

AD-A167 551

UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS AT
NAVAL STATION NORFOLK 07AC(NAACU) CHILDS ENGINEERING
CORP WEDFIELD MA JUL 82 CHES/NAUFAC-PPG-1-82 (13)

1/8

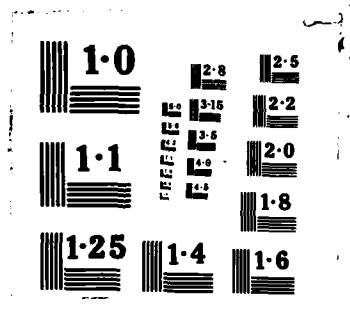
UNCLASSIFIED

NO2477-81-C-0448

P/G 13/2

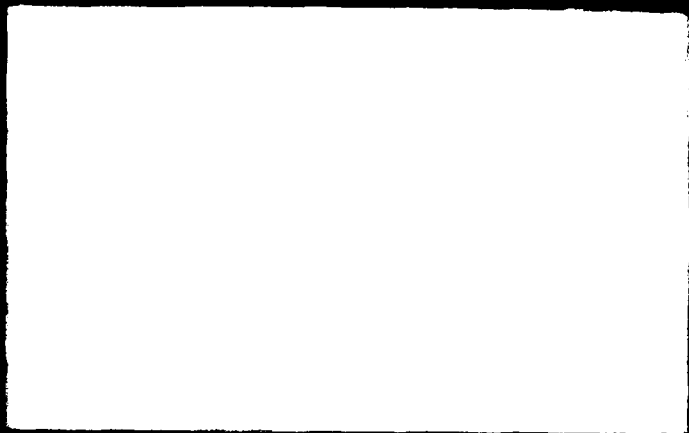
NL





①

AD-A167 551



DTIC FILE COPY

DTIC
ELECTE
MAY 05 1986
S D

86 4 22 001

UNDERWATER FACILITIES
INSPECTIONS
AND
ASSESSMENTS
AT

1

*Original contains color
plates: All DTIC reproductions
will be in black and
white*



NAVAL STATION
NORFOLK, VA
II

FPO-1-82-(13) JULY 1982

PERFORMED FOR:

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C. 20374

UNDER:

CONTRACT N62477-81-C-0448
TASK 1

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

BY:

CHILDS ENGINEERING CORPORATION
MEDFIELD, MASSACHUSETTS 02052

DTIC
ELECTE
MAY 05 1986
S D

86 4 22 001

DISCLAIMER NOTICE

**THIS DOCUMENT IS BEST QUALITY
PRACTICABLE. THE COPY FURNISHED
TO DTIC CONTAINED A SIGNIFICANT
NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.**

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

AD-A167551

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

3. DISTRIBUTION AVAILABILITY OF REP.
Approved for public release;
distribution is unlimited

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

4. PERFORMING ORGANIZATION REPORT NUMBER

5. MONITORING ORGANIZATION REPORT #
FPO-1-82(13)

6a. NAME OF PERFORM. ORG. 6b. OFFICE SYM
Childs Engineering Corp.

7a. NAME OF MONITORING ORGANIZATION
Ocean Engineering
& Construction
Project Office
CHESNAVFACENGCOM

6c. ADDRESS (City, State, and Zip Code)
Medfield, MA 02052

7b. ADDRESS (City, State, and Zip)
BLDG. 212, Washington Navy Yard
Washington, D.C. 20374-2121

8a. NAME OF FUNDING ORG. 8b. OFFICE SYM

9. PROCUREMENT INSTRUMENT INDENT #
N62477-81-C-0448, Task 1

8c. ADDRESS (City, State & Zip)

10. SOURCE OF FUNDING NUMBERS
PROGRAM PROJECT TASK WORK UNIT
ELEMENT # # # ACCESS #

11. TITLE (Including Security Classification)
Underwater Facilities Inspections & Assessments at Naval Station Norfolk,
VA II

12. PERSONAL AUTHOR(S)

13a. TYPE OF REPORT 13b. TIME COVERED 14. DATE OF REP. (YYMMDD) 15. PAGES
FROM TO 82-07 122

16. SUPPLEMENTARY NOTATION

17. COSATI CODES
FIELD GROUP SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if nec.)
Underwater inspection, Mooring inspection
Naval Station Norfolk, VA

19. ABSTRACT (Continue on reverse if necessary & identify by block number)
The objective of the underwater facility assessments conducted at the Naval
Station, Norfolk, Virginia is to provide a generalized structural condition
report of certain facilities within the Activity. The facilities are Piers
22, 23, 25, 2, 3, 4, C, D, E, and Bulkheads CEP-102 and CEP-176. Each (Con't)
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT 21. ABSTRACT SECURITY CLASSIFICATION
SAME AS RPT.

22a. NAME OF RESPONSIBLE INDIVIDUAL
Jacqueline B. Riley
DD FORM 1473, 84MAR

22b. TELEPHONE 22c. OFFICE SYMBOL
202-433-3881
SECURITY CLASSIFICATION OF THIS PAGE

BLOCK 19 (Con't)

facility was inspected by a team of Engineer/Divers using visual/tactile, non-destructive techniques. Typical and critical elements were photo-documented.

Conditions throughout the Activity were diverse. In general, the newer piers or portions of piers were in better condition than the older elements. Conditions in the older piers ranged from excellent to marginal.

The majority of the piers exhibited some major structural damage. This damage was usually in the form of cracked or broken perimeter piles. It appears that these piles have been impacted by vessels or camels. In conjunction with the perimeter structural pile damage it was also noted the pier fender systems exhibited localized failure, also the result of vessel impact.

Repair of the damaged structural piles is of prime importance.

Piers 22 and 23 are both approximately the same size and age and both were enlarged in the same fashion. Pier 22 has undergone a repair program to its older structural piles while Pier 23 has not. The repairs to Pier 22 are effectively protecting the piles from further deterioration, although some piles need further repair. Pier 23 has not been repaired and consequently is suffering severe deterioration. Through structural analysis of the remaining strength of the piles, it has been determined that the pier load capacity need not be reduced.

It is recommended that repairs similar to those found on Pier 22 (concrete jacketing) be undertaken on Pier 23 as soon as possible.

The condition of Piers 25, C, D, and E is excellent except for those piles that have been damaged by vessel impact. Other than the damaged piles, there are no immediate repairs necessary. This is a reflection of the relatively young age of the piers.

Piers 2, 3 and 4 are generally in excellent condition. In Piers 2 and 3 the noted deterioration seems to be localized. In a localized area piles have lost considerable cross sectional area. Although this condition has not threatened the structural integrity of the pier, it is serious. The damaged areas should be repaired by a method similar to that used on Pier 22 (concrete jacketing). The exposed portion of the steel sheet pile bulkhead on Pier 4 is in good condition. The protective concrete face which has been cast against the steel sheet piling has some small voids at the mudline, which are open to the steel sheet pile. The concrete is in good condition with no evidence of fill leaching out.

The Bulkheads CEP-102 and CEP-176 are in fair condition. Deterioration is occurring in the area of mean low water and the concrete cap. This deterioration is in the form of spalling on the corners of the concrete sheet piles in the tidal zone and cracking and displacement of the cap. These conditions could be the cause of some loss of fill behind the sheet piles, but there was no obvious indication that this was happening. The spacing between the sheet piles ranges from 1/2" to 3". There could be fill leaching out from the spaces, but again, there were no obvious indications of this occurring. A previous study has been made of this area and a repair contract has been let. The repairs described in this contract are adequate and we recommend reference to this contract for further or more detailed information.

EXECUTIVE SUMMARY

The objective of the Underwater Facility Assessments conducted at the Naval Station, Norfolk, Virginia is to provide a generalized structural condition report of certain facilities within the Activity. The facilities are Piers 22, 23, 25, 2, 3, 4, C, D, E and Bulkheads CEP-102 and CEP-176. Each facility was inspected by a team of Engineer/Divers using visual/tactile, non-destructive techniques. Typical and critical elements were photo-documented.

Conditions throughout the Activity were diverse. In general, the newer piers or portions of piers were in better condition than the older elements. Conditions in the older piers ranged from excellent to marginal.

The majority of the piers exhibited some major structural damage. This damage was usually in the form of cracked or broken perimeter piles. It appears that these piles have been impacted by vessels or camels. In conjunction with the perimeter structural pile damage it was also noted the pier fender systems exhibited localized failure, also the result of vessel impact.

Repair of the damaged structural piles is of prime importance.

Piers 22 and 23 are both approximately the same size and age and both were enlarged in the same fashion. Pier 22 has undergone a repair program to its older structural piles while Pier 23 has not. The repairs to Pier 22 are effectively protecting the piles from further deterioration, although some piles need further repair. Pier 23 has not been repaired and consequently is suffering severe deterioration. Through structural analysis of the remaining strength of the piles, it has been determined that the pier load capacity need not be reduced.

Availability Codes	
Dist	Avail and/or Special
A-1	23

It is recommended that repairs similar to those found on Pier 22 (concrete jacketing) be undertaken on Pier 23 as soon as possible.

The condition of Piers 25, C, D and E is excellent except for those piles that have been damaged by vessel impact. Other than the damaged piles, there are no immediate repairs necessary. This is a reflection of the relatively young age of the piers.

Piers 2, 3 and 4 are generally in excellent condition. In Piers 2 and 3 the noted deterioration seems to be localized. In a localized area piles have lost considerable cross sectional area. Although this condition has not threatened the structural integrity of the pier, it is serious. The damaged areas should be repaired by a method similar to that used on Pier 22 (concrete jacketing). The exposed portion of the steel sheet pile bulkhead on Pier 4 is in good condition. The protective concrete face which has been cast against the steel sheet piling has some small voids at the mudline, which are open to the steel sheet pile. The concrete is in good condition with no evidence of fill leaching out.

The Bulkheads CEP-102 and CEP-176 are in fair condition. Deterioration is occurring in the area of mean low water and the concrete cap. This deterioration is in the form of spalling on the corners of the concrete sheet piles in the tidal zone and cracking and displacement of the cap. These conditions could be the cause of some loss of fill behind the sheet piles, but there was no obvious indication that this was happening. The spacing between the sheet piles ranges from 1/2" to 3". There could be fill leaching out from the spaces, but again, there were no obvious indications of this occurring. A previous study has been made of this area and a repair contract has been let (Naval Drawings No. 4075236 to No. 4075254). The repairs described in this contract are adequate and we recommend reference to this contract for further or more detailed information.

NAVAL STATION
NORFOLK, VIRGINIA
EXECUTIVE SUMMARY TABLE

<u>FACILITY</u>	<u>YEAR BUILT</u>	<u>TOTAL NO. OF PILES/ LIN. FT. OF BULKHEAD</u>	<u>SIZE (LXW (FT.))</u>	<u>STRUCTURES</u>	<u>RECOMMENDATIONS</u>
Pier 22	1944 Expanded 1969	935/0	1302 x 50	16" square pre-cast concrete piles, 16" pre-stressed concrete piles.	1) Restrict capacity of severely damaged piles by driving new piles by driving casting new concrete. 2) Jacket heavily damaged concrete. 3) Re-inspect after 5 years there
Pier 23	1944 Expanded 1969	902/0	1255 x 50	16" square precast concrete piles, 16" pre-stressed concrete piles.	1) Restrict capacity of severely damaged piles by driving new piles by driving casting new concrete. 2) Jacket heavily damaged concrete. 3) Re-inspect after 5 years there
Pier 25	1977	1131/0	1400 x 70	16" square precast concrete piles, 16" pre-stressed concrete piles.	1) Restrict capacity of severely damaged piles by driving new piles by driving casting new concrete. 2) Jacket heavily damaged concrete. 3) Re-inspect after 5 years there
Pier 2	1943	4250/0	1340 x 170	18" square precast concrete piles.	1) Restrict capacity of severely damaged piles by driving new piles by driving casting new concrete. 2) Jacket heavily damaged concrete. 3) Re-inspect after 5 years there
Pier 3	1942	4300/0	1307 x 170	18" square precast concrete piles.	1) Restrict capacity of severely damaged piles by driving new piles by driving casting new concrete. 2) Jacket heavily damaged concrete. 3) Re-inspect after 5 years there

NAVAL STATION
NORFOLK, VIRGINIA

EXECUTIVE SUMMARY TABLE

<u>TURES</u>	<u>RECOMMENDATIONS</u>	<u>EST. COST OF RECOMMENDATIONS (THOUSANDS)</u>
quare pre- concrete piles, re-stressed ete piles.	1) Restrict capacity loading in the area of severely damaged piles and repair piles by driving 2 sister piles and casting new cap.	\$ 69
	2) Jacket heavily spalled areas in concrete.	179
	3) Re-inspect after construction and 5 years thereafter.	
quare precast rete piles, 16" stressed concrete s.	1) Restrict capacity loading in the area of severely damaged piles and repair piles by driving 2 sister piles and casting new cap.	111
	2) Jacket heavily spalled areas in concrete.	656
	3) Re-inspect after construction and 5 years thereafter.	
square precast rete piles, 16" stressed concrete s.	1) Restrict capacity loading in the area of severely damaged piles and repair piles by driving 2 sister piles and casting new cap.	143
	2) Jacket heavily spalled areas in concrete.	1
	3) Re-inspect after construction and 5 years thereafter.	
square precast rete piles.	1) Restrict capacity loading in the area of severely damaged piles and repair piles by driving 2 sister piles and casting new cap.	37
	2) Jacket heavily spalled areas in concrete.	284
	3) Re-inspect after construction and 5 years thereafter.	
square precast rete piles.	1) Restrict capacity loading in the area of severely damaged piles and repair piles by driving 2 sister piles and casting new cap.	27
	2) Jacket heavily spalled areas in concrete.	67
	3) Re-inspect after construction and 5 years thereafter.	

NAVAL STATION
NORFOLK, VIRGINIA
EXECUTIVE SUMMARY TABLE

<u>FACILITY</u>	<u>YEAR BUILT</u>	<u>TOTAL NO. OF PILES/ LIN. FT. OF BULKHEAD</u>	<u>SIZE (LXW (FT.))</u>	<u>STRUCTURES</u>	<u>RECOMMENDATION</u>
Pier 4	1942	2100/2760	1346 x 250	18" square precast concrete piles. Steel sheet pile bulkhead with concrete face.	1) Restrict capacity of severely damaged piles by driving casting new concrete. 2) Jacket heavily damaged concrete. 3) Re-inspect after 5 years thereafter.
Pier C	1952	140/0	400 x 20	18" square precast concrete.	1) Re-inspect in 5 years.
Pier D	1952	140/0	400 x 20	18" square precast concrete.	1) Re-inspect in 5 years.
Pier E	1952	140/0	400 x 20	18" square precast concrete.	1) Re-inspect in 5 years.
CEP-102	1943	0/1750	1750	2' precast concrete sheet piles.	1) Refer to Repair CEP-102, CEP-176, CEP-111 (Construction No. 2470-81-B-1) 2) Re-inspect after 5 years.
CEP-176	1943	0/900	900	2' precast concrete sheet piles.	1) Refer to Repair CEP-102, CEP-176, CEP-111 (Construction No. 2470-81-B-1) 2) Re-inspect after 5 years.

