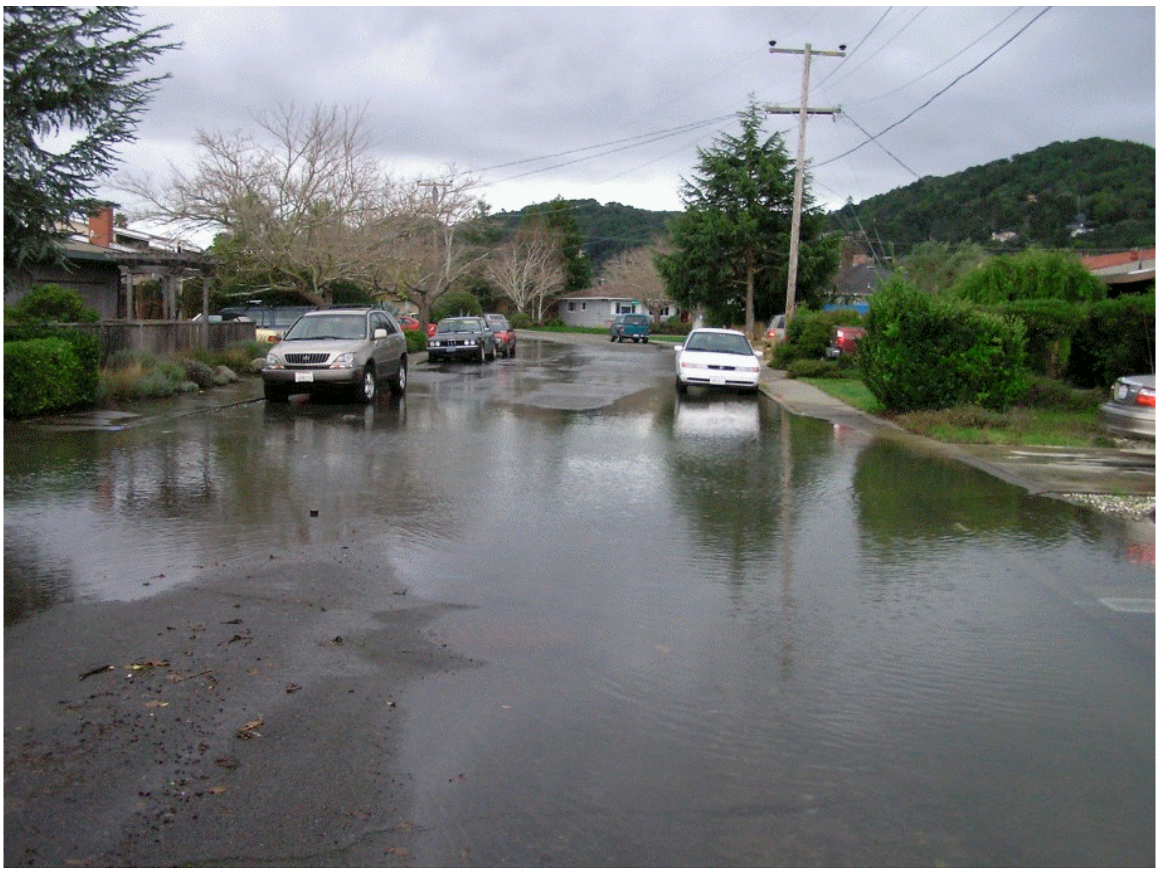
- FINAL REPORT -

TOWN-WIDE STORM DRAINAGE AND FLOOD CONTROL STUDY PHASE 1



FOR

TOWN OF CORTE MADERA

May 2007

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1. EXECUTIVE SUMMARY

1.1. Purpose of Study

The purpose of this Study is to update the Town's Storm Drainage Master Plan in a phased approach. This project is Phase 1 of this update and includes Watersheds 5, 6 and 7 (Refer to Exhibit A).

The Town's objective for this project is to study the flooding potential and assess the flood control facilities within Watersheds 5, 6 and 7. The study at a minimum should provide "realistic and viable solutions for the prevention of tidal flooding, alternative methods for the elimination of curb and street ponding, and a list of future capital improvements necessary for sustained operation of existing facilities and for the improvement of sub-standard and/or now inadequate drainage systems throughout the watersheds".

1.2. Study Limits

The study limits encompass Watersheds 5, 6 and 7 (Refer to Exhibit A) in the Town of Corte Madera.

Watershed 5 consists of the Marina Village, a relatively flat low lying development of approximately 87 homes north of Paradise Drive.

Watersheds 6 and 7 consist of individual housing on steep hillsides in their upper reaches and more standard residential and commercial subdivision developments on their relatively flat lower portions. The lower portions of Watersheds 6 and 7, north of Paradise Drive, consist of the low lying development of Mariner Cove of approximately 424 homes. The lower portion of Watershed 6 south of Paradise Drive is the development of Marin Estates.

1.3. Conclusions

Based on this study, the following are our conclusions:

1.3.1. Flood-related Problems

The flood related problems in the study area can generally be described by location as follows:

- Upper watersheds on the hillsides (south of Paradise Drive), the flood problems are mainly due to undersized storm drain pipes and poor inlet conditions. There are very few upper watershed flood problems as reported by the Town, and the Town plans to correct these by routine maintenance and replace old corrugated metal pipes (CMP's) with new storm drains as needed. Therefore, no specific recommendations are included in this study for storm drainage improvements in the upper watersheds, except that we recommend that an annual budget of approximately $100,000 per year be provided for this routine maintenance and replacements.
- Lower watersheds on relatively flat terrain (north and south of Paradise Drive), the flood problems are due to "extreme settlement, including a significant amount of differential settlement, and very poor and inferior design and construction practices" in the low-lying subdivisions of Mariner Cove, Marina Village and Marin Estates. "These subdivisions have settled to the point where they are subject to tidal flooding and extensive curb and street ponding".

1.3.2. Flooding Conditions Within Lower Watersheds

There are two types of flooding conditions in the lower watersheds:

- Flooding due to storm water runoff in areas that have an inadequate local storm drainage system (interior drainage problems)
- Flooding due to tidal inundation by waters of San Francisco Bay and San Clemente Creek

Of the two flooding conditions, tidal inundation has caused the majority of flooding in residential properties (yards and some garages), but street ponding due to an inadequate storm drainage system and differential settlement has become very common and continues to be a major concern for the Town and the residents. The solutions to these two flooding problems are basically independent of each other, yet both need to be solved for a total comprehensive solution.

1.3.3. Flooding Solutions

The solutions to these two flooding conditions are as follows:

- In general, the solution to the inadequate storm drainage system is to provide continuous curb drainage in areas of curb ponding and to replace and/or augment the existing storm drainage system with new storm drain pipes, catch basins, manholes and pump stations to discharge storm flows including storm events coincident with high tides.
- In general, the solution to the tidal inundation is to install a floodwall along the Bay and San Clemente Creek and raise the existing Marta Marsh levee to protect against high tide events.

