to San Francisco Bay by five 150,000 gallon per minute (gpm) diesel engine powered pumps at the Marina Lagoon Pump Station. Circulation and water quality are enhanced by allowing bay water from Belmont Slough to flow into the lagoon at the O'Neil Tide Gate at an average rate of 52 million gallons per day. Figure 7-1 shows these features.

Beneficial Uses

While Marina Lagoon's primary purpose is flood protection for bayside areas in San Mateo and Foster City; the facility also provides significant aesthetic and recreational benefits to residents, particularly those living along the lagoon's shoreline. Consequently the City has attempted to balance the flood protection and aesthetic functions of the Marina Lagoon; recognizing that during the winter flood season, public safety must take precedence over appearances.



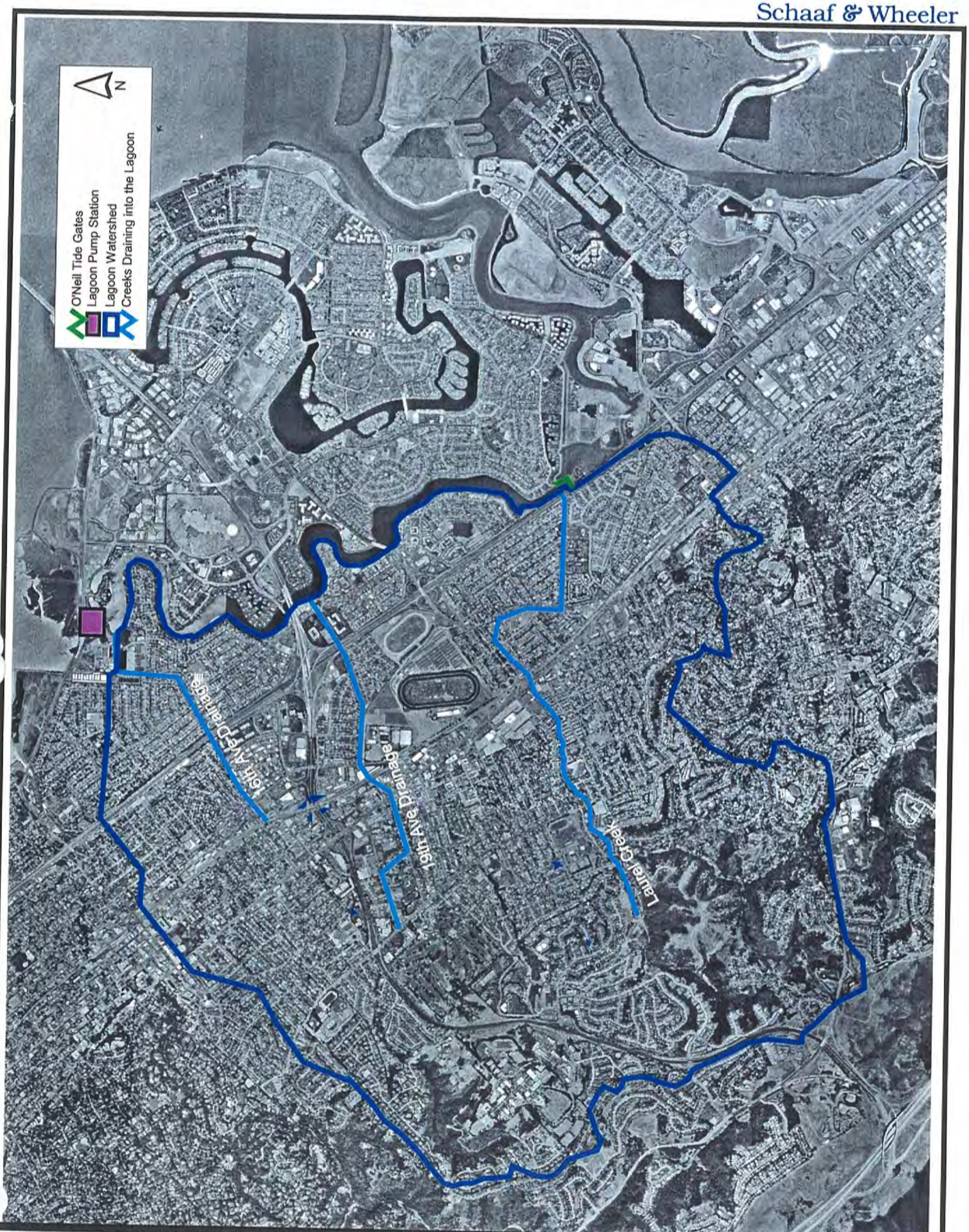


Figure 7-1: Marina Lagoon System

Lagoon Operation

Lagoon levels are regulated on a seasonal basis to optimize flood control, recreation, aesthetics, and ecological benefits. Currently during the winter, the operating level is lowered to elevation 95 feet (San Mateo datum) to reserve flood storage. During the summer, the water level is maintained at an elevation of 96.5 to provide optimal conditions for swimming, boating, and other recreational uses. (The lagoon is draw down to elevation 93 between January 15 and February 15 each year to facilitate pier work on houses and docks, and for the City to maintain the facility.) Using the O'Neill Slough intake gates and the discharge pumps controls water levels.

