SHORE EROSION CONTROL REPORT

PREPARED FOR:

ARUNDEL-ON-THE-BAY
PROPERTY OWNER'S ASSOCIATION
P.O. Box 4665
Annapolis, MD 21403

July 2009

Andrews, Miller & Associates

A DIVISION OF DAVIS, BOWEN & FRIEDEL, INC.
ARCHITECTS ENGINEERS SURVEYORS

❑ 401 ACADEMY STREET, SUITE 1, CAMBRIDGE, MD 21613 • 410.228.7117 • FAX 410.228.2735
❑ 15 OLD SOLOMONS ISLAND ROAD, SUITE 104, ANNAPOLIS, MD 21401 • 410.897.1004 • FAX 410.897.1005
❑ ONE PLAZA EAST, SUITE 200, P.O. BOX 93, SALISBURY, MD 21803-0093 • 410.543.9091 • FAX 410.543.4172
❑ 23 NORTH WALNUT STREET, P.O. BOX 809, MILFORD, DE 19963 • 302.424.1441 • FAX 302.424.0430
❑ 106 NORTH WASHINGTON STREET, P.O. BOX 1065, EASTON, MD 21601-3128 • 410.770.4744 • FAX 410.770.4515
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SHORE EROSION CONTROL REPORT

ARUNDEL ON THE BAY PROPERTY OWNERS ASSOCIATION
ANNE ARUNDEL COUNTY, MARYLAND

TABLE OF CONTENTS

A. PURPOSE

The purpose of this report is to provide Arundel-on-the-Bay Property Owner's Association (AOTB) a general plan/study/analysis tool to assist in planning for maintaining and improving the shore erosion control measures located along the community's +/- two miles of shoreline. Included within this report are the following:

- Coastal Processes Analysis.
- Base Map with conceptual design layout.
- Conceptual Design Details.
- Opinion of Probable Costs.

Although a roadside drainage analysis was not included within the current scope of this report, consideration should be given for future roadside improvements to convey storm water runoff through the shore erosion control protection measures.

B. BACKGROUND

According to a letter from the Anne Arundel County Office of Budget dated April 1, 2004, AOTB has been a valid Shore Erosion Control District since the fall of 1934. Maryland Annotated Code (Article 25,167F) allows the County to impose a shore erosion control tax for *"maintenance, repair and reconstruction of shore erosion control works".* The Anne Arundel County Code (Article 6, 3-106) details the budget process whereas Article 6, 3-102 outlines the administrative affairs of the Erosion Control District.

Since the late '70s, Andrews, Miller & Associates (AMA) has been involved with the design and permitting for many of the shore erosion control measures currently lining the Chesapeake Bay within the Community. During the tenure of Ms. Wilma Coble in 1982 and earlier, AMA designed the bulkhead renovation (AMA# 7705) including armor stone enhancement for the shoreline extending from Cedar Avenue to approximately 300' south of Magnolia Avenue (excluding the shoreline extending from Redwood Avenue to 200' north of Sycamore Avenue). The majority of these proposed improvements were ultimately implemented under the State of Maryland's Shore Erosion Control funded program, administered as a tax district referenced above. Stone breakwaters were designed by AMA in 1989 and ultimately constructed under Mr. Steven

Ford's direction outboard of the Community's park along Magnolia Avenue (AMA# 89012). After Hurricane Isabel in 2004, an analysis of the shoreline's condition (as impacted by the hurricane) extending from Cedar Avenue to Chestnut Avenue, Hollywood Avenue to Narraganset Avenue, at Rockway Avenue and the bulkhead along the Community Park's shoreline (AMA# 04014) was performed under the tenure of Mr. Frank Florentine. Construction of the stone revetment located at the end of Rockway Avenue was ultimately constructed in 2008 using FEMA/MEMA moneys. Copies of the previously prepared reports and MDE/USACE permits obtained by AMA are included in the Appendix of this report.

C. STUDY AREA

Located south of Annapolis on a +/- 100 acre peninsula, the Arundel-On-The-Bay residential community fronts on the Chesapeake Bay to the east and south and on Fishing Creek to the west (Figure 1).

Figure 1

ADC Map Permit Use #20710173

The 1847 peninsula that formerly separated the waters of Fishing “Cove” from the Chesapeake Bay ultimately eroded thereby opening the “Cove” to the Bay. Fishing “Cove” has subsequently become known as Fishing Creek after the erosion of the peninsula (Figure 2).

Due to the extent of the study area, which consists of approximately 2 miles of shoreline (see Figure 1), the project’s study area was divided as follows: “Bay Frontage” extending from Cedar Avenue-East to Narraganset Avenue, “The Point Frontage” extending from Narraganset Avenue to Magnolia Avenue-West, and “Fishing Creek Frontage” extending from Magnolia Avenue- West to Cedar Avenue- West.

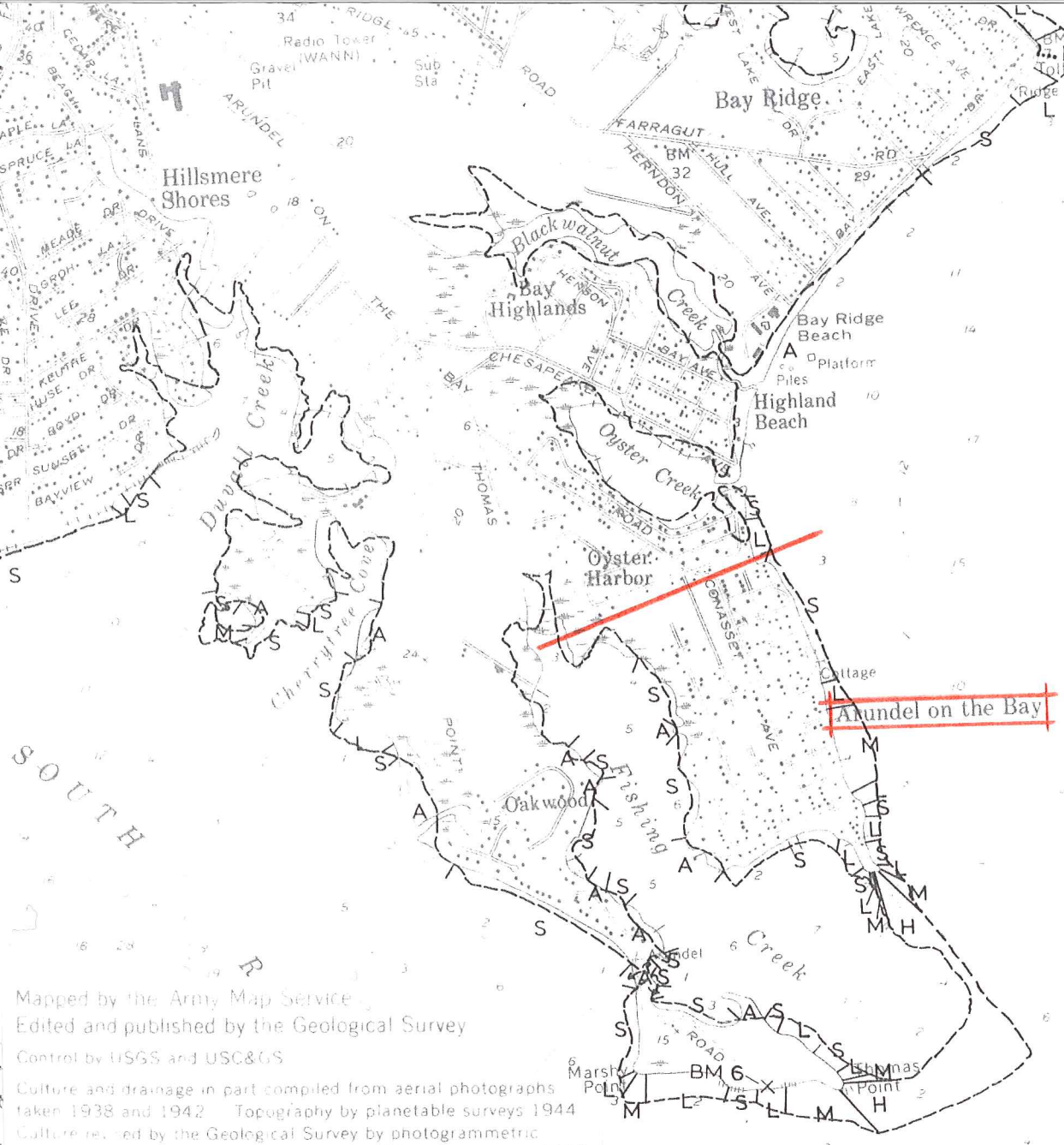
D. COASTAL PROCESSES ANALYSIS

In order to evaluate potential wave conditions along the three frontages referenced, an evaluation of off-shore and near shore site conditions was conducted. Our evaluation and recommendations are presented in the following paragraphs.

Water Levels: Normal water level variations at the AOTB area are generally dominated by astronomical tides, although wind effects can be important. Astronomical tides are semi-diurnal tides, with a period of approximately 12.5 hours, resulting in two high tides and two low tides each day. The mean tidal range at the site is approximately 1.0 feet.

During storm conditions, water levels are dominated by storm surge and wave setup in combination with astronomical tides. Storm surge is a temporary rise in water level generated either by large scale extra-tropical storms known as northeasters or by hurricanes. The rise in water level results from wind stresses, the low pressure of the storm disturbance and the Coriolis force. Wave setup is a term used to describe the rise in water level due to wave breaking. A comprehensive evaluation of storm-induced water levels for several Chesapeake Bay locations has been conducted by the Virginia Institute of Marine Science (1978) as part of the Federal Flood Insurance Program.

Storm surges result in more extreme water levels, which affect flooding, overtopping of structures and maximum expected depth limited wave heights in shallow areas. The closest recording station located to



Mapped by the Army Map Service
Edited and published by the Geological Survey
Control by USGS and USC&GS
Culture and drainage in part compiled from aerial photographs taken 1938 and 1942. Topography by planetable surveys 1944
Culture revised by the Geological Survey by photogrammetric methods from aerial photographs taken 1955. Field check 1957
Hydrography compiled from USC&GS charts 550 (1951) and [illegible]

Map prepared by Maryland Geological Survey with funds from National Oceanographic Atmospheric Administration (NOAA) made available through Department of Natural Resources Coastal Zone Management Program
Compiled by Robert D. Conkwright, 1975
Basic data from M.G.S. Bulletin 6

HISTORIC EROSION RATE MAP

SCALE 1:24000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY [illegible] FEET

Erosion Rate Graphs

A. Line graphs represent a measured rate of erosion for specific points along the shoreline.

B. Histograms indicate prevalent erosion rate categories for different shoreline areas.

FIGURE 2

1847 SHORELINE ————————
1934 SHORELINE —·—·—·—
BASE MAP SHORELINE 1970

Erosion Rate Symbols

1847-1934		1934-1970
A	accretion	a
S	slight <2	
L	low 2-4	l
M	moderate 4-8	m
H	high >8	h
F	fill	

low l

AOTB is Annapolis. The data for Annapolis is summarized in Table 1. It is assumed that these water levels apply to the AOTB area.

Table 1: Storm surge levels for selected return periods at Annapolis, Md.

Return Period	Surge Level (ft, NGVD)	Surge Level (ft, MLW)
10	4.0	3.7
25	5.2	4.9
50	6.2	5.9
100	7.2	6.9

Wave Conditions: In general, the wave height and period (time in seconds for two successive crests or troughs to pass a fixed point) of waves reaching an area are dependent on the fetch (distance over water that the wind blows for a given direction), depth of water over a given fetch, the wind velocity and duration. Longer fetch lengths, deeper water over the fetch, higher wind velocities and longer durations result in greater wave heights propagating into an area.

Fetch Determination: The wave approach directions (fetches) critical to the study area include the NE: "Bay Frontage"; SE: "The Point Frontage" and SW: "Fishing Creek Frontage". These fetch directions were chosen and the fetch lengths computed using the procedure contained in ETL 1110-2-305 (September 1983). The average depth along each fetch was also computed. These data are required to calculate the offshore wind generated wave heights and periods.

Design Wind Conditions: To evaluate the wind conditions in the AOTB area, an analysis of digital wind records from Baltimore Washington International (BWI) Airport was performed. This data was obtained from the National Climatic Data Center, a division of the National Oceanic and Atmospheric Administration (NOAA), for the period between 1951 and 1982. The wind data set included the fastest mile peak daily wind gusts over this period.

To determine the return frequency of various extreme wind events, an external analysis of the data set was performed based on a Gumbel distribution. This technique required a curve-fit of the statistical distributions

derived from the annual extreme wind speed information. Distributions were developed for each of the primary wind directions evaluated above. Since the primary purpose for developing wind conditions is to assess the local wave climate, fastest mile wind speed was converted to one-hour wind speed for input to the U.S. Army Corps of Engineers Automated Coastal Engineering System (ACES 1.07). These extremal wind conditions are shown in Table 2.

Table 2: Design wind speeds for different return periods (One-hour speed in mph)

Return Period Years	NE" "Bay Frontage"	SE "The Point"	SW "Fishing Creek"
5	31.1	31.1	38.6
10	36.4	37.1	45.3
25	44.6	46.8	55.5
50	51.9	54.8	64.1
100	59.8	64.1	74.7

Design Wave Conditions. Based on the design wind conditions developed above, storm wave climatology was developed for the primary wave approach directions affecting the study area using the shallow water wave forecasting equations as presented in the Automated Coastal Engineering System (ACES 1.07) computer program. Wave heights were developed corresponding to the wind speed and return period to develop the design storm wave conditions. A summary of this wind generated wave climatology is presented in Table 3.

Table 3: Design wave heights for various period storm events (ft.)