1.4. Recommendations

We propose that the solutions to the two flooding conditions within the lower watersheds be phased, with the intent that the solutions to the inadequate storm drainage systems be constructed first. This is because we anticipate that construction of these interior drainage improvements would present significantly fewer and lesser environmental impacts than solutions to the tidal flooding problems.

1.4.1. Storm Drainage Improvements

We recommend the system of storm drainage improvements shown on Exhibit G of this study. These improvements consist of:

1. Seven underground stormwater pump stations
2. Replacing sections of standard curb and gutter with grated drain lines
3. Installation of additional street catch basins
4. Replacement of some sections of storm drain pipe with larger pipes
5. Installation of additional new storm drain pipes and manholes

The underground stormwater pump stations will be relatively small, having 6′ diameter, 8′ diameter, or 10′x10′ square wet wells. For a typical pump station layout refer to Exhibit H. The pumping units will be of the submersible types, as shown on Exhibit I.

In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of grated line drains as shown on Exhibit J.

1.4.2. Tidal Inundation Improvements

We recommended the following tidal inundation improvements (Refer to Exhibit K):

1. Install steel sheetpile floodwall with concrete facing and cap along the Bay side with an initial top of wall elevation 8.0 (NGVD). *Refer to Exhibit M, Sheet 1 of 3.* Wall to be constructed with enough sheetpile embedment to allow the top of the wall to be raised by up to 5 feet in the future. This would allow for additional protection and could account for future settlement. For comparison, Elevation 7.0 (NGVD) is the minimum allowable floor elevation for new building construction in a flood plain in the Town of Corte Madera, per Town ordinance.

2. Install steel sheet pile floodwall with concrete facing and cap along San Clemente Creek with an initial top of wall elevation 8.0 (NGVD). *Refer to Exhibit M, Sheet 2 of 3.* Wall to be constructed with enough sheetpile embedment to allow the top of the wall to be raised by up to 2 feet in height to account for future settlement.

3. Raise existing earth levees along Marta Marsh to Elevation 8.0 (NGVD). *Refer to Exhibit N.*

4. Install Rock riprap in front of bay side floodwall in the locations shown on Exhibit K*. Refer to Exhibit M, Sheet 2 of 3.*

5. Install floodwall stairway access*. Refer to Exhibit O, Sheets 4 and 5.*

6. Remove and replace affected existing docks. Details to be determined during final design.

7. Install lined drainage ditch and gravity outlet drainage boxes behind floodwalls. Provide outlet pipes with "duckbill" type check valves. *Refer to Exhibit O, Sheet 3.*

The height of the floodwalls and Levee vary along their lengths. (For profiles of the floodwall and levee refer to Exhibit L.) In general, most of the length of the floodwall varies in height from approximately 3′ to 5′± above the existing ground at the floodwall location. (Some segments of floodwall are lower or higher in height than this range, as shown on the profiles.)

1.4.3. Recommended Elevations for Tops of Floodwalls

Upon reviewing the numerous past reports and tidal studies by various agencies, we recommend use of the following 100-year top of floodwall design elevations:

- *Floodwall next to San Clemente Creek* - Elevation 8.0′ (NGVD). (Corps of Engineers (COE) preliminary 100-year design elevation. Refer to the Corps May 1996 Draft San Clemente Creek Feasibility Report.)
- *Floodwall along San Francisco Bay* - Initial construction to Elevation 8.0′ (NGVD) with design provisions to raise to Elevation 11.0′ (NGVD) in the future. While the COE recommendation is Elevation 13.0′ (NGVD), we believe that the Corps wave run-up of 5.0′ can be reduced to 3.0 feet by placing rock rip-rap in front of wall to absorb some of the wave energy.

The reduced initial construction top of wall elevation along the bay (from Elevation 11.0′ to 8.0′) is to reduce the visual and access impact of the floodwall, especially for homes fronting on the bay. This will still provide flood protection at approximately the estimated

10-year level. (Assumes approximate 10-year Future Stillwater Tide of 6.0 feet NGVD plus 2 feet for possible wave run up and freeboard.)

1.4.4. FEMA (Federal Emergency Management Agency) Requirements

If the Town of Corte Madera decided to update the Town's FEMA Flood Insurance Rate Map (FIRM), FEMA would have the following requirements.

FEMA would require that a Levee/Floodwall System Analysis Form be filled out. To qualify for FEMA-approved 100-year protection for the study area, the following minimum freeboards for coastal conditions (bay-side floodwall) would have to be provided above the base flood elevation:

- 1.0 foot above the height of the one percent wave for the 100-year stillwater surge elevation or maximum wave runup (whichever is greater).
- 2.0 feet above 100-year stillwater surge elevation.

The Bay side floodwall would need to be raised to Elevation 11.0 NGVD.

A stability and seepage analysis of the existing levee system would need to be performed to FEMA standards in and north of the study area, which may include the North Levee along the old railroad right-of-way to Corte Madera Creek. Based on the FEMA Levee/Floodwall System Analysis, improvements to the North Levee system may also be required.

For a FEMA Flood Insurance Rate Map (FIRM) revision, FEMA would require an Interior Drainage Study of the site. Upon approval by FEMA, they would issue an A-99 Interim Designation Letter of Map Revision (LOMR).

FEMA also requires that, for 100-year protection, stormwater pump stations be provided with permanent "on-site" stand-by generators or other uninterruptible power sources.

1.5. Estimated Preliminary Construction Cost Estimates

The following budgetary level construction cost estimates were prepared using escalated unit prices to mid 2008 (Refer to Appendix A).

The construction cost estimates do not include any cost for utility relocations, permanent or temporary construction easements, environmental studies, permitting, or engineering design services.

The recommended Storm Drainage Improvements total construction cost is estimated to be $9,800,000.

The recommended Tidal Inundation Improvements total construction cost is estimated to be $16,200,000.

2. INTRODUCTION

2.1. Purpose of Study

The Town of Corte Madera is seeking to update its Storm Drainage Master Plan in a phased approach. This project is Phase 1 of this update and includes Watersheds 5, 6 and 7 (Refer to Exhibit A), which encompass the southeastern portion of the Town, which drains into San Francisco Bay mainly through San Clemente Creek.

The Town's objective for this project is to study and assess the flood control facilities within Watersheds 5, 6 and 7. The study at a minimum should provide "realistic and viable solutions for the prevention of tidal flooding, alternative methods for the elimination of curb and street ponding, and a list of future capital improvements necessary for sustained operation of existing facilities and for the improvement of sub-standard and/or now inadequate drainage systems throughout the watersheds".