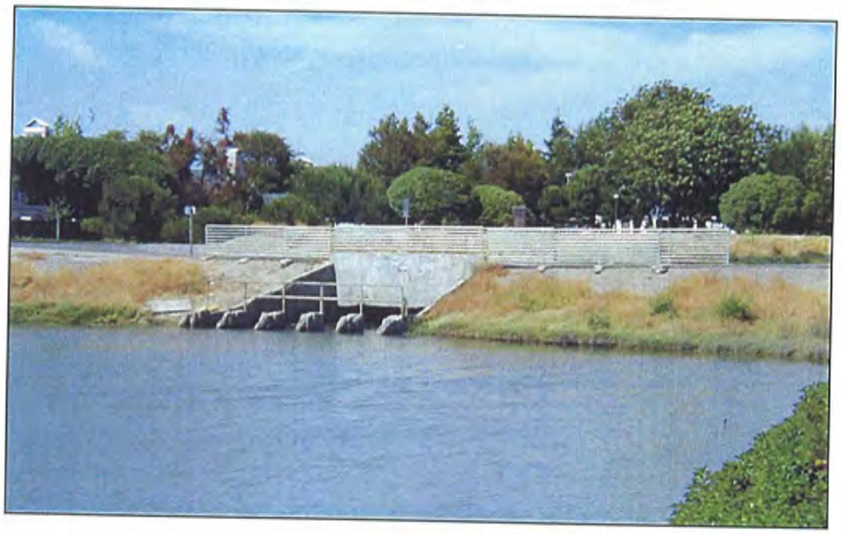


Photo 7-1: O'Neill Slough Tide Gate at Southern End of Marina Lagoon. (Picture is for a summer low tide with no inflow.)

Photo 7-2: Marina Lagoon Pump Station in Background with Slough Remnant to San Francisco Bay in Foreground, as seen from J. Hart Clinton Drive.

PROPOSED MODIFICATIONS TO LAGOON OPERATION

As discussed in Chapters 5 and 6, it is desirable to minimize maximum winter water levels in Marina Lagoon. Lower lagoon levels will improve hydraulic performance in the lower reaches of the three tributary channels, thereby minimizing the need for and height of floodwalls on 16th Avenue Drain, 19th Avenue Drain, and Laurel Creek.

Current winter operating procedures draw the normal lagoon level by 18 inches to elevation 95 feet on the City datum. Iterative analyses of design water surface profiles in the lagoon's tributaries show that the optimal winter operating level should be an additional foot lower at **elevation 94 feet.** Further reductions in maximum lagoon levels are not warranted, because channel hydraulics do not change upstream.

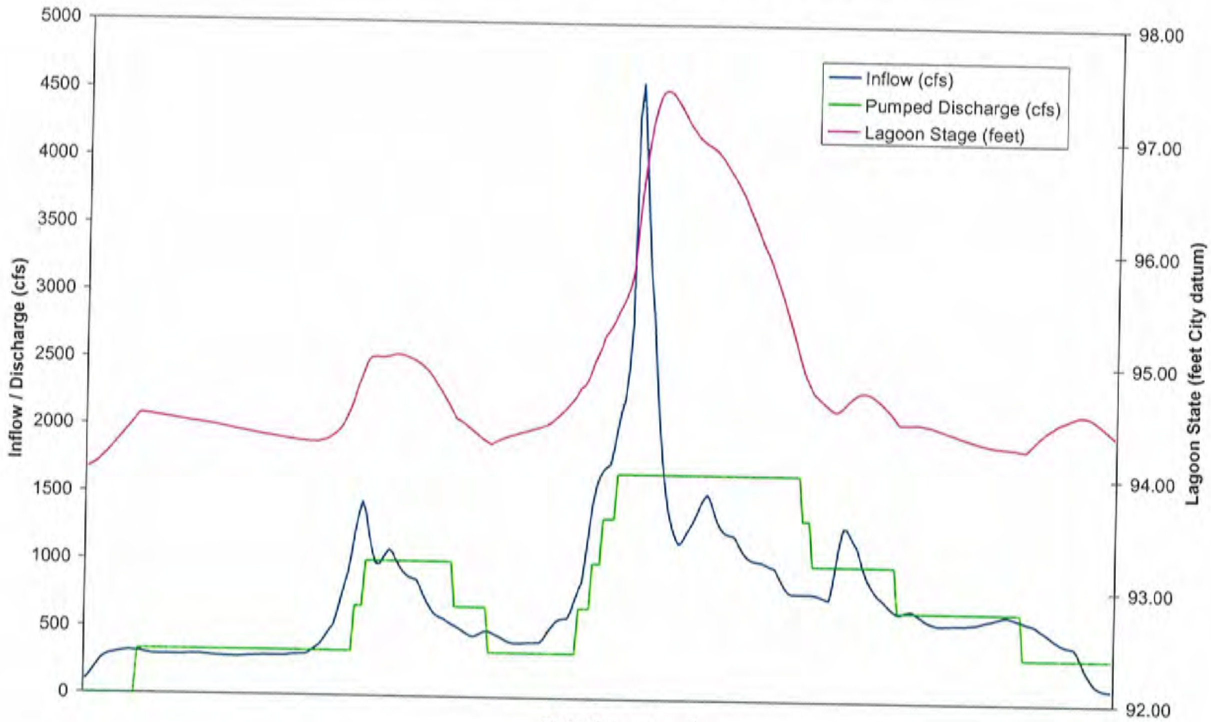
The following settings are recommended for the five diesel-driven pumps assuming a nominal capacity of 150,000 gpm each. Settings are given on the City's datum. These settings will lower the starting water surface elevation for the creeks and drainage channels by about 2.5 feet. The City should be able to modify the automatic pump settings with minimal effort.