NAVAL STATIONNORFOLK, VIRGINIAEXECUTIVE SUMMARY TABLE

<u>STRUCTURES</u>	<u>RECOMMENDATIONS</u>	<u>EST. COST OF RECOMMENDATIONS (THOUSANDS)</u>
square precast rete piles. Steel t pile bulkhead with rete face.	1) Restrict capacity loading in the area of severely damaged piles and repair piles by driving 2 sister piles and casting new cap. 2) Jacket heavily spalled areas in concrete. 3) Re-inspect after construction and 5 years thereafter.	\$ 48 17
square precast rete.	1) Re-inspect in 5 years.	N/A
square precast rete.	1) Re-inspect in 5 years.	N/A
square precast rete.	1) Re-inspect in 5 years.	N/A
precast concrete t piles.	1) Refer to Repairs to Bulkheads CEP-102, CEP-176 and Quaywall CEP-111 (Construction Contract No. 2470-81-B-1363). 2) Re-inspect after repairs and again in 5 years.	N/A
precast concrete t piles.	1) Refer to Repairs to Bulkheads CEP-102, CEP-176 and Quaywall CEP-111 (Construction Contract No. 2470-81-B-1363). 2) Re-inspect after repairs and again in 5 years.	N/A

TABLE OF CONTENTS

	<u>PAGE</u>
EXECUTIVE SUMMARY	i
Section 1.0 INTRODUCTION	1-1
1.1 Report Content	1-1
Section 2.0 ACTIVITY DESCRIPTION	2-1
2.1 Location of Activity	2-1
2.2 Existing Facilities	2-1
Section 3.0 INSPECTION PROCEDURE	3-1
3.1 Level of Inspection	3-1
3.2 Inspection Procedure	3-1
3.3 Inspection Equipment	3-2
Section 4.0 FACILITIES INSPECTED	4-1
4.1 Pier 22	4-7
4.1.1 Description	4-7
4.1.2 Observed Inspection Condition	4-14
4.1.3 Structural Condition Assessment	4-17
4.1.4 Recommendations	4-18
4.2 Pier 23	4-20
4.2.1 Description	4-20
4.2.2 Observed Inspection Condition	4-27
4.2.3 Structural Condition Assessment	4-29
4.2.4 Recommendations	4-30
4.3 Pier 25	4-31
4.3.1 Description	4-31
4.3.2 Observed Inspection Condition	4-39
4.3.3 Structural Condition Assessment	4-40
4.3.4 Recommendations	4-41
4.4 Pier 2	4-42
4.4.1 Description	4-42
4.4.2 Observed Inspection Condition	4-48
4.4.3 Structural Condition Assessment	4-50
4.4.4 Recommendations	4-51
4.5 Pier 3	4-52
4.5.1 Description	4-52
4.5.2 Observed Inspection Condition	4-58
4.5.3 Structural Condition Assessment	4-59
4.5.4 Recommendations	4-60

TABLE OF CONTENTS (Cont'd.)

	<u>PAGE</u>
4.6 Pier 4	4-61
4.6.1 Description	4-61
4.6.2 Observed Inspection Condition	4-70
4.6.3 Structural Condition Assessment	4-72
4.6.4 Recommendations	4- 3
4.7 Pier C	4-74
4.7.1 Description	4-74
4.7.2 Observed Inspection Condition	4-76
4.7.3 Structural Condition Assessment	4-76
4.7.4 Recommendations	4-77
4.8 Pier D	4-78
4.8.1 Description	4-78
4.8.2 Observed Inspection Condition	4-80
4.8.3 Structural Condition Assessment	4-80
4.8.4 Recommendations	4-80
4.9 Pier E	4-81
4.9.1 Description	4-81
4.9.2 Observed Inspection Condition	4-83
4.9.3 Structural Condition Assessment	4-83
4.9.4 Recommendations	4-83
4.10 Bulkhead CEP-102	4-84
4.10.1 Description	4-84
4.10.2 Observed Inspection Condition	4-86
4.10.3 Structural Condition Assessment	4-87
4.10.4 Recommendations	4-88
4.11 Bulkhead CEP-176	4-89
4.11.1 Description	4-89
4.11.2 Observed Inspection Condition	4-91
4.11.3 Structural Condition Assessment	4-92
4.11.4 Recommendations	4-93

APPENDIX

LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
1	Location Map	2-2
2	Vicinity Map	2-3
3	Jurisdiction Map	2-4
4	Facilities Location	2-5
5	Berthing Utilization	2-6
6	Inspection Path	3-3
7	Pile Conditions	4-3
8	Pile Conditions	4-4
9	Pile Conditions	4-5
10A - 10F	Pier 22 Pile Plan & Pile Conditions	4-8-13
11A - 11F	Pier 23 Pile Plan & Pile Conditions	4-21-26
12A - 12G	Pier 25 Pile Plan & Pile Conditions	4-32-38
13A - 13E	Pier 2 Pile Plan & Pile Conditions	4-43-47
14A - 14E	Pier 3 Pile Plan & Pile Conditions	4-53-57
15A - 15H	Pier 4 Pile Plan & Pile Conditions	4-62-69
16	Pier C Pile Plan & Pile Conditions	4-75
17	Pier D Pile Plan & Pile Conditions	4-79
18	Pier E Pile Plan & Pile Conditions	4-82
19	CEP-102 Plan & Elevation	4-85
20	CEP-176 Plan & Elevation & Typical Section .	4-90

LIST OF PHOTOGRAPHS

<u>PHOTO NO.</u>	<u>DESCRIPTION</u>	<u>FOLLOWS PAGE</u>
1	Pier #3, Bents #66, 67, 68, Pile A, showing a variety of severe structural damage	4-2
2	Pier 23, Bent 35, Pile B, shows heavy spalling, (3" deep) on the corner of pile in the tidal zone	4-2
3	Pier 3, Bent 6, Pile 1, shows heavy spalling in tidal zone with exposed rebar. The rebar and adjacent concrete have been cleaned of corrosion and biofouling	4-2
4	Pier C, Bent 6, Pile 1, typical marine growth at El -1 and 1" of spalling on corner of pile	4-2
5	Pier 25, Bent 22, Pile L, example of pile in good condition with no spalling	4-2
6	Pier 22, Bent 36, Pile F, shows cracking on the corner of pile at El -10	4-15
7	Pier 22, Bent 40, Pile J, example of cracking and spalling on the corner just below the repair (El -6). (Bottom of repair is at top of photo	4-15
8	Pier 23, Bent 66, Pile J, example of severe structural damage	4-27
9	Pier 23, Bent 64, Pile J, shows severely damaged pile at El -05, heavy spalling and rebar partially cleaned of corrosion and biofouling. The tie wire is exposed horizontally	4-28
10	Pier 23, Bent 66, Pile G, at El -7.0 shows crack and area of soft concrete (1") chipped away by diver on corner of pile	4-28
11	Pier 25, Bent 23, Pile L, severely damaged pile, at El 0.0, shows pre-stressing strands and tie wire	4-39
12	Pier 2, overview of south side of pier looking west	4-42
13	Pier 2, Bent 82, Pile A, pile cracked and spalled with rebar exposed at El +5.0	4-48
14	Pier 2, Bent 84, Pile B, example of cracking of a pile at El +6	4-48

LIST OF PHOTOGRAPHS (Cont'd.)

<u>PHOTO NO.</u>	<u>DESCRIPTION</u>	<u>FOLLOWS PAGE</u>
15	Pier 2, Bent 53, Pile N, at El -1.0, heavy spalling with rebar exposed. The concrete and rebar have been cleaned of biofouling and corrosion	4-49
16	Pier 2, Bent 58, Pile 1, shows light spalling in the tidal zone to a depth of 2"	4-49
17	Pier 3, overview of south side of pier looking west	4-52
18	Pier 3, Bent 5, Pile G, example of light spalling in the tidal zone on the corner of the pile (2" deep)	4-58
19	Pier 4, Bents 92, 93, Pile DD, shows 2 consecutive perimeter piles severely damaged . . .	4-70
20	Pier 4, Bent 93, Pile DD, at El -2.0 shows rebar (partially cleaned) of broken pile entering concrete.	4-70
21	Pier 4, Bent 110, Pile DD looking at the corner of the pile at El +0.0, shows pile in good condition	4-70
22	Pier 4, on north face of bulkhead, between Bents 84 and 85, example of void in the concrete face exposing rebar and steel sheet pile at El -8 (approximate dimensions 2' x 1')	4-71
23	Pier D, Bent 10, Pile A, shows a pile at El 0.0 with spalling of less than 1" on the corner	4-80
24	Pier E, overview of pier looking west	4-81
25	Pier E, Bent 16, Pile D, example of light spalling on a corner in the tidal zone. A straight edge is representing the original pile dimension	4-83
26	Bulkhead CEP-102, Station 21+50, at the mud line (El -17) shows cracking of corner and light spalling	4-86
27	Bulkhead CEP-176, Station 39+45, at El -4.0 shows spalling on edges of 2 piles	4-91

This report is a product of the Underwater Inspection Program conducted by the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (NAVFACENGCOM) under NAVFAC's Specialized Inspection Program.

This program sponsors task-oriented engineering services for the inspection, analysis and design, and monitoring of repairs for the submerged portions of selected Naval Waterfront Facilities. All services required to produce this report were provided by Childs Engineering Corporation of Medfield, Massachusetts under Task No. 1.0 of Contract No. N62477-81-C-0448.

1.1 REPORT CONTENT

The report contains a description of inspection procedures, the results of the inspection and analysis of the findings, accompanied by pertinent drawings and photographs. Specifically, the inspection results include a description of the location, existing facilities, its observed condition and a structural assessment of that condition. Recommendations for each facility, including cost estimates (based on present local prices) for any repair work, are also included. Structural assessment calculations and cost estimate breakdowns can be found in the Appendix.

SECTION 2.0

ACTIVITY DESCRIPTION

The purpose of this section is to provide a general description of the Naval Station in Norfolk, Virginia. The section includes brief descriptions of the Naval Station's location and existing facilities. The information is provided to aid in identification of the facility and to support all considerations necessary to accurately assess the condition of facilities inspected under this task. (Reference 1)

2.1 LOCATION OF ACTIVITY

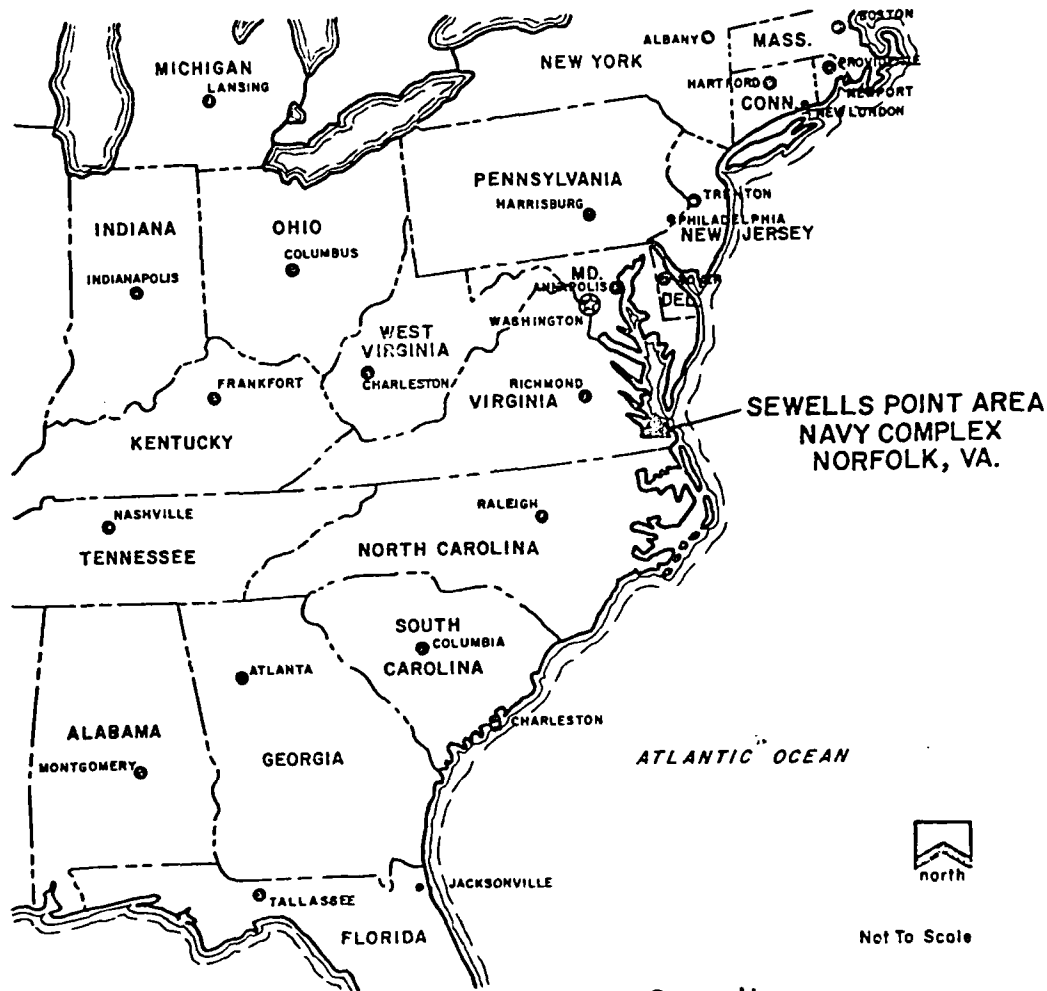
Located at latitude 36 degrees 55 minutes North and longitude 76 degrees 22 minutes West, the Norfolk Naval Station piers form one part of the much larger Sewells Point Area Navy Complex (Figures 1, 2, 3 & 4). The Sewells Point Complex is situated in the world's largest natural harbor, Hampton Roads. This strategic location enjoys access to the Atlantic Ocean through Chesapeake Bay, providing a natural protective site for its main function of home porting the majority of current active ships in the Atlantic Fleet (see Figure 2). (Reference 1)

2.2 EXISTING FACILITIES

In 1917 the Navy acquired the naval station. Since that time, the Navy has constructed over 3,000 buildings and developed major waterfront facilities and an all-weather airfield. There are 15 waterfront facilities in the naval station. The total footage of berthing is 34,977 of which there is 93% utilization (see Figure 5).

2.3 REFERENCE

- 1) Sewells Point Area Navy Complex Master Plan

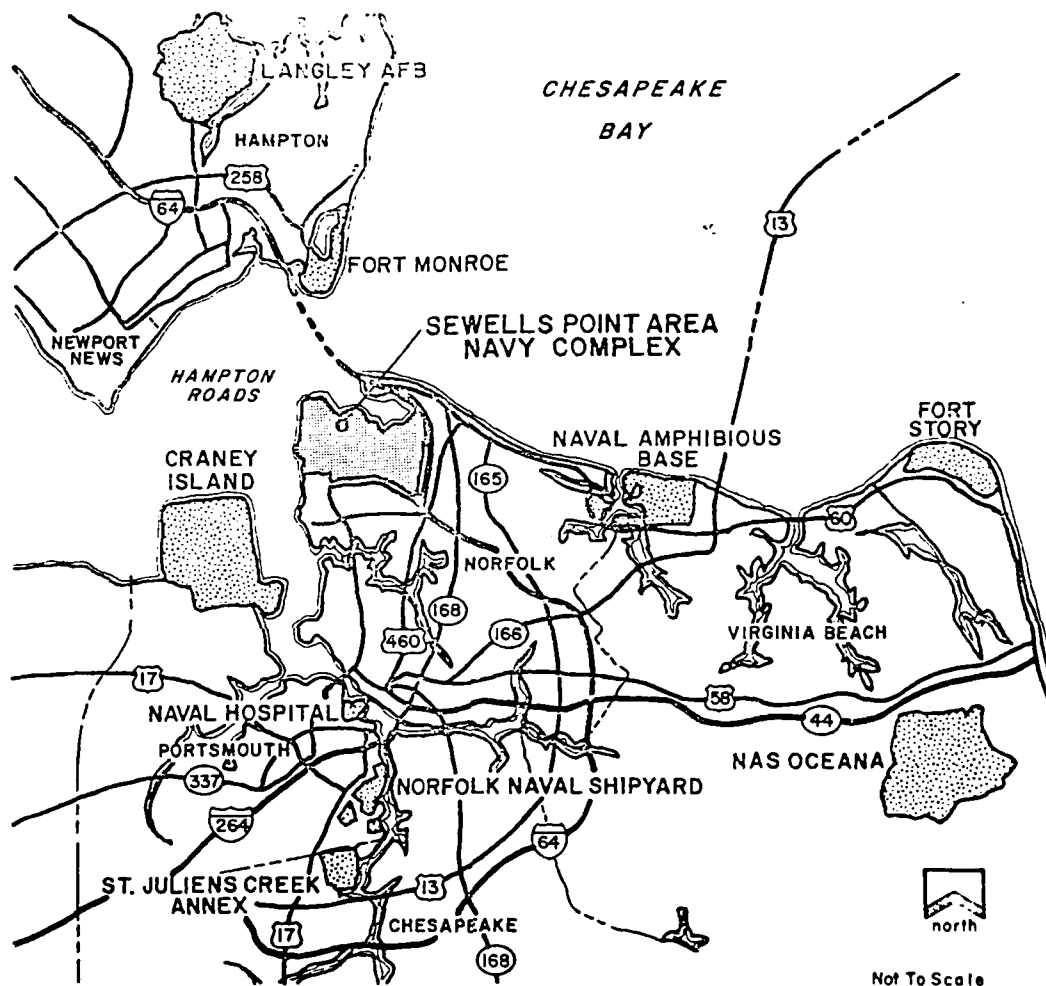


Sewells Point Area Navy Complex

NOTE:

REFERENCE TAKEN FROM
SEWELLS POINT AREA NAVY COMPLEX
MASTER PLAN.