2.2. Study Limits

The study limits encompass Watersheds 5, 6 and 7 (Refer to Exhibit A) in the Town of Corte Madera.

Watershed 5 (approximately 35 acres) consists of the Marina Village, a relatively flat low lying development of approximately 87 homes north of Paradise Drive that generally drains northerly to marsh areas that ultimately drain to the Marina Village Pump Station. The Marina Village Pump Station pumps storm flows northerly to the Hahn Canal through to Shorebird Marsh and into the Bay.

Watersheds 6 and 7 consist of individual housing on steep hillsides in their upper reaches and more standard residential and commercial subdivision developments on their relatively flat lower portions. Most of Watershed 6 (approximately 392 acres) south of Paradise Drive (including Marin Estates) drains to the San Clemente Pump Station, which ultimately discharges into San Clemente Creek via a force main in Paradise Drive and by gravity through a culvert under Paradise Drive that is controlled by an automatic tide gate. Most of Watershed 7 drains by gravity and ultimately drains directly to San Francisco Bay. The lower portions of Watersheds 6 (approximately 72 acres) and Watershed 7 (approximately 7 acres), north of Paradise Drive, consist of the low lying development of Mariner Cove of approximately 424 homes, which drain by gravity to San Clemente Creek and San Francisco Bay.

2.3. Scope of Services

The following tasks are copied from the agreement for professional services between the Town of Corte Madera and A-N West, Inc. The word "We" refers to A-N West and/or their subconsultants. The phrase "Cost Estimate" in all cases refers to a "Statement of Probable Construction Costs" which is based on the preliminary designs presented in this Phase 1 study.

Task 1 – Review Existing Documents

Review existing documents relating to flooding and flood control in the watersheds. Documents to be reviewed will include those listed in Paragraph VI "Partial List of Existing Documents and Studies" of the Request for Proposal, A-N West, Inc. past studies and plans within the watersheds, and existing aerial and topographic maps available from the Town of Corte Madera, including the Storm Drainage Maps dated 1985.

We will use these existing Storm Drainage Maps dated 1985 as a reference for general layout of the existing storm drainage system, its pipe sizes, and its drainage inlet locations.

Task 2 – Review and Assessment of Existing Facilities

We will meet with the Town Engineer and Maintenance Staff to review the existing flood control and drainage facilities including existing storm water pump stations, slide and flap gates, areas of known levees and floodwalls, and areas of known flooding and erosion. After reviewing the existing documents in Task 1 and reviewing the existing facilities with the Town, we will make extensive site visits to observe the existing facilities and observe overland flow patterns and document these on our plans.

Task 3 – Preparation of Aerial Topographic Maps

The mapping will include:

- Aerial topographic mapping of entire project area at a scale of 1″=100′ with 2′ contours and spot elevations. Scope of work to include flight control survey and digital mapping in AutoCAD2002 format.
- Rectified Digital Color Orthophotos in the form of tiff images.
- Aerial topographic mapping of project area north of Paradise Drive and east of the old railroad grade at a scale of 1″=20′ with 1′ contours and spot elevations. Scope of work to include flight control survey and digital mapping in AutoCAD2002 format.
- Rectified Digital Orthophotos in the form of tiff images.

We have assumed that no supplemental field survey will be needed. If it is needed it would be a change of scope and fee.

Task 4 – Preparation of Geotechnical Assessment

Our geotechnical assessment will evaluate subsurface conditions in order to perform settlement analyses to predict estimated future settlement in Watersheds 5, 6 and 7. Our proposed scope of geotechnical services includes:

- Research and review available geotechnical reference data. This will include review of our in-house geotechnical database, as well as review of reports available from the Town of Corte Madera. This will likely also include coordination with the Town to obtain copies of 3 geotechnical reports prepared as part of previous flood control studies.
- Obtain historical marsh surveys to determine the limits of the original marshes and extent of the underlying bay mud.
- Perform subsurface exploration with three borings/probes to obtain samples for laboratory testing and determine the subsurface conditions at locations where the data is lacking.
- Perform four to five consolidation tests on undisturbed samples of bay mud to estimate the percent consolidation to date.
- Review previous survey data within the project area to determine amount of settlement that has occurred with the survey time frames.

- Expand and refine the existing bay mud contour maps (using data obtained from above scope) to include documented bay mud areas within Watersheds 5, 6 and 7.
- Perform settlement analyses to determine the estimated total settlement and rate of settlement from development on the bay mud areas. Our analyses will be correlated with settlement data and will include approximate percent settlement complete to date and future settlement within specified time frames (i.e. next 10, 20, 50 and 100 years).
- We will document our geotechnical findings in the Study Report (Task 12).

Task 5 – Evaluation and Update of Hydrology, Hydraulics and Tidal Influence

Working with the Town Engineer and Staff, we will establish and/or update the study-specific hydrologic and hydraulic design criteria, including tidal influence. Some of the criteria to be addressed:

- Design storm return period for flows required to pass under roadways in pipes or culverts.
- Freeboard limits for open channel flow.
- Maximum allowable spread of runoff onto City streets (street flow).
- Maximum permissible extent of temporary ponding in streets and private property during the 100 year event.
- Combination of different storm return periods (10 year, 25 year and 100 year) with different tide elevations.

We propose to update the watershed hydrology by generally using the Rational Method of analysis (Q=CIA).

We will evaluate the hydraulics of storm drain pipes, street gutters, potential detention pond storage (surface, and large underground pipes and/or tanks if feasible), pump stations, gravity outfalls and a combination of the above.

Task 6 – Preparation of Alternative and Recommended Conceptual/Preliminary Plans

We will prepare up to three schematic alternative Preliminary Plans. They will be evaluated and presented in the Study Report (Task 12) with one of them being a recommended solution.

Some possible alternative solutions to the inadequate storm drainage system may include pump stations, upsizing storm drain pipes, replacing rolled curb and gutter with standard curb and gutter, adding slotted drains in the gutter, adding additional catch basins and drainage inlets, adding additional outfalls with flap or slide gates, and evaluating the potential for detention pond storage (surface and large underground pipes and/or tanks).

Some possible alternative solutions to the tidal flooding may include earth levees, flood walls (sheet pile or cantilever walls depending on height), combination levee/floodwall, and different levels of flood protection (i.e. 25 year, 50 year, 100 year etc. with different levee and floodwall heights.

We propose showing alternative solutions to the inadequate storm drainage systems in the upper portions of the watersheds south of Paradise Drive schematically on the new 100 scale topographic maps (proposed sheet size 36" x 48").

We propose showing the alternative solutions to both the inadequate storm drainage systems and tidal flooding in the lower portions of the watersheds north of Paradise Drive on the new 20 scale topographic maps (proposed sheet size 36" x 48").

We will also provide schematic sections and details of the storm drain improvements and preliminary profiles and sections of levees and floodwalls.

Task 7 – Preparation of Preliminary Cost Estimate

We will prepare preliminary budgetary construction cost estimates of the alternative and recommended conceptual solutions. These will be provided in the Study Report (Task 12).

Task 8 – Jurisdictional Assessment

We will prepare a jurisdictional assessment of the regulatory agencies which may require permits including the Army Corps of Engineers, BCDC, F&G, F&W and the RWQCB. We will document the jurisdictional assessment in the Study Report (Task 12).

Task 9 – Review FEMA Requirements

We will review FEMA requirements as they relate to the conceptual preliminary plans. We will document the FEMA requirements in the Study Report (Task 12).

Task 10 – Brief Discussion of Potential Environmental Impacts

We will evaluate in general potential environmental impacts that may be associated with the conceptual solutions and briefly describe these impacts in the Study Report (Task 12). The basis of the evaluation will be the information from existing study reports and a brief site visit.

Task 11 – Brief Discussion of Existing Property Impacts

We will evaluate in general, potential impacts on properties within the watersheds including impacts to access and views that may be associated with the conceptual solutions studied; and briefly describe these impacts in the Study Report (Task 12).

Task 12 – Preparation of Study Report

We will prepare and submit a Draft Study Report with the Draft Conceptual/Preliminary Plans, and Draft Preliminary Cost Estimates. After the Town's review of the draft documents, we will incorporate the Town's comments and submit a Final Study Report, Final Conceptual Preliminary Plans and Final Preliminary Cost Estimates.

Task 13 – Prepare and Attend Meetings

We will prepare for and attend at least five public meetings for public outreach, presentation of progress reports and presentation of the Final Report to the Flood Control Board and Town Council.

3. STUDY MEANS AND METHODS

3.1. Vertical Datum

Unless noted otherwise, all elevations in this study are referenced to the National Geodetic Vertical Datum (NGVD) of 1929. NGVD is approximately Mean Sea Level. The other commonly used vertical datum is Mean Lower Low Water (MLLW) which is used in Tide Tables. The difference between these two datums varies with locality. To approximately relate NGVD elevations to the MLLW datum in the San Clemente Creek area, add 2.6 feet to the NGVD elevation to obtain the corresponding approximate MLLW elevation. (Refer to Exhibit R.) Expressed as a formula:

APPROXIMATE ELEVATION MLLW (Tide Tables) = ELEVATION NGVD + 2.6′ FEET

3.2. Base Mapping

The base mapping for this Study (Watersheds 5, 6 and 7) was new aerial topography mapping of the entire project area at a scale of 1″=100′ with 2′ contours and a more detail aerial topographic mapping of the project area north of Paradise Drive and east of the old railroad right of way at a scale of 1″=20′ with 1 ‘ contours and spot elevations. Rectified digital orthophotos in the form of tiff images were also prepared.

The existing drainage systems shown on the new base mapping were based on the Town of Corte Madera's Storm Drainage Maps dated 1985. The Town's Maps were used for general layout of the existing storm drainage systems, pipe sizes, and drainage inlet locations. This information was rectified with the new aerial orthophotos. No field survey of existing drainage systems was performed. (It would have been outside the scope of services for this Study.)

3.3. Hydrologic and Hydraulic Standards Applied to the Study

<u>Hydrology</u>

Hydrologic calculations for this study were based on using the Rational Method of Analysis (Q=CiA) (Refer to Appendix C).

The stormwater runoff flow (Q) was calculated for the 25 year and 100 year return periods. The Town of Corte Madera uses the 25 year return period for design of new storm drainage systems and the 100 year return period event for the design of new pump stations.

The Rainfall Intensity (i) was based on CALTRANS (District 4) Rainfall Intensity-Duration-Frequency Charts.

For the Tributary Area Drainage Maps refer to Exhibit E.

<u>Hydraulics</u>

Using the calculated flows for each subwatershed, backwater calculations (assumed "Full Pipe" condition) were prepared to analyze the existing and new improved storm drainage systems and to evaluate if the existing and new improved systems can discharge to the existing outfalls or new proposed pump stations without flooding (Refer to Appendix C). For this study, "without flooding" is defined as:

1. For 25 year runoff: Backwater surface elevations no higher than catch basin or drainage inlet grate elevations (NGVD)

2. For 100 year runoff: Backwater surface elevations no higher than the top of the street curb elevations (NGVD)

3.4. Tides

Numerous past reports have performed extensive studies of tidal effects in the Study Area and have documented stillwater tides and design tide elevations including wave run-up and freeboard for floodwall and levee designs for various tide event frequencies. The following is a summary and comparison of some of documented stillwater tide elevation data.

Table 1
Still-Water Tide Elevations (NGVD)
San Francisco Bay at San Clemente Creek

Tide Event	May 1986	Oct 1988	May 1991	June 1991	May 1992	May 1996
Frequency	W&K	PWA	URS	CDM	EMI	COE
	(NGVD)	(NGVD)	(NGVD)	(NGVD)	(NGVD)	(NGVD)
10 year	5.7					5.6
25 year	6.2					-
50 year	6.6					6.0
100 year	7.1	6.4	6.5	6.4	6.5	6.1
500 year						6.4

W&K Winzler & Kelly Consulting Engineers
PWA Philip Williams & Associates
URS URS Consultants
CDM Camp Dresser & McKee Inc.
EMI Earth Metrics Inc.
COE Corps of Engineers

For design tide elevations refer to Table 3 in the Recommended Tidal Inundation Improvement section of this report.

3.5. Settlement Analysis

The settlement analysis was limited to the Mariner Cove and Marina Village residential developments in Corte Madera, California. Based on the aerial photographs and subsurface borings, original site grading consisted of the placement of 8 to 9 feet of fill material in 1958 over the former marsh. The marsh deposits consist of soft, compressible, high plasticity, silty clay (CH) commonly referred to as bay mud. The thickness of the bay mud within the project area varies from about 0 to 110 feet. (Refer to Exhibit F)

The placement of fill material over bay mud causes consolidation of the bay mud and settlement of the ground surface. The amount and rate of settlement depends on the amount of surface loading, thickness of the bay mud, compression properties of the bay mud and subsurface drainage layers. In general, the bay mud consolidates quicker following the initial loading and slows over time. Our laboratory testing provides consolidation properties for the bay mud and indicates that the deeper portions of the bay mud are significantly under-consolidated (settlement not complete). Survey data from 1985 and 2006 was reviewed to correlate our settlement analysis. A summary of the calculated settlement to date and estimates of future settlements are presented in Table 2. Actual settlements may vary from the predicted due to variations in the thickness of fill, interpreted bay mud thickness contours, bay mud consolidation characteristics, and subsurface drainage characteristics.