Table 7-1: Recommended Marina Lagoon Pump Settings
(Given as Elevation on City Datum)

Pump	On-Level	Off-Level
Lead	94.5	94.0
Lag1	94.75	94.25
Lag2	95.0	94.5
Lag3	95.25	94.75
Lag4	95.5	95.0

With pump settings as tabulated in Table 7-1, Marina Lagoon has sufficient storage and pumping capacity to handle the design 100-year inflow from all three major tributaries, plus local runoff. (Foster City Public Works staff believes that there are no storm drain outfalls into Marina Lagoon from the east.) As demonstrated by Figure 7-2, the maximum water surface elevation in the lagoon occurs after the tributary creeks have peaked. When the influent creeks are at their maximum discharge, the lagoon level is estimated to be 96.4 feet (City), with a maximum level of 97.5 feet about two hours later.

Figure 7-2: Marina Lagoon 100-year Storm Operation



IMPROVEMENTS

As discussed in Chapter 4, the containment levee at the south end of Marina Lagoon also serves to provide outboard protection from Belmont Slough tides. Remedial work is necessary to raise the earthen levee and headwall of the O'Neil Slough Tide Gate. As evidenced by the photograph, the concrete tide gate has experienced significant structural degradation. This facility needs to be rehabilitated or replaced altogether. Chapter 8 provides cost estimates.

Photo 7-3: O'Neill Slough Tide Gate Condition

CHAPTER 8
CAPITAL IMPROVEMENTS

Chapters 4 through 7 provide the results of coastal and residual interior floodplain analyses. Within each chapter, capital improvements are recommended to eliminate regulatory flood hazards within San Mateo. This chapter summarizes the costs of those capital improvements, and calculates the benefits that various collections of projects provide to residents affected by flooding.

COST OF IMPROVEMENTS

Order of magnitude cost estimates are provided for each identified capital improvement project in Appendix E. Table 8-1 provides a summary by project category. Costs have been estimated using information from other projects, cost estimating guides, and engineering judgment.

Table 8-1: Proposed Capital Improvement Summary

Flooding Source	Cost to Provide 100-year Flood Protection
San Francisco Bay	$6,000,000
North Shoreview Drainage	$8,000,000
16th Avenue Drainage	$10,500,000
19th Avenue Drainage	$5,000,000
Laurel Creek	$27,500,000
TOTAL	**$57,000,000**

BENEFITS

Each of the five project categories listed in Table 8-1 provides the benefit of reduced flood risk and relief from mandatory flood insurance purchases to the property owners within the areas of improvement outlined in Figure 8-1. In some instances the benefit areas overlap. For instance, properties in the North Shoreview neighborhood benefit from both outboard levee projects and the rehabilitation of the local pump stations.

To avoid a complicated discussion, the sum total of each project component is assumed to benefit its entire benefit area. Although, for instance, upstream properties may not directly benefit from downstream capacity improvements; those downstream improvements allow upstream problems to be fixed without exceeding system capacity further downstream.

