IV. ENGINEERING FEASIBILITY

An engineering analysis of the site conditions in the Marina and the proposed improvements in the project was performed to determine the engineering feasibility of the project. The analysis was divided into three parts: Site Conditions, Project Elements, and Construction Cost Estimate.

A. Site Conditions

A. I Climatology

The site climate is characterized by mild and moderately wet winters and by dry, cool summers. Winter rains from November through March account for over 80% of the average annual rainfall. Severe winter storms with gale winds and heavy rains occur occasionally. The summer weather is dominated by a cool sea breeze which is light in the morning and increases in magnitude in the afternoon. A sea fog, arriving during the late afternoon or evening, is another persistent feature of the summer weather. Although this fog has a tendency to burn off by early afternoon, it contributes significantly to the typically overcast conditions experienced during San Francisco summers. Mean monthly temperatures vary between approximately 49°F in January and 64°F in September.

Wind

Mean and maximum directional wind speeds are presented in Table IV-1. Mean speeds are based upon Alameda Naval Air Station (NAS) wind data for the period 1945-1972 (State of California, 1978), and maximum (fastest mile) wind speeds are based upon an analysis of wind data at the Alameda NAS and at San Francisco by Ecker and Whelan (1983). Due to local topographic influences, surface wind speeds and direction at the site may vary from those shown in Table IV-1.

TABLE IV-I

DIRECTION	% OCCURANCE OF MEAN SPEED	MEAN SPEED (mph)	MAXIMUM SPEED (mph)
N	4.7	7.4	43
NNE	I.I	6.5	33
NE	I.I	5.9	30
ENE	0.6	5.7	30
E	2.2	5.4	26
ESE	3.1	7.6	33
SE	5.0	10.0	47
SSE	2.9	9.9	43
S	4.4	8.5	47
SSW	3.2	8.6	36
SW	7.6	9.1	47
WSW	9.3	10.3	33
W	22.1	11.5	43
WNW	9.7	10.2	43
NW	7.0	8.0	39
NNW	S 0	78	39

A.2 Existing Environmental Conditions

Water Depths

The most recent bathymetric survey that includes all of both basins was completed by Sea Surveyor in May 1995. The depths in the inner basin of the West Harbor berthing area vary from 6 feet to 9 feet below MLLW and in the entrance channel from 9 feet to 14 feet below MLLW. Depths in the outer basin of the West Harbor berthing areas vary from 4 feet to 11 feet below MLLW and in the entrance channel from 7.5 feet to 25 feet below MLLW.

Depths in the East Harbor berthing areas vary from 5 feet to 8 feet below MLLW. The depth in the entrance channel is approximately 10 to 15 feet below MLLW.

Tides

The tides of San Francisco Bay are of a semi-diurnal mixed typed with two high and two low waters each day with a diurnal inequality (i.e. a difference in height between successive high waters or low waters). Changes in winds and barometric conditions can cause variations in the tide level from day to day, and are not factored into the daily tide predictions for the area. These variations are, however, factored into the determination of the tidal planes,

which are presented in Table IV-2 for the Presidio tide gage station, the closest station to the project site (NOS, 1984).

TABLE IV-2

TIDAL PLANE	FEET ABOVE MLLW
Highest Observed Water Level	8.9
Mean Higher High Water	5.8
Mean High Water	5.2
Mean Tide Level	3.2
Mean Sea Level (NGVD)	2.8
Mean Low Water	1.1
Mean Lower Low Water	0.0
Lowest Observed Water Level	-2.7

The city datum is a commonly used reference for landside construction in San Francisco. This datum is 11.67 feet above MLLW at the Presidio Tide Station.

Currents

The variation in tidal currents is similar to that of the tide, though the relation of current to tide is not constant. Currents exhibit a semi-diurnal inequality and are frequently affected by wind or variations in river discharge. Tidal current charts for San Francisco Bay (NOAA, 1973) show maximum current speeds in the open water areas north of the harbor to be 1-2 knots on a flood current and 2-4 knots on an ebb current.

Current data within the harbor areas is not available. However, it may be concluded that tidal currents within the harbor basins are minimal relative to the open water area. Wiegel (1967) noted that currents displayed a secondary effect in the East Harbor, causing waves from a westerly direction to refract into the harbor.

Tsunamis

Calculations of runup due to seismic sea waves (tsunamis) of distant origin have been made for San Francisco Bay by the U.S. Army Waterways Experiment Station (1975). The values presented in Table IV-3 are water levels that would be exceeded on the average of once per 100 and once per 500 years. The statistical effect of the astronomical tides on tsunami runup was recognized in the analysis.