Table 2
Calculated Current and Future Settlement
Watersheds 5, 6 and 7
Corte Madera, California

	CALCULATED	ESTIMATED FUTURE SETTLEMENT				TOTAL
BAY MUD	SETTLEMENT					CALCULATED
THICKNESS	TO DATE	10	30	50	100	SETTLEMENT
(FT.)	(2006) (FT.)	YEARS	YEARS	YEARS	YEARS	(FT.)
10	1.7	0.0	0.0	0.0	0.0	1.7
20	3.0	0.0	0.0	0.0	0.0	3.0
30	3.9	0.0	0.0	0.0	0.0	3.9
40	4.5	0.1	0.2	0.2	0.2	4.7
50	4.6	0.3	0.5	0.6	0.7	5.3
60	4.3	0.3	0.8	1.0	1.2	5.7
70	4.1	0.4	0.9	1.3	1.8	6.1
80	3.9	0.3	1.0	1.4	2.0	6.4
90	3.5	0.5	0.9	1.5	2.2	6.7
100	3.2	0.7	1.0	1.5	2.3	6.9
110	3.1	0.2	0.8	1.3	2.2	7.0

Note: Settlement calculations based on 8.5 feet of fill placed in 1958, Compression Index Cc’ of 0.32, Coefficient of Consolidation Cv of 10 ft^2/yr, and double drainage conditions.

Note that for Bay Mud Thicknesses greater than 50 feet, that future settlement will continue to occur beyond 100 years.

For the complete Draft Geotechnical Investigation (including Settlement Study) refer to Appendix B.

4. FLOODING CONDITIONS

4.1. History of Flooding

According to the U.S. Army Corps of Engineers (Corps) May 1996 Draft San Clemente Creek Feasibility Report,

> *"documented flood data in the study reach are scarce, but extensive flooding is known to have occurred as early as 1956 and recorded flood events have occurred from 1961 through the present. The largest rainstorm on record occurred in January 1982 during a tide with a peak stage of 4.2 feet NGVD, however floods in 1983, 1987 and 1989 occurred exclusively as a result of extreme tides."*

Flooding conditions have also been reported in the Winzler & Kelly (W&K) May 1986 Mariner Cove Flood and Drainage Study. The Study reported

> *"There are two separate causes of existing flooding in Mariner Cove. These are tidal flooding and flooding due to storm runoff. Of the two, tidal flooding is more significant and has caused the majority of flooding to date. This flooding includes yard flooding and some garage flooding. No thresholds have been breached. However, several of the lower homes have had foundations submerged. This water tends to remain behind after tides recede and either dry up slowly or require pumping.*
>
> *Less severe flooding has occurred due to storm runoff. There is a particular problem at the intersection of Paradise Drive and Prince Royal Passage due to poorly designed cross connection of storm drain mains. In addition, due to uneven settlement and, perhaps, poor initial grading, there are low points in streets and yards that do not drain properly. Most street ponding is being handled by Town maintenance crews as they occur. The crews install drop inlets at these low points and run small diameter lines to the main storm drains."*

Curb ponding has also been documented by the Town and by A-N West. (Refer to Exhibit B.)

Some of the highest observed tide water levels are as follows:

- 10.0′ ± (MLLW) = 7.4′ ± (NGVD) in December 1997 at Corte Madera Creek (from Town Public Works)
- 8.87′ ± (MLLW) = 6.3′ ± (NGVD) on 01-27-83 at SF Presidio (from W&K May 1986 Report)
- 8.17′ ± (MLLW) = 5.6′ ± (NGVD) on 02-06-78 at Corte Madera Creek (from W&K May 1986 Report)

4.2. Types of Flooding

There are two main flooding conditions that need to be addressed and solved in the lower watersheds:

- Flooding due to storm water runoff in areas that have an inadequate storm drainage system (interior drainage problems)

- Flooding due to tidal inundation.

The flood related problems in Watersheds 5, 6 and 7 can generally be described as follows:

- Upper watershed flood problems on the hillsides are mainly due to undersized storm drain pipes and poor inlet conditions. There are very few upper watershed flood problems as reported by the Town, and the Town plans to correct these by routine maintenance and replace old corrugated metal pipes (CMP's) with new storm drains as needed. Therefore, no specific recommendations are included in this study for storm drainage improvements in the upper watersheds, except that we recommend that an annual budget of approximately $100,000 per year be provided for this routine maintenance and replacements.
- Lower watershed flood problems on relatively flat terrain are due to "extreme settlement, including a significant amount of differential settlement, and very poor and inferior design and construction practices" in the low lying subdivisions of Mariner Cove, Marina Village and Marin Estates. "These subdivisions have settled to the point where they are subject to tidal flooding and extensive curb and street ponding".

FEMA mapped the floodplain limits within Corte Madera Creek on its FIRM Map dated 1976 (Refer to Exhibit C) with a base flood elevation of 6.0' NGVD.

Flood mapping of San Clemente Creek was prepared and shown in the Camp Dresser & McKee Inc. (CDM) June 1991 Report. The CDM Report identified Mariner Cove Subdivision, Marina Village Subdivision, Detention Storage Area south of Paradise Drive, and the Low areas along Highway 101 as potential flood areas. According to the CDM Report:

> *"Flood tides from the San Francisco Bay enter San Clemente Creek and pass generally unobstructed along the creek and into the Mariners Cove Subdivision located to the east. If the peak of the tide is high, it will overtop Paradise drive and enter the Detention Storage Area to the south. Flood tides will also overtop levees located on the west side of the creek and enter the storage pond of the Marina Village Pump Station. Under extreme flooding, tidal water will extend from the Marina Village area northerly along Highway 101."*

In addition, based the CDM report, the Earth Metrics, Inc. May 1992 Report stated that

> *"A count of the properties in the 100 year floodplain indicates that approximately 534 residential properties out of 738 are subject to flooding, as well as some 28 businesses."*

For comparison, the 1976 FEMA base flood elevation of 6.0' NGVD was plotted on the current 2006 topography (Refer to Exhibit D), which shows a greater area of potential flooding mainly due to land subsidence (i.e. settlement). As shown on Exhibit D, the base flood elevation of 6.0' NVD would inundate most of the waterfront properties in Mariner Cove including some inland properties and portions of adjacent streets.

5. IMPROVEMENTS

5.1. Introduction

We have studied solutions to address the two main conditions in the study lower watersheds:

- Flooding due to storm water runoff in areas that have an inadequate storm drainage system (interior drainage problems)
- Flooding due to tidal inundation

Of the two flooding conditions, tidal inundation has caused the majority of flooding in residential properties (yards and some garages), but street ponding due to an inadequate storm drainage system and differential settlement has become very common and continues to be a major concern for the Town and the residents.

The solutions to these two flooding problems are basically independent of each other, yet both need to be solved for a total comprehensive solution.

We propose that the solutions to these two flooding conditions be phased, with the intent that the solutions to the inadequate storm drainage systems be constructed first. This is because we anticipate that construction of these interior drainage improvements would present significantly fewer and lesser environmental impacts than solutions to the tidal flooding problems. Thus construction of the interior drainage improvements could begin much earlier than tidal inundation improvements.

5.2. Recommended Storm Drainage Improvements

In general, the solution to the inadequate storm drainage system is to provide continuous curb drainage in areas of curb ponding and to replace and/or augment the existing storm drainage system with new storm drain pipes, catch basins, manholes and pump stations to discharge storm flows including storm events coincident with high tides.

The recommended storm drainage improvements are as follows:

Watershed #6 (Marin Estates south of Paradise Drive and Paradise Drive). Refer to Exhibit G, Sheet 3.

1. Replace some existing standard curb and gutter with Grated Line Drains in the gutter.
2. Install additional street catch basins.
3. Replace some existing storm drain pipes with larger pipes.
4. Install additional new storm drain pipes and manholes.

Watershed #5 (Marina Village north of Paradise Drive). Refer to Exhibit G, Sheet 2.

1. Install one (1) Underground Submersible Storm Water Pump Station north of Harbor Drive (near House #121).
2. Replace some existing standard curb and gutter with Grated Line Drains in the gutter.
3. Install additional street catch basins.
4. Replace some existing storm drain pipes with larger pipes.
5. Install additional new storm drain pipes and manholes.

Watersheds #6 and #7 (Mariner Cove north of Paradise Drive). Refer to Exhibit G, Sheets 1 and 2.

1. Install six (6) Underground Submersible Storm Water Pump Stations at the following locations:
   - At west end of Spindraft Passage (near House #2 and #6)
   - Near the middle of Channel Drive (near House #14 and #18)
   - Near the intersection of Golden Hind Passage and Seawolf Passage
   - Near Houses #163 and #167 Golden Hind Passage
   - Near Houses #287 and #289 Golden Hind Passage
   - Near Houses #323 and #327 Golden Hind Passage
2. Replace some existing rolled curb and gutter with Grated Line Drains in the gutter.
3. Install additional street catch basins.
4. Replace some existing storm drain pipes with larger pipes.
5. Install additional new storm drain pipes and manholes.

The storm water pump stations will be relatively small and submersible (i.e. below ground) with 6' diameter, 8' diameter, or 10'x10' square wet wells. For a typical pump station layout refer to Exhibit H. For typical submersible pump station details and photo refer to Exhibit I.

The storm water pump stations will be provided with a gravity by-pass pipe in case of pump station failure. The existing gravity pipes near the pump stations will be used for the by-pass pipes. Just upstream of the gravity by-pass pipe a Gravity By-Pass Manhole will be installed with a "Duck-Bill" check valve. The manhole invert will be one and one-half foot lower than the check valve invert to provide room for sediment without obstructing the "Duck-Bill" check valve. (Refer to Exhibit Q.)

In areas where there is street ponding or "bird baths" due to differential settlement, the existing curb and gutter will be replaced by segments of Grated Line Drains. For typical Grated Line Drains details and photos refer to Exhibit J.

5.2.1. Alternative Storm Drainage Improvements

The Alternative Storm Drainage Improvements that were considered were as follows:

1. Providing fewer and larger pump stations. This alternative was evaluated and ruled out because it is impractical in such a relatively flat watershed. This alternative would require much larger and deeper pipes (in some cases, deep below groundwater) to combine subwatershed areas and connect them to the new pump stations. These larger pump stations would also have to be at a much greater depth.
2. Replace existing storm drain pipes with larger pipes instead of constructing new pump stations. This alternative was evaluated but also ruled out because it would not eliminate street ponding/flooding during moderate to high tide events. Larger storm drain pipes would provide little benefit during high tides because the high tide elevations are almost as high as the existing catch basin grate elevations.

5.3. Recommended Tidal Inundation Improvements

In general, the solution to the tidal inundation is to install a floodwall along the Bay and San Clemente Creek and to raise the existing Marta Marsh levee to protect against high tide events.

Upon reviewing the past reports and tidal studies, we recommend using the Corps of Engineers (COE) preliminary 100 year design elevations for this Study with the following modification – that the Floodwall 100 Year Design Elevation along the Bay be set to 11.0' NGVD because we believe that the Corps wave run-up of 5.0' can be reduced by placing rock rip-rap in front of wall, which will absorb some of the energy. We recommend that the Floodwall 100 Year Design Elevation along the Creek be set at the Corps recommended 8.0' NGVD.

Table 3
San Clemente Creek
Preliminary 100 Year Design Elevations (NGVD)

	Stillwater Tide	Stillwater Tide (Future)	Wave Run-up	Freeboard	Total	Design Elevations
May 1996						
COE						
(NGVD)		Year 2050				
(ALONG BAY)						
Floodwall	6.1	6.7	5.0	1.0	12.7	13.0
Levee	6.1	6.7	2.5	1.0	10.2	11.0
(ALONG CREEK)						
Floodwall	6.1	6.7	0	1.0	7.7	8.0
Levee	6.1	6.7	0	1.0	7.7	8.0
May 1986						
W&K						
(NGVD)		Year 2085				
(ALONG BAY)						
Floodwall	7.1	9.0	2.0	1.0	12.0	12.0
Levee	7.1	9.0	2.0	1.0	12.0	12.0
(ALONG CREEK)						
Floodwall	7.1	9.0	0	1.0	10.0	10.0
Levee	7.1	9.0	0	1.0	10.0	10.0

The recommended tidal inundation improvements are as follows:

Watershed #5 (Marina Village) and Watershed #6 (Mariner Cove) north of Paradise Drive). Refer to Exhibit K.

1. Install steel sheetpile floodwall with concrete facing and cap along the Bay side with an initial top of wall at Elevation 8.0 NGVD. (See Exhibit M, Sheet 1 of 3.) Wall to be constructed with enough sheetpile embedment to allow the top of the wall to be raised by up to 5 feet in the future. This would allow for additional future protection (up to 100-year) and could account for future settlement.

For comparison, Elevation 7.0 NGVD is the minimum allowable floor elevation for new building construction in a flood plain in Corte Madera, per Town ordinance.

2. Install steel sheetpile floodwall with concrete facing and cap along the creek side with an initial Top of Wall Elevation 8.0 NGVD. (See Exhibit M, Sheet 3 of 3.) Wall to be constructed with enough sheetpile embedment to allow the top of the wall to be raised by up to 2 feet to account for future settlement.
3. Raise existing earth levees along Marta Marsh to Elevation 8.0 NGVD, which is the Corps of Engineers (COE) preliminary 100-year design elevation and the same elevation as the floodwall along the Creek. (See Exhibit N.)
4. Install rock rip-rap in front of bay side floodwall in locations shown on Exhibit K. (See Exhibit M, Sheet 2 of 3.)
5. Install access stairs across the floodwalls at selected locations. (See Exhibit O, Sheets 4 and 5 of 5.)
6. Remove and replace those portions of existing docks as necessary to construct the floodwalls and install rip-rap where shown.
7. Install lined drainage ditch behind floodwalls. (See Exhibit O, Sheet 3 of 5.)
8. Install gravity outlet drainage boxes. (See Exhibit O, Sheet 3 of 5.)
9. Install outlet pipes with "duckbill" check valves. (See Exhibit O, Sheet 3 of 5.)

The heights above ground level of the floodwalls and levee will vary along their lengths, as shown on Exhibit L. In general, most of the length of the floodwall varies in height from approximately 3 ± feet to 5 ± feet above the existing ground at the floodwall location. However, as shown on Exhibit L, some segments of the floodwall will be lower or higher in height than this range.

For floodwall typical sections refer to Exhibit M.

For levee typical section refer to Exhibit N.

For floodwall details refer to Exhibit O.

We recommend that the floodwalls be sheet piling for the following reasons:

- There will be a minimal permanent encroachment on each property due to the narrow width of the wall.
- Sheet piling tends to have less settlement due to the weight of the wall than any other types of wall, especially in or over Bay Mud.
- Sheet piling will provide a better subsurface barrier against ground water seepage than other types of walls.

We also recommend that the sheet piling be made of steel because it is stronger than other material, which is especially required along the Bay segment, for the greater loading conditions.

5.3.1. Alternative Tidal Inundation Improvements

The alternative tidal inundation improvements that were considered were as follows:

1. Alternative "A" – Provide higher initial top of floodwall elevation of 11.0 ft NGVD on the Bay segment to provide the Corps of Engineers 100 year design protection. Refer to Exhibit P.

   Some advantages of initial top of floodwall elevation 11.0 ft NGVD:

   - It would provide the Corps of Engineers 100 year design protection immediately.
   - It would avoid future raising of floodwall and the associated construction impact on property owners, except if there was future land subsidence in which case the wall might be raised.

   Some disadvantages of initial top of floodwall elevation 11.0 ft NGVD:

   - The property owners along the Bay would have a significant visual and access impact due to the additional 3 feet of floodwall height.
   - This alternative does not eliminate the potential for future floodwall raising caused by future land subsidence.

2. Alternative "B" – Use vinyl sheet piling on the Creek segment only (steel sheet piling would still be required on the Bay segment because of greater loading conditions).

   Some advantages of vinyl sheet piling are as follows:

   - Lower material and installation costs
   - Lighter and easier to install
   - Salt water corrosion resistant
   - Comes in different colors (standard gray or clay)

   Some disadvantages of vinyl sheet piling are as follows:

   - Tends to have more deflection than steel sheet piling, especially when encountering "floating boulder" in the bay mud.
   - Fire and heat damage potential
   - Resistance to some solvents is poor
   - Other colors of vinyl such as brown, blue and green are expensive and could be more costly than steel sheet piling
   - More difficult to extend wall height than steel

3. Alternative "C" – Raise existing house foundation walls and provide new floodwall between houses. This alternative was studied by the Corps of Engineers in their 1996 report. The Corps alternative "consisted of raising approximately 130 homes along San Francisco Bay and San Clemente Creek. House foundations would be modified and raised to 9 feet NGVD along the bayfront and to 8 feet NGVD along San Clemente Creek. The raised foundations would be connected together by floodwalls between adjacent houses, providing a continuous floodwall with a 100-year level of protection for all property inboard of the foundations. Existing levees

along Muzzi Marsh, and on the west side of San Clemente Creek would be raised to 8 feet NGVD."

This alternative was ruled out by the Corps at the early stage of their study because of the significant effects on the homeowners. These effects included temporary displacement of all waterfront residents during construction and significant changes to appearance and character of the neighborhoods. These changes would be due to the increased height of the house ridgelines above street level that would create a visual "looming effect" along the waterfront. In addition, the waterfront homeowners would lose their backyards to periodic flooding. For the above reasons, we have also ruled out this alternative.

4. In addition to the three alternatives above, the other flood barriers that were considered but ruled out were:

    - Earth Levees – were ruled out because of the very large permanent encroachment on each property and the large potential for settlement due to the earth levee weight on the weak bay mud soils.
    - Concrete or Masonry Floodwalls on Spread Footing – were ruled out because they would require excessively large spread footings and would still have the potential for greater settlement than sheetpiling. In addition, these types of walls would not provide as good of a subsurface barrier against groundwater seepage as sheetpiling.

6. IMPACTS

6.1. Potential Environmental Impacts

The recommended storm drainage improvements will have very localized disturbance to existing wetlands at the locations of proposed stormwater pump stations discharge pipes and discharge structures. Because of this localized disturbance, the storm drainage improvements may only require a JARPA permitting process.

The recommended tidal inundation improvements will disturb the existing wetlands for almost the full length of the proposed floodwalls and levees which will require a CEQA review. It is anticipated that a full Environmental Impact Report (EIR) will be required for the tidal inundation improvements.

The placement of floodwalls, levees, rock riprap, temporary rock construction pads and discharge pipes and structures in wetlands are considered "fill". The temporary working pad disturbance (for the floodwalls) is estimated to be approximately 4.5 acres total.

Based on past reports, "there are two endangered species documented as being present in or near the project area, the salt march harvest mouse and the California clapper rail."

During the review of the permit application process and pursuant to Section 7 of the Endangered Species Act, a determination will be required as to whether or not the construction activities related to the improvements "will have adverse impacts on the continued existence of threatened or endangered species or on critical habitats for these species." A mitigation plan would probably be required for replacement of any lost habitat and wetlands.

6.2. Existing Property Impacts

The impacts to the existing properties due to the recommended storm drainage improvements would include property disturbance due to installation of storm water pump station discharge pipes between some of the houses and installation of storm water discharge structures behind the rear yards of some of the houses.

The impacts to the existing properties due to the recommended tidal inundation improvements would include visual and view impacts to the houses directly along the Bay and San Clemente Creek due to the installation of the floodwalls. The floodwalls would impair property owners' access to the water and to their boat docks. In addition, these properties would be disturbed during construction of the floodwalls, stairs over the floodwalls, drainage swales, pump station outfall pipes, and drainage facilities constructed behind the floodwalls.

6.3. Jurisdictional Assessment

Both the recommended storm drainage improvements and recommended tidal inundation improvements will be within the jurisdictions of the following agencies.

1. U.S. Army Corps of Engineers (Corps)
2. U.S. Fish and Wildlife Service (USFWS)
3. National Marine Fisheries (NMFS)
4. California Department of Fish and Game (CDFG)
5. California Regional Water Quality Control Board (RWQCB)
6. Bay Conservation and Development Commission (BCDC)
7. Town of Corte Madera

Depending on the scope and location of the recommended improvements, permits will be required from some or all of the above Jurisdictions.

We anticipate that the following permits will be required:

- BCDC Permit
- Corps Section 404 and/or Section 10 Permit for placing fill that into the waters and/or wetlands of the United States. The Corps will consult with USFWS and NMFS as part of their permit process.
- CDFG Streambed Alteration Agreement is likely to be required.
- RWQCB Letter of Determination. RWQCB will also need a copy of the BCDC Permit as a part of their review process.
- National Pollution Discharge NPDES Permit. Required for construction of the floodwall sumps with tide gates and stormwater pump station discharge pipes and structures. These permit regulates the discharge of pollutants from a point source into navigable waters.
- Town of Corte Madera Building, Grading and Erosion Control Permits.

6.4. Federal Emergency Management Agency (FEMA) Requirements

If the Town of Corte Madera decided to update the Town's FEMA Flood Insurance Rate Map (FIRM), FEMA would have the following requirements.

For FEMA's review of the recommended tidal inundation improvements, FEMA would require that a Levee/Floodwall System Analysis Form be filled out.

For a project to provide 100-year protection in what they would consider a "coastal" setting, FEMA would require that the following minimum freeboard be provided above the base flood elevation:

Coastal

1.0 foot above the height of the one percent wave for the 100-year stillwater surge elevation or maximum wave runup (whichever is greater).

2.0 feet above 100-year stillwater surge elevation.

The Bay side floodwall would need to be raised to Elevation 11.0 NGVD.

A stability and seepage analysis of the existing levee system would need to be performed to FEMA standards in and north of the study area, which may include the North Levee along the old railroad right-of-way to Corte Madera Creek. Based on the FEMA Levee/Floodwall System Analysis, improvements to the North Levee system may also be required.

FEMA also requires that for 100 Year protection, all storm water pump stations be provided with permanent "on-site" non-interruptible power source, such as stand-by generators.

For the Town to obtain a revision to the FEMA Flood Insurance Rate Map (FIRM), they would have to submit an Interior Drainage Study of the site. Once FEMA accepts the study, they will issue an A-99 Interim Designation Letter of Map Revision (LOMR).

7. SUMMARY OF COST ESTIMATES

7.1. Introduction

The following budgetary level construction cost estimates were prepared using escalated unit prices to mid 2008.

The construction cost estimates do not include any cost for utility relocations, permanent or temporary construction easements, environmental studies, permitting, or engineering design services (Refer to Appendix A).

7.2. Storm Drainage Improvements

The recommended storm drainage improvements have an estimated total construction cost of $9,800,000. The breakdown by tributary sub-watershed is as follows (Refer to Exhibit G):

Table 4
Recommended Storm Drainage Improvements
Engineer's Cost Estimate (2008 Prices)

ITEM NO.	ITEM DESCRIPTION	COST
1	Trib A	$ 72,000
2	Trib B	$ 1,380,000
3	Trib C	$ 53,000
4	Trib D	$ 440,000
5	Trib E	$ 101,000
6	Trib F	$ 772,000
7	Trib G	$ 280,000
8	Trib H	$ 562,000
9	Trib J	$ 148,000
10	Trib K	$ 923,000
11	Trib L	$ 501,000
12	Trib M	$ 1,224,000
13	Trib N	$ 508,000
14	Trib P	$ 885,000
15	Trib Q	$ 977,000
16	Trib Paradise Drive	$ 330,000
17	Trib South of Paradise Drive (Including Tribs R, S, T and Miscellaneous)	$ 565,000
	RECOMMENDED STORM DRAINAGE IMPROVEMENTS GRAND TOTAL	**$ 9,721,000**
	RECOMMENDED STORM DRAINAGE IMPROVEMENTS ROUNDED TOTAL	**$ 9,800,000**

In addition, for comparison the following Table 5 is the approximate Pump Station construction cost breakdown by pump station size.

Table 5
Approximate Pump Station Cost By Size
Engineer's Cost Estimate (2008 Prices)

TRIB NO.	APPROX. TRIB DRAINAGE AREA (ACRES)	APPROX. NO. OF PUMPS	APPROX. CAPACITY OF EA. PUMP (CFS)	APPROX. TOTAL PUMP STATION CAPACITY (CFS)	APPROX. PUMP STATION COST*
Trib B	16.22	3	6.7	20	$ 560,000
Trib D	2.58	1	5.0	5	$ 250,000
Trib F	13.31	3	5.0	15	$ 390,000
Trib K	8.40	2	5.0	10	$ 280,000
Trib M	13.49	3	5.0	15	$ 390,000
Trib P	8.33	2	5.0	10	$ 280,000
Trib Q	15.07	3	5.0	15	$ 390,000

*Note: Approximate Pump Station Cost does not include a contingency in the above Table. (Refer to Appendix A.)

7.3. Tidal Inundation Improvements

The recommended tidal inundation improvements have an estimated total construction cost of $16,200,000.

7.3.1. Alternative Improvements

Alternative "A" (Bay Side Floodwall Top Elevation = 11.0 NGVD) tidal inundation improvements have an estimated total construction cost of $16,800,000.

Alternative "B" (Creek Side Vinyl Sheet Pile Floodwall) tidal inundation improvements have an estimated total construction cost of $14,000,000.

7.3.2. Future Floodwall Extensions

The approximate estimated construction cost to raise the floodwalls (in 2008 Prices) are:

Bay (+8 NGVD to +13 NGVD) and Creek (+8 NGVD to +10 NGVD) = $3,300,000.

7.4. Potential Funding Sources

The following are potential funding sources:

- Town's General Fund
- Assessment District(s)
- User Fees
- Bonds
- Storm Drainage Fees for Development and Redevelopment Projects
- Federal Grants

Of the sources listed, assessment districts, user fees, and bonds require elections that are subject to the California Constitutional Amendment added by Proposition 218, which was passed in 1996. This amendment requires a two-thirds majority for approval. While benefit assessments only require a majority vote, the votes are weighted in proportion to property assessments.

"Storm Drainage Fees for Development and Redevelopment Projects" can be imposed without an election, but this option is limited because most of the study area has already been developed with no plans for redevelopment.