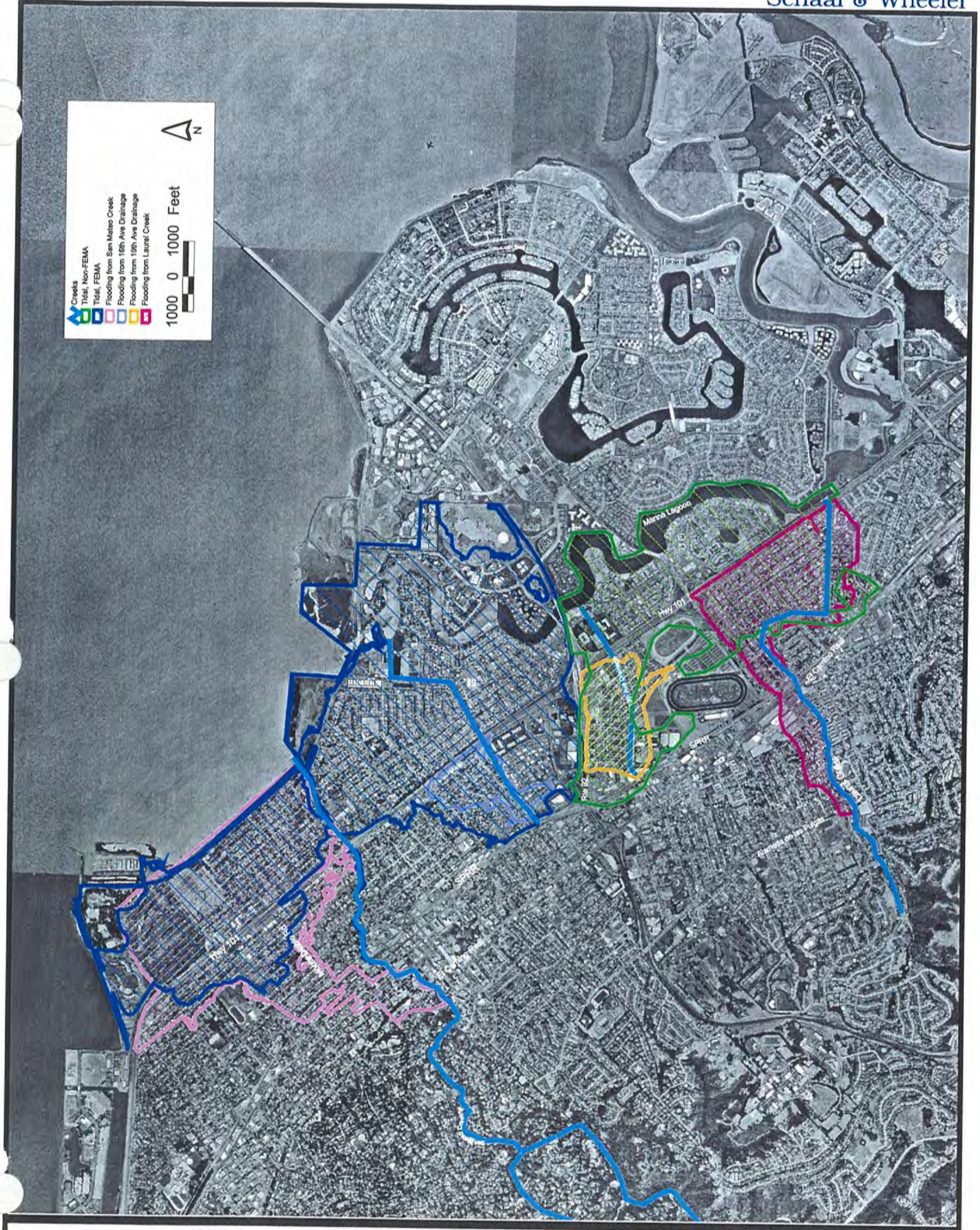


Figure 8-1: Benefit Areas

Calculation of Benefits

This flood management strategy study considers two types of benefits:

1. The avoidance of flood damages; and
2. Eliminating the cost of purchasing flood insurance.

Flood damage prevention benefits could be assessed by calculating average annual flood damages assuming that capital improvement projects are not built; in other words, the no project alternative. Damage to property resulting from a flood consists of direct structural damage, the cost of evacuation, victim aid, emergency flood protection measures, business losses, and crop losses.

Average Annual Damages. To estimate average annual damages, one would prepare multiple hydrologic and hydraulic models at various flood flow frequencies (e.g. 2-year, 10-year, 25-year, 100-year, 500-year, etc.) and map the level of inundation at each frequency. Agencies such as the Corp of Engineers use this approach in "risk-based" design, and have tables of structural and non-structural damage as a function of property values for various depths of flooding. Average annual benefits (avoided damage) are then calculated by multiplying the benefits expected by preventing flooding to a given depth by the probability of occurrence of that level of flooding in any year. This method of benefit calculation is not presented herein, primarily due to a lack of flood damage during more frequent events.

Elimination of Flood Insurance. This type of benefit is calculated in lieu of average annual damages rather than in addition to average damages. The logic behind this approach is an assumption that flood insurance provides a tangible benefit to relieve property owners from flood damage. As an example, the Corps of Engineers will include the cost of administering NFIP programs as a benefit in their risk-based assessments, but not the value of flood insurance premiums themselves.

However, one can calculate the equivalent benefit of flood insurance that is assumed to cover average annual damages. Properties that are removed from a Special Flood Hazard Area, or are kept out of new regulatory flood hazard areas, receive a direct project benefit equivalent to their eliminated annual flood insurance premium.

The following parameters are used to calculate flood insurance premiums for each property owner. Italicized parameters indicate those that are available on Metro-Scan information furnished by the City. Other parameters must be assumed, as discussed shortly. Parameters are listed in general descending order of importance relative to the calculation of flood insurance premiums:

1. *Property's elevation with respect to base flood elevation.*
2. Whether insurance is purchased before or after FIRM date.
3. *Occupancy type, especially with regard to condominiums.*
4. Type of construction:
   a. Slab on grade
   b. Basement or crawl space
   c. Elevated structure
   d. Split level
5. The number of floors
6. Coverage amount, which is equal to the structure's replacement value.
7. Contents coverage.
8. Deductible.

To fill in the gaps in benefit calculation, the following assumptions have been made. To protect against a large number of protests for over payment (i.e. too high a benefit is assigned to an owner), all individual benefits are calculated for the least expensive insurance possible.