TABLE IV-3

Return Period (Years)	Runup Level (Ft Above MLLW)
100	10
500	16.6

Moffatt & Nichol (1976) reported that water level fluctuations within San Francisco Bay during the tsunami resulting from the Alaskan earthquake of March 1964, ranged between two and three feet. The tsunami of May 1960 was also greatly attenuated after passing through the Golden Gate.

Waves

Excessive wave action is a problem within both harbors, causing damage to vessels and floats in the outer harbor areas under storm conditions. An attempt to remedy the problem in the East Harbor was undertaken in the 1970's by constructing a breakwater addition linking the seawall and the previously detached breakwater. Wave action continues to be a problem, however. For example, significant damage to floats and berthed boats occurred during strong northeasterly winds on December 14 -15, 1988 (Moffatt & Nichol Engineers, 1988). Damage was concentrated in the outer basin of the West Harbor, and the docks adjacent to the entrance channel in the East Harbor. Repair costs were approximately $150,000 (1988 dollars). Damage to floats in the outer basin of the West Harbor and the East Harbor occurred again in February 1997 (personal communication with Gary Davis, Harbormaster).

This section examines the wave conditions at the harbor entrances and the effect of the protective structures on the wave energy levels incident to both harbors.

(i) Incident Wave Conditions

Waves incident at the Marina can be from locally generated wind waves, longer period waves generated in the Pacific Ocean, or ship-generated waves.

Long period waves generated in the Pacific Ocean provide the most severe incident wave conditions from the northwesterly direction; locally generated wind waves provide the most severe incident wave conditions from the northeasterly direction.

Long period waves originating in the Pacific Ocean are transformed by refraction, diffraction and shoaling as they propagate across the San Francisco offshore bar and are transmitted into San Francisco Bay. An analysis of such long period waves at Fort Point Station was done by Ecker and Whelan (1983). This analysis revealed highest significant wave heights of 5.2 feet with corresponding wave periods of 13 seconds. A similar analysis by Moffatt and Nichol, Engineers (1976) for Fisherman's Wharf Harbor revealed significant wave heights of less than 3 feet. Based upon these results it may be concluded that the maximum long period incident wave conditions at the project site are approximately a 5 foot significant wave height with a corresponding 13 second wave period. Wiegel (1967) observed waves of 8 to 10 second period and 2 to 3 foot (average) height breaking at the seawall just west of East Harbor during two major storms.

An analysis of locally generated wind waves, based upon Alameda NAS wind data (State of California, 1978), revealed that significant wave heights of up to approximately 4 feet with wave periods of up to 4 seconds are likely to occur at the harbor entrances. These results are in agreement with previous locally generated wind wave analyses presented by the U.S. Army Corps of Engineers (1973) for Gas House Cove Harbor, U.S. Army Corps of Engineers (1985) for Fisherman's Wharf Harbor, and Ecker & Whelan (1983) for Fort Point Station. Moffatt & Nichol, Engineers personnel estimated from visual observations wave heights of about 4 feet with periods of about 4 seconds from the northeast during the December 1988 storm.

Ship-generated waves resulting from traffic outside the harbor have short periods and can be considered to be similar, but less critical, than locally generated waves. High-speed passenger ferries, which are becoming more prevalent, can produce waves with longer periods and heights of two to three feet, similar to the swell incident to the site. Wiegel (1967) noted that ship-generated waves entered the East Harbor and that the worst approach direction was the northeast.

The U.S. Army Corps of Engineers installed a wave recording system on the end of the breakwater at the entrance to East Harbor. This gage was in operation from August, 1968 to March, 1969. The Corps of Engineers (1971) reported that while waves of large magnitude occur relatively infrequently, waves from *Vi* to I foot in height were continuously present at the harbor entrance.

(ii) East and West Harbor Wave Conditions

Waves are transformed on entering the harbors due to the effects of diffraction, refraction, shoaling and reflection. Wave diffraction, which involves lateral transfer of wave energy along a wave crest, is the dominant wave transformation mode for this situation.

Wave action within the East Harbor and the outer basin of the West Harbor has caused excessive vessel motions and damage. Wave action in the inner basin of the West Harbor has generally not been a problem.

Sedimentation

Sedimentation within the harbors has not been a major problem in the past. Dredging operations occurred on an infrequent basis. Phillip Williams and Associates (1986) reported that the total dredging required in the West Harbor from 1973 - 1986 was about 3,500 cubic yards, yielding an average of 250 cubic yards per year. However, the rate of sediment accumulation in the East Harbor and the outer basin of the West Harbor is reported to have recently increased.

The source for this deposited material is literally transported sand from Crissy Field Beach and fine suspended sediments present in the water column. The sand drifts eastward along Crissy Field Beach due to prevailing wave conditions. This sand forms the beach on the Bay side of the protective peninsula at the West Harbor and appears to be the source of the tip shoal which has formed inside the West Harbor Entrance. Fine suspended sediments in the water column, which are carried by tidal action to both the East and West Harbors, tend to settle out and accumulate in the lower energy environments provided by the harbor basins.