Return Period Years	NE" "Bay Frontage"	SE "The Point"	SW "Fishing Creek"
5	3.7	3.4	0.8
10	4.5	4.1	1.0
25	5.5	5.1	1.2

Note that the wave height for a 25 year storm event within Fishing Creek is 1.2'. This relatively small wave height is due to the limited off-shore fetch and the relatively shallow depths within the Creek. The sheltered shoreline has resulted in only slight erosion (<2'/yr.) as shown on the "Historic Erosion Rate Map" (Figure 2) since the 1800s. However, due to boat traffic within the Creek and the "potential" to create a boat wake >

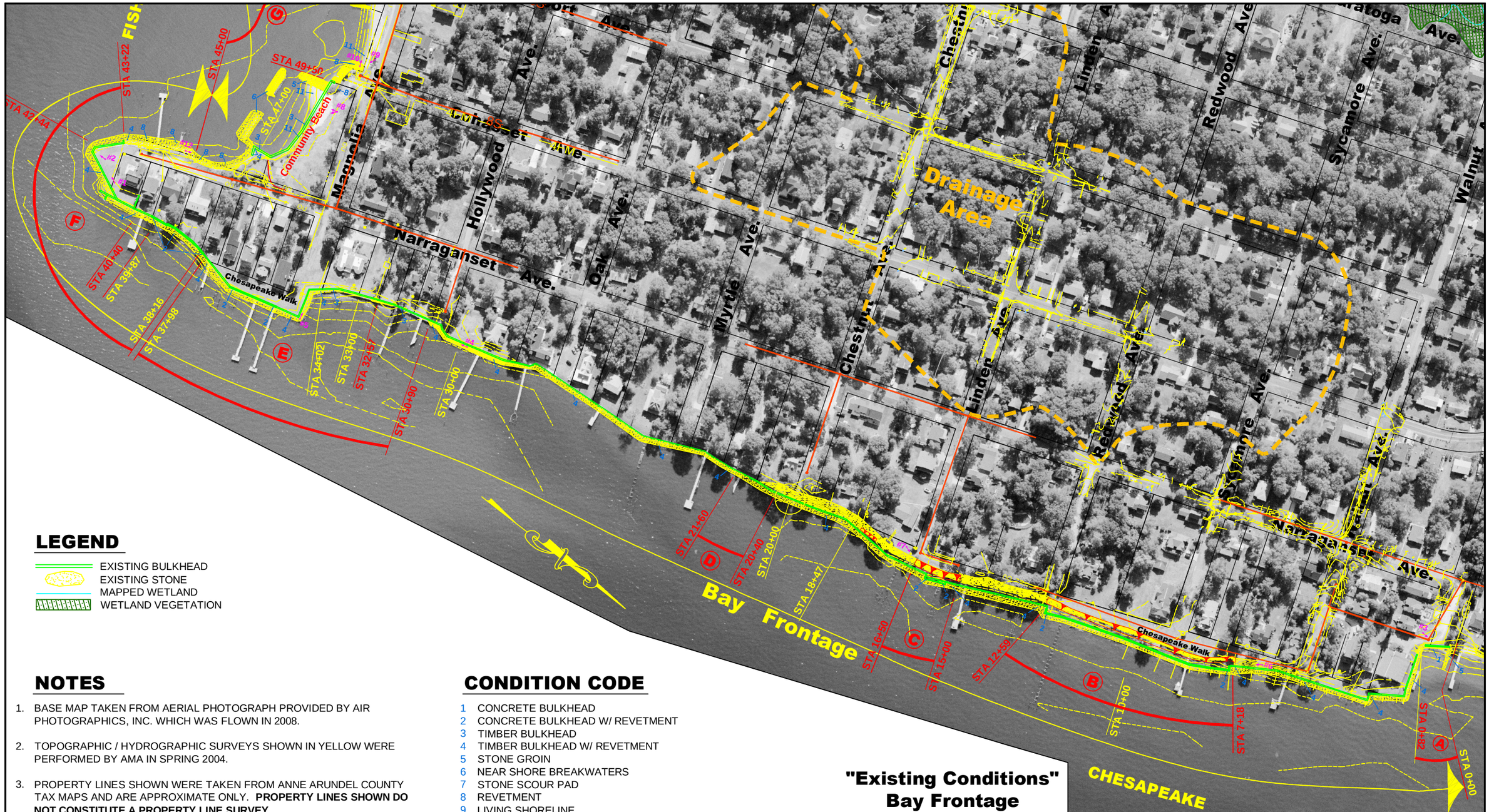
1.2', AMA recommends that any new or retrofitted stone structures within the Creek be designed for a minimum 2' high wave.

E. SHORELINE CONDITION SURVEY

"Bay Frontage": Approximately 4500' of shoreline along the "Bay Frontage" (Figure #3) extends from Cedar Avenue southerly to the westerly end of Narraganset Avenue. Various existing shore erosion control protection measures include concrete bulkheads, timber bulkheads and combinations of concrete/timber bulkheads supplemented with stone revetments. Newly reconstructed piers along with the decayed remains of storm damaged timber piers and groins are randomly located along the shoreline. A major shoreline improvement renovation project (designed by AMA) was performed during the mid '80s including construction of new timber bulkheads, placement of new and rearrangement/ enhancement of existing armor stone, and repair of many of the existing concrete bulkheads.

Stone Revetments

The majority of armor stones at the stone revetments located outboard of the bulkheads appear to be adequately sized for a 25 year storm event (standard used throughout the Chesapeake Bay). The exception is at Narraganset Avenue (Sta. 41+50) (Photo #1) where the range of armor stone is significantly undersized and to a lesser extent south of Chestnut Avenue (Sta. 21+00). Armor stone does not extend to the top of the bulkhead south of Chestnut Avenue (Sta. 21+00), thereby exposing the structure to the ravages of storms. Armor stone located at the point of Narraganset Avenue was catastrophically displaced during Hurricane Isabel but has subsequently been repositioned, apparently re-using the same undersized stone. Erosion land-ward of the shoreline improvement measures at this area has occurred, apparently due to waves overtopping the structure (Photo #2). Based upon design calculations for wave conditions along the Bay Front for a 25 year storm event (Appendix 1), the armor stone should range in size from 600# to 1600# when placed on a 2 horizontal to 1 vertical slope.



LEGEND

- EXISTING BULKHEAD
- EXISTING STONE
- MAPPED WETLAND
- WETLAND VEGETATION

NOTES

1. BASE MAP TAKEN FROM AERIAL PHOTOGRAPH PROVIDED BY AIR PHOTOGRAPHICS, INC. WHICH WAS FLOWN IN 2008.
2. TOPOGRAPHIC / HYDROGRAPHIC SURVEYS SHOWN IN YELLOW WERE PERFORMED BY AMA IN SPRING 2004.
3. PROPERTY LINES SHOWN WERE TAKEN FROM ANNE ARUNDEL COUNTY TAX MAPS AND ARE APPROXIMATE ONLY. **PROPERTY LINES SHOWN DO NOT CONSTITUTE A PROPERTY LINE SURVEY.**
4. REFER TO TABLE 4 FOR RECOMENDED SHORELINE AND UPLAND IMPROVEMENTS.

CONDITION CODE

1 CONCRETE BULKHEAD
2 CONCRETE BULKHEAD W/ REVETMENT
3 TIMBER BULKHEAD
4 TIMBER BULKHEAD W/ REVETMENT
5 STONE GROIN
6 NEAR SHORE BREAKWATERS
7 STONE SCOUR PAD
8 REVETMENT
9 LIVING SHORELINE
10 STONE FILLED GABIONS
11 SAND BEACH
12 MOUNDED REVETMENT
13 UNPROTECTED

GRAPHIC SCALE

0 125 250

(IN FEET)
1 inch = 250 ft.

"Existing Conditions"
Bay Frontage

Andrews, Miller & Associates

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DES:	—	DATE:	July 2009
DRN:	CDH	SCALE:	1" = 250'
CHK:	GOW	JOB #:	07062

Figure 3

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Photo #1

Photo #2

Little or no armor stone is located outboard of the concrete bulkhead at the end of Cedar Avenue (Sta. 0+00) (Photo #3) or the timber bulkhead located between Magnolia Avenue and Hollywood Avenue (Sta. 33+00) (Photo #4 & #5).

Photo #3

Photo #4

Photo #5

Bulkheads:

Although the majority of the older timber bulkheads, located behind the stone revetments, appear to be in varying states of decay, the massive amounts of armor stone located along the bulkhead's face have generally maintained the alignment of the older structures and have stabilized the upland immediately landward of the structures. However, several isolated and randomly spaced areas located landward of these bulkheads have developed sumps in the lawns. These sumps are apparently the result of soil leaking through gaps that have developed between the tongue and grooves of the timber sheets, through decayed sheeting, at gaps located around improperly sealed culverts/ conduits that penetrate the sheeting, at corners of bulkheads that were inadequately sealed, and at connections between timber and concrete bulkheads. Discussions with the homeowner located south of Hollywood Avenue described loss of fill due to undermining of the bulkhead's sheeting.

Approximately 850' of the shoreline along the "Bay Frontage" is protected with concrete bulkheads supplemented with stone revetments. The top elevations of the concrete bulkheads (except for the structure located south of Magnolia Avenue which is at elevation +5.4' MLW) are lower than the adjacent timber structures. The average top elevation of the Cedar Avenue concrete bulkhead is +3.0' MLW (+/- 6 year storm induced water level) whereas the concrete structures between Sycamore and Redwood Avenues and at Linden Avenue are +4.3' MLW (+/- 15 year storm level). The majority of the exposed concrete bulkheads have spalled surfaces (Photo #3).

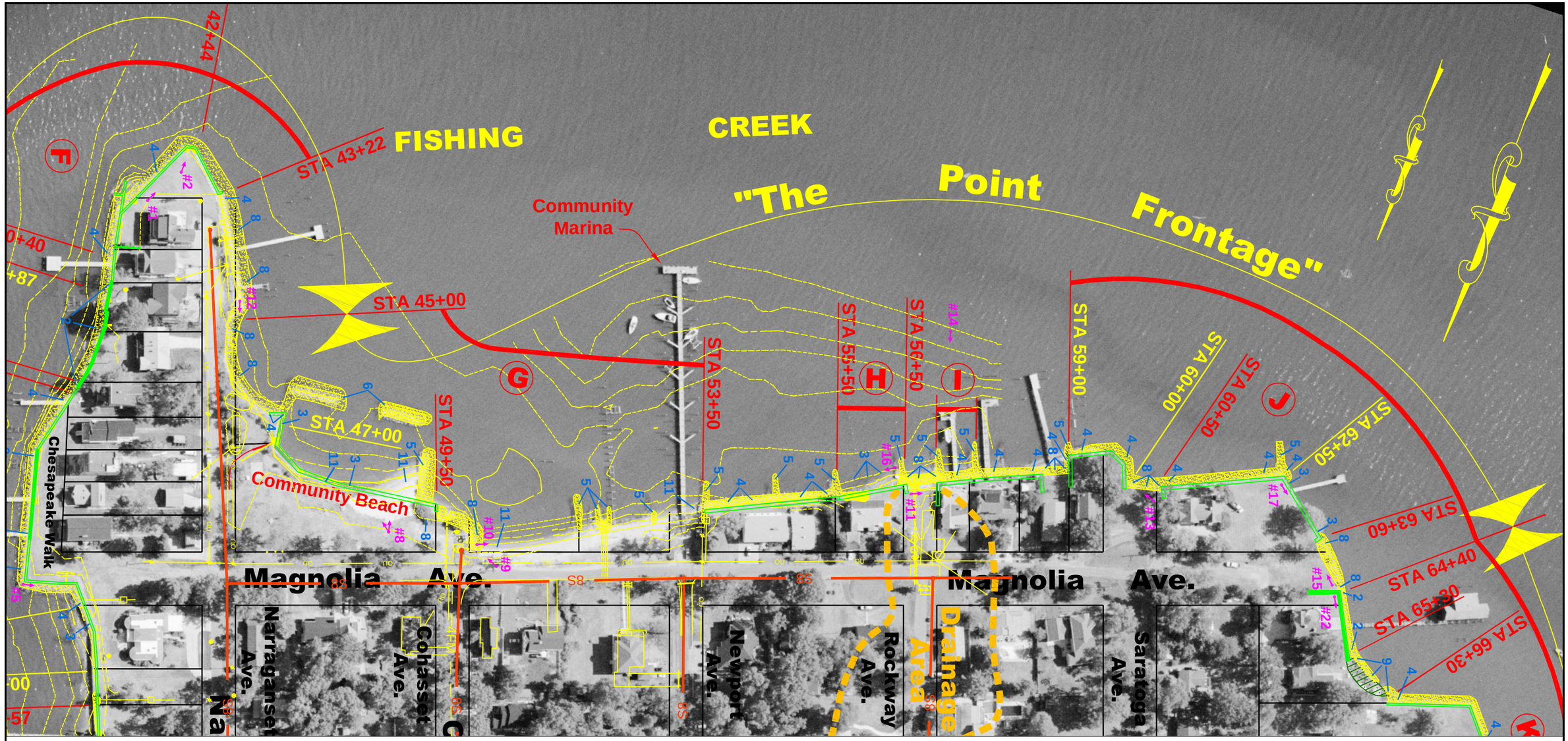
Apparently due to the lower elevation of the concrete bulkheads between Sycamore and Redwood Avenues and at Linden Avenue, erosion of the high banks landward and adjacent to the concrete bulkheads occurred during Hurricane Isabel. Further erosion of the bank could potentially threaten the stability of the sewerage system located landward of the banks at this area along Chesapeake Walk. The bank at the northerly end of Chesapeake Walk (about 100' north of Sycamore Avenue) has eroded to within about 15' of the sewer line (Sta. 7+20) (Photo #6). Significant erosion has also occurred landward and adjacent to the storm damaged concrete structure in the vicinity of Linden Avenue (Sta. 15+00) (Photo #7).

Photo #6 (2004)

Photo #6 (2008)

Photo #7

<u>"The Point Frontage":</u> Approximately 1940' of shoreline along the "The Point Frontage" (Figure #4) extends from Narraganset Avenue westerly to Magnolia Avenue. Various existing shore erosion control protection measures include timber bulkheads, segmented stone breakwaters (located outboard of the community beach), stone revetments, rubble revetments, stone groins, and timber bulkheads supplemented with stone revetments. The newly reconstructed community marina pier is located at the end of Newport Avenue. Two outfall pipes with flap valves (that drain portions of Newport and Magnolia Avenues) extending into Fishing Creek are located east of the community's marina. Decayed remains of storm damaged timber piers are randomly located along the shoreline.



NOTES

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4. REFER TO TABLE 5 FOR RECOMENDED SHORELINE AND UPLAND IMPROVEMENTS.

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7 STONE SCOUR PAD
8 REVETMENT
9 LIVING SHORELINE
10 STONE FILLED GABIONS
11 SAND BEACH
12 MOUNDED REVETMENT
13 UNPROTECTED

GRAPHIC SCALE

0 75 150

(IN FEET)
1 inch = 150 ft.

LEGEND

EXISTING BULKHEAD
EXISTING STONE
MAPPED WETLAND
WETLAND VEGETATION

"Existing Conditions"
The Point Frontage

Andrews, Miller & Associates

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CAMBRIDGE, MARYLAND (410) 228-7117
ANNAPOLIS, MARYLAND (410) 897-1004
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Figure 4

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Segmented Stone Breakwaters and Stone Groins

The top elevation of two existing stone breakwaters and terminal stone groin constructed in the late '80s at the community beach are on the order of +2.5' MLW (Sta. 49+00) (Photo #8) which is 1.5' lower than the design recommendations previously provided by AMA. The lower crest heights are apparently allowing wave energy to overtop the structures thereby creating excessive sand movement land-ward of the structures and erosion landward of the low profile timber bulkhead.

Photo #8

Low profile stone groins are randomly spaced along the shoreline beginning at the community's beach (Photo #9) and extending westerly beyond Rockway Avenue. A stone scour apron is at the storm drain outfall located east of the community marina. The top elevations of these structures and the undersized armor stones are providing limited shore erosion control protection.

The primary function of groins is to prevent or minimize the littoral transport of sand along a shoreline. Unless a shoreline is located in a sheltered area with limited offshore fetches or is supplemented with additional erosion control structures (i.e.: breakwaters) located off-shore to minimize the erosive energy of waves, groins are typically not recommended as a shore erosion control measure. Over time, storm generated waves have a tendency to seasonally shift the shoreline, ultimately migrating the mean high water line landward. This appears to be the scenario that has occurred between the community beach and the marina along Magnolia Avenue. The existing beach has migrated landward to about 25' from the paved roadway (Sta. 50+00) (Photo #10).