1. Coverage is equal to assessed structure value, capped as appropriate for occupancy.

2. Ratings are based on one or more floors (2 specifically) with a basement or crawlspace below grade.

3. The insurance deductible is the maximum $5,000.

4. Contents coverage is not mandatory and therefore not purchased.

5. Pre-firm rates are used. This provides the least expensive insurance.

Figure 8-2 graphically shows equations that were derived to calculate project benefits within each zone shown on Figure 8-1. Table 8-2 provides a summary of project costs, the number of properties that benefit from that project, average annual benefits per parcel, and the benefit-cost ratio based on flood insurance premium avoidance. Benefits are calculated with a typical twenty-year bond amortization at six percent interest. The benefit-cost ratio is based on total project cost and total benefit; the source of funding is immaterial. Detailed GIS-based spreadsheets are available to calculate individual property assessments, but they are complex and not included with this report.

Figure 8-2
Annual Insurance Premium Cost Vs. Coverage (PRE - FIRM Rates)
Assumes: Diagram #1 - One or more floors, slab on grade construction; maximum deductable; zero contents coverage; 2+ Floors

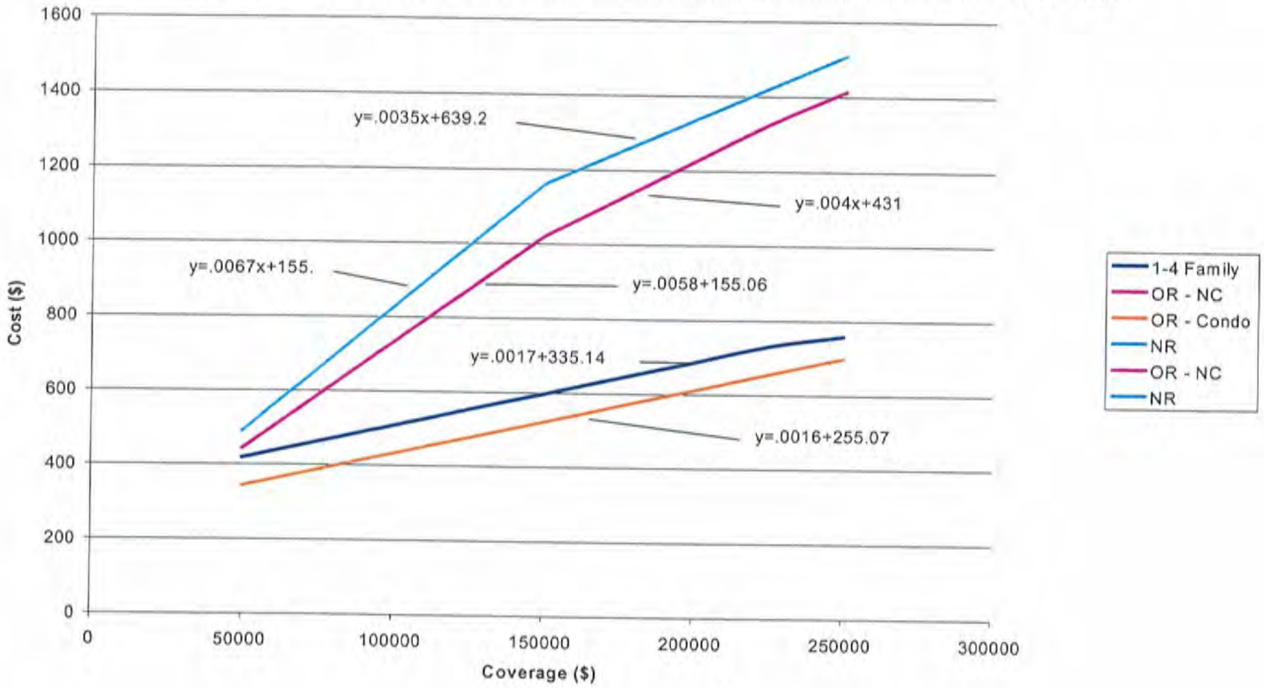


Table 8-2: Calculation of Project Benefits

Flooding Source	Remediation Cost	Parcels Benefiting	Average Annual Assessment	B/C Ratio
FEMA Tidal Flooding[1]	$6,000,000	5,510	$40	5.8
All Tidal Flooding[1]	$6,000,000	8,130	$30	8.7
North Shoreview Drainage	$8,000,000	655	$1,100	0.5
16th Avenue Drainage	$10,500,000	490	$1,900	0.3
19th Avenue Drainage	$5,000,000	440	$1,000	0.6
Laurel Creek	$27,500,000	1,500	$1,600	0.4

[1]$2.5M assessment; $4.5M from other sources

CHAPTER 9
FUNDING

Chapter 8 presents a Capital Improvement Program to reduce flood risks from various sources throughout San Mateo. This chapter provides a brief overview of several funding mechanisms available to the city to finance capital flood protection projects.

FUNDING SOURCES

The City is operating under political and legal constraints to the raising of monies for public works projects. Residents in public forums have voiced their political concerns, and the City's attorney must work through the legal aspects of each type of potential funding mechanism. This study does not attempt to promulgate a detailed financing plan; rather, it provides a menu of possible capital sources for City leaders and residents to consider.