A five year dredging plan developed in 1994 included an estimated requirement for 220,000 cubic yards of maintenance dredging from 1994 to 1998 (Advanced Biological Testing, Inc., 1994). The volume estimate included 105,000 cubic yards for the East Harbor and 115,000 for the West Harbor. The quantities were estimated for permitting purposes and included a substantial over-dredge volume. Actual maintenance dredging should be less. Dredging of the entrance channel and turning basin in the West Harbor was completed in 1996. Additional dredging is planned for 1997.

Water Quality

The City and County of San Francisco Clean Water Program has monitored coliform bacteria levels at several stations within the Marina. Available data reviewed spans the period January 1987 to August 1988.

Three outfalls discharge wastewater overflows in the area during peak runoff events. The system is designed to average eight overflows per year. Two of the outfalls discharge into the Marina. The Pierce Street outfall, which discharges into the outer basin of West Harbor, and the Laguna Street outfall, which discharges into the East Harbor. The Baker Street outfall discharges directly into the Bay, west of the West Harbor.

The monitoring program data revealed occasional violation of California Regional Water Quality Control Board bacterial standards for water-contact recreation. Almost all the violations occurred at the beach area in the West Harbor. Most of the violations were related to rainfall runoff, and there was no consistent pattern of excessive bacterial counts.

A.3 Geotechnical

Subsurface soil conditions for the Marina are contained in Geotechnical Reports previously prepared for the City. These include Dames & Moore (December, 1961) and Geotechnical Consultants, Inc. (Parsons Brinkerhoff, October, 1983). The types of soils encountered at the site, in descending order from the surface, include artificial fill. Younger Bay Mud, Bay Side Sands, Older Bay Mud and Franciscan Bedrock.

A Geotechnical Engineering Study was prepared by Harding Lawson Associates to evaluate the seawall and slope stability around the West Harbor perimeter. The study concluded that channel dredging is possible using side slopes of 3:1 protected, or 5:1 unprotected.

B. Project Elements

A Master Plan for the San Francisco Marina was undertaken by the San Francisco Recreation and Park Department to identify the parts of the Marina for which repairs or upgrades were necessary (SFDPW, 1989). Those existing facilities in urgent need of repair or upgrade were identified as Priority Project Elements. Several of these elements are not presently proposed due to public concerns regarding visual quality, marina expansion, and traffic impacts. The berth count resulting from the proposed improvements will remain approximately the same. The following paragraphs describe the proposed Project Elements.

Construction of East Harbor Breakwater Improvements

The existing East Harbor breakwater provides sheltering for waves from the northwest direction, although long period wave action causes surging on occasion. The breakwater provides little protection for waves from the north or northeast directions, and this condition is exacerbated because these waves can enter by passing beneath the Fort Mason Pier. Additional breakwater segments as shown in Figure 4B will reduce wave action in the East Harbor. An innovative breakwater system has been proposed, which will require further testing to validate its performance. A portion of the breakwater consists of a slotted wall to protect the berths from waves incident from the north and northeast while limiting the reflection of waves from the northwest direction. The approximate wave energy reduction in the most exposed area of the East Harbor is estimated to be about 90% for the critical northeast direction. There will be an increase in wave energy due to partial reflection of waves incident from the northwest direction. The benefit of the sheltering should more than compensate for the increase in reflected wave energy.

Replacement of the Floating Docks in the East Harbor and Inner Basin of the West Harbor

New floating docks will replace the existing docks in the East Harbor and inner basin of West Harbor. The current number of berths and their configuration will be approximately maintained. Marginal walkways will be added to extend new barrier-free access to a greater number of berths. Reconfiguration of some the new berths in the West Harbor to align with the prevailing westerly winds is provided.

Upgrade of Utilities at all Berths

New electrical, water, and telephone utilities will be provided on the new floating docks.

Electrical improvements will use standard receptacles and provide a minimum capacity of30 amps per berth. The water system capacity will be increased and fire protection stations will be provided on the new floating docks. The telephone system will be replaced and standardized.

Replacement of all Gangways and Security Gates

All gangways will be replaced with standard low-maintenance aluminum units. Security gates will be replaced and relocated to access platforms at the top of the gangways. The security locks will be replaced with an improved security

system. A reduction in the number of gangways is proposed due to the addition of the marginal walkways.

Special access ramp systems are scheduled for construction in 1997 and are therefore treated as existing facilities in this study. These access ramps comply with the requirements of the Americans with Disabilities Act (ADA). One access ramp will be constructed in each Harbor. To extend the access on the floating docks, new marginal walkways are provided.