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.
NA	NAVAL STATION	NORFOLK, VA
	LOCATION MAP	FIG NO 1



Sewells Point Area Navy Complex

NOTE:

REFERENCE TAKEN FROM
SEWELLS POINT AREA NAVY COMPLEX
MASTER PLAN.

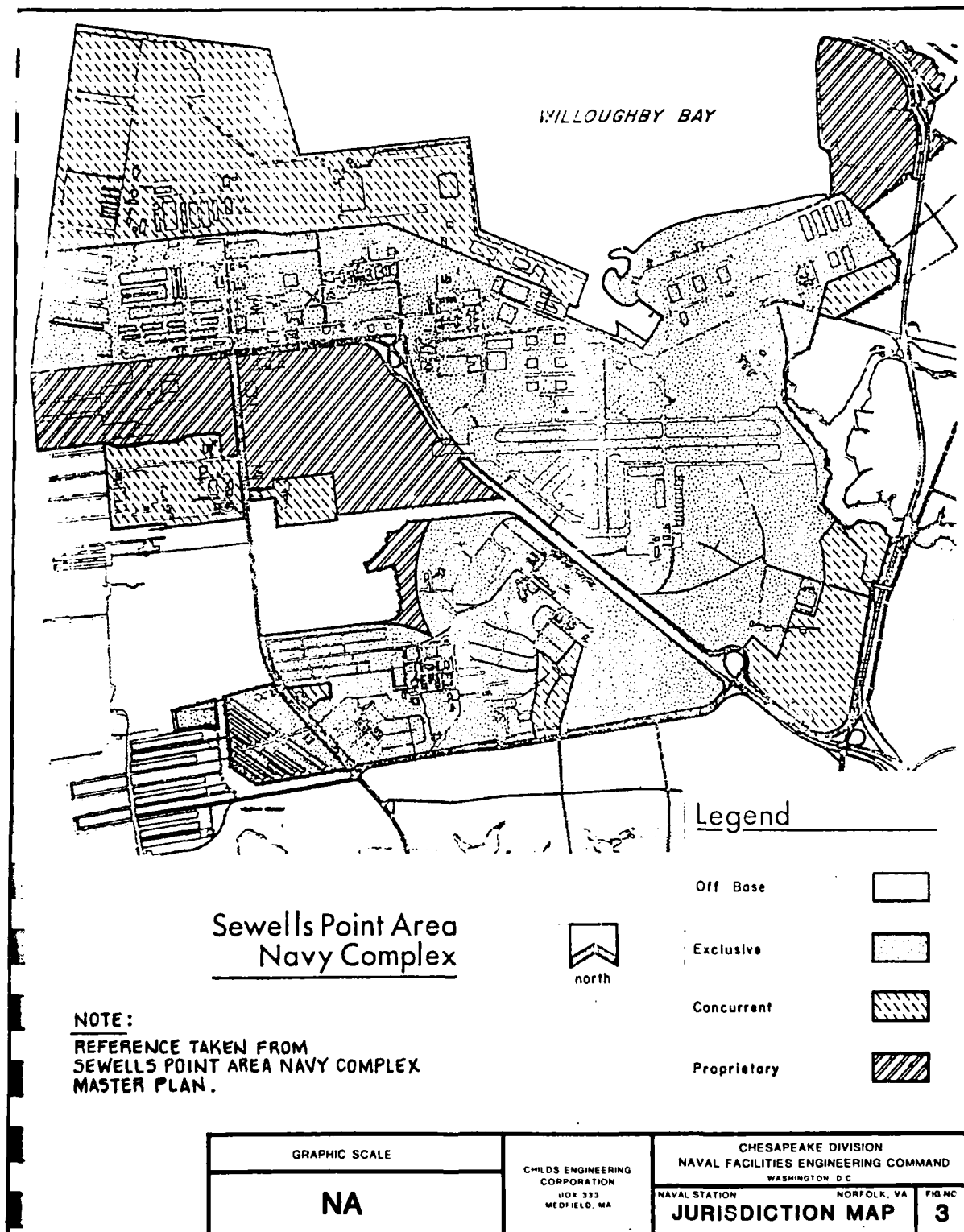
GRAPHIC SCALE

NA

CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

NAVAL STATION NORFOLK, VA FIG NO
VICINITY MAP 2





FACILITIES
INSPECTED

PIER C, D, & E

PIER 4

PIER 3

PIER 2

PIER 25

PIER 23

PIER 22

NOTE:
REFERENCE TAKEN
FROM NAVAL STATION
GENERAL INFORMATION
PLAN NO. 11100/2 (7/81).

CEP 102

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D C	
NA		NAVAL STATION NORFOLK, VA FACILITIES' LOCATION 4	

Charrette 10347

TABLE 7: BERTHING UTILIZATION							
PIER	PIER LENGTH	REQUIRED FB			% UTILIZATION		
		SOUTH SIDE	NORTH SIDE	TOTAL	SOUTH SIDE	NORTH SIDE	TOTAL
12	1305	1127	1182	2309	86	91	88
11	1400	1373	1127	2500	98	81	89
10	1300	NA	1269	1269	NA	98	98
7	1352	1214	1373	2587	90	101	96
5	1353	1252	1309	2561	93	97	95
4	1346	1282	1245	2527	95	93	94
3	1307	1265	1202	2467	97	92	94
2	1340	1246	1326	2572	93	99	96
25	1400	1312	1278	2590	94	91	93
24	1400	1246	1278	2524	89	91	90
23	1255	1196	1119	2315	95	89	92
22	1303	1240	1119	2359	95	86	91
21	1405	1196	1196	2392	85	85	85
20	1455	1430	1430	2860	98	98	98
S. Blvd. 1200		1145	NA	1145	95	NA	95
TOTAL	20122 (37744FB)	17524	17453	34977	XX	XX	93

NOTE:

REFERENCE TAKEN FROM
SEWELLS POINT AREA NAVY COMPLEX
MASTER PLAN.

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
		NAVAL STATION	NORFOLK, VA
NA		BERTHING UTILIZATION	
			5

Between June 9 and July 16 of 1982, a three-person Engineer/Diver, Technician/Diver inspection team performed an on-site underwater inspection of various piers and bulkheads, at the Naval Station in Norfolk, Virginia. The level of inspection to be performed, the type of structure being inspected, actual on-site conditions and past experience, combined with a thorough knowledge of engineering theory, dictated the inspection procedures that were followed.

3.1 LEVEL OF INSPECTION

The inspection techniques used had to be sufficient to yield information necessary to make a general condition assessment of the supporting structure of each facility, identify any areas that were mechanically damaged or in advanced states of deterioration and formulate repair and maintenance recommendations with cost estimates. In general, this means utilizing visual/tactile inspection techniques. Photographic documentation of typical as well as unusual conditions were also obtained.

3.2 INSPECTION PROCEDURE

A dive team consisting of two divers and a tender performed the on-site inspection. Depending on the layout of the individual pier, the divers would inspect alternate bents or each take a portion of a bent. A Level I inspection, which is a general inspection of the full length of the pile, was performed on all exterior perimeter piles and every pile in every third bent (see Figure 6). The modified Level I, a swim-by inspection at El -2 to -4, was performed on every pile. A Level II inspection, where the piles were inspected for their full length and band-cleaned of biofouling and debris on three sides, was performed on 7% of the piles. The band-

cleaning was executed at El 0.0 on two-thirds of the Level II piles, and the remaining Level II piles were band-cleaned either at the mudline or mid-depth.

When inspecting the concrete sheet pile bulkhead, a Level II inspection was performed every 300 linear feet. This involved cleaning a 1 square foot section at 3 elevations; mudline, mid-depth and mean low water. Also, the divers performed a swim-by inspection at the mudline and mean low water.

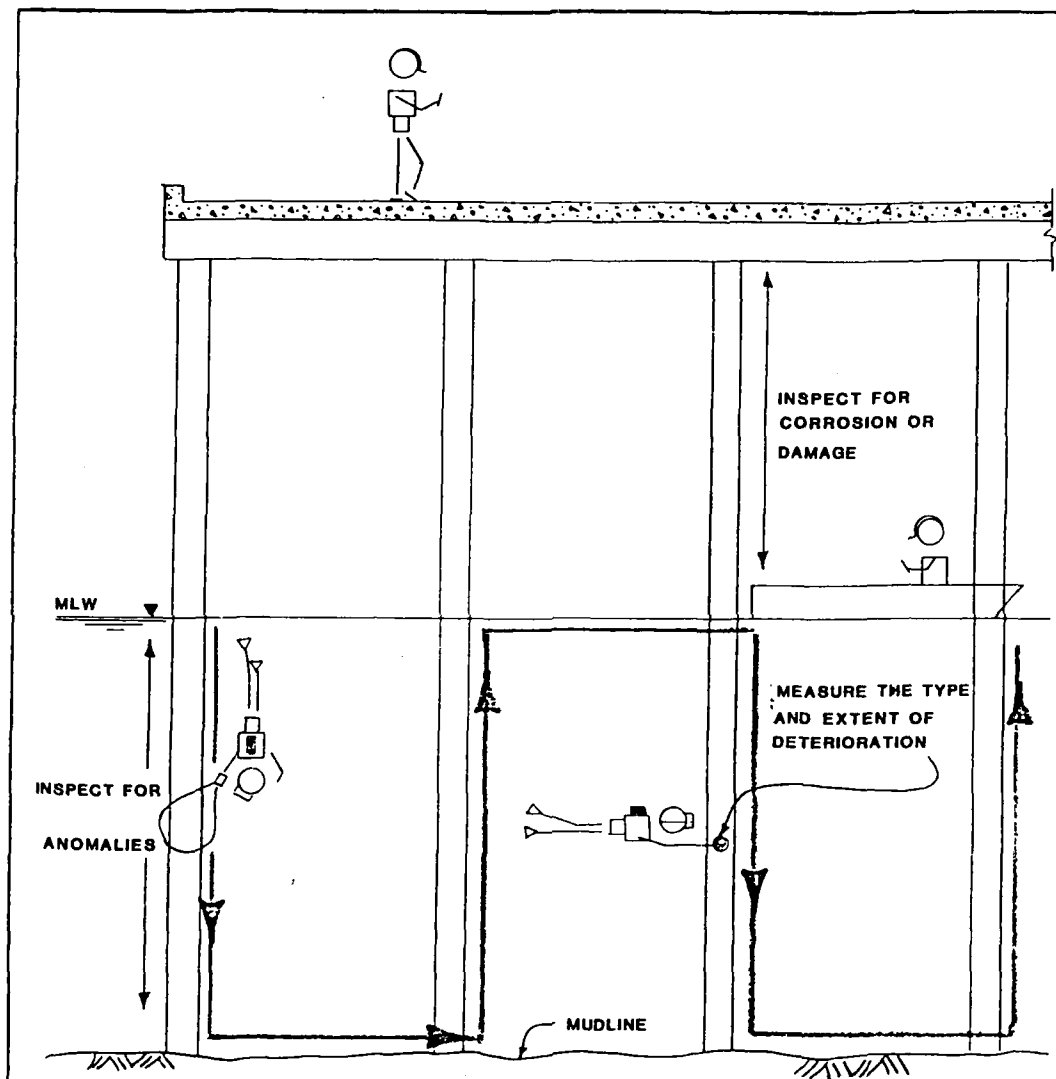
In all levels of inspection, the concrete was regularly hit with a hammer to gauge the soundness of the concrete and to detect any softness that might be present.

It should be noted that non-destructive methods of inspection were employed. The conditions noted reflect direct observation of structural components. Information which may infer knowledge of conditions not accessible by non-destructive testing methods is based on government-furnished documents, our knowledge of structures in similar environments and/or generally accepted engineering theories.

3.3 INSPECTION EQUIPMENT

Equipment used for the inspection included a Minolta SRT200 camera with 28mm and 200mm lenses and strobe, a Nikonos III underwater camera with Nikon close-up lens and a 7" x 9" stainless steel framer, clear water box (for use in low visibility conditions) and strobe, dive lights, 100-foot sounding tape, 200-foot fiberglass tape, 6-foot folding rules, chipping hammers and dive knives.

Choice of equipment was made as a result of past experience. Most of the equipment is straightforward, easy to implement, and has proven reliable under hard use.



**TYPICAL DIVER INSPECTION PATH
LEVEL I**

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
NA		NAVAL STATION INSPECTION PATH	NORFOLK, VA FIG. NO. 6

SECTION 4.0

FACILITIES INSPECTED

Within this section of the report, each facility inspected at the Naval Station, Norfolk Virginia, is referenced separately. The discussion of each facility is presented in four parts:

1) a description of the construction and function of the structure, which is derived both from the on-site inspection and from the referenced government-furnished drawings; 2) an enumeration of general and specific conditions observed during the on-site inspection; 3) a qualitative assessment of the structural condition of the facility based on the inspection data; and 4) recommendations for actions to be taken to insure long-term, cost-effective maintenance and utilization of the facility. Detailed breakdowns of cost estimates are included in the Appendix.

Marine growth profiles were noted at each facility. These profiles were similar for all the facilities at the Naval Station. In general, oysters and barnacles, along with a covering of soft growth, including algae, sponges and various marine invertebrates, covered the concrete piles. This growth extended from mean low water to within 1' to 2' of the mudline. The thinning out of growth at the mudline is probably due to either scouring or a change in the level of the mudline attributed to dredging. Oysters in some areas were as thick as 4", but generally were scattered thinly along with barnacles. The soft growth was usually about 1" thick and could be found throughout each facility in combination with the oysters and barnacles.

On the concrete piles, deterioration was noted with respect to its structural significance. Piles not capable of supporting the imposed load were noted as severely damaged. This anomaly displayed one or more of the following characteristics:

- 1) Pile snapped clean above mean low water and displaced (see Figure 7, Condition No. 1).

- 2) Rebar still attached to the pile cap, but concrete is missing from the pile cap to El -2± (see Figure 7, Condition No. 2, Photo 1).
- 3) Piles cracked and broken, below mean low water at El -10± to El -5± and displaced (see Figure 8, Condition No. 3).

A condition where the concrete has spalled to a point where the cross-sectional area of the remaining pile has marginal capabilities to support its designed load is noted as heavy spalling, (see Photo 2). In many cases of heavy spalling, rebar is exposed to the water and has experienced corrosion (see Figure 9, Photo 3).

Spalling that does not immediately threaten the structural integrity of the pile was noted as light (see Figure 9, Photo 4).