General Funds

If allowed, the City could conceivably cover all or portions of the Capital Improvement Program: It is unlikely, however, that projects of this magnitude could be paid for out of the City's reserves.

Loans

The City would apply to the **California Infrastructure Bank** for a loan to finance up-front costs subject to approval of the project by owners or voters. The interest cost is very low and is not likely to be any lower in the future. It is a source of borrowing that is less costly than financing assessment bonds. This could show property owners that the city is endeavoring to lessen their costs.

Grants

Grant funding may be available through local, regional, state, of federal governments. As an adjunct to this funding source, agencies responsible for facilities that need improvement; for example, Caltrans; might be expected to pay for those improvements.

Corps of Engineers

The United States Army Corps of Engineers has been approached by the City, and indicate that they may be willing to participate in the enhancement of flood protection in San Mateo. Key to their participation is whether there is a federal interest. Two general avenues are available:

- Special Congressional legislation (e.g. Napa River Project)
- Special assistance programs administered by the San Francisco District

Congressional legislation is possible for San Mateo's flood protection system improvements. However, the earliest the USACE could even begin to evaluate a request is at the end of the next fiscal year (July 2003). Consequently, the **Rehabilitation Program (RIP)** authorized by Public Law 84-99 may be a fortuitous source of funding for many of the identified capital improvements.

The RIP is a public assistance program administered by the San Francisco District Corps of Engineers. Its purpose is to provide rehabilitation assistance to public agencies for flood control works that are damaged by floods and coastal storms. Under this program, the federal government pays for 80 percent of the projects' costs, and the local cost share is 20 percent. To be eligible for the RIP, San Mateo must request assistance and demonstrate that:

- The City has the financial capability of providing its local share;
- Proposed improvements provide a minimum of 10-year protection to urban areas;
- A maintenance program is established to meet certain minimum criteria; and
- Erosion protection is provided for design flows.

If the Corps accepts the City's request for assistance, the San Francisco District will begin its own rehabilitation investigation. When criteria are met, the Corps will sign an agreement with the City dealing with lands, easements, and other rights-of-way; hold harmless clauses; and maintenance and operation conditions. The Corps awards and manages construction contracts for repair, and then gives the completed facility back to the City for operation and maintenance. Table 9-1 uses RIP criteria to screen possible capital projects for eligibility. An assumption is made that all improvements will be engineered with more than 10-year protection.

Table 9-1: Screening for USACE RIP Funding Eligibility

Requirement	**Outboard Levees**	**North Shoreview**	**16th Ave. Drain**	**19th Ave. Drain**	**Laurel Creek**
Primary Purpose is Flood Control	YES	YES	YES	YES	YES
B/C Ratio ≥ 1	YES	NO	NO	NO	NO
Public Sponsor	YES	YES	YES	YES	YES
Drainage Area ≥ 1.5 mi²	N/A	YES	YES	YES	YES
Minimum 10-year Flow ≥ 800 cfs	N/A	NO	NO	YES	NO

Special Legislation

State legislators have discretionary funds available even in this time of budget curtailment. If the City has a strong relationship with their legislative delegation it would be worthwhile to explore special legislation that would provide a share of the total cost subject to voter approval of the remaining cost. This would be a strong incentive for approval.

Redevelopment Agency

This source of funding may be applicable when flood protection problems are contributing to a "blighted" condition in particular neighborhoods. The assessment of this funding source must be made on a case-by-case basis. There may also be opportunities for flood protection improvements in conjunction with creek restoration, wetlands creation, and park enhancements that are part of individual redevelopment projects.

Taxation

Although "taxation" is not the most popular term, the formation of a **Mello-Roos District** could allows for the adoption of a tax designed to fit the needs of one of the projects outlined in Chapter 8. The tax cannot be on assessed value and can be any formula that is equitable and fits the needs of the project. A 2/3 vote is required but with good advance preparation and a strong support committee, it may be achievable.

Benefit-Assessment Districts

A benefit-assessment district assigns project costs in direct proportion to the benefits received. A general assessment district formation procedure is outlined below.

1. It is strongly recommended that some attitude measurements be undertaken before proceeding to form the benefit assessment district. This is typically done through phone polling by a neutral agency. Calls are made to about one percent of the affected properties. This pre-testing can help identify key issues to focus on during the campaign; sort out the amount persons are willing to pay or not pay; and identify previously unknown barriers to success.

2. A survey is needed of the top 100 assessment amounts. These property owners should be called upon to meet together and learn more about the project, the process, the importance to the community and willingness to support the campaign. Costs for this process will depend upon the number of meetings and the extent of hospitality offered.

3. The assessment is levied annually. The annual levy does not require re-approval from property owners unless the amount first approved at formation of the benefit assessment is to be increased. As long as it is the same or less, the staff can administratively process the required paper work through council and to the county for collection.