Dredging to Provide Adequate Basin Depths in the East and West Harbors

Dredging will be performed to restore original design depths in both harbors. Dredging will provide navigable depth in the main access channel, turning basin and Yacht Club guest docks in the West Harbor.

The actual quantity of project related dredging will be determined by scheduling requirements and the amount of dredging accomplished in the next few years. Dredging costs will depend on disposal requirements that will be better understood after sediment sampling and testing is completed. An allowance for dredging is included in this project.

Renovation of Degraded ShoreUne Revetments in the East and West Harbors

Existing rip-rap slopes around the interior shorelines of the Marina are currently degraded as a result of erosion and rock slope sloughing, primarily in the East Harbor, and in the West Harbor near gangway I and at the toe of the walls in the vicinity of the Harbormaster's office. Reconstruction will key the slopes at the toe and provide filter fabric below the rip-rap to improve the stability of the revetment. A reinforced concrete wall is proposed at the top of the existing slope in the East Harbor due to space limitations.

Construction of Parking Access Control Gates

Conversion of two existing parking areas to peak-use controlled parking will be considered, with one at East Harbor, and one along Marina Boulevard at the inner basin of West Harbor. Traffic control gates will be installed and operated during peak-use hours to allow boater-only access to these parking areas.

Construction ofLandscaping and Public Access Improvements

Landscaping and universal public access improvements will be provided in landside areas around both Harbors. Landscaping will be required along the perimeter of the East Harbor where reconstruction of the perimeter revetments is proposed.

Construction Staging

The project includes replacement of floats in stages to limit displacement of existing tenants during construction. The staging will involve replacement of portions of the floats, and associated dredging and perimeter treatments, in a step-wise progression. In this way, a manageable number of tenants will be temporarily relocated for each stage. Careful planning is required, and a construction cost premium is expected.

C. Construction Cost Estimate

The estimated construction cost for the Marina improvements are contained in Table IV-4.

Table IV - 4

Moffatt & Nichol Engineers
San Francisco Marina
East and West Harbor Replacement
OPINION OF PROBABLE CONSTRUCTION COSTS

06/11/97
EST. BY: RTB & CGT

#	DESCRIPTION	QTY.	UNIT	UNIT COST	TOTAL
	WEST HARBOR				
1	**Mobilization and Demobilization**	1	LS	5%	$222,235
2	**West Harbor Dock Replacement**	279	Berth	$10,800	$3,013,200
3	**Dock Utility Upgrade and Replacement**	279	Berth	$2,500	$697,500
4	**New Gangways**	10	EA	$17,000	$170,000
5	**New Security Gates**	9	EA	$3,000	$27,000
6	**Dredging - West Harbor (Allowance)**	1	LS	$60,000	$60,000
7	**Upgrade West Harbor Revetments**	1600	LF	$200	$320,000
8	**Parking Access Control Gates**	2	EA	$16,000	$32,000
9	**Landscaping Allowance**	1	LS	$125,000	$125,000
			WEST HARBOR SUBTOTAL		$ 4,666,935
	CONSTRUCTION STAGING		5%		$ 233,347
	CONSTRUCTION CONTINGENCY		10%		$ 466,694
	ESTIMATED ENGINEERING & ADMINISTRATION COSTS		10%		$ 536,698
	TOTAL WEST HARBOR				$ 5,903,673
	TOTAL PER BERTH				$21,160
	EAST HARBOR				
1	**Mobilization and Demobilization**	1	LS	5%	$325,120
2	**East Harbor Slotted Breakwater**	205	LF	$5,000	$1,025,000
3	**East Harbor Sheetpile Breakwater**	230	LF	$3,400	$782,000
4	**East Harbor Dock Replacement**	341	Berth	$6,900	$2,352,900
5	**Dock Utility Upgrade and Replacement**	341	Berth	$2,500	$852,500
6	**New Gangways**	5	EA	$17,000	$85,000
7	**New Security Gates**	6	EA	$3,000	$18,000
8	**Dredging - East Harbor (Allowance)**	1	LS	$270,000	$270,000
9	**Upgrade East Harbor Revetments**	1600	LF	$600	$960,000
10	**Parking Access Control Gates**	2	EA	$16,000	$32,000
11	**Landscaping Allowance**	1	LS	$125,000	$125,000
			EAST HARBOR SUBTOTAL		$ 6,827,520
	CONSTRUCTION STAGING		5%		$ 341,376
	CONSTRUCTION CONTINGENCY		10%		$ 682,752
	ESTIMATED ENGINEERING & ADMINISTRATION COSTS		10%		$ 785,165
	TOTAL EAST HARBOR				$ 8,636,813
	TOTAL PER BERTH				$ 25,328
	TOTAL ESTIMATE				$ 14,540,486
	TOTAL PER BERTH				$ 23,452

Environmental/permitting/hazardous material costs are not included.