The observed cracking and spalling of the concrete piles are the result of one or all of the following actions: 1) mechanical damage; 2) electrochemical processes; and, 3) chemical action. In general, all three elements have probably acted together to cause the observed deterioration.

Concrete submerged in seawater for as long as some of these piles have been has allowed the seawater to penetrate to the reinforcing. Once the seawater reached the rebar, the rebar corroded causing tension in the concrete, resulting in cracking. In addition to the corrosion of the rebar, the seawater and its components have reacted chemically with the cement causing deterioration.

Wind and wave action together with infrequent freezing and thawing have mechanically deteriorated the concrete resulting in the observed spalling. Other mechanical damage would include ship impact which has probably caused the displacement and snapping of some of the perimeter piles.

Nominal spalling (see Figure 9, Photo 5), was not noted during the inspection due to its insignificant effect on the integrity of the structure.

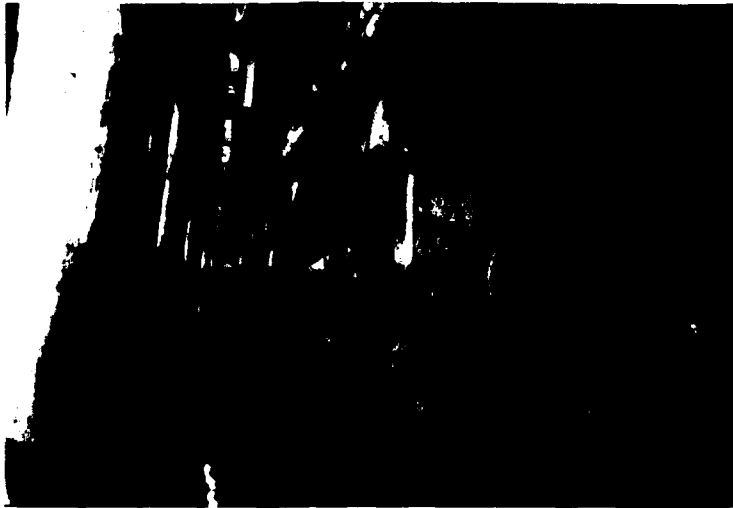


PHOTO #1: Pier #3, Bents #66, 67, 68,
Pile A, showing a variety of
significantly damaged piles.

PHOTO #2: Pier 23, Bent 35, Pile B, shows
heavy spalling, (3" deep) on the
corner of pile in the tidal zone.

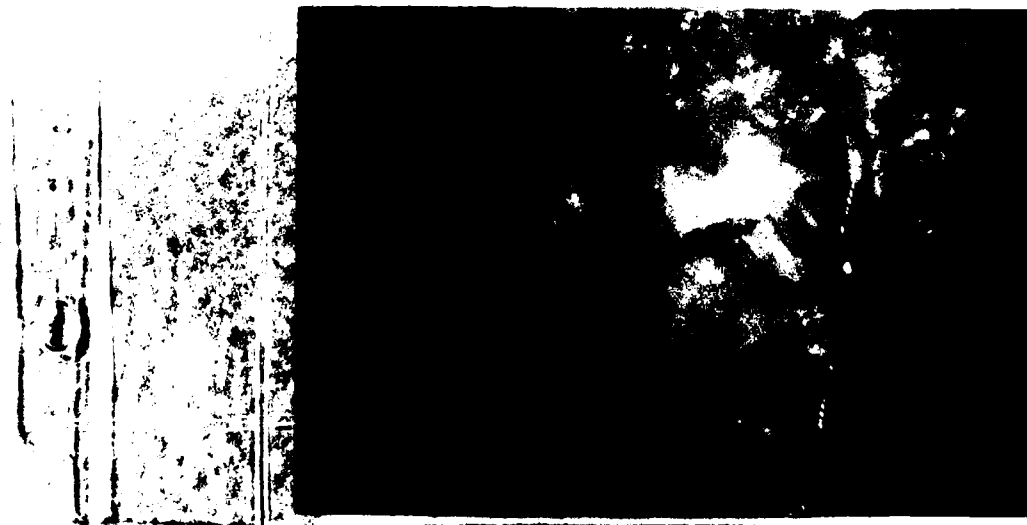


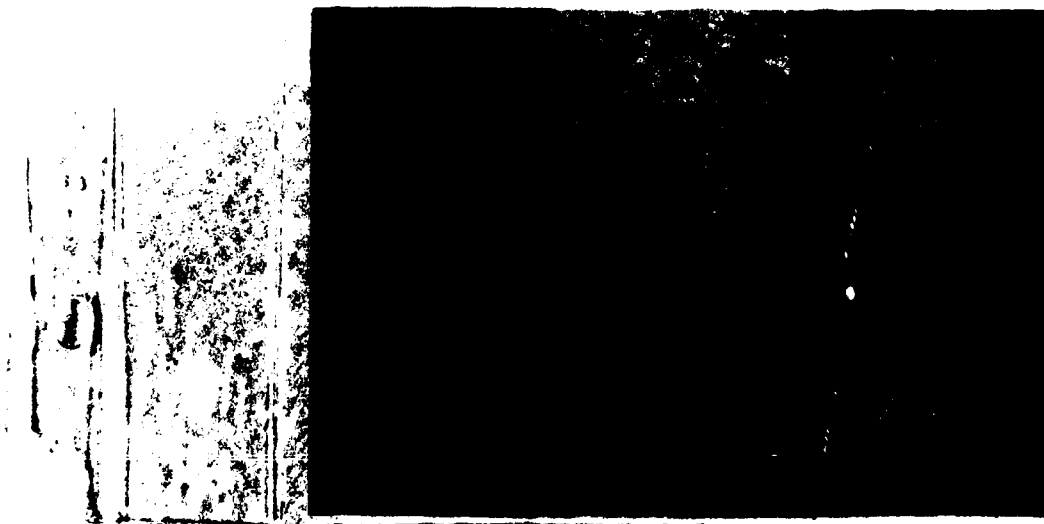
PHOTO #3: Pier 3, Bent 6, Pile 1, shows heavy spalling in tidal zone with exposed rebar. The rebar and adjacent concrete have been cleaned of corrosion and bio-fouling.

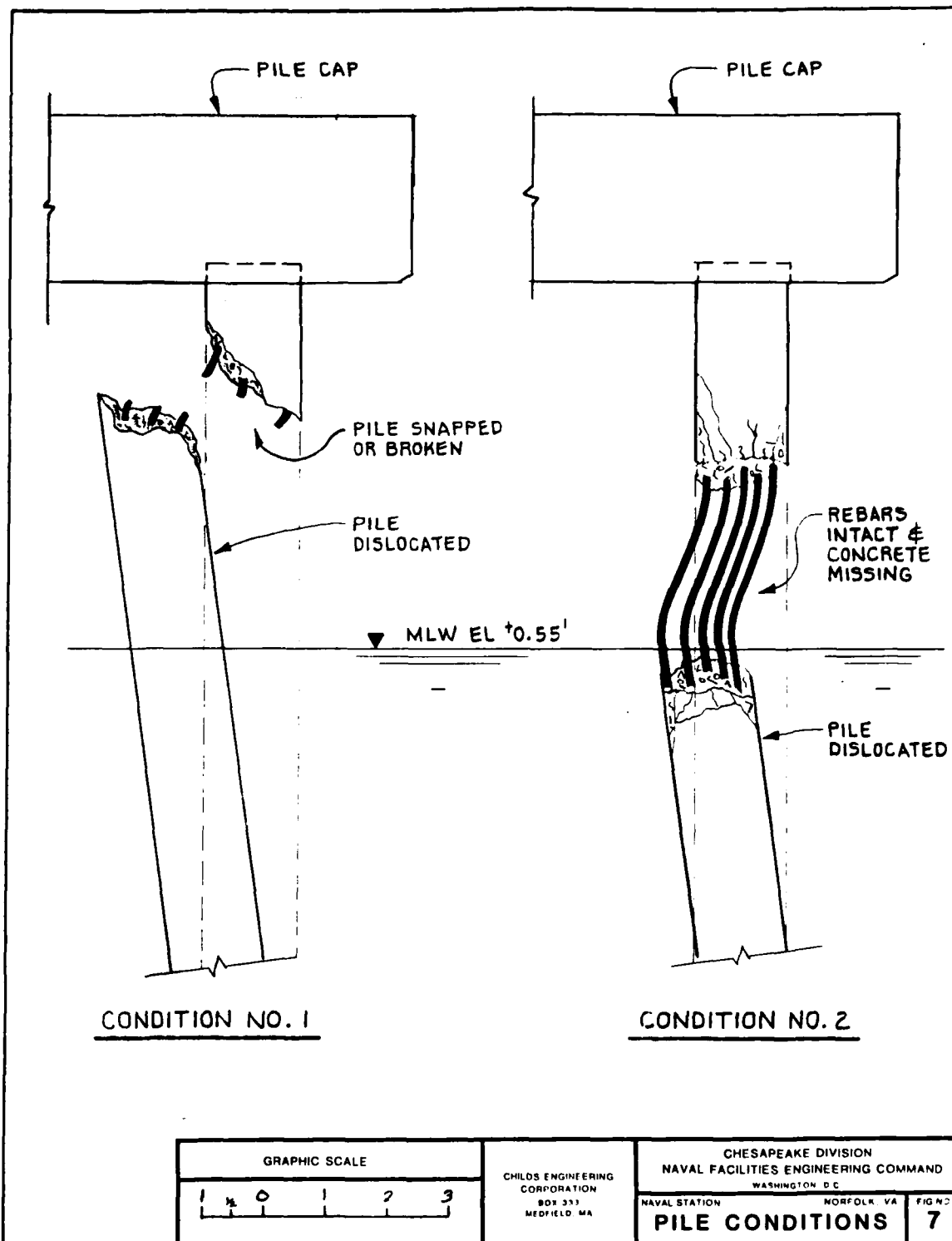




PHOTO #4: Pier C, Bent 6, Pile 1, typical marine growth at El -1 and 1" of spalling on corner of pile.

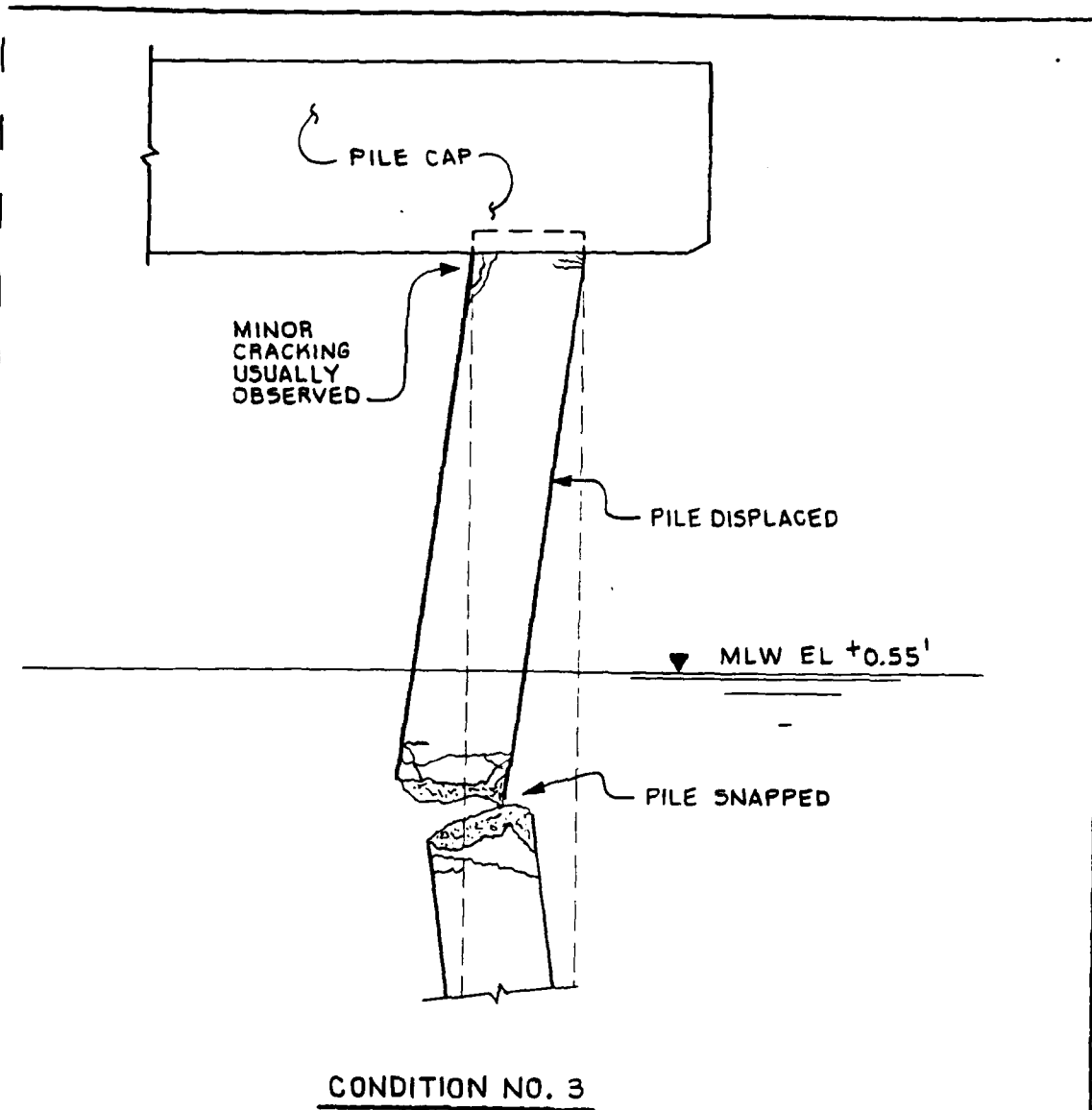
PHOTO #5: Pier 25, Bent 22, Pile L, example of pile in good condition with no spalling.