4. The ballot sent to property owners can be designed to combine an information statement and the return form showing approval or disapproval of the specific assessment proposed. The form can be designed to allow a tear off section for return mailing with pre-paid postage on the form. This device can conserve costs for multiple mailings of information, resolutions and the approval/protest form. The returned ballot forms are public records and can be examined by those interested. In some cases persons have been upset by the fact that their name is shown on the protest form and others can determine how they responded to the process. (Incidentally, the process is not defined as an election but a protest hearing with written responses.) The vote taken is for the dollar value of assessments favoring the proceeding. Once $1 more than 50 percent of the total to be assessed is reported in favor, the proceeding is completed. Note that it is not required that 50 percent of all property owners record their approval/protest — only 50 percent of the total dollars to be assessed.

5. Based on experience with other benefit assessment projects (for parks, flood control and mosquito abatement projects) it can be estimated that between two and five percent of all owners will file inquiries about the project and the process. City staff needs to prepare for this and have an assigned person responsible for consistent and reliable answers. If maintenance and operation costs are required for improvements (and recovery of administrative costs for the processing of the assessment) a separate funding mechanism may be needed. This could be a drainage maintenance district or possibly a flood control maintenance service charge added to the monthly sewer or water bills sent out by the City. This is an issue that requires further review.

If the assessment proceeding is completed before the 4th Monday of July in any fiscal year, it will be possible to collect revenue in the next fiscal year (December and April). If that date is missed then no revenue will be available until the subsequent fiscal year. Property owners currently paying for flood insurance may be the fact that the project will have to be installed and certified by FEMA before insurance policies are no longer required. This can mean that property owners would be paying both insurance premiums and the new benefit assessment for a period of one or two years. Thus, while in the long term there will be significant savings, those savings may not materialize in the near term.

CHAPTER 10
CONCLUSIONS AND RECOMMENDATIONS

This chapter provides a final summary of study findings, and recommendations for future action to reduce the flood risk in San Mateo.

STUDY FINDINGS

Several conclusions have been reached regarding San Mateo's regulatory flood risks, and methods to reduce that risk:

1. On the whole, FEMA appears to have properly mapped regulatory flood risks, where it has mapped those risks.

2. Limiting the examination of flood risk to areas north of Highway 92 is arbitrary, and does not provide property owners south of the limit of study with a reasonable understanding of their flood risks.

3. Substantial flood risks from interior residual flooding will remain even if regulatory tidal flooding is corrected.

4. Correcting coastal flooding hazards is very cost effective.

5. Benefit to cost ratios for remedial to reduce the risk of extreme residual interior flooding are less than unity.

RECOMMENDATIONS

Reducing regulatory flood risk remains a worthy goal despite some of the daunting economic information presented in this report. Other than funding a portion of the levee projects to address coastal flooding from San Francisco Bay, asking property owners to shoulder the entire burden of capital improvements to ameliorate flood risk is cost prohibitive. Therefore, the City should continue its efforts to identify other sources of funding.

One promising source of outside monies is the Corps of Engineers Rehabilitation Program, which can provide 80 percent of a project's cost. Of the capital projects identified, the outboard levee system improvements appear to meet the guidelines of this program. The City should pursue the Corps' cooperation while pressing ahead with the several activities.

Actions to Remediate Flood Risks

City officials have laid out a comprehensive long-term plan to address the regulatory flood risks identified in this study. One of the more important considerations in northern San Mateo is whether to address the floodplain in a piecemeal fashion, or in its entirety. Substantial reductions in mapped special flood hazard areas can be achieved by completing the identified capital improvement projects. The magnitude of risk reduction, as measured by the benefit-cost ratio of achieving that reduction, generally follows this order:

1. Crystal Springs Reservoir spill mitigation through operation contract
2. Outboard levee improvements
3. North Shoreview pump station rehabilitation and inboard levee system
4. 16^{th} Avenue Drainage Channel remediation

In southern San Mateo, citizens should be notified of this study's findings and proposed flood management strategies. Property owners should also be encouraged to purchase optional flood insurance at the less expensive pre-FIRM rates. Unfortunately it appears that resolving flood issues south of Highway 92 will be much more expensive and difficult to justify from a flood insurance perspective. Further risk-based studies could change the benefit-cost ratios in the south, but this is uncertain.

Other Flood Management Strategies

The City is also encouraged to prepare a comprehensive storm drain master plan. Other municipalities have found this type of "living document" extremely beneficial to the management of flood risk and drainage problems. At some point flooding from larger sources will be addressed; a storm drain master plan is essential to make sure that local drainage problems do not persist to the point where frequent flooding is still prevalent.

Discounts on flood insurance premiums can be obtained in communities that qualify for the Community Rating System (CRS) because they have floodplain management programs that go beyond minimum NFIP requirements. Discounts may range from 5 to 45 percent depending upon the mitigation, planning, and preparedness activities that are taken. Storm drain master plans are an example of a planning document used in a CRS application. This study represents the best available information on flood risk in San Mateo to date, and is another example of City preparedness. San Mateo will be eligible to apply for a Community Rating in the fall of 2002.