Photo #9

Photo #10

Revetments

The majority of the armor stones at the stone revetments and the stone revetments located outboard of the bulkheads located east of Saratoga Avenue appear to be correctly sized for a 25 year storm event. The stone revetment at the end of Rockway Avenue (Sta. 56+50) (Photo #11) was constructed in 2008 at a cost of approximately $700/ linear foot (which includes drainage improvements constructed immediately landward and through the structure).

Photo #11

Similar to the “Bay Frontage” conditions, the armor stone size along “The Point Frontage” should range from 600# to 1600# when placed on a 2 horizontal to 1 vertical slope. However, it was noted that combinations of concrete rubble, undersized armor stones, and gabion sized stone were incorporated into the revetments along the northwesterly side of Narraganset Avenue (Sta. 45+00) (Photo #12), the end of Saratoga Avenue (Sta.60+00) (Photo #13), and the end of Magnolia Avenue (Sta. 64+00). Erosion of the shoreline is actively occurring in the vicinity of Sta. 46+00.

Photo #12 Photo #13

Further, armor stone does not extend to the top of the bulkheads west of Rockway Avenue (Photo #13 and #14), thereby exposing the structures to the ravages of storms. Also, little or no armor stones are located outboard of the timber bulkheads at the Community's beach, east of Rockway Avenue, or immediately south of Magnolia Avenue (Sta. 63+00) (Photo #15)

Photo #14 Photo #15

Timber Bulkheads

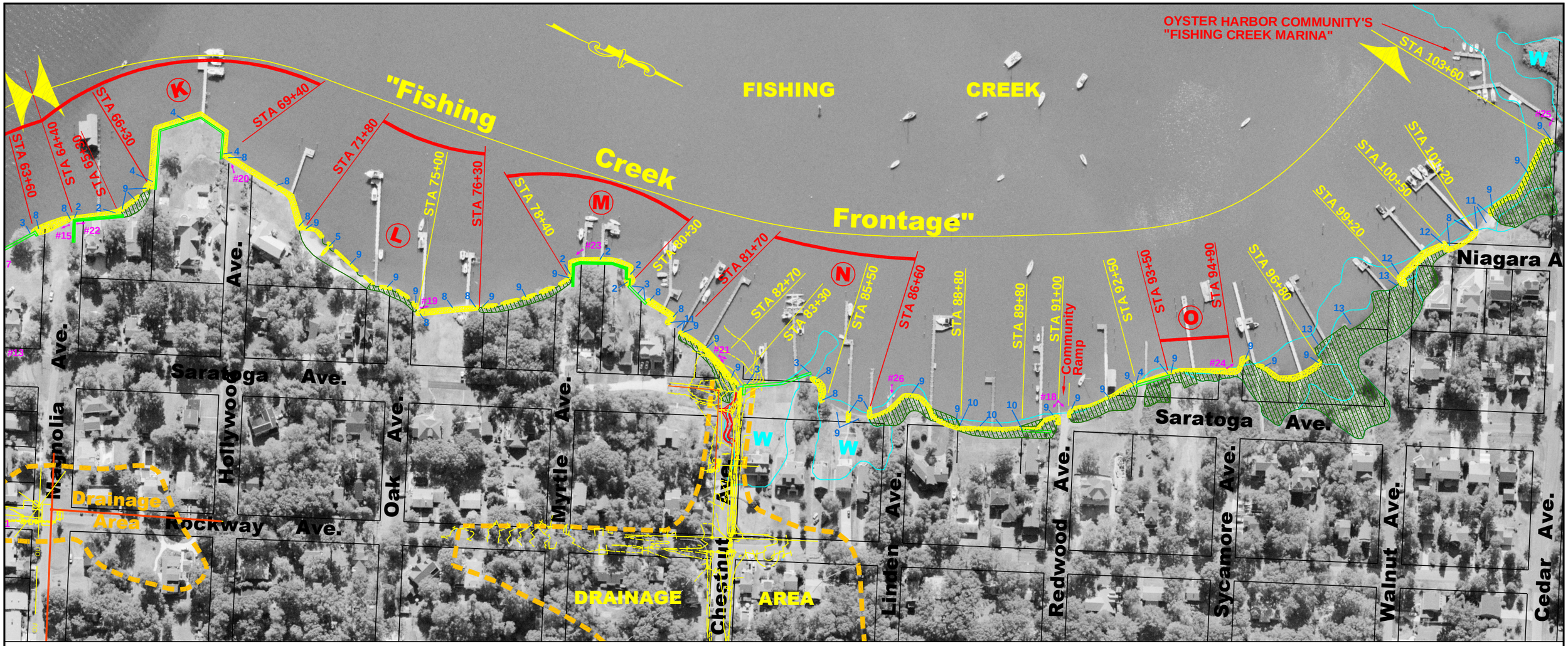
The existing timber bulkheads appear to be generally in good condition except for the structures located immediately east of Rockway Avenue (Sta. 55+00) (Photo #16) and south of Magnolia Avenue (Sta. 62+00) (Photo #17). The structure located immediately east of Rockway Avenue is in a general state of disrepair and is reaching the end of its serviceable life. The lawn behind the timber structure near Magnolia Avenue has numerous sumps. The top elevation of the existing low profile timber bulkhead located landward of the stone breakwaters at the Community's beach (Sta. 48+00) is on the order of +2.5' MLW

(18” above MHW). Soil has eroded from behind portions of the structure; apparently due to erosive wave energy overtopping the structure during storm events.

Photo #16 Photo #17

<u>“Fishing Creek Frontage”:</u> Approximately 3920’ of shoreline along the “Fishing Creek Frontage” (Figure #5) extends from Magnolia Avenue northerly to Cedar Avenue. Various existing shore erosion control protection measures include concrete bulkheads, timber bulkheads, stone revetments, stone filled gabion baskets, combinations of concrete/timber bulkheads supplemented with stone revetments and “Living Shoreline” type projects. Approximately 200’ of shoreline located south of Walnut Avenue is unprotected and heavily inundated with phragmites. Numerous piers line the shore and two boat houses/ shelters extend into the Creek. The Community’s boat ramp is located at the end of Redwood Avenue (Sta. 91+00) (Photo 18).

Photo #18



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4. WETLANDS SHOWN WERE TAKEN FROM TIDAL WETLAND MAP #85.
5. DRAINAGE AREA DELINEATION FLOWING TO CHESTNUT AVENUE-WEST DETERMINED FROM PRELIMINARY DRAINAGE STUDY PERFORMED BY ANDREWS, MILLER & ASSOCIATES. (SEE APPENDIX #3)
6. REFER TO TABLE 6 FOR RECOMENDED SHORELINE AND UPLAND IMPROVEMENTS.

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11 SAND BEACH
12 MOUNDED REVETMENT
13 UNPROTECTED

LEGEND

EXISTING BULKHEAD
EXISTING STONE
MAPPED WETLAND
WETLAND VEGETATION

GRAPHIC SCALE
0 100 200
(IN FEET)
1 inch = 200 ft.

"Existing Conditions"
Fishing Creek Frontage

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ANNAPOLIS, MARYLAND (410) 897-1004
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DES: —	DATE: July 2009	Figure 5
DRN: CDH	SCALE: 1" = 200'	
CHK: GOW	JOB #: 07062	

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Stone Revetments/ Reinforcement

Stone revetments are randomly located along the Fishing Creek shoreline. Types of stone structures include low profile revetments located north of Hollywood Avenue (Sta. 70+00) and between Myrtle and Chestnut Avenues (Sta. 81+00) incorporating small riprap to a high mounded revetment at Niagara Avenue (Sta. 100+00) incorporating large armor stones. Stone located between Linden Avenue and Chestnut Avenues (Sta. 85+30) has no defined shape and appears to have been dumped. Erosion is occurring behind the low profile revetment located north of Oak Avenue (Sta. 75+50) (Photo #19), apparently due to waves overtopping and eroding the ground behind the structure.

Stone reinforcement is located outboard of the existing timber and concrete bulkheads that protrude into the Creek at Hollywood Avenue (Sta. 68+00) and north of Myrtle Avenue (Sta. 79+50). These stone structures are conservatively sized for a 25 year storm event. Although providing scour protection, the armor stone does not extend to the top of the bulkheads (Photo #20). There is no armor stone outboard of the timber bulkhead at Saratoga Avenue located immediately north of Chestnut Avenue (Sta. 84+00).

Photo #19

Photo #20

Low profile stone filled gabions are another means of preventing erosion that has been utilized within the Creek between Linden and Redwood Avenues (Sta. 89+50). The gabions appear to be in good condition.

Based upon design calculations for wind generated wave conditions within Fishing Creek (Appendix 1), State Highway Administration Specification for Class I Rip-Rap (d50=40#) is adequate for a 25 year storm event when placed on a 2 horizontal to 1 vertical slope. Many of the existing low profile stone structures

within the Creek utilize this stone size. However, AMA recommends an armor stone range of 100# to 300# in the event boat wakes >1.2' (wave height for a 25 year storm event) occurs within the Creek.

Bulkheads

Except for the low profile horizontal beamed bulkhead located between Myrtle and Chestnut Avenues (Sta. 80+50) the existing timber bulkheads within the Creek are in a general state of disrepair. The timber structure that protects the point south of Hollywood Avenue (Sta. 69+00) has numerous decayed structural members. Filter fabric has been placed along the landward side of the sheeting which appears to have been previously reinforced with horizontal timber boards. Likewise, the structure located at Saratoga Avenue immediately north of Chestnut Avenue (Sta.84+00) (Photo #21) also has decayed structural members and is also reaching the end of its serviceable life.

Photo #21

The existing concrete bulkhead located north of Magnolia Avenue (Sta. 64+50) (Photo #22) is constructed of concrete blocks and appears to be in reasonably good condition although a sink hole has developed north of the existing pier. The top of another concrete structure that protects the point north of Myrtle Avenue (Sta. 79+00) is spalling. There is evidence that concrete was poured over the armor stone after it's initial placement. Although aesthetically unpleasing, the poured concrete/armor stone structure is apparently soil-tight since there is no evidence of soil loss behind the structure (Photo #23).

Photo #22

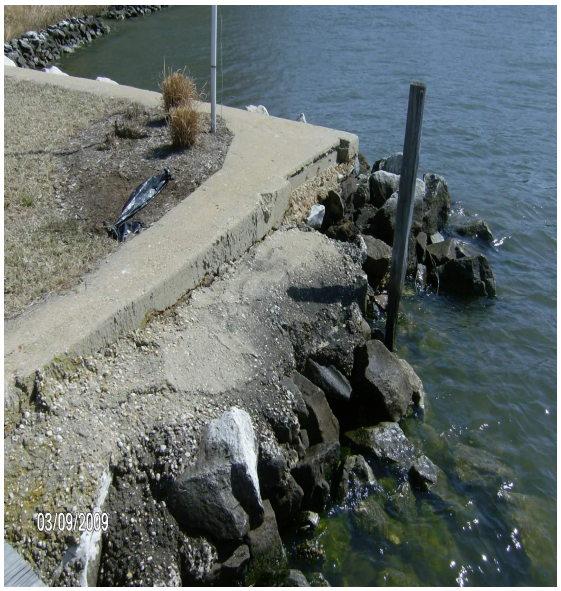

Photo #23

<u>"Living Shorelines"</u>

A <u>"Living Shoreline"</u> is a low cost means of shoreline protection for generally sheltered areas and is the preferred method of controlling shore erosion by the regulatory agencies (see "*Permitting Considerations*"). "Living Shorelines" have been extensively used to stabilize the shoreline within the Creek. This method of shoreline protection entails importing coarse sand fill material (if required) prior to sprigging wetland vegetation consisting primarily of spartina patens planted above the mean high water (MHW) line and spartina alterniflora planted between MHW and mid-tide. In order to minimize sand movement during and after establishment of the wetland vegetation, stone groins, sills, and/or segmented stone breakwaters are typically incorporated into the "Living Shorelines" construction.

All of these methods have been incorporated as a means of shoreline protection within the Creek to varying degrees of success. A high stone sill has recently been constructed north of Sycamore Avenue (Sta. 95+00) (Photo #24) whereas a low profile stone sill protects the wetlands at the head of the Creek (Sta. 103+60) (Photo #25). Little to no wetland vegetation is growing behind the "Living Shoreline" breakwater system located south of Oak Avenue (Sta. 72+00) or between groins located south of Linden Avenue (Sta. 86+00).

Photo #24 Photo #25

Erosion is occurring landward of the stone sill located south of Chestnut and Sycamore Avenues (Sta. 82+50) as well as south of Sycamore Avenue (Sta. 94+50). This apparently is the result of the top of the sill being too low and the lack of filter fabric up the landward edge of the sill. Waves and high tides overtop the structures and "wash" the sand/ bank material through the stone due to the lack of filter fabric.

Maintenance of the wetland vegetation is essential to ensure success of a "Living Shoreline" project. Maintenance should include removal of invasive species that migrate into the wetlands (i.e.: phragmites), trimming overhanging limbs to allow sunlight to shine on the vegetation, removal of leaves, flotsam, and other debris which could smother the vegetation, excluding waterfowl into the planted areas, limiting foot traffic, etc. Phragmites, an invasive and aggressive type of vegetation, is established along the shoreline and has invaded and overcome many of the wetland plantings associated with the existing "Living Shorelines" projects (Photo #26). Generally, it appears that maintenance is lacking on the majority of the "Living Shoreline" erosion control projects.

Photo #26

Although it is not within AMA's scope to review the special conditions listed in MDE/USACE permits issued for the "Living Shoreline" projects constructed within the Creek, the State typically includes conditions within their licenses as follows: 1) substrate fill material shall have *"no more than 10% of the material passing through a standard number 100 sieve"*, and 2) "*the project shall be maintained as a wetland, with non-nuisance species' aerial coverage of at least 85% for three consecutive years. If 85% coverage is not attained, the reasons for failure shall be determined, corrective measures shall be taken, and the area shall be replanted."*

These conditions are to ensure the success of the "Living Shoreline" erosion control project and to alleviate adverse impacts to the surrounding water body. For example, placing fine grained sand as part of a "Living Shoreline" project creates the potential for the material to erode during the normal tidal cycles and storm events. Once the material becomes suspended, the roots of the wetland plantings become exposed and the plants either die or wash into the Creek. The fine sand material, lost due to the erosion, then becomes a source of sediment thereby degrading water quality and filling the Creek's bottom. Similar to structural shore erosion control practices, maintenance and using the proper material is critical to the success of a 'Living Shoreline" project.

"Phragmites Shorelines"

Approximately 200' of shoreline located south of Walnut Avenue has no shoreline protection measures. However, the shoreline is heavily inundated with phragmites and does not appear to be eroding. While phragmites has low food and habitat value for wildlife (red wing blackbirds will nest in the reeds), obscures waterviews and is an invasive and aggressive form of vegetation, it is providing soil erosion control and shoreline protection along this section of shoreline.

F. PERMITTING CONSIDERATIONS

Numerous permits and approvals are necessary prior to construction of any shoreline improvements. Specific permits and approvals required are as follows: Maryland Department of the Environment (MDE) License, U.S. Army Corps of Engineers (USACE) Permit, the Anne Arundel County building and grading

permits, the Natural Resource & Conservation Resource's (NRCS) sediment and erosion control approval as-well-as the Chesapeake Bay Critical Areas Commission's (CAC) approval. Mitigation of disturbed areas landward of MHW with plantings of trees and/or shrubs is required as a condition for CAC approval. Depending upon the amount of disturbance, the channel-ward encroachment and the linear footage of the proposed improvements, the processing time necessary to obtain approvals from the various regulatory agencies currently range from 5 – 10 months.

During the permit approval process, MDE and the USACE considers the need for the proposed erosion control measure, the appropriateness of the structure for eliminating erosion, temporary and permanent impacts to the environment, potential effects to navigation, etc. Further, depending upon the magnitude of a proposed project, these agencies advertise the proposed project through public notices inserted in the local newspapers and direct notices to environmental agencies including the Environmental Protection Agency, Fish and Wildlife Service, National Marine Fisheries, Maryland Department of Natural Resources, et al.

On October 1, 2008, the "Living Shoreline Protection Act of 2008 took effect in Maryland mandating that *"Improvements to protect a person's property against erosion shall consist of nonstructural shoreline stabilization measures that preserve the natural environment, such as marsh creation".* Exceptions to this State mandate include: *1)"In areas designated by Department mapping as appropriate for structural shoreline stabilization measures, and 2) In areas where the person can demonstrate to the Department's satisfaction that such measures are not feasible, including areas of excessive erosion, areas subject to heavy tides, and areas too narrow for effective use of nonstructural shoreline stabilization measures".* Mapping by MDE has not been developed as of the writing of this report. It is AMA's professional opinion that site conditions along the "Bay Frontage" and "The Point Frontage" require structural shoreline stabilization measures whereas within "The Fishing Creek Frontage", *"marsh creation"* measures (i.e.: "Living Shorelines") is feasible and appropriate. Therefore, rehabilitated and/ or new shore erosion control improvements should be considered accordingly.

The definition of "functional" in the State Wetlands Law (COMAR 26.24.01.02B24) means "*Performing at least 85 percent of the action that a structure was originally designed to perform*." Since 'Living

Shorelines" is the mandated means for protecting shorelines, structural shore protection measures that fail or decay to a condition <85% of their intended function within Fishing Creek will more than likely be required to be replaced with Living Shorelines' type of shoreline protection.

The existing boat house and shelter currently located within Fishing Creek are in varying states of decay. State law (COMAR 26.24.04.02C) does not allow new residential boat houses to be constructed within tidal waters. Although the existing structures currently have limited use due to their condition, AMA recommends that these structures not be demolished if the property owners intend to refurbish and/or reconstruct them in the future. Once removed without new permits from MDE and the USACE in place, it will be extremely difficult to obtain an approval.

G. CONCLUSIONS

It was brought to AMA's attention prior to the initiation of this investigation that internal discussions had been held within the community to possibly construct off-shore stone breakwaters on the Chesapeake Bay, similar to AMA's Bay Ridge design. Considering the existing shoreline improvements currently protecting the "Bay Frontage" and "The Point Frontage" areas and the limited erosion within "The Fishing Creek Frontage", particularly considering the new "Living Shorelines" regulation, it is AMA's opinion that construction of off-shore breakwaters to supplement the existing protection measures is not appropriate and would not be approved by the regulatory agencies. Further, removal of the existing structures to construct off-shore breakwaters would provide reduced storm protection from what is currently provided, would be extremely expensive and very controversial. AMA strongly recommends against replacing the existing shore erosion control measures with construction of new off-shore breakwaters on the Bay.

Overall, the erosion control measures currently lining the shoreline of AOTB have generally stabilized the shoreline fronting on the Chesapeake Bay and Fishing Creek. However, given the existing decayed condition of several bulkheads; steep, vertical banks located landward of low level concrete bulkhead along Chesapeake Walk (erosion potentially threatening the County's sewerage system), and lack of maintenance on many of the existing "Living Shoreline" projects within Fishing Creek, repair and stone enhancement along portions of the shoreline is needed to maintain the stability of the shoreline.

H. RECOMMENDATIONS

The following recommendations are based upon our experience and judgment as qualified professional engineers familiar with the marine construction industry and environmental permitting procedures. The criterion for rehabilitation or replacement used in this report is based upon our opinion of: 1) the current functionality of the shore protection measure to prevent continuing and/or future erosion of the shoreline, 2) the anticipated life expectancy of the shore protection measure before significant improvements and/or replacement are required, and 3) the ability of the shore protection measure to provide storm protection for a 25 year storm event. Priority values range from High (≤ 5 years); to Moderate (5 to 15 years); to Low (>15 years). Priority rankings are based upon AMA's professional opinion.

The recommendations include the eradication of the kudzu located along the banks of the Chesapeake Bay and the phragmites which has invaded many of the "Living Shorelines" shore protection projects. Both forms of vegetation are aggressive and invasive species. Total eradication is necessary in order to prevent re-growth. Environmental approvals are required prior to removal which mandates mitigation at a 1:1 ratio. Best results for eradication are with herbicide treatment applied in the late summer or fall when nutrients are being actively transported to the roots. As with most aggressive exotic species, eradication requires persistence in monitoring and thoroughness in treating patches during a multi-year program. Re-vegetation is an important last step to ensure that any residual kudzu or phragmites does not reestablish. AMA recommends that AOTB obtain the services of a profession landscape contractor experienced in eradication of these aggressive species.

Based upon AMA's surveys, site visits and evaluations, our recommendations for prioritization of shoreline rehabilitation are as follows:

HIGH PRIORITY WORK AREAS: < 5 YEARS

-BAY FRONTAGE- (Table 4, Page 43)

- **AREA 'B' Station 7+18 to Station 12+59 [Priority #8]:** The top elevation of the existing concrete bulkhead along this length of shoreline is on the order of 4.3' MLW (approximate still-water elevation for

a 15 year storm event). The recommended design standard for erosion control structures in the Chesapeake Bay region is a 25 year storm event. Therefore, the structure is regularly overtopped during the design storm event, thereby potentially eroding the high vertical banks located landward of the structure.

The County's sewer line parallels the shoreline from Walnut Avenue to Linden Avenue. During Hurricane Isabel, the bank eroded to within approximately 15' of the sewer line in the vicinity of Sycamore Avenue (Photo #6). Therefore, to prevent further erosion during severe storm events and potential damage to the existing sewerage system, AMA recommends that the concrete structure's surface be parged and any cracks repaired prior to extending the existing stone revetment (located channel-ward of the concrete bulkhead) higher with a stone apron constructed over the bulkhead as shown in Figure 6. Further, the bank should be graded at a stable slope, the kudzu eradicated and the graded bank's surface topsoiled and seeded. The estimated cost of construction is on the order of $190K to $260K.

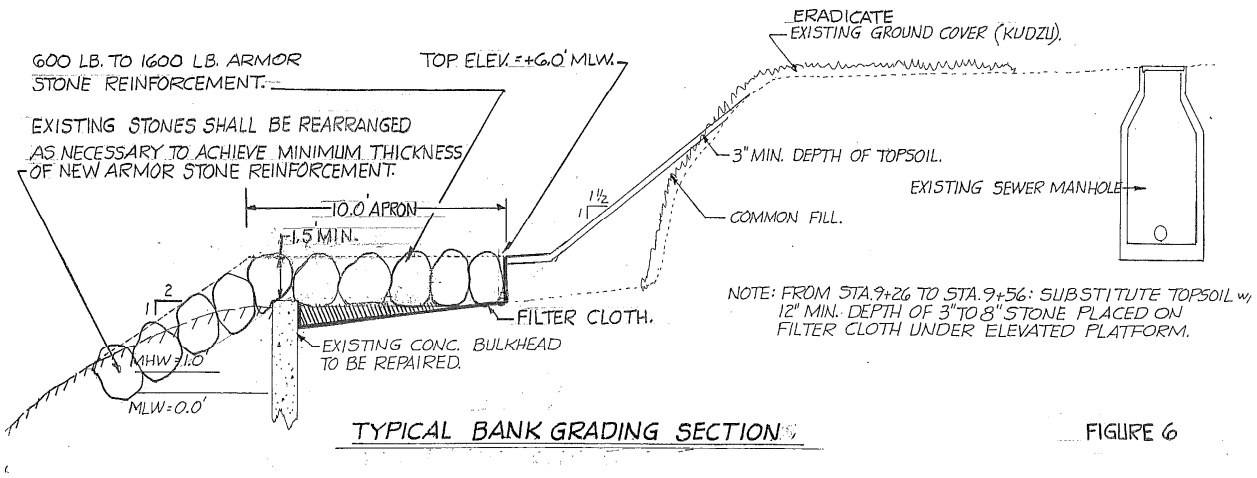

Figure 6

- **AREA 'C' Station 15+00 to Station 16+50 [Priority #5]:** Similar to Area "B" referenced above, the existing concrete bulkhead's top elevation at this area is on the order of 4.3' MLW. Erosion has occurred landward and on the flanks of the existing concrete bulkhead. Therefore, to prevent further erosion during severe storm events and potential damage to the existing sewerage system landward of

this area, AMA recommends that the damaged concrete slab and block wall be removed, the concrete structure's surface be parged and any cracks repaired prior to extending the existing stone revetment (located channel-ward of the concrete bulkhead) higher with a stone apron constructed over the bulkhead as shown in Figure 7. Further, the steep bank should be graded at a stable slope, the kudzu eradicated and the graded bank's surface topsoiled and seeded. The estimated cost of construction is on the order of $50K to $70K.

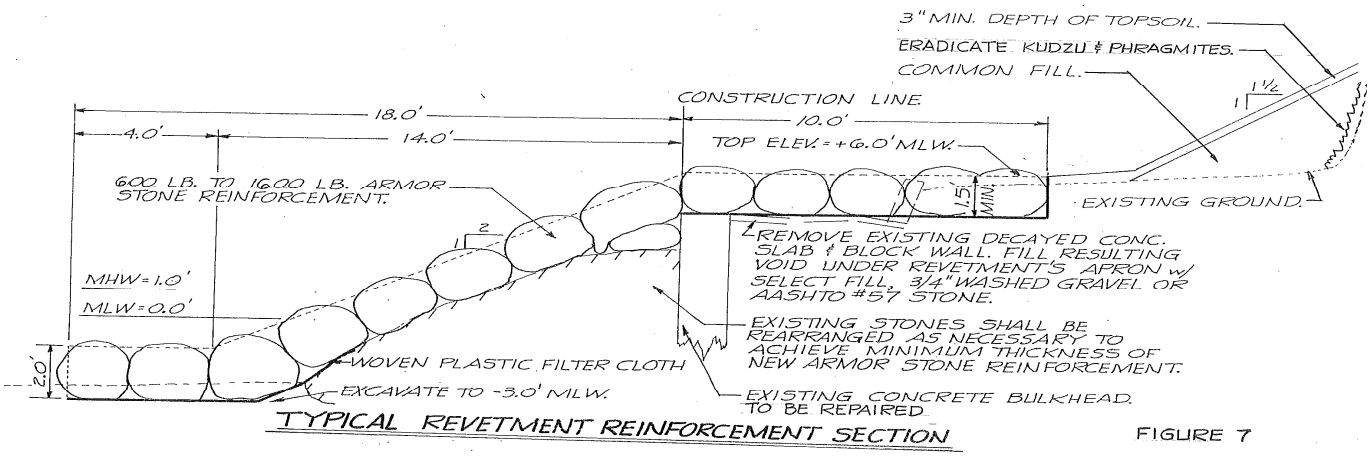

Figure 7

- **AREA 'D' Station 20+40 to Station 21+60 [Priority #7]:** The majority of the visible timber structural components along this section of shoreline have decayed. Sumps and sink holes are randomly located along the land-ward side of the "aged" timber bulkhead which is an indicator that the sheeting is reaching the end of its serviceable life. Further, the existing armor stone located channel-ward of the bulkhead is generally undersized and does not extend to the top of the bulkhead. AMA recommends that the existing sheeting be enhanced, the undersized stone on the structure's surface be rearranged as necessary to allow placement of larger 600# to 1600# armor stone, and the top elevation of the armor stone be raised to the top of the bulkhead along the length of the structure as shown in Figure 8. The estimated cost of construction is on the order of $35K to $50K.

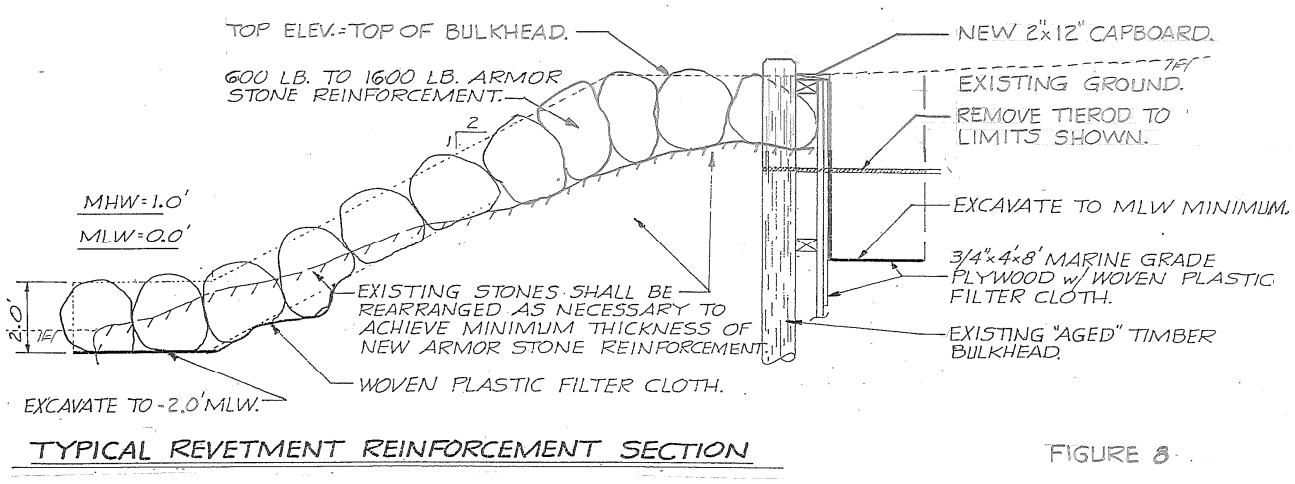

Figure 8

- **AREA 'E' Station 30+90 to Station 32+57 [Priority #4]:** Numerous sink holes are located landward of the existing "aged" timber bulkhead which is an indicator that the sheeting is reaching the end of its life. Further, the property owner has stated that temporary repairs had recently been performed to prevent soil from washing into the Bay from under the sheeting. Records indicate that the bulkhead had previously been repaired in the '80s. Although stone reinforcement was also recommended at that time, placement of armor stone was not implemented. The approximate face height (distance from the top of the bulkhead to the Bay's bottom elevation) varies from 5' to 8'. The ground elevation channelward of the existing bulkhead is three (3') feet deeper now compared to the elevation in the early '80's. Due to the age, the numerous sink holes and the face height of the timber bulkhead, AMA recommends that the existing sheeting be enhanced and stone reinforcement be placed along the length of the structure as shown in Figure 9. The estimated cost of construction is on the order of $60k to $85K.

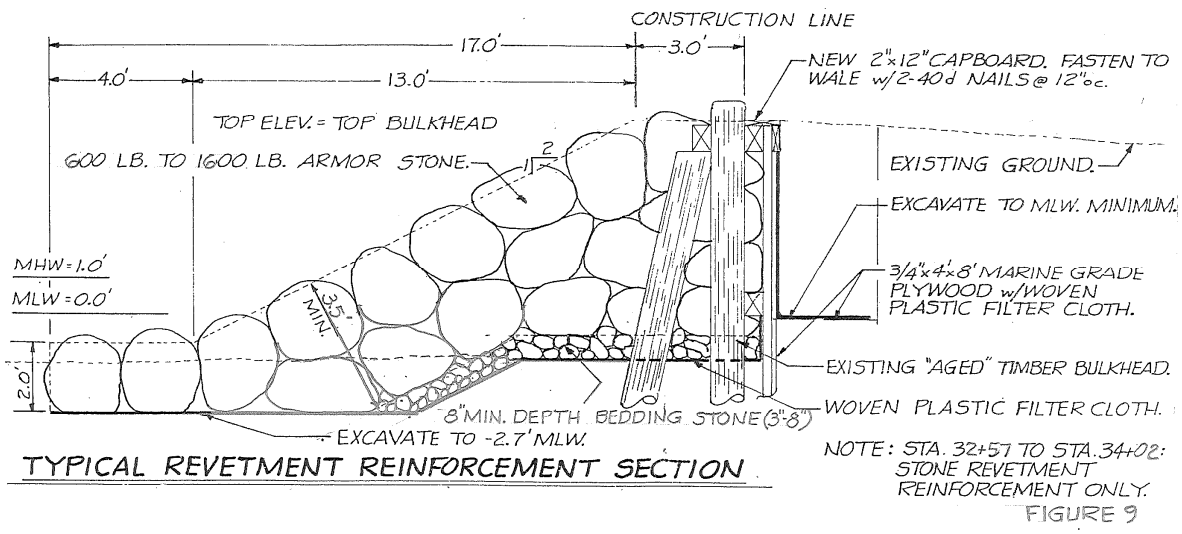

Figure 9

- **AREA 'F' Station 40+40 to Station 43+22 [Priority #10/13]:** Land that protrudes into a water body generally has a tendency to experience greater erosion due to more frequent and severe wave attack during storm events. This area is an example of such an occurrence. Although the top elevation of the timber bulkhead is above existing grade (+4.5' MLW), overtopping has occurred as evidenced by the erosion landward of the structure (Photo #2). In addition, the sheeting has decayed along portions of the bulkhead where sumps have randomly developed along the landward side of the sheeting. Further, the armor stone located channel-ward along portions of the bulkhead is undersized. AMA recommends replacing the undersized stone with 600# to 1600# armor stone, and extending the stone higher with a stone apron constructed over the bulkhead after the existing sheeting is enhanced as shown in Figure 10. The estimated cost of construction is on the order of $75K to $100K.

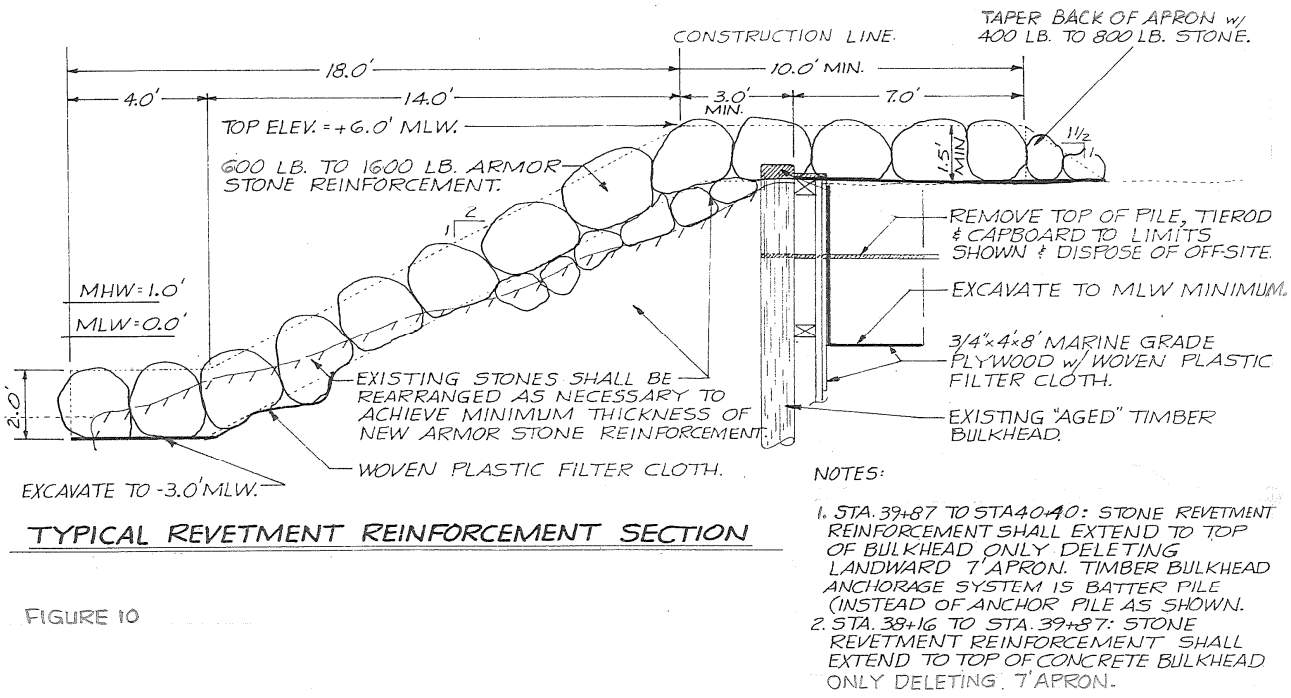

Figure 10

-THE POINT FRONTAGE- (Table 5, Page 44)

- **AREA 'G' Station 49+50 to Station 53+50 [Priority #14]:** The randomly placed stone groins and sand beach located along this area are providing limited storm protection. The existing beach has migrated landward to about 25' from the paved roadway (Photo #10). Therefore, at a minimum, AMA recommends construction of three segmented stone breakwaters, as shown in Figure 11, an intermediate stone groin and enhancement of the existing westerly terminal groin as shown in Figure 12 to provide an additional buffer between the MHW line and the existing roadway and overhead utilities. The stone groin will minimize sand transport along the existing beach. Upon extension of the existing storm drain outfalls, the beach area could either be re-nourished with imported commercially purchased sand material or with material obtained from nearby mechanical dredging projects as shown in Figure 13. Both commercially purchased sand or dredged sand material would need to meet MDE size requirements previously referenced in this report. Beach nourishment could be undertaken either immediately after construction of the breakwaters and groins, at a later date when additional funds become available or whenever a nearby mechanical dredging project, having sand material compatible

for beach nourishment, requires a disposal site. The estimated cost of construction for the breakwaters and groins is on the order of $140K to $190K whereas extension of the storm drains and placement of commercially purchased sand is on the order of $50k to $60K. Using dredged sandy material as a source for beach nourishment should require minimal or no cost to AOTB.

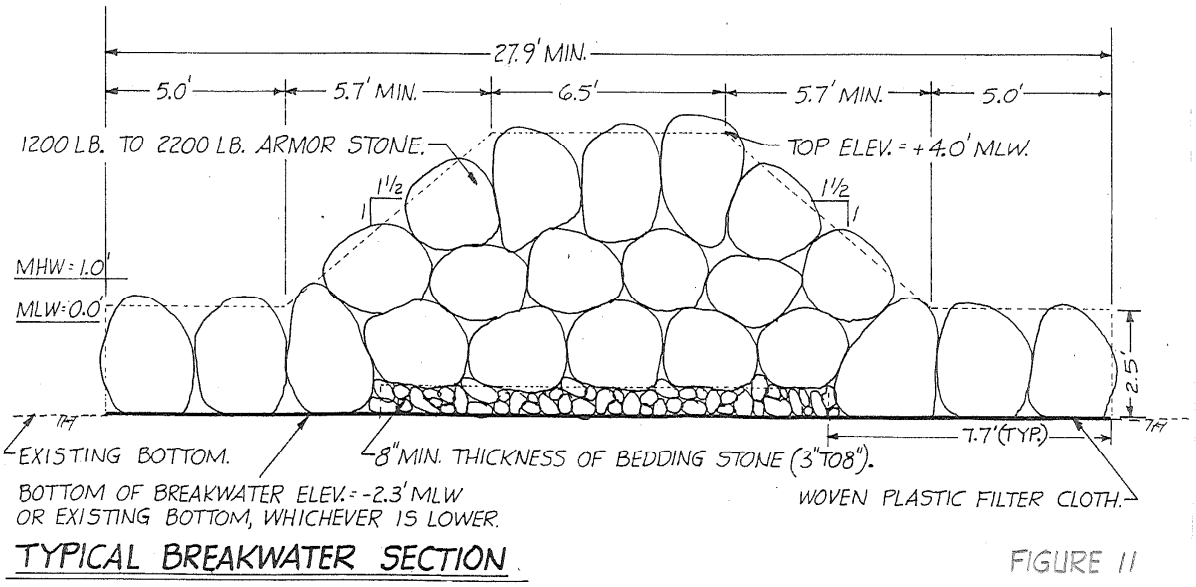

Figure 11

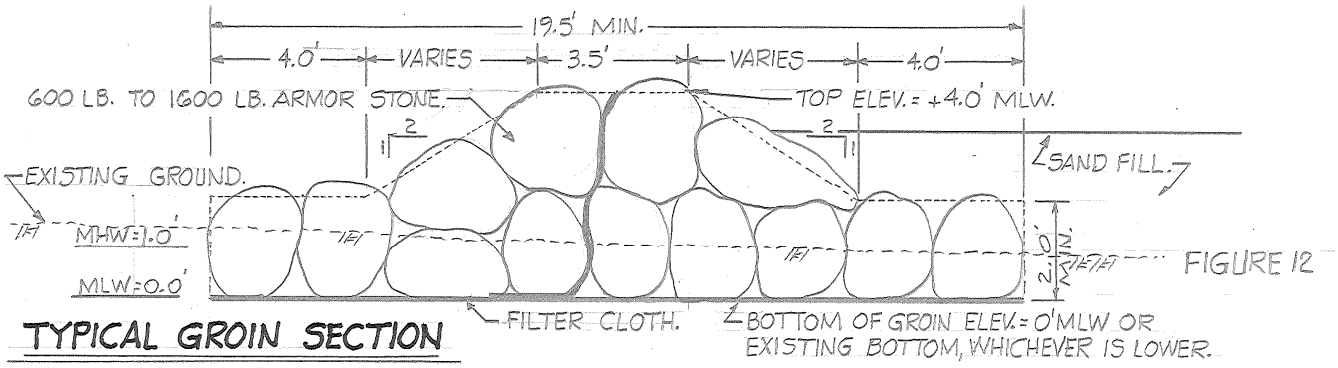

Figure 12

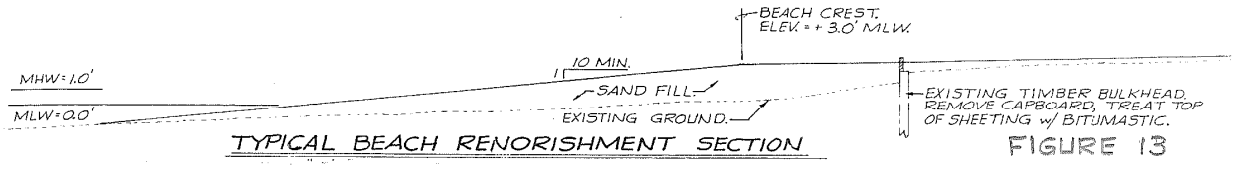

Figure 13

- **AREA 'H' Station 55+50 to Station 56+50 [Priority #1]:** The existing timber bulkhead is in a general state of decay and has reached the end of its serviceable life. Due to the condition of the structure, AMA recommends that the bulkhead be removed and replaced with a new stone revetment as shown in Figure 14. The estimated cost of construction is on the order of $50 to $65K.

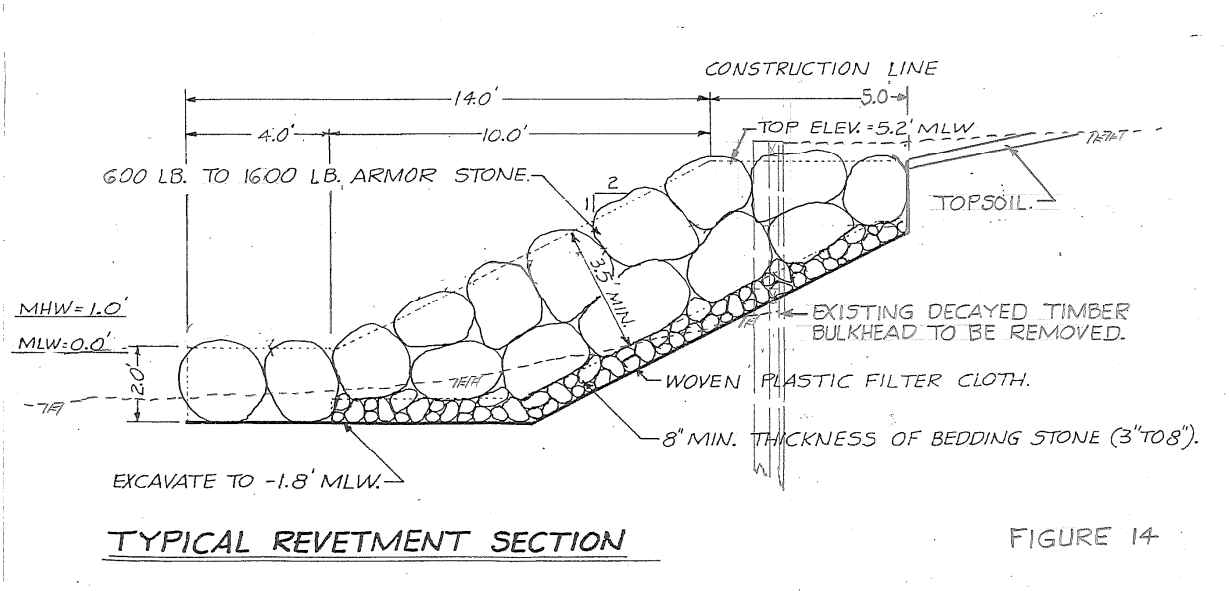

Figure 14

- **AREA 'J' Station 60+50 to Station 63+60 [Priority #9/ #3]:** Although stone reinforcement is located channel-ward of the existing bulkhead that fronts toward the Chesapeake Bay (Sta. 60+50 to Sta. 62+50), the stone appears to be SHA Rip-rap class II (20# to 700#). Numerous sink holes are located

landward of the existing timber bulkhead which is an indicator that the sheeting is reaching the end of its life. Due to the age, the numerous sink holes and the undersize stone and the total lack of stone reinforcement along the Creek frontage, AMA recommends that the existing sheeting be enhanced along the entire length of the structure, a layer of 600# to 1600# armor stone be placed over the existing stone from Sta. 60+50 to Sta. 62+50, and new stone reinforcement be placed from Sta. 62+50 to Sta. 63+60 as shown in Figure 8 and Figure 9 respectively. The estimated cost of construction is on the order of $105K to $140K.

-FISHING CREEK FRONTAGE- (Table 6, Page 45)

- **AREA 'K' Sta. 64+40 to Sta. 65+30 [Priority #6]:** A sink hole has developed landward of the concrete block bulkhead north of the existing pier and has been partially filled with rubble. The class I riprap located channel-ward of the bulkhead does not extend to the top of the structure and the existing ground's surface landward of the bulkhead is about 8" lower than the top of the structure. AMA recommends repairing the bulkhead in the area of the sink hole and placing an armor stone overlay on the existing class I riprap using 100# to 300# armor stone as shown in Figure 15. The cost of construction would be on the order of $10K to $15K.

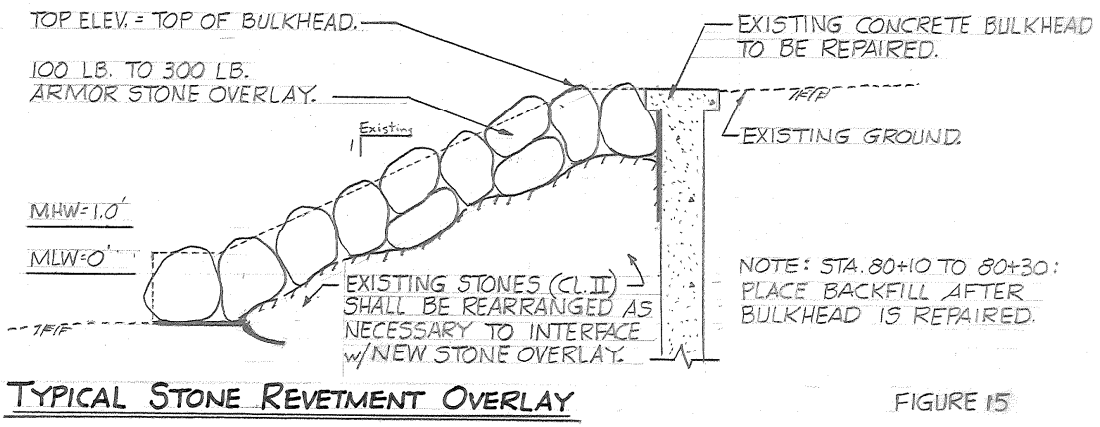

Figure 15

- **AREA 'K' Station 66+30 to Station 69+40 [Priority #11]:** Land that protrudes into a water body generally has a tendency to experience greater erosion due to more frequent and severe wave attack

during storm events. Numerous sink holes are located landward of the existing timber bulkhead which is an indicator that the sheeting is reaching the end of its serviceable life. Due to the decayed condition of the existing timber bulkhead and since the existing stone reinforcement does not extend to the top of the bulkhead, AMA recommends that the existing sheeting be enhanced, the sink holes filled and stone reinforcement using 600# to 1600# armor stone extend to the top of the structure as shown in Figure 8. The estimated cost of construction is on the order of $ 95K to $130K.

- **AREA 'L' Sta. 71+80 to Sta.75+00 [Priority #20]:** The primary component of a "Living Shorelines" project and the reason it's called a "Living Shoreline" is vegetation. This area has the structural components in-place that is needed to minimize sand movement. However, there was no wetland vegetation lining the shoreline at the time of the site visit. AMA recommends that the area be planted with the appropriate type of wetland vegetation as-soon-as-possible to prevent erosion of the sand. The estimated cost of planting is on the order of $13K to $18K. Prior to planting, the sieve size of the sand previously placed should be tested to confirm that it meets the minimum requirements as recommended in this report and as typically required by the MDE license.

- **AREA "L" Sta. 75+00 to Sta. 76+30 [Priority #15]:** Erosion is extending into the lawn behind the low profile stone revetment along the length of the shoreline, apparently due to the lack of filter cloth (along the revetment's land-ward interface) and wave energy overtopping the structure. AMA recommends that filter cloth be placed under and land-ward of the existing stone and new 100# to 300# armor stone be placed over and land-ward of the existing revetment as shown in Figure 16. The estimated cost of construction is on the order of $13K to $18K.

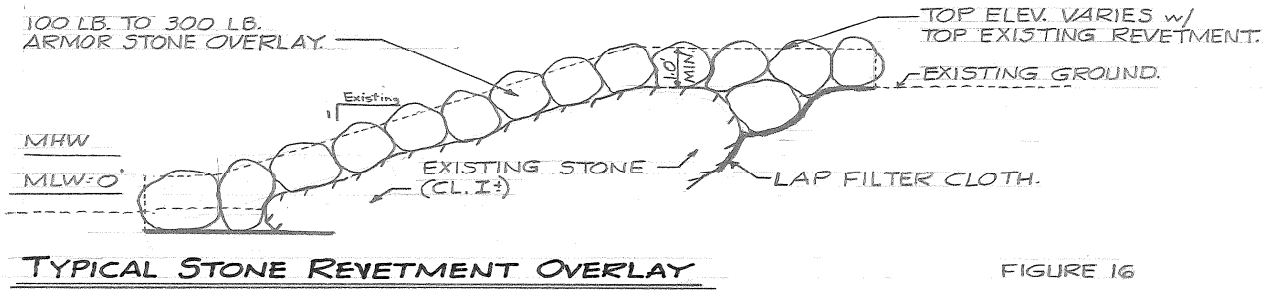

Figure 16

- **AREA 'N' Sta. 81+70 to Sta. 83+30 [Priority #12/#16/#18]:** Erosion has occurred land-ward of the stone sill extending into the lawn from Sta. 81+70 to Sta. 82+40; into the phragmites lined shoreline from Sta. 82+40 to Sta. 83+00 and into the outlet ditch from Sta. 83+00 to Sta. 83+30. Similar to the preceding scenario, the lack of filter cloth along the land-ward interface and wave energy overtopping the sill apparently washed the sand (incorporated into the "Living Shoreline" project) out from behind the sill which destroyed the wetland vegetation which started the erosion of the shoreline. AMA recommends that the stone sill be overlayed with new 100# to 300# armor stone to a higher top elevation, filter cloth be placed under and within the structure, the phragmites be eradicated, within the footprint of the proposed sand fill, sand fill be imported and placed between the existing eroded bank and the new sill with the filled areas planted with the appropriate wetland vegetation as shown in Figure 17. The estimated cost of construction is on the order of $37K to $50K.

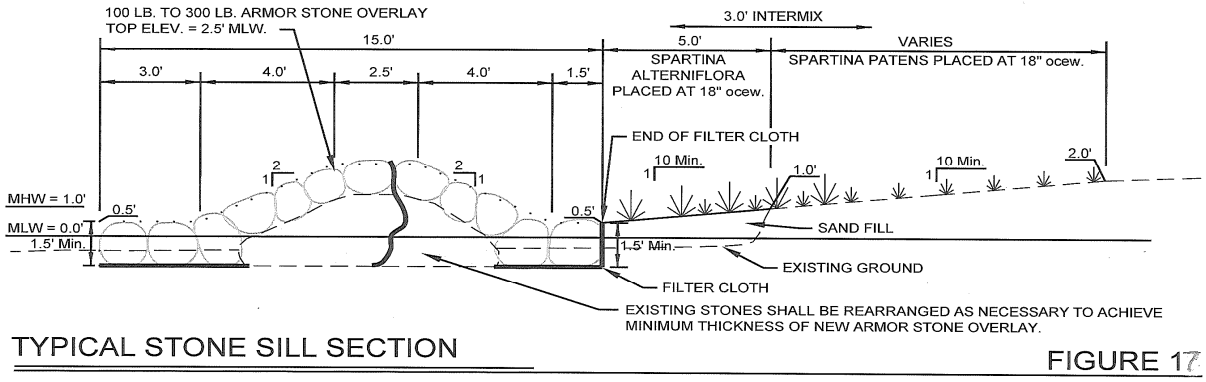

Figure 17

The recommended shoreline improvements that extends across Chestnut Avenue (Sta. 83+00 to Sta. 83+00) should consider the existing ditch that currently outfalls into the Creek at this area. As referenced in Appendix 3 (Preliminary Chestnut Avenue Outfall Design), a large part of the community drains to this area. The top of the stone sill should be lowered at this area only to accommodate future drainage improvements within AOTB.

- **AREA 'N' Sta. 83+30 to Sta. 85+10 [Priority #2]:** The soil has settled and numerous sink holes were noted along the landward side of the decayed timber bulkhead during the site visit. The structural components of the existing timber bulkhead, particularly the timber wale system, appears to be reaching the end of their serviceable life. Therefore, AMA recommends that 100# to 300# armor stone reinforcement be placed on filter cloth channel-ward of the existing bulkhead and enhancement of the existing sheeting as shown on Figure 18. The structural replacement of the decayed timber bulkhead with construction of basically a stone revetment could present a challenge for obtaining approvals from the environmental agencies considering their preference for "Living Shorelines." The estimated cost of construction is on the order of $80K to $110K.

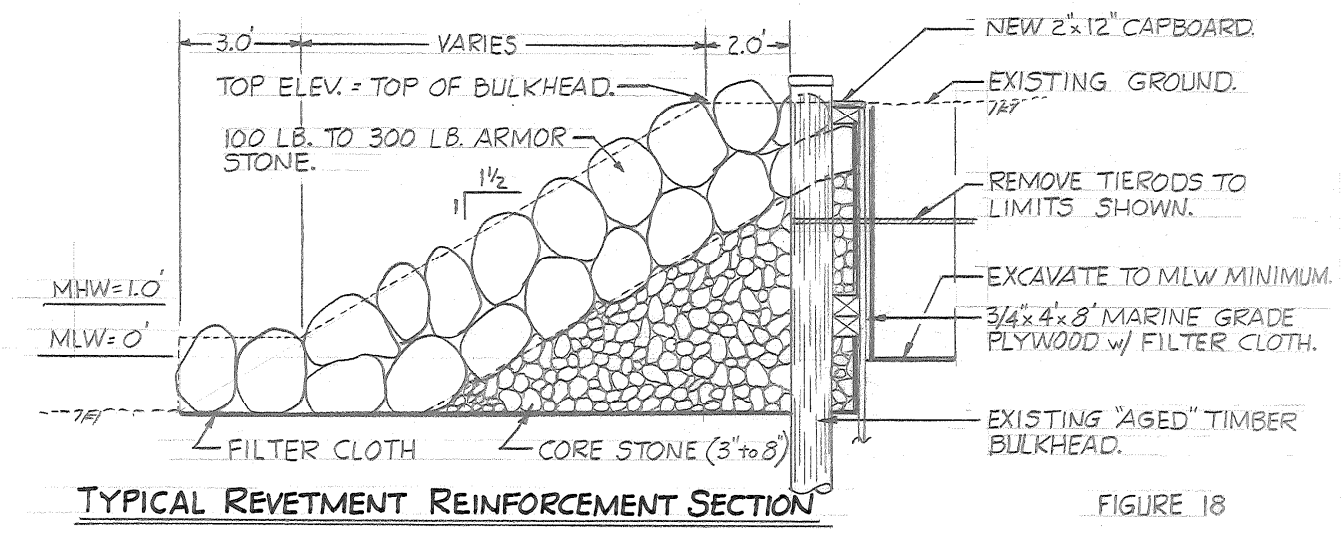

Figure 18

- **AREA "N" Sta. 85+50 to Sta. 86+60 [Priority #19]:** Erosion, primarily between Sta. 86+00 to Sta. 86+60, is occurring along portions of the shoreline, apparently due to the loss of the sand surface sub-strata. The stone groins located under the existing piers are generally stabilizing sand movement along the shoreline. However, except for phragmites located at the southerly end of the "Living Shorelines" project, the shoreline does not have significant amounts of wetland plantings. AMA recommends that sand be placed along portions of the shoreline that have eroded, the phragmites within the footprint of the new sand fill be eradicated, and the entire area be planted with the appropriate type of wetland

vegetation to alleviate sand movement and prevent further erosion. The estimated cost is on the order of $4K to $6K.

- **AREA "0" Sta. 93+70 to Sta. 94+90 [Priority #17]:** Erosion has occurred land-ward of the stone sill extending into the lawn and phragmites lined shoreline. The lack of filter cloth along the land-ward interface and wave energy overtopping the low profile sill has apparently washed the sand (incorporated into the "Living Shoreline" project) out from behind the sill which destroyed the wetland vegetation which started the continued erosion of the shoreline. AMA recommends that the top of the existing sill be raised using 100# to 300# armor stone, filter cloth be placed within the structure, the phragmites within the footprint of the proposed sand fill be eradicated, sand fill be imported and placed between the existing eroded bank and the rehabilitated sill and the filled areas planted with the appropriate wetland vegetation as shown in Figure 19. The estimated cost of construction is on the order of $20K to $25K.

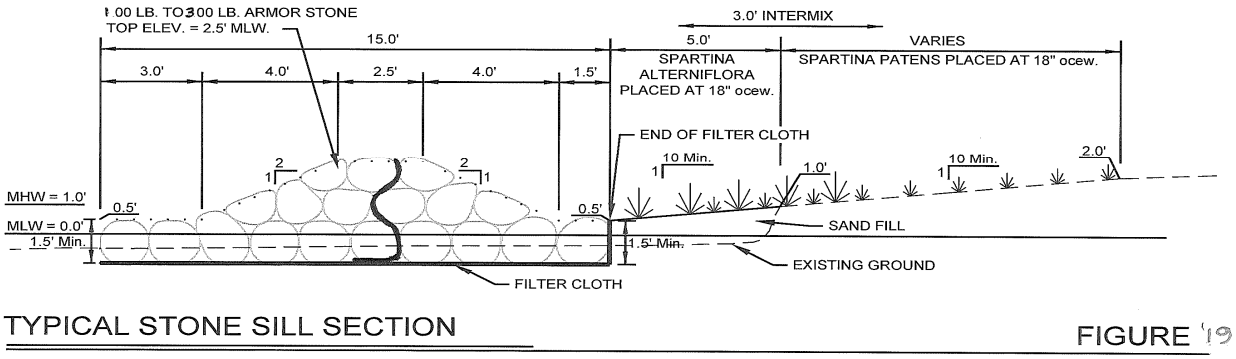

Figure 19

MODERATE PRIORITY WORK AREAS: 5 TO 15 YEARS

-BAY FRONTAGE- (Table 4, Page 43)

- **AREA "A" Sta. 0+00 to Sta. 0+82 [Priority #33]:** The configuration of the shoreline at this area takes an abrupt perpendicular bend thereby achieving the characteristics of a long groin. Sand has

accumulated channel-ward of the existing concrete bulkhead, apparently originating from littoral transport along Oyster Cove Community's shoreline. Although the existing concrete bulkhead is significantly spalled along the top of the structure, no sink holes have developed land-ward of the structure. In order to maintain the future stability of the concrete bulkhead, AMA recommends that the concrete structure's surface be parged, and additional 600# to 1600# armor stone reinforcement be placed on filter cloth as shown in Figure 20. Further, AMA recommends that the existing stone groin be reconfigured and reconstructed using 600# to 1600# armor stone as shown in Figure 12. The estimated cost of construction would be on the order of $10K to $13K and $15K to 22K respectively.

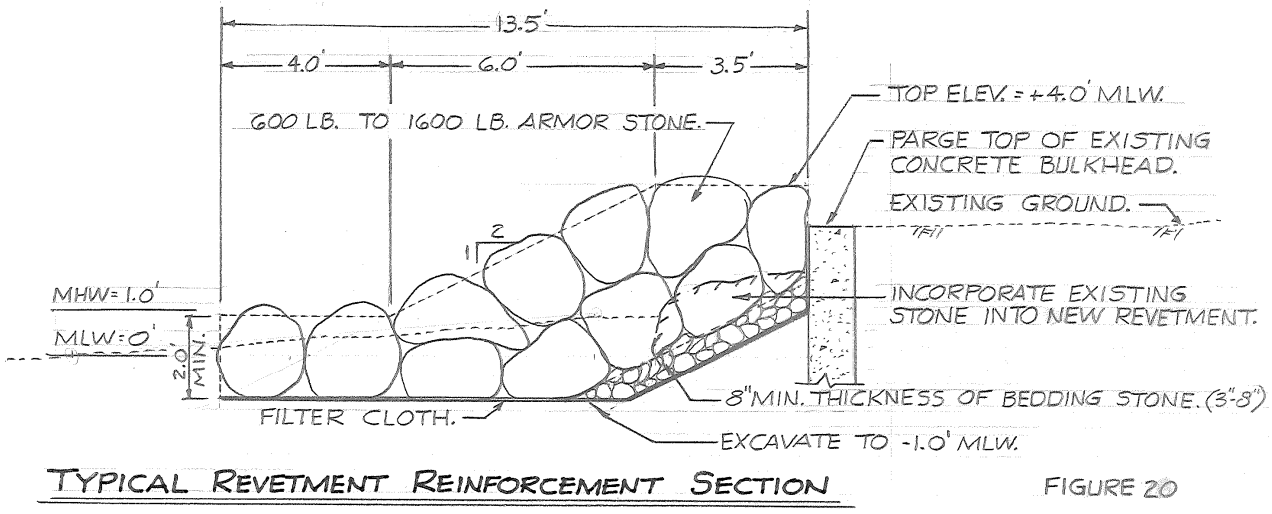

Figure 20

- **AREA 'E' Sta. 32+57 to Sta. 34+02 [Priority #21]:** Records indicate that the timber bulkhead was constructed in the '80s. Although no sink holes were noted during the site visit and the structure currently appears to be functioning well, AMA recommends replacement of the existing cap board, and new 600# to 1600# armor stone reinforcement placed on filter cloth, as shown in Figure 9. As the structure continues to age, it could potentially need sheeting enhancement within the next 15 years. The typical life expectancy of a timber bulkhead located in severe environmental conditions without the need for significant maintenance is 25 to 35 years. Stone reinforcement was also recommended in conjunction with the construction of the new timber bulkhead in AMA's '80s design. The estimated cost

of construction would be on the order of $50k to $70k. The cost of construction could be reduced if the work is done in conjunction with the adjacent priority work area.

- **AREA 'E' Sta. 34+02 to Sta. 37+98 [Priority #29]:** Records indicate that new timber bulkheads were constructed from Sta. 34+55 to Sta. 35+05 and Sta. 37+04 to Sta. 38+16 and that the remaining timber and concrete bulkheads along this area were repaired in the '80s. However, it was noted that several sink holes have developed landward of the structures, generally at bends along the structure's alignment, and at penetrations through the structures for drainage pipes and utility conduits leading to piers. AMA recommends that the penetrations through the structures be adequately sealed and the sink holes filled. The cost of construction would be on the order of $6K to $8K and could be repaired using relatively light construction equipment.

- **AREA 'F' Sta. 38+16 to Sta. 40+40 [Priority #25/ #22]:** The existing concrete and timber bulkheads along this length of shoreline are generally in a good state of repair with only one sink hole noted landward of the concrete bulkhead in the vicinity of a pier. AMA recommends that the penetration through the concrete bulkhead be adequately sealed and the sink hole filled, the top of the concrete bulkhead parged and 600# to 1600# armor stone reinforcement be placed along the length of the structure as shown in Figure 10. The cost of construction would be on the order of $45K to $60K. The cost of construction could be reduced if the work is done in conjunction with the adjacent priority work.

-THE POINT FRONTAGE- (Table 5, Page 44)

- **AREA 'G' Sta. 45+00 to Sta. 47+00 [Priority #26]:** Slabs of concrete rubble and Class I Riprap are located approximately 5' from Narraganset Avenue that leads to the southerly peninsula and provides access to four properties. Overhead utilities, including a utility pole positioned within the footprint of the rubble, are located over the dumped concrete/stone material. The County's sewerage system is located within the roadway approximately 15' from the rubble. Portions of the shoreline are actively eroding. In order to maintain access and prevent damage to the existing utilities during severe storm events, AMA recommends construction of a new revetment using 600# to 1600# armor stone as shown in Figure 21. The cost of construction would be on the order of $75K to $100K.

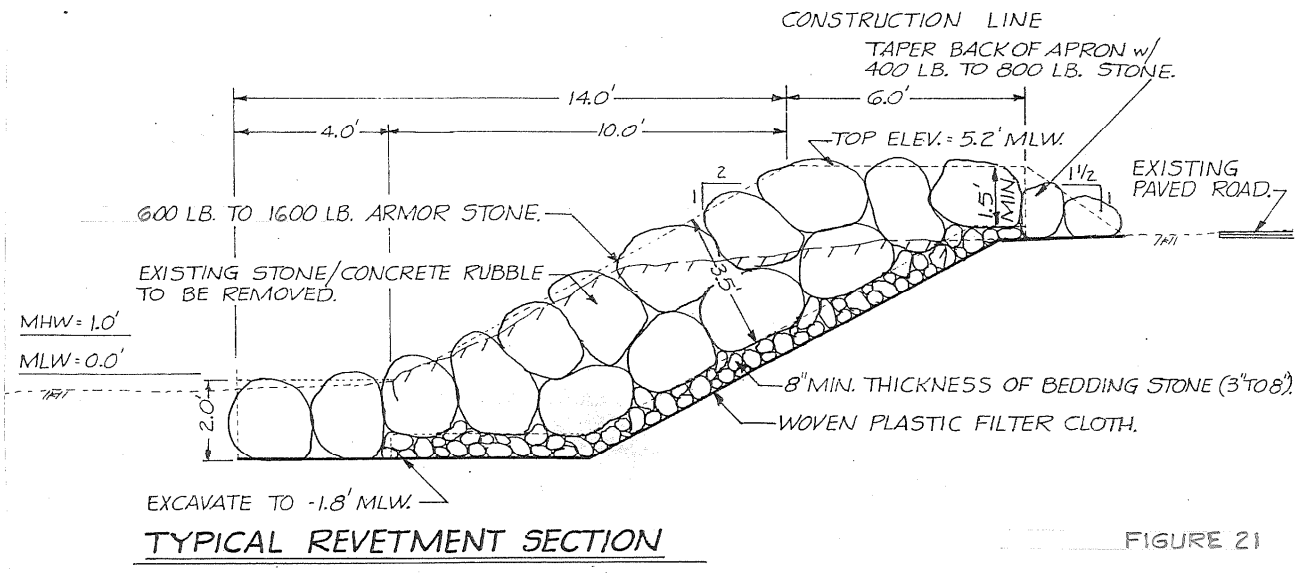

Figure 21

- **AREA 'G' Sta. 47+00 to Sta. 49+50 [Priority #30]:** The two existing stone breakwaters previously designed by AMA were constructed in the late '80s. However, the structures are approximately 18" lower than designed and beach nourishment was apparently not implemented as part of the construction. AMA recommends rehabilitation of the existing stone breakwaters by raising the crest to the designed top elevation of +4.0' MLW using 1200# to 2200# armor stone as shown in Figure 11, nourish and enhance the existing beach with imported commercially purchased sand material placed land-ward, over and channel-ward of the existing bulkhead, removal of the bulkhead's cap boards and cutting off the bulkhead piles above the upper wale as shown in Figure 13. The cost of construction would be on the order of $50K to $65K.

- **AREA 'I' Sta. 57+00 to Sta. 57+60 [Priority #23]:** Although the majority of the hardware that fastens the structural timber members together is either rusted or missing, the existing timber bulkhead otherwise appears to generally be in a good state of repair. Although no sink holes were noted during the site visit and the structure currently appears to be functioning well, AMA recommends continued monitoring of the structure, additional 600# to 1600# armor stone reinforcement extending to the top of the bulkhead and potentially sheeting enhancement within the next 15 years as the structure continues to age, as shown in Figure 8. The cost of construction would be on the order of $13K to $18K.

- **AREA 'J' Sta. 59+00 to Sta. 60+00 [Priority #24]:** Although no sink holes were noted during the site visit and the structure currently appears to be functioning well, AMA recommends continued monitoring of the structure, new 600# to 1600# armor stone reinforcement and potentially sheeting enhancement within the next 15 years as the structure continues to age as shown in Figure 8. The cost of construction would be on the order of $25K to 30K.

- **AREA 'J' Sta. 60+00 to Sta. 60+50 [Priority #27]; Sta. 63+60 to Sta. 64+40 [Priority #28]:** AMA recommends construction of a new stone revetment using 600# to 1600# armor stone from Sta. 60+00 to Sta. 60+50 as shown in Figure 21 and a stone overlay using a minimum of 100# to 300# armor stone from Sta. 63+60 to Sta. 64+40 as shown in Figure 16. The cost of construction would be on the order of $25K to $30K and $8K to $11K respectively.

-FISHING CREEK FRONTAGE- (Table 6 Page 45)

- **AREA 'M' Sta. 78+40 to Sta. 80+10 [Priority #32]:** Although no sink holes were noted during the site visit, the concrete crown covering the top of the stone revetment has spalled and it appears that the armor stone has settled along portions of the shoreline. Therefore, AMA recommends repairing the concrete bulkhead/ crown and placing an armor stone overlay on the existing class II riprap using 100# to 300# armor stone as shown in Figure 15. The cost of construction would be on the order of $25K to $35K.

- **AREA 'M' Sta. 80+10 to Sta. 80+30 [Priority #31]:** The shoreline is protected with the remains of a concrete bulkhead with armor stone placed along the channel-ward side of the structure. Brush and debris have been dumped between the bulkhead and lawn. AMA recommends repairing the concrete bulkhead, placing stone reinforcement using 100# to 300# armor stone on filter cloth, backfilling the bulkhead with sand and stabilizing the surface with wetland vegetation. Although obtaining approvals from the environmental agencies could be a challenge, it is our opinion that retrofitting the existing structure would have less impact on the environment while improving the existing shore protection measures. The cost of construction would be on the order of $ 3K to $4K.

- **AREA 'M' Sta. 85+10 to Sta. 85+50 [Priority #34]:** Stone and rubble have been dumped channel-ward of the phragmites that connects the existing bulkhead to the south with the "Living Shoreline" to the north. AMA recommends eradication of the phragmites, within the footprint of the proposed sand fill, construction of a new stone sill using 100# to 300# armor stone supplemented with imported sand fill within the footprint of the proposed sand fill, and planting with the appropriate wetland vegetation as shown in Figure 19. The cost of construction would be on the order of $25K to $30K. The cost of construction could be reduced if the work is done in conjunction with the adjacent priority work area.

H. SUMMARY

The proceeding is a generalized summary of our findings noted during several site reconnaissance visits and our previous experience working at AOTB. We do believe that they cover most of the major areas/items of concern that could develop within the next 15 years. However, it does not cover those items which may not be apparent during a simple visual inspection, particularly relating to the timber bulkhead investigation. Priority ratings are based upon conditions observed by AMA during the writing of this report. Priorities could change as the structures continue to age and deteriorate. Regular scheduled monitoring of the shoreline's condition should be implemented to ensure that shoreline improvements are functioning as intended. The plans and sections included within this report are schematic only at this time. An overall schematic plan delineating areas of existing and proposed shoreline improvements is attached at the end of this report (Figure 22).

Further, the "Recommendations" and the "Opinion of Probable Cost" presented are based upon AMA's experience and represents our best judgment as experienced and qualified professional engineers familiar with the marine construction industry. However, we cannot and do not guarantee that proposals, bids or actual project or construction costs submitted and/or performed by the Contractors will not vary from the Opinion of Probable Costs specified.

Scope of Work

	Area *	Station		Shoreline Condition		Upland Condition		Figure	Estimated Cost	Priority
		From	To	Existing	Recommendations	Existing	Recommendations			
"Bay Frontage"					CEDAR AVENUE					
	A	0+00	0+82	Concrete bulkhead; scattered stone revetment and groin.	●Parge top of concrete bulkhead. ●Additional Stone Reinforcement ●Refurbish Stone Groin	Gravel road surface with grass parking area.	● Revegetate Disturbed Areas	20/12	$25K-$35K	5-15 yrs 33
		0+82	2+27	Stone Revetment; timber pier; timber bulkhead w/stone reinforcement.	None	Lawn; Stone lined swale; Rock walk.	None	—	—	> 15 yrs
					WALNUT AVENUE					
		2+27	7+18	Timber bulkhead with stone reinforcement; timber pier; groin remains	None	Grass walkway, County sewer landward of bank from Sta. 5+10 to Sta. 16+45.	None	—	—	> 15 yrs
					SYCAMORE AVENUE					
	B	7+18	12+59	Concrete bulkhead with stone reinforcement; timber pier; pier and groin remains.	●Repair concrete bulkhead. ●Additional Stone Reinforcement	High, Steep vertical banks; invasive plant species along bank and lower walk; Elevated platform over vertical bank; ponding water between bank and bulkhead; Culvert extending from road ditch to bulkhead; County sewer landward of bank from Sta. 5+10 to Sta. 16+45.	●Grade vertical bank at 1 1/2 H to 1 V. ●Grade bank at 1 1/2 H to 1V under elevated platform. ●Placing 12" min. depth of 3" to 8" stone on filter cloth. ●Place fill between bottom of bank and bulkhead at positive grade. ●Eradicate invasive species and vegetate bank and lower walkway.	6	$190K - $260K	≤ 5 yrs 8
					REDWOOD AVENUE					
		12+59	15+00	Timber bulkhead with stone reinforcement; timber pier; pier and groin remains.	None	High, steep bank; invasive plant species along bank and lower walk; Culvert extending from road ditch through bulkhead at Sta. 12+72.	●Eradicate invasive species and vegetate bank and lower walkway.	—	—	> 15 yrs
					LINDEN AVENUE					
	C	15+00	16+50	Concrete bulkhead; decayed concrete slab and block wall; Stone reinforcement; Pier remains.	●Additional Stone Reinforcement with apron. ●Removal and disposal of decayed concrete slab and block wall.	High, steep, vertical bank, invasive plant species along bank and lower walk; Vehicular access along upper bank; County sewer landward of bank from Sta. 5+10 to Sta. 16+45.	●Grade vertical bank to 1 1/2 H to 1 V from Sta. 15+00 to Sta. 16+53. ●Place topsoil between bank and bulkhead. ●Eradicate invasive species and vegetate bank and lower walkway.	7	$50K - $70K	≤ 5 yrs 5
					CHESTNUT AVENUE					
		16+50	18+47	Timber bulkhead with stone reinforcement; Pier and groin remains.	None	High, steep bank, invasive plant species along bank; Lawn.	●Eradicate invasive species and vegetate bank and lower walkway.	—	—	> 15 yrs
		18+47	20+40	Timber bulkhead with stone reinforcement; Timber Piers.	None	Bank and Lawn.	None	—	—	> 15 yrs
	D	20+40	21+60	Timber bulkhead with stone reinforcement, timber pier, pier remains	●Additional Stone Reinforcement (with sheeting enhancement).	Lawn, bank, brush, scattered sink holes.	●Fill sink hole. ●Revegetate disturbed areas.	8	$35K -$50K	≤ 5 yrs 7
					MYRTLE & OAK AVENUES					
		21+60	30+90	Timber bulkhead with stone reinforcement; Timber Piers; Pier and groin remains.	None	Bank, brush, lawn, concrete slabs, retaining walls.	None	—	—	> 15 yrs
					HOLLYWOOD AVENUE					
	E	30+90	32+57	"Aged" timber bulkhead with scattered sink holes; Timber piers; Pier and groin remains.	●Stone reinforcement (with sheeting enhancement).	Lawn, Scattered sink holes.	●Fill sink hole. ●Revegetate disturbed areas.	9	$60K - $85K	≤ 5 yrs 4
		32+57	34+02	Timber Bulkhead	●Replace capboard. ●Stone reinforcement only.	Lawn with drainage swale.	●Revegetate disturbed areas.	9	$50K - $70K	5- 15 yrs 21
					MAGNOLIA AVENUE					
		34+02	37+98	Timber bulkhead with stone reinforcement; Sinkholes at pier and bulkhead bends; Timber piers; Pier Remains; Lawn with drainage swales and outfall pipes.	●Seal existing sheeting at sink holes only. ●Reconnect dislocated concrete pipe.	Lawn with drainage swales; Scattered sink holes.	●Fill sink holes. ●Revegetate disturbed areas.	—	$6K - $8K	5 - 15 yrs 29
		37+98	38+16	Timber bulkhead with stone reinforcement.	None	Lawn with drainage swales.	●Revegetate disturbed areas.	—	—	> 15 yrs
	F	38+16	39+87	Concrete bulkhead with stone reinforcement; Pier remains.	●Additional Stone Reinforcement. ●Seal bulkhead at sink hole only. ●Parge top concrete bulkhead.	Lawn; Sink hole.	●Fill sink hole. ●Revegetate disturbed areas.	10	$35K - $45K	5- 15 yrs 25
		39+87	40+40	Timber bulkhead with stone reinforcement; Pier remains.	●Additional Stone Reinforcement.	Lawn.	●Revegetate disturbed areas.	10	$10K - $15K	5- 15 yrs 22
		40+40	42+44	"Aged" timber bulkhead with stone reinforcement and scattered sink holes; Bulkhead remains.	●Stone Reinforcement and Apron. ●Sheeting Enhancement.	Lawn; Sink holes	●Drainage swale. ●Fill sink holes. ●Revegetate disturbed areas.	10	$65k - $85K	≤ 5 yrs 10
					NARRAGANSET AVENUE					
		42+44	43+22	Timber bulkhead with stone reinforcement and scattered sink holes.	●Stone Apron only. ●Sheeting Enhancement	Lawn; Sink holes	●Fill sink holes. ●Revegetate disturbed areas.	10	$10K - $15K	≤ 5 yrs 13
		43+22	45+00	Stone revetment; Timber piers, Pier remains	None	Lawn; Gravel roadway.	None	—	—	15 yrs

* Refer to Figure 3 and Figure 22

"Bay Frontage" Cost Summary	
Priority - High	$410K to $565K
Priority - Moderate	$126K to $173K

Table 4

Scope of Work

	Area *	Station		Shoreline Condition		Upland Condition		Figure	Estimated Cost	Priority
		From	To	Existing	Recommendations	Existing	Recommendations			
"The Point"					NARRAGANSET AVENUE					
	G	45+00	47+00	Dumped concrete rubble and small stone; Low profile timber bulkhead, Eroding bank.	●New Stone Revetment ●Stone Reinforcement	Paved roadway; Grass area.	None	21	$75K - $100K	**5- 15 yrs 26**
		47+00	49+50	Stone breakwaters; Stone groin; Low profile timber bulkhead; Sand beach; Stone Revetment.	● Rehabilitate Existing Stone Breakwaters ●Beach Nourishment. ●Cut off pile tops & remove capboard (200 L.F.).	Grassed, sand and lawn areas; Decayed outfall pipe with sink hole; Sewage pump station.	●Drainage swale with pipe outlet. ●Fill sink holes. ●Extend sand beach further landward. ●Revegetate disturbed areas.	11/13	$50K - $65K	**5- 15 yrs 30**
					COHASSET AVENUE					
		49+50	53+50	Stone groins; Sand beach; Pier remains, Community Marina.	●New Stone Breakwaters ●New Stone Groin ●Beach Nourishment	Sand beach; New pipe outfalls; Paved public road (Magnolia Avenue).	●Beach Nourishment. ●Extend outfalls.	11/12/13	$190K - $250K	**≤ 5 yrs 14**
					NEWPORT AVENUE					
		53+50	55+50	Timber bulkhead with stone reinforcement and stone groins.	None	Lawn	None	—	—	**> 15 yrs**
	H	55+50	56+50	Decayed Timber bulkhead without stone reinforcement; Stone groins.	●New Stone Revetment.	Lawn; sink holes.	●Fill sink hole. ●Revegetate disturbed areas.	14	$50K - $65k	**≤ 5 yrs 1**
					ROCKWAY AVENUE					
		56+50	57+00	New Stone Revetment (2008)	None	Gravel roadway; Grassed area; Drainage improvements including catch basins and outfall pipe.	None	—	—	**> 15 yrs**
	I	57+00	57+60	Timber bulkhead with stone reinforcement; Stone groin; Timber Pier.	●Stone Reinforcement. ●Bulkhead Rehabilitation and sheeting enhancement.	Lawn	None	8	$13K - $18K	**5- 15 yrs 23**
		57+60	58+60	Timber bulkhead with stone reinforcement; Stone groin; Timber Pier	None	Lawn	None	—	—	**> 15 yrs**
		58+60	59+00	Stone Revetment, Sand Beach, Timber Pier.	None	Lawn	None	—	—	**> 15 yrs**
	J	59+00	60+00	Timber bulkhead with Stone Reinforcement; Stone Groin; Decayed Pier	●Stone Reinforcement and sheeting enhancement.	Lawn	●Revegetate disturbed areas.	8	$25K - $30K	**5- 15 yrs 24**
					SARATOGA AVENUE					
		60+00	60+50	Rip Rap	●New Stone Revetment	Scrub Brush, Lawn	●Revegetate disturbed areas.	21	$25K - $30K	**5- 15 yrs 27**
		60+50	62+50	Timber Bulkhead with stone reinforcement; Stone Groin (CL 2)	●Stone Reinforcement and sheeting enhancement.	Lawn, sinkholes	●Revegetate disturbed areas. ●Fill Sink Holes	8	$65K - $85K	**≤ 5 yrs 9**
		62+50	63+60	Decayed timber bulkhead, Timber pier	●New Stone Reinforcement and sheeting enhancement.	Lawn, Extensive sink holes	●Fill sink hole. ●Revegetate disturbed areas.	9	$40K - $55K	**≤ 5 yrs 3**
					MAGNOLIA AVENUE					
		63+60	64+40	Stone/ Rubble Revetment	●Stone Overlay	Lawn	●Revegetate disturbed areas.	16	$8K - $11K	**5- 15 yrs 28**

* Refer to Figure 4 and Figure 22

"The Point" Cost Summary	
Priority - High	**$335K to $455K**
Priority - Moderate	**$196K to $254K**

Table 5

Scope of Work

"Fishing Creek"

Area *	Station From	Station To	Shoreline Condition: Existing	Shoreline Condition: Recommendations	Upland Condition: Existing	Upland Condition: Recommendations	Figure	Estimated Cost	Priority
				MAGNOLIA AVENUE					
K	64+40	65+30	Block wall; Rip Rap (Class I); Sink hole, Decayed pier and boat house.	●Stone Overlay ●Bulkhead Repair	Lawn	●Fill sink hole ●Revegetate Disturbed Areas.	15	$10K - $15K	≤ 5 yrs 6
K	65+30	66+30	Stone Sill with Wetlands	None	Wetland/ Lawn	None	—	—	> 15 yrs
K	66+30	69+40	Decayed timber bulkhead with stone reinforcement; timber pier.	●Stone Reinforcement ●Sheeting Enhancement	Lawn.	● Revegetate disturbed areas.	8	$95K - $130K	≤ 5 yrs 11
				HOLLYWOOD AVENUE					
	69+40	71+80	Stone Revetment (Class I); Timber Pier	None	Lawn	None	—	—	> 15 yrs
L	71+80	75+00	Stone Breakwaters and Groin (Class I); Sand Beach; Timber Pier	● Sprig wetland plantings ●Eradicate phragmites.	Lawn, Scrub Brush	●Eradicate phragmites.	—	$13K - $18K	≤ 5 yrs 20
				OAK AVENUE					
L	75+00	76+30	Stone Revetment (Class 1+) w/ erosion; Timber Piers	●Rehabilitate/ Raise Revetment	Lawn	● Revegetate disturbed areas.	16	$13K - $18K	< 5 yrs 15
	76+30	78+40	Stone Breakwaters (Class I) w/ wetland plantings	None	Wetlands Plantings; Trees	●Backfill w/ topsoil ●Revegetate disturbed areas	–	—	> 15 yrs
				MYRTLE AVENUE					
M	78+40	80+10	Concrete crown over Stone Reinforcement (Class II); Timber Piers	●Repair Concrete Bulkhead. ●Stone Overlay.	Lawn	● Revegetate disturbed areas.	15	$25K - $35K	5- 15 yrs 32
M	80+10	80+30	Concrete wall remains, dumped stone/ debris.	●Repair Concrete Bulkhead. ●Stone Overlay.	Debris; Rubble	●Backfill w/ sand. ●Revegetate w/ wetland.	15	$3K - $4K	5- 15 yrs 31
	80+30	80+80	Timber Bulkhead (horizontal beam) with Sand Beach	None	Lawn	None	—	—	> 15 yrs
	80+80	81+50	Stone Revetment (Class I); Timber Pier	None	Lawn	None	—	—	> 15 yrs
	81+50	81+70	Sand Beach; Timber Pier.	None	Lawn	None	—	—	> 15 yrs
N	81+70	82+40	Stone Sill (Class II) w/ Wetland Planting and Eroding Bank; Timber Pier.	●Rehabilitate/ Raise Sill ●Place Sand Fill ●Plant Wetland Vegetation	Lawn	● Revegetate disturbed areas.	17	$10K - $15K	≤ 5 yrs 12
N	82+40	83+00	Stone Sill (Class II)	●Rehabilitate/ Raise Sill	Wetland/ Shrubs Bushes	None	17	$7K - $10K	≤ 5 yrs 16
				CHESTNUT AVENUE					
N	83+00	83+30	Drainage Swale Opening	● New Stone Sill	Tidal Drainage Swale	● Stormwater Management Retrofit	19	$20K - $25K **	≤ 5 yrs 18
N	83+30	85+10	Decayed Timber Bulkhead; Timber Piers	● Stone Reinforcement ●Sheeting Enhancement	Lawn	● Revegetate disturbed areas.	18	$80K - $110K	≤ 5 yrs 2
N	85+10	85+50	Dumped Stone; Phragmites Bank	● New Stone Sill ●Place Sand Fill ●Plant Wetland Vegetation	Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	19	$25K - $30K ***	5- 15 yrs 34
N	85+50	86+60	Sand Beach; Stone Groins; Timber Piers	● Beach Nourishment ● Plant Wetland Vegetation	Lawn	None	—	$4K - $6K	≤ 5 yrs 19
				LINDEN AVENUE					
	86+60	87+70	Stone Sill (Class I); Wetland Vegetation; Timber piers	None	Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs
	87+70	88+80	Stone Revetment (Class I) w/ Wetland Channelward	None	Lawn	None	—	—	> 15 yrs
	88+80	89+80	Stone Filled Gabions; Timber Pier	None	Lawn	None	—	—	> 15 yrs
	89+80	92+50	Stone Sill (Class II); Timber Piers; Community Boat Ramp; Boat Shelter	None	Retaining Wall, Wetlands, Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs
				REDWOOD AVENUE					
	92+50	93+50	Timber Bulkhead w/ Stone Reinforcement (Class II); Timber Pier.	None	Lawn/ Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs
O	93+50	94+90	Eroding Bank; Low Stone Sill; Timber Pier	●New Stone Sill ●Place Sand Fill ●Plant Wetland Vegetation	Wetlands/ Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	19	$20K - $25K	≤ 5 yrs 17
				SYCAMORE AVENUE					
	94+90	96+80	High Stone Sill; Timber Piers	None	Wetlands/ Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs
	96+80	99+20	Unprotected wetland; Timber Piers	● Stone Sill	Wetlands/ Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs
				WALNUT AVENUE					
	99+20	100+50	Mounded Stone Revetment (Class III); Timber Pier	None	Wetlands/ Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs
				NIAGARA AVENUE					
	100+50	101+20	Stone Revetment (Class III); Timber Pier	None	Lawn	None	—	—	> 15 yrs
	101+20	101+60	Sand Beach	None	Lawn	None	—	—	> 15 yrs
	101+60	103+60	Stone Sill (Class III)	None	Wetlands/ Phragmites	●Eradicate phragmites. ● Revegetate Disturbed Areas.	—	—	> 15 yrs

** inlcudes $14K - $19K SWM retrofit
*** inlcudes 15K - $20K phrag removal and mitigation

* Refer to Figure 5 and Figure 22

Class of Rip-Rap	Size	% of Total by weight
I	Heavier than 150 lb Heavier than 40 lb. Less than 2 lb.	0 50 10 Max
II	Heavier than 700 lb Heavier than 200 lb. Less than 20 lb.	0 50 10 Max
III	Heavier than 2000 lb Heavier than 600 lb. Less than 40 lb.	0 50 10 Max

Summary of Costs		
Area	**Priority High**	**Prioirty Moderate**
Bay Frontage	**$410K to $565K**	**$126K to $173 K**
The Point	**$335K to $455K**	**$196K to $254K**
Fishing Creek	**$272K to $372K**	**$53K to $69K**
TOTAL	**$1017K to $1392K**	**$375K to $496K**

"Fishing Creek" Cost Summary	
Priority - High	**$272K to $372K**
Priority - Moderate	**$53K to $69K**

Table 6