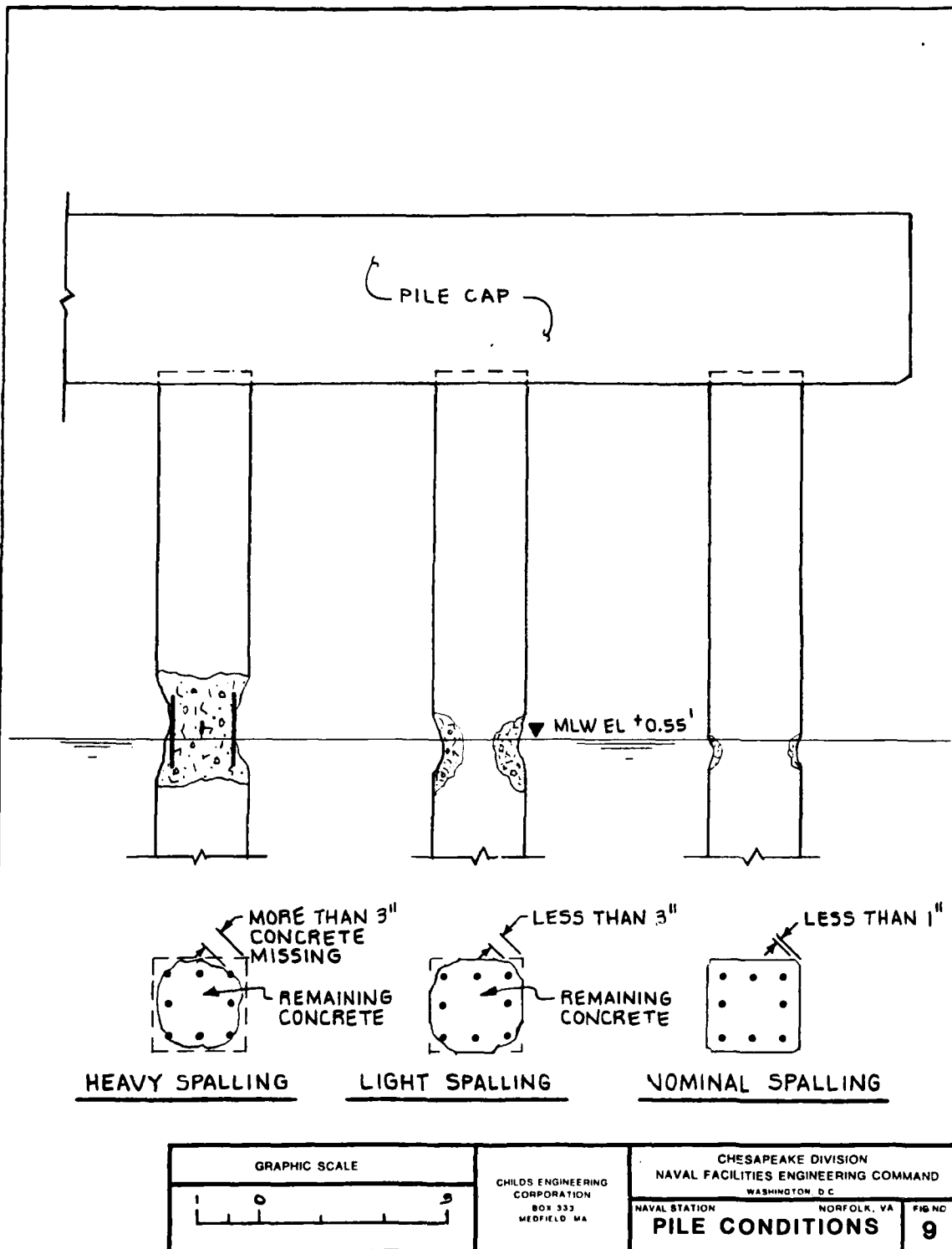
Charrette 10347

4-3



GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
		NAVAL STATION PILE CONDITIONS	NORFOLK, VA FIG NO 8

Charrette 10347



Charrette 10347

The term "superstructure" is also used throughout this report. It refers to that portion of the facility above the splash zone, including, for example, pile caps, beams and the underside of the decking. Only a cursory inspection was made of this area as it was beyond the scope of this project. A more detailed examination of this portion of each facility should be made by the Naval Station, particularly in instances where the cursory examination revealed extensive deterioration.

Hereafter in this report, there will be reference to these common conditions.

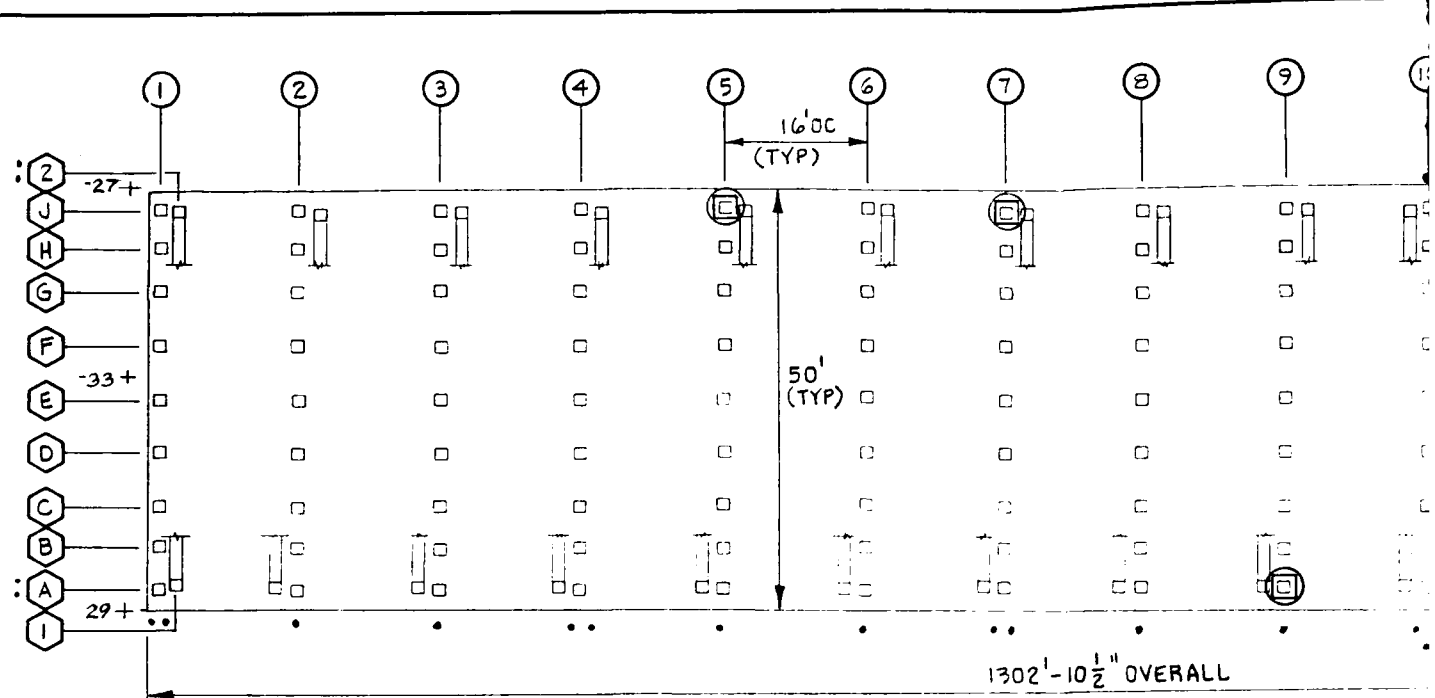
4.1 PIER 22

4.1.1 DESCRIPTION

Pier 22 is the southernmost facility inspected in this task, located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station, Norfolk, Virginia, (see Figure 4). During the inspection period this pier was functioning as a berthing area for submarines (SSN's), destroyers, and subteners. With respect to Bulkhead CEP-102, it is perpendicular to the bulkhead at Station 30+17, based on the stationing of the site plan on the cover sheet of Repairs to Bulkheads CEP-102, CEP-176 & Quaywall CEP-111, NAVFAC Drawing No. 4075236.

The pier was constructed in 1944 and extended in 1969. It is 1302' long and 50' wide. The original pier was 755' long and the extension is 547' long. The reinforced concrete deck is supported by 935 bearing piles arranged in 85 bents (see Figures 10A-10F). The piles are all precast reinforced concrete, 16" square. Piles in the new section are 16" square prestressed precast concrete. The design bearing capacity of each pile is 40 tons.

Reference: Department of the Navy, Naval Facilities Engineering Command, NAVFAC Drawings Nos. 4050656 through 4050660



PLAN
SCALE AS SHOWN

LEGEND

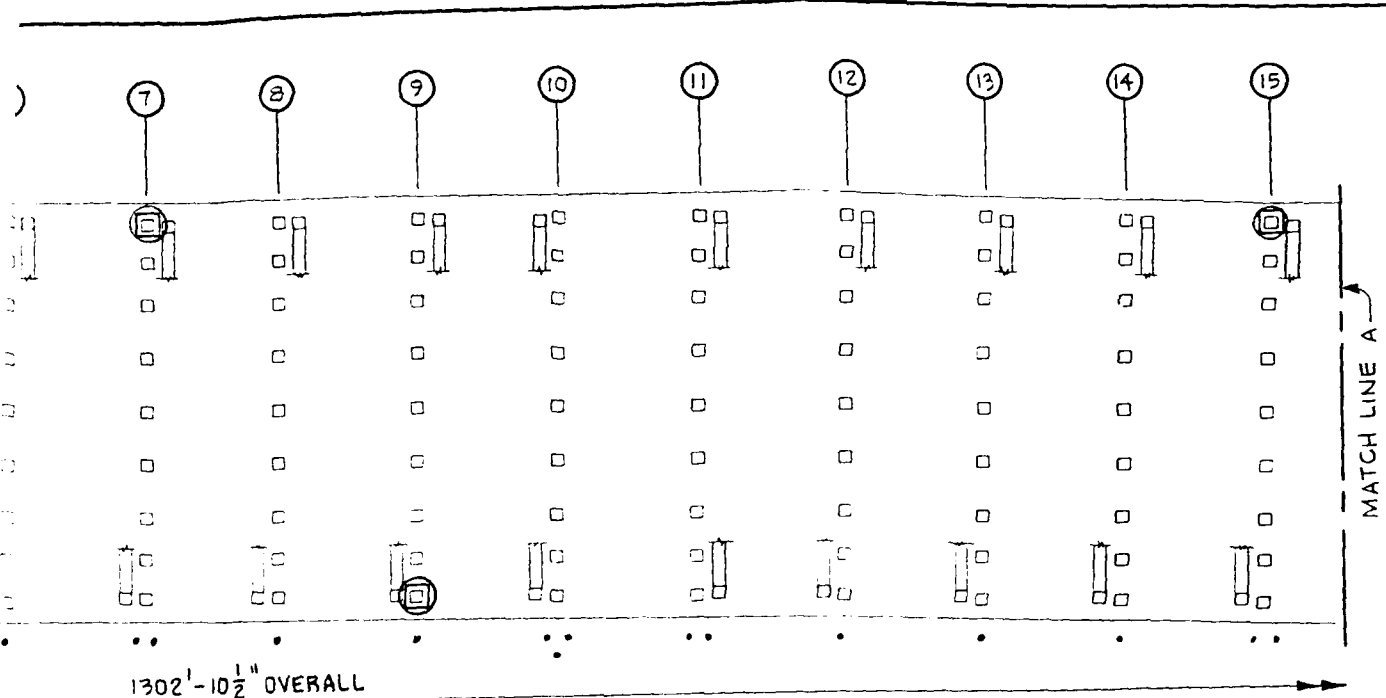
- ⊞ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- ◻ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

LEVELS OF

- MODIFIED L
- .. LEVEL I
- ∴ LEVEL II

NOTE:
REFERENCE TAKEN FROM
NAVFAC DWG NOS. 4050656 THRU 4050660.

5 0
1111



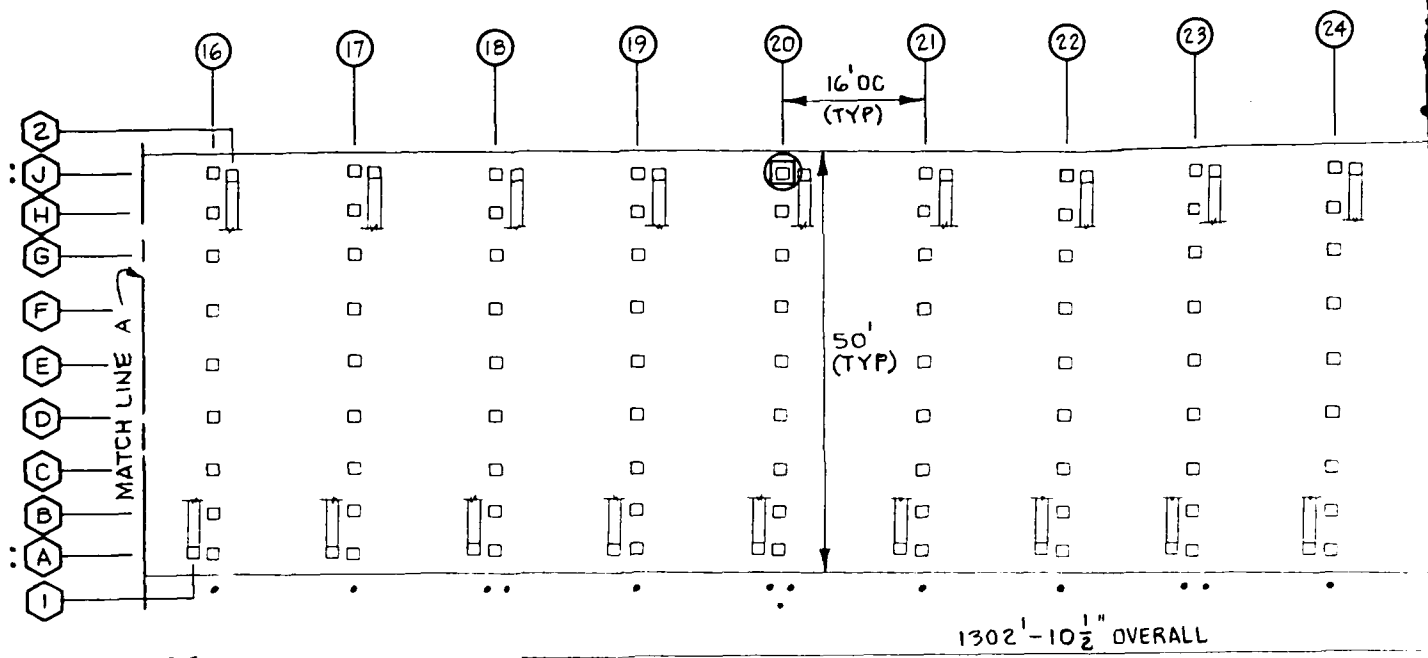
PLAN
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II



GRAPHIC SCALE 5 0 5 10 20 30	CHILDS ENGINEERING CORPORATION 808 333 WILFIELD MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
		NAVAL STATION PIER 22	FIGURE 10A

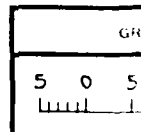


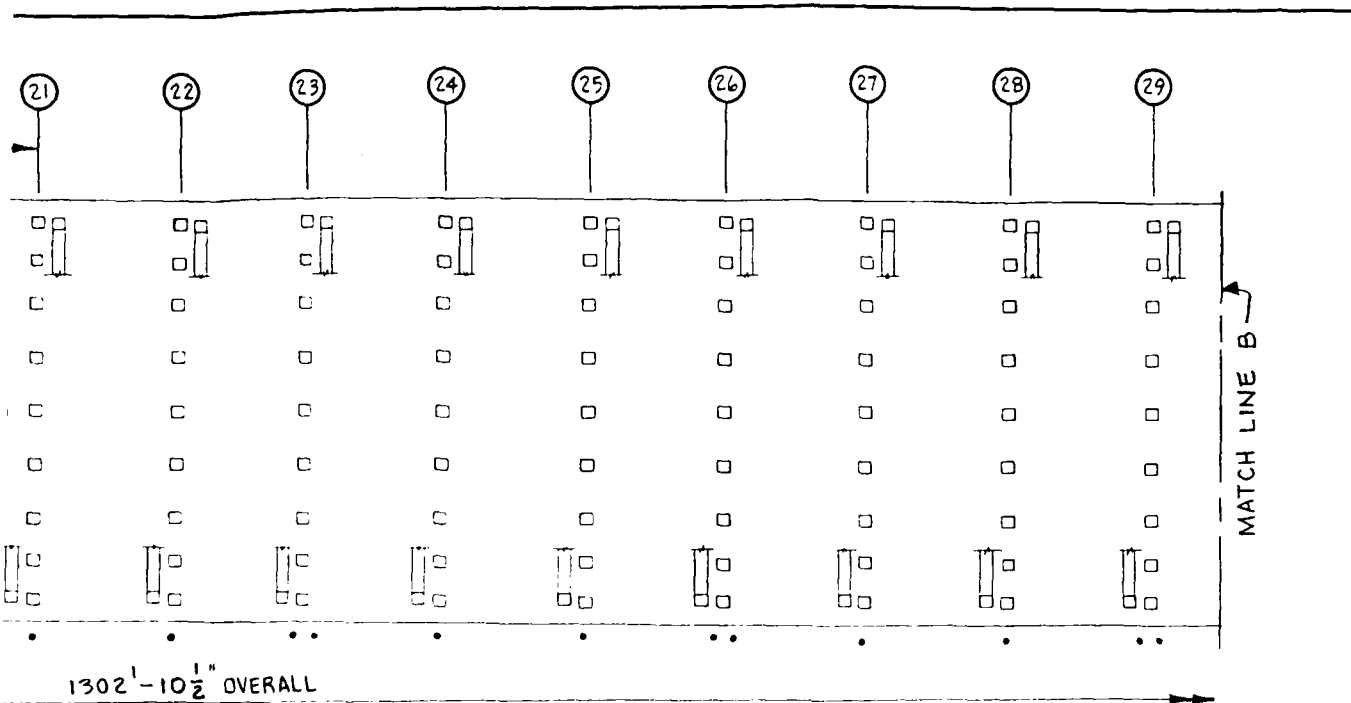
PLAN
SCALE AS SHOWN

- LEGEND**
- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
 - ◻ HEAVY SPALLING, REBAR EXPOSED
 - HEAVY SPALLING, NO REBAR EXPOSED
 - △ LIGHT SPALLING
 - +25 SOUNDING IN FEET BELOW MLW

- LEVELS OF INTEREST**
- MODIFIED LEVEL
 - .. LEVEL I
 - ∴ LEVEL II

NOTE:
REFERENCE TAKEN FROM
NAVFAC DWG NOS. 4050656 THRU 4050660.





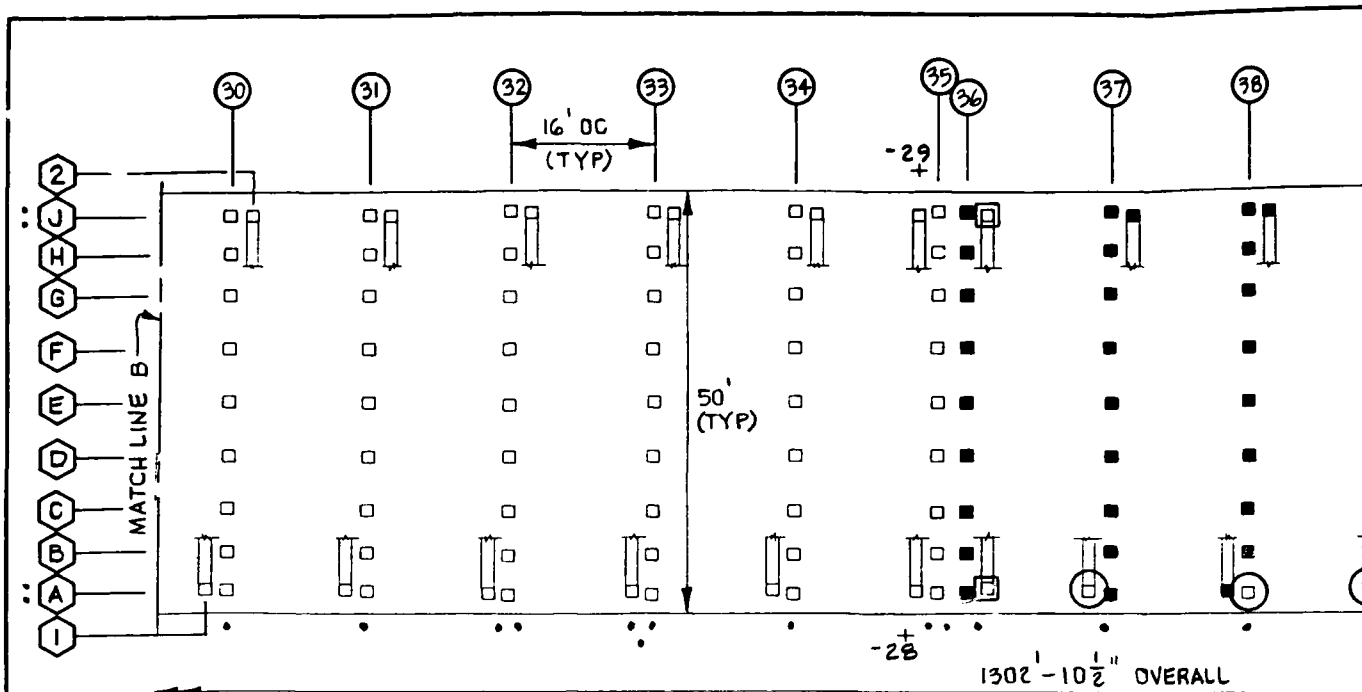
PLAN
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II



GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D.C.	
5	0	NAVAL STATION	FIG NO
5	10	PIER 22	10B
20	30	NORFOLK, VA	



NOTE:

REFERENCE TAKEN FROM
NAVFAC DWG NOS. 4050656 THRU 4050660.

PLAN

SCALE AS SHOWN

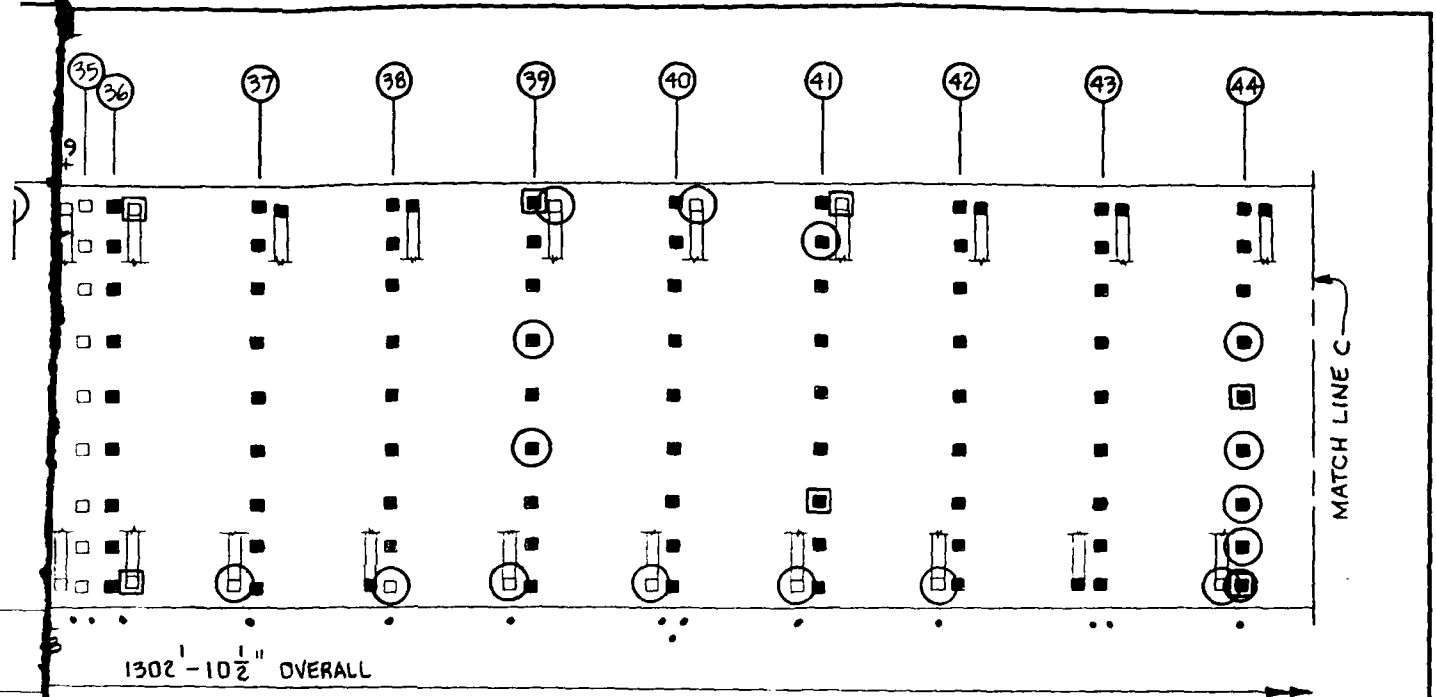
LEGEND

- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

LEVEL

- MODIF
- .. LEVEL
- ∴ LEVEL

NOTE: SHADED PILE INDICATES CONCRETE JACKETING



PLAN

SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

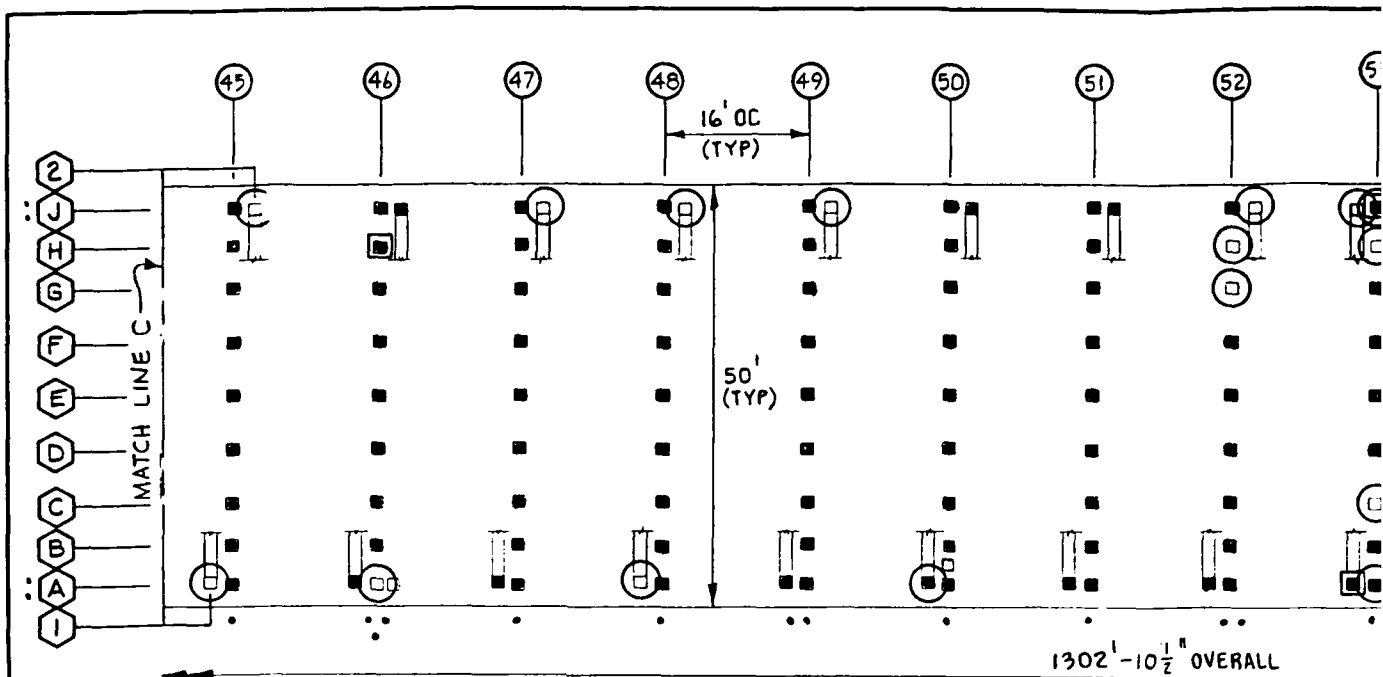


IF I
LEV REPLACEMENT)
POSED
EXPOSED

MLW

RETE JACKETING

GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
5	0 5 10 20 30	NAVAL STATION	NORFOLK, VA
		PIER 22	
CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		FIG NO 10C	



PLAN
SCALE AS SHOWN

LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- ◯ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

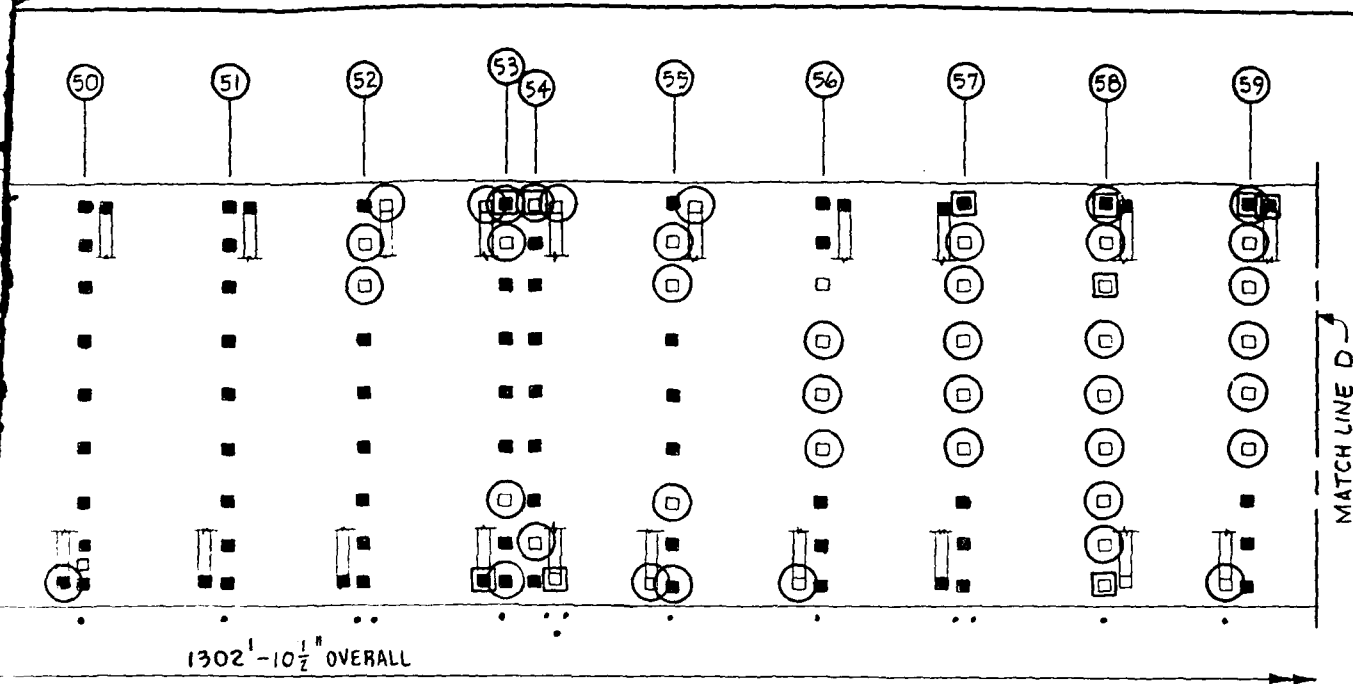
LEVELS

- MODIFIED I
- .. LEVEL I
- ∴ LEVEL II

NOTE: SHADED PILE INDICATES CONCRETE JACKETING

NOTE:

REFERENCE TAKEN FROM
NAVFAC DWG NOS. 4050656 THRU 4050660.



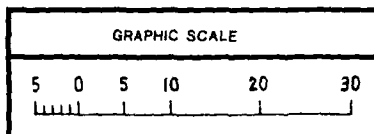
PLAN
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

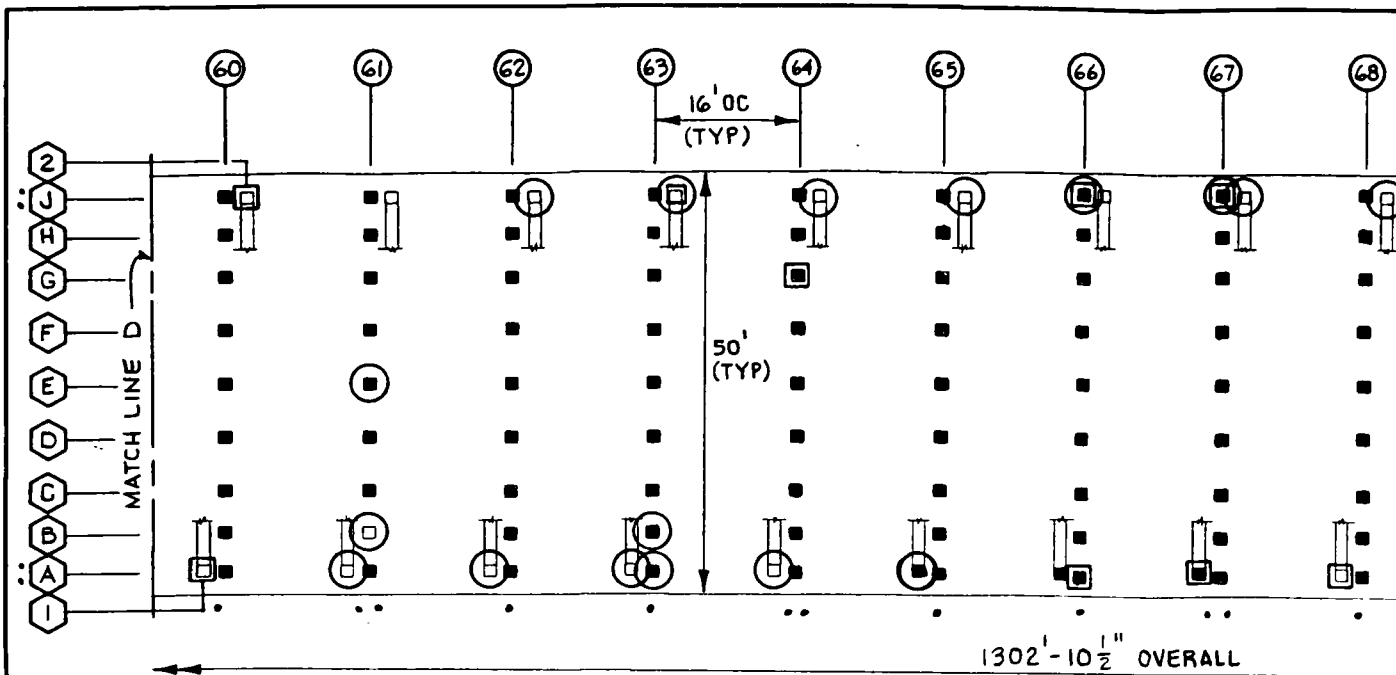


CONCRETE JACKETING



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D.C.		
NAVAL STATION	NORFOLK, VA	FIG NO
PIER 22		10D



PLAN
SCALE AS SHOWN

LEGEND

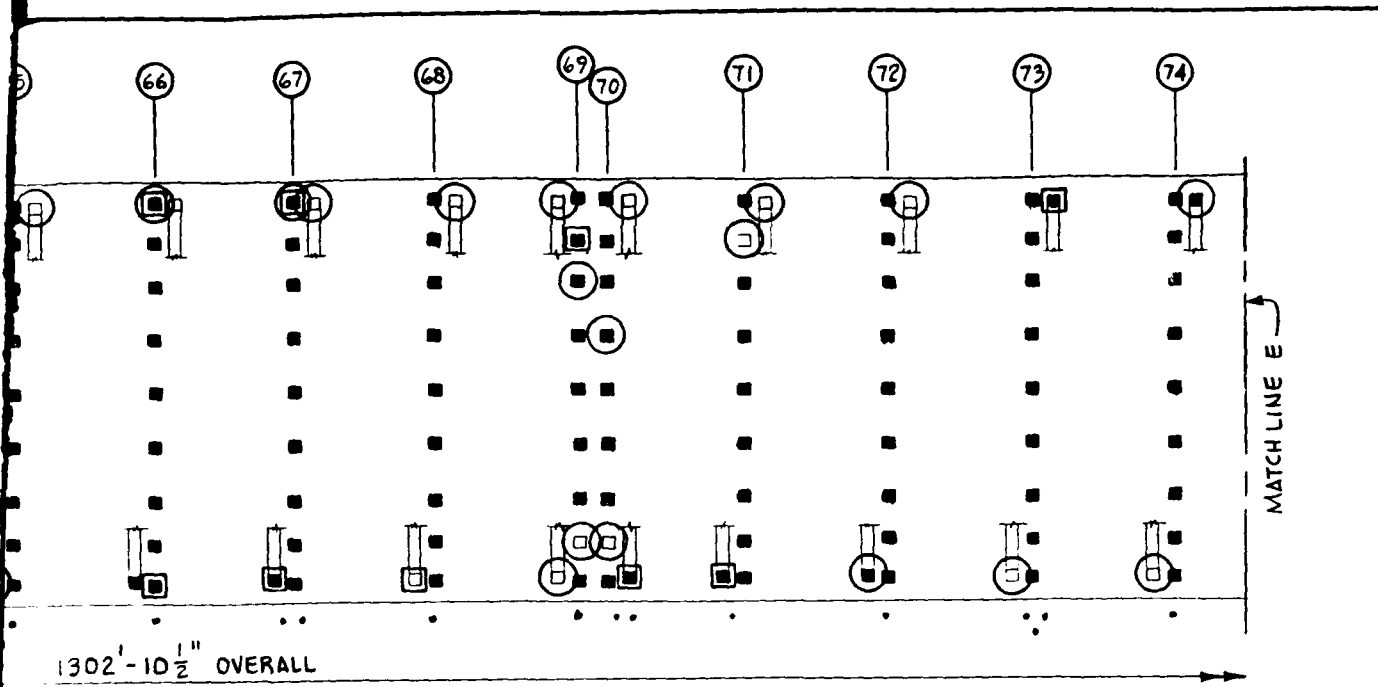
- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

LEVELS

- MODIFIED
- .. LEVEL I
- ∴ LEVEL II

NOTE: SHADED PILE INDICATES CONCRETE JACKETING

NOTE:
REFERENCE TAKEN FROM
NAVJAC DWG NOS. 4050656 THRU 4050660.



PLAN

SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

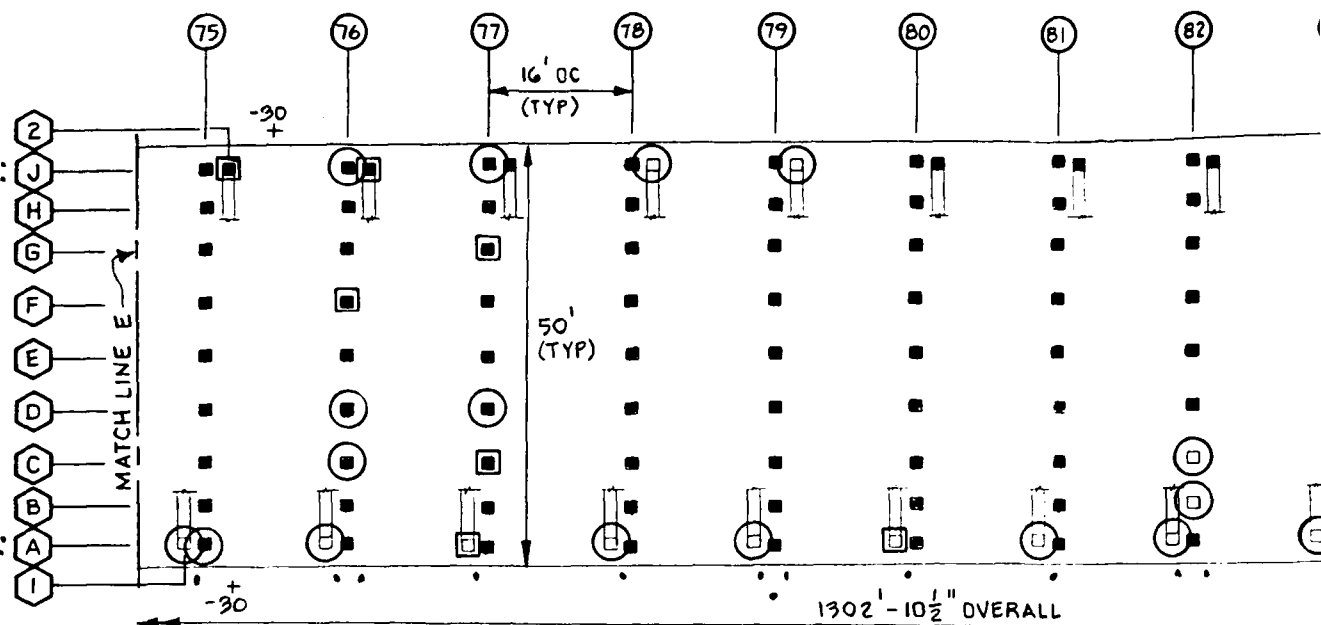


ES REPLACEMENT)
 EXPOSED
 ARE EXPOSED
 W MLW

E JACKETING

GRAPHIC SCALE 5 0 5 10 20 30	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
		NAVAL STATION PIER 22 NORFOLK, VA	FIG. NO. 10E

6 THRU 4050660.



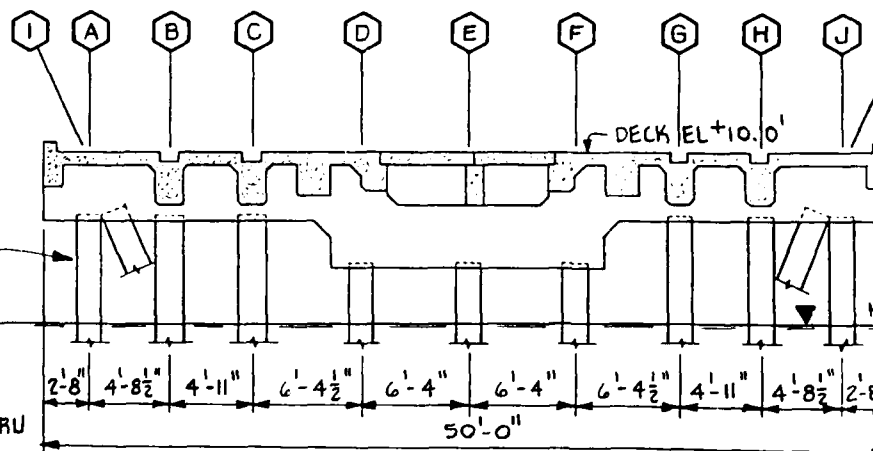
PLAN

SCALE AS SHOWN

16" SQUARE
PRECAST
CONC PILE
(TYP)

NOTE:

REFERENCE TAKEN FROM
NAVFAC DWG NOS. 4050656 THRU
4050660 & 4013238.

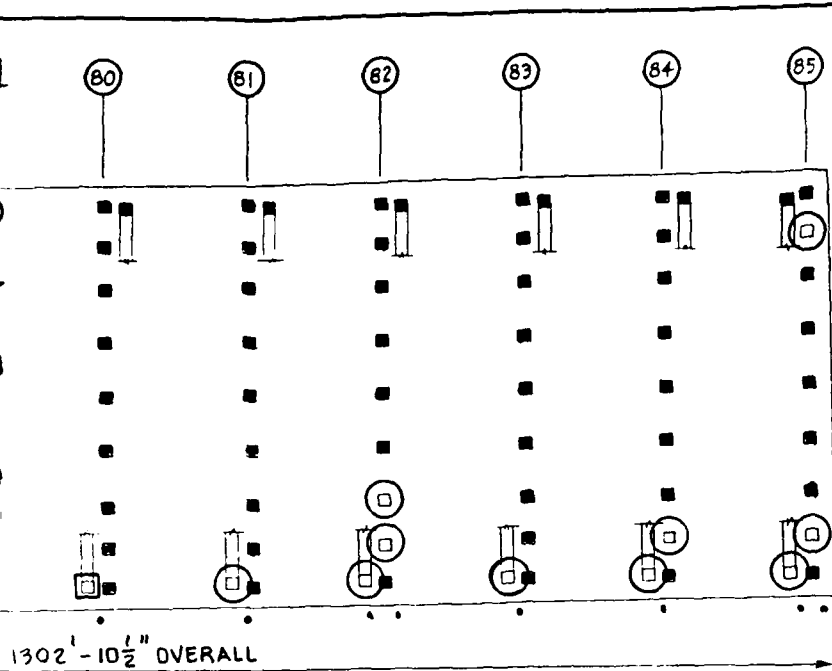


TYPICAL CROSS SECTION

SCALE AS SHOWN

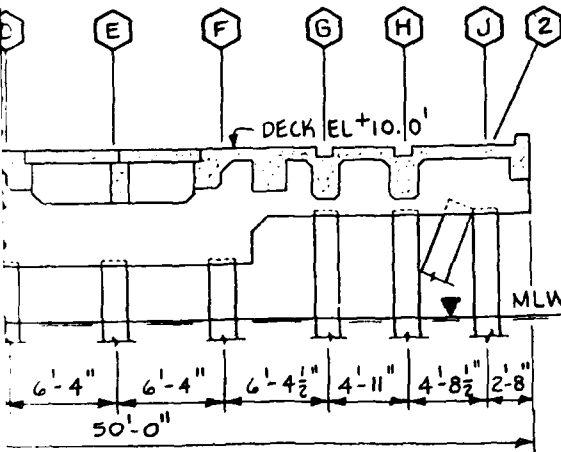
NOTE: SHADED PILE INDICATES CONCRETE JACKETING

5
L
5
L



PLAN

SCALE AS SHOWN



LONGITUDINAL CROSS SECTION

SCALE AS SHOWN

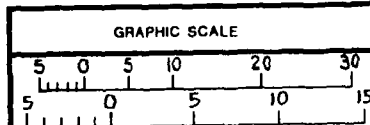
LEGEND

- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

SKETCHING



CHLOS ENGINEERING CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
NAVAL STATION	NORFOLK, VA
PIER 22	FIG NO 10F

4.1.2 OBSERVED INSPECTION CONDITION

Severely damaged piles were noted throughout the pier. A list of piles that exhibit severe structural damage follows:

<u>Bent #</u>	<u>Pile</u>	<u>Bent #</u>	<u>Pile</u>
5	J	54	J
7	J	58	J
9	A	59	J
15	J	63	J
20	J	66	J
44	A	67	J
53	J		

The description of general conditions found will be divided into two parts, one for the old section of the pier and one for the new. This procedure was adopted due to the diversity of the conditions found in the two sections. The numbering of the bents starts outshore at #1 and ends at the Bulkhead with #85.

General conditions noted in the new section (Bents 1-35) are as follows:

- 1) General condition of piles is good to excellent with no major anomalies noted.
- 2) Hairline cracking on 25% of the piles is noted. The cracking is located in the tidal zone on one or more faces of the pile.
- 3) Typical spalling of the piles in this section was observed to be 0" to 1" deep and 0" to 3" long. This spalling is located in the area of mean low water and is cosmetic with no structural significance.
- 4) A cursory inspection of the superstructure revealed good conditions. Some pile caps and deck beams are exhibiting hairline cracking. A more detailed inspection of this area should be made by the Naval Station.

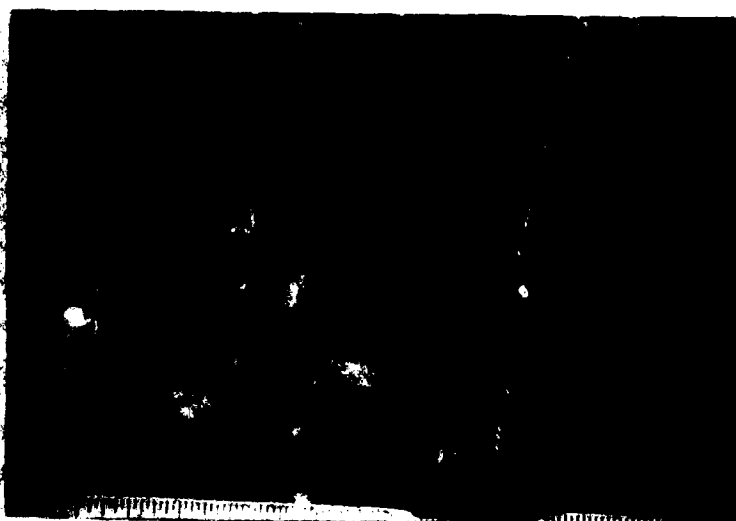
General Conditions noted in the old section (Bents 36-85) are as follows:

- 1) The structural piles have undergone an extensive repair program. 80% of the piles have been repaired by jacketing with concrete in the tidal zone to El -5± using one of two forming methods. The majority of repairs were made using a fabric form with a rigid (wood) form at the bottom of the fabric. These repairs were located in the area of El +3.0 to El -5.0. This technique resulted in repairs having good straight lines, well-defined form work at the bottom of the repairs, and a maximum coverage of the deteriorated concrete area. The second type of repair was noted infrequently. This technique used a similar fabric form without the rigid form at the bottom. The form was tied off at El -3.0 and extended to El +2.0. Repairs made using the second method generally were shorter, had irregularities in the concrete and coverage of the pile was as little as 2" to 3" as opposed to 3" to 6" in the first method. The condition of the concrete in both methods of repair is good.
- 2) Below the repaired area, 90% of the piles exhibited some minor deterioration in the form of cracking (see Photo 6). The size of the cracks ranged from hairline to 3/8" wide. Typically they would run from the repair area down to El -12.0, but occasionally they would run to the mudline. Concrete in the area of the crack is often soft and when the cracks occur at the corners, 1 to 3 inches of concrete can be chipped off the corner area.
- 3) In some cases the cracking is accompanied by spalling as described in Section 4.0 (see Photo 7). This condition is found just below the repair area. 28% of



PHOTO #6: Pier 22, Bent 36, Pile F shows cracking on the corner of pile at El -10.

PHOTO #7: Pier 22, Bent 40, Pile J, example of cracking and spalling on the corner just below the repair (El -6) (Bottom of repair is at the top of the photo)



the repaired piles are in this state and 21% of the heavily spalled piles have rebar exposed.

- 4) 57% of the batter piles have not been repaired and are suffering heavy deterioration in the tidal zone. This includes heavy spalling, cracking of the corners and exposed rebar.
- 5) A cursory inspection of the superstructure reveals that it has been repaired with pneumatically placed concrete. Cracks appear on unrepaired as well as repaired areas of the underside of the superstructure. A more detailed examination of this area should be made by the Naval Station.

4.1.3 STRUCTURAL CONDITION ASSESSMENT

Severely damaged piles are a serious problem. Piles in this condition should be repaired as soon as possible.

Bents 1-35 show little or no structural deterioration. The hairline cracking in the tidal zone is probably due to either the action of driving the piles or possibly could have occurred during the manufacture of the pile.

Bents 36-85 have suffered significant deterioration. The repairs are effectively preserving the portion of the pile that is in the tidal zone. Below the repairs the piles are beginning to decay. A structural analysis of the heavily spalled piles (see Appendix), indicates that the capacity of the piles to support the design load is unaffected at this time. If deterioration is allowed to continue, the capacity of the piles will have to be re-evaluated.

4.1.4 RECOMMENDATIONS

For Pier 22, it is recommended that all severely damaged and heavily spalled piles be repaired as soon as possible.

The superstructure, in areas where there is severe damage to structural piles, has limited capability to carry its designed live loading. Moderate live loading, such as imposed presently, will be transmitted through the superstructure to adjacent piles. Capacity loading should be restricted in these areas until repairs have been made.

We recommend that the severely damaged piles be repaired by driving 2 piles on either side of the damaged pile and pouring a new cap over the two new piles to support the old cap. The estimated cost to repair one damaged pile is \$5,307 (see Appendix). There are 13 piles in need of this type of repair. The total estimated cost is \$68,991.

Piles that are heavily spalled should be repaired to prevent further loss of cross sectional area. The soft concrete should be chipped away to sound concrete, and rebars should be cleaned, if there is significant loss of metal area, they should be replaced. The piles that have not been repaired should be jacketed in concrete from El +5.0 to El -5.0. If a fabric form is used, the estimated cost per pile is \$1,320 (see Appendix). There are 107 piles in need of this repair, the estimated total cost is \$141,240.

The piles that have been previously repaired and are exhibiting heavy spalling below the existing repairs should be fixed. The concrete jacket should be extended down to El -10.0. Assuming the existing repairs are to El -3.0, the new repairs would extend down 7 feet. At an estimated cost of \$132.00 per linear foot, this repair would cost \$924.00 per pile. In all there

are 41 piles that need to have their jackets extended. This would cost an estimated \$37,884.

All repairs should be inspected after completion. The entire pier should be re-inspected in 5 years. The immediate inspection will insure that the repairs have been properly constructed. The follow-up inspection will determine the change of conditions with respect to time.

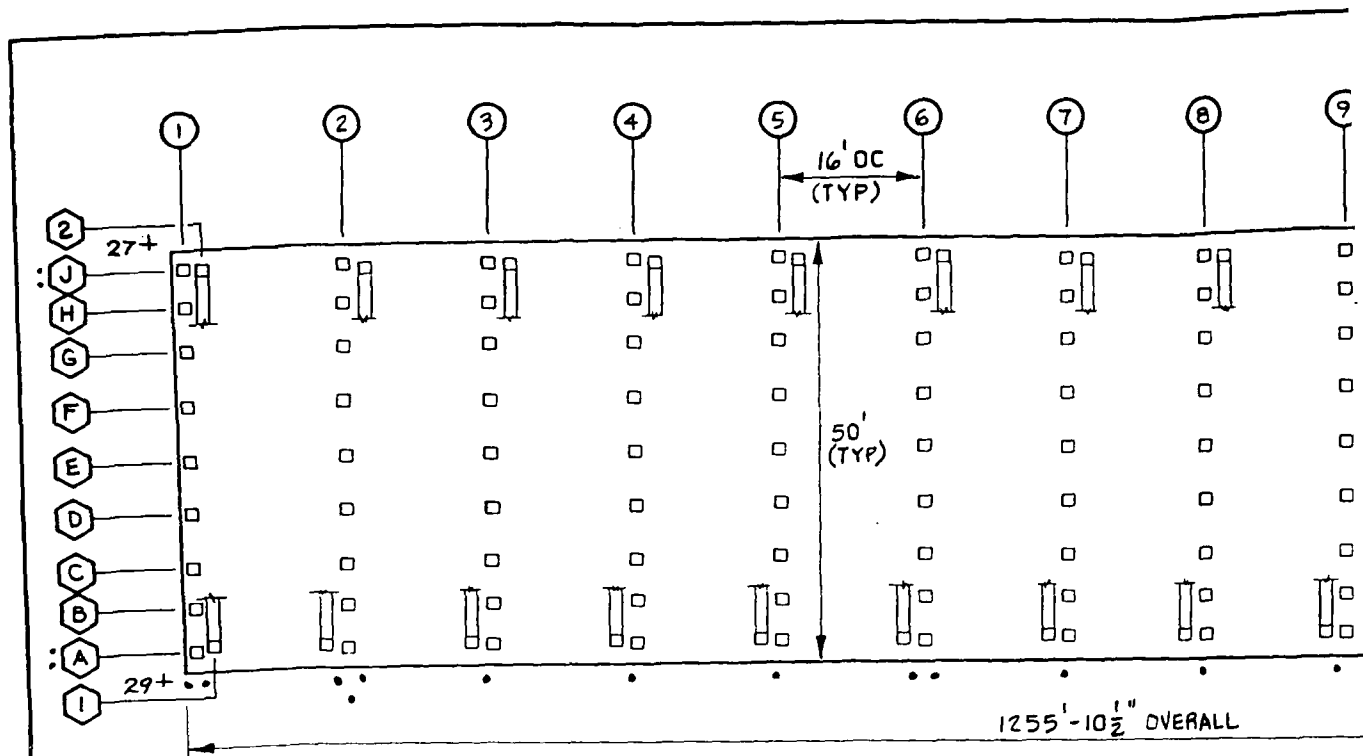
4.2 PIER 23

4.2.1 DESCRIPTION

Pier 23 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station (see Figure 4). This pier was functioning as a berthing area for submarines, (SSN's), destroyers and subteners. With respect to Bulkhead CEP-102, it is perpendicular to the bulkhead at Station 35+14, based on the stationing of the site plan on the cover sheet of Repairs to Bulkheads CEP-102, CEP-176 & Quaywall CEP-111, NAVFAC Drawing No. 4075236.

The pier was constructed in 1944 and extended in 1969. It is 1255' long and 50' wide. The original pier was 755' long and the extension is 500' long. The reinforced concrete deck has approximately 902 bearing piles arranged in 82 bents (see Figures 11A-11F). The piles are all precast concrete, 16" square. Piles in the new section are 16" square pre-stressed precast reinforced concrete. The design bearing capacity of each pile is 40 tons.

Reference: Department of the Navy, Naval Facilities Engineering Command, NAVFAC Drawings Nos. 4050659 through 4050665.



PLAN
SCALE AS SHOWN

LEGEND

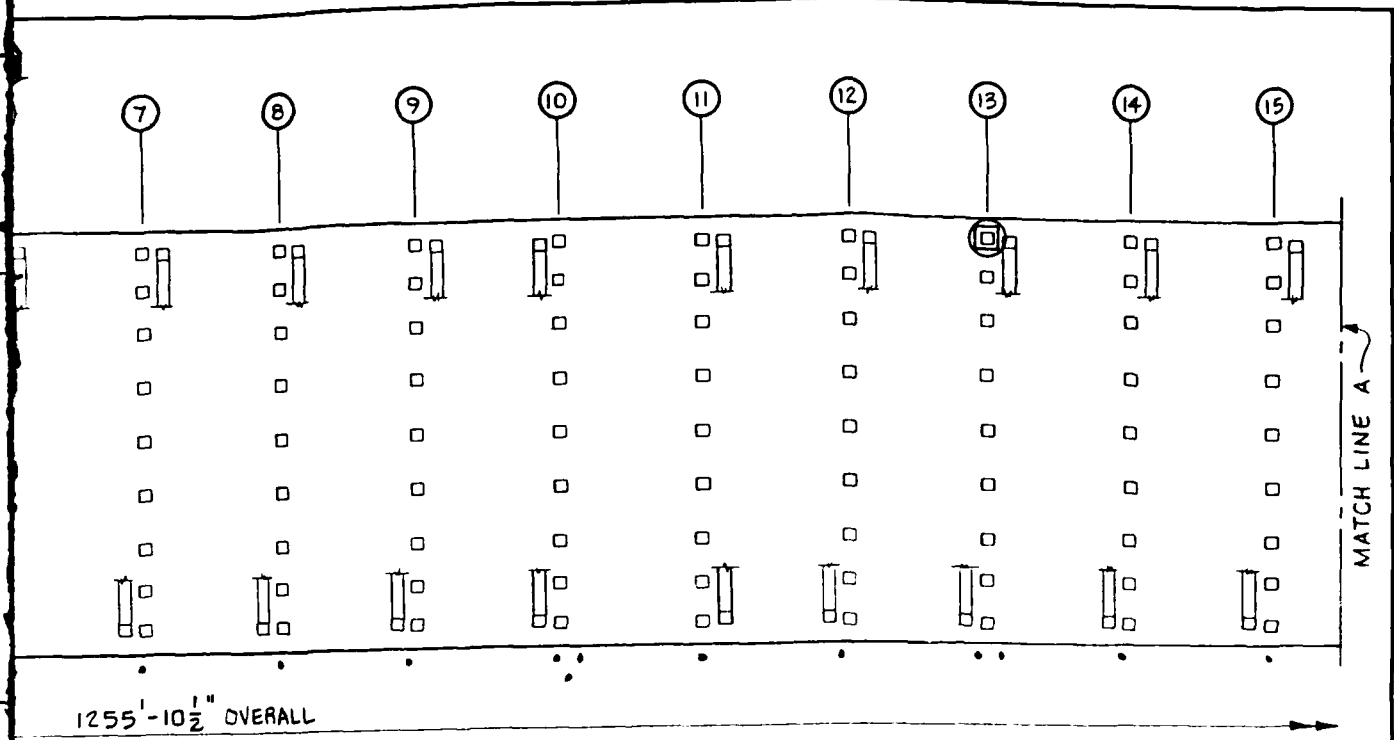
- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- + SOUNDING IN FEET BELOW MLW

LEVE

- MODIF
- .. LEVEL
- ∴ LEVEL

NOTE:

REFERENCE TAKEN FROM
NAVFAC DWG NOS. 4050661 THRU 4050665.



PLAN

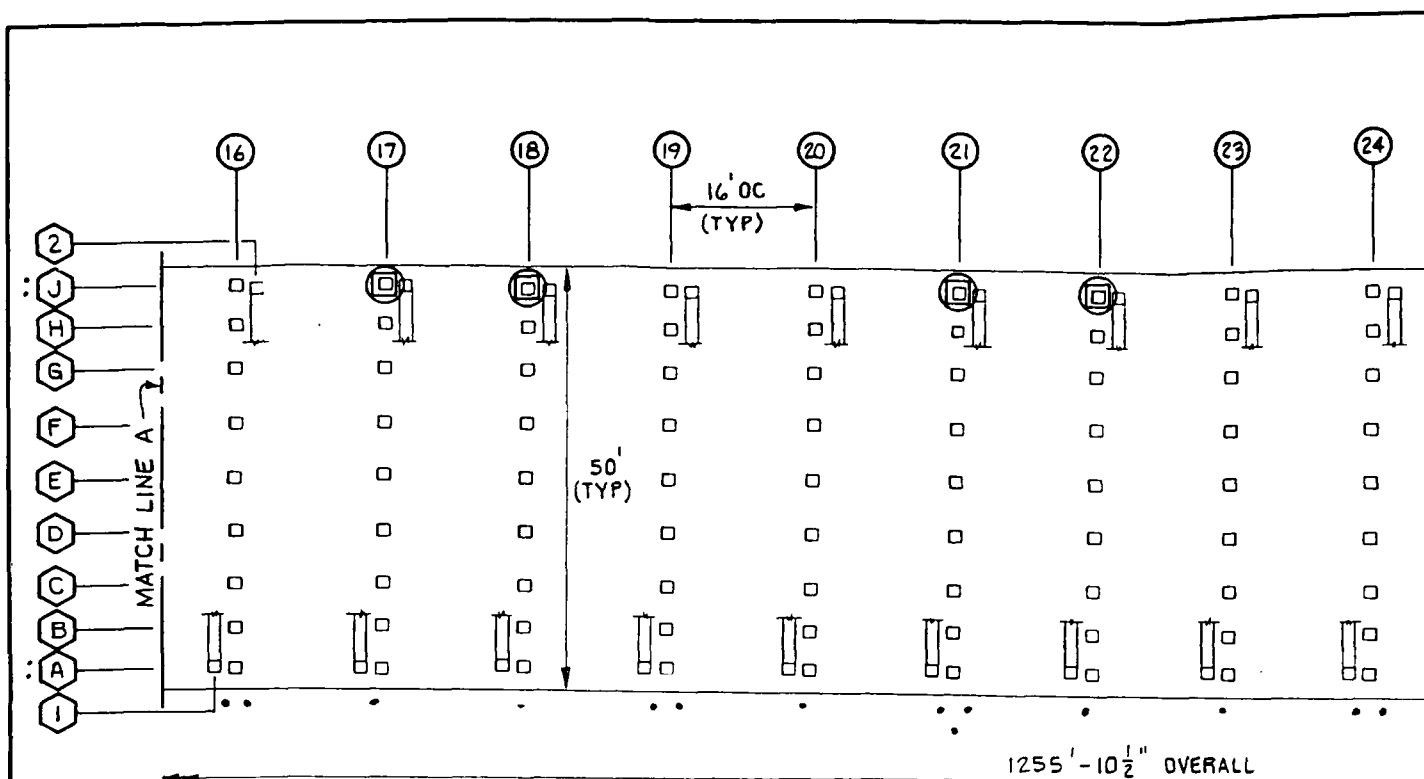
SCALE AS SHOWN

LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II



GRAPHIC SCALE 5 0 5 10 20 30	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. NAVAL STATION NORFOLK, VA FIG. NO. PIER 23 11A
--	--	---



PLAN
SCALE AS SHOWN

LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊡ HEAVY SPALLING, REBAR EXPOSED
- ⊞ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