APPENDIX A
LIST OF TECHNICAL TERMS AND ACRONYMS

Acre-Foot	A quantity of water that would cover 1 acre to a depth of 1-foot, equal to about 325,000 gallons.
Aggradation	The geologic process by which streambeds and floodplains are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of *degradation*.
Alluvial	Deposition by the action of running or receding water.
Amortization	The process of liquidating a debt by installing payments or payment into a sinking fund; to prorate over a defined period at a specified interest rate.
Antecedent	An event that precedes another event.
Backwater	Water held back by a downstream control such as a bridge, constricted channel, or tide.
Base Flood	See *one-percent flood*.
Bed Load	Sediment bouncing or rolling along the bottom of a stream. See also *suspended load*.
Bypass	A facility in which floodwater is *diverted* around a channel reach with limited capacity.
Caltrans	California Department of Transportation.
CDFG	California Department of Fish and Game.
CEQA	California Environmental Quality Act.
City	City of San Mateo, California.
Confluence	The junction of two streams.
Conveyance	The ability of a stream or channel to pass a certain rate of flow.

Cross Section	A vertical section of a stream channel or structure that provides a side view of the structure; a transect taken at right angles to flow direction.
Cfs	A rate of flow equivalent to 1 cubic foot, about 7 ½ gallons, passing a point during 1 second (approximately 450 gallons/minute).
Degradation	The geologic process by which stream and river beds lower in elevation. It is the opposite of *aggradation*.
Design Flow	The magnitude of streamflow (see *discharge*) that is used in design of channel modifications and structures across channels.
Discharge	The volume of water passing through a channel during a given period of time, usually measured in cubic feet per second (cfs).
El Niño	A disruption of the ocean-atmosphere system in the Tropical Pacific having important consequences for weather and climate around the globe. An El Niño tends to increase rainfall across the southern tier of the United States. The 1997-1998 El Niño was very strong, and caused destructive flooding throughout Northern California.
Ephemeral Stream	A stream that flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table. Many of the streams in San Mateo and on the San Francisco Peninsula are ephemeral. Water present during the dry season may accumulate from groundwater, irrigation runoff, or backwater from San Francisco Bay or Marina Lagoon. See *perennial streams*.
FEMA	Federal Emergency Management Agency.
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study

Floodplain	An area of land inundated by *floodwaters*. Floodplains may consist of standing or moving water.
Floodwaters	Those flows of water that cannot be contained within the natural stream channel.
Freeboard	Vertical distance between the top of an embankment adjoining a channel and the water level in the channel. It is a factor of safety designed into a project.
Gravel	Sediment particles larger than sand and ranging from 0.25 to 3 inches in diameter.
Hydrograph	A plot of *discharge* (flow) against time.
Mean Sea Level	The average height of the surface of the sea of all stages of the tide over a 19-year period.
Mitigation	To moderate, reduce, or alleviate the impacts of a proposed activity; includes, in order: (a) avoiding the impact by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; c) rectifying the impact by repairing, rehabilitation, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; (e) compensating for the impact by replacing or providing substitute resources or environments (Council of Environmental Quality, 1978).
National Geodetic Vertical Datum (NGVD)	The *mean sea level* in 1929.
NFIP	National Flood Insurance Program.
One Hundred Year Flood	The *one-percent flood*.

One Percent Flood	A flood magnitude that has a one percent chance of being equaled or exceeded in any one year.
Ordinary High Water	The area of a watercourse subject to Section 404 of the Federal Clean Water Act of 1972. The area affected is determined by the elevation of the 2.3-year flood event (ordinary high water flow) which is field checked by biologists using physical characteristics.
Overbank	In a river or creek, the area between the main channel and the limits of the *floodplain*.
Overflow	*Floodwater* that leaves a channel over its bank(s).
Perennial Stream	A stream that flows continuously throughout the year. See also *ephemeral stream*.
RCB	Reinforced Concrete Box (culvert).
Reach	A subdivision of the creek for convenience of study and reference.
Riparian	Vegetation and wildlife living within, and immediately adjacent to a river, stream or lake. In this report, riparian means the creek environment.
Riverine Flooding	Flooding from a freshwater source such as a river, creek, or stream.
Roughness Coefficient	Represents the frictional resistance of a surface to the flow of water. Used in hydraulic computations.
RWQCB	Regional Water Quality Control Board.
SFHA	Special Flood Hazard Area
SPRR	Southern Pacific Railroad.
Stillwater Surge	The highest elevation of a tide due to astronomic and barometric forces. Also referred to as "storm surge"

Suspended Load	The part of the total sediment load that is carried for a considerable period of time at the velocity of the flow, free from contact with the streambed. See also *bed load.*
SWRCB	California State Water Resources Control Board.
Tidal Flooding	Flooding from a saltwater body subject to influence from tides, such as an ocean, estuary, or bay.
USACE	United States Army Corps of Engineers.
USFWS	United States Fish and Wildlife Service.
USGS	United States Geological Survey.
Wash Load	The part of the *suspended load* comprised of very fine, colloidal particles such as clay.
Watershed	The geographical region or area drained by a stream. May also be referred to as a drainage basin, catchment or tributary.
Wave	Generally refers to waves that form on open water due to wind.
Wave Runup	The height to which water will rise when a wave hits a coastal barrier such as a levee.
Wetlands	As used herein, areas that under normal circumstances have hydrophytic vegetation, hydric soils, and wetland hydrology.
WWTP	Wastewater treatment plant.

APPENDIX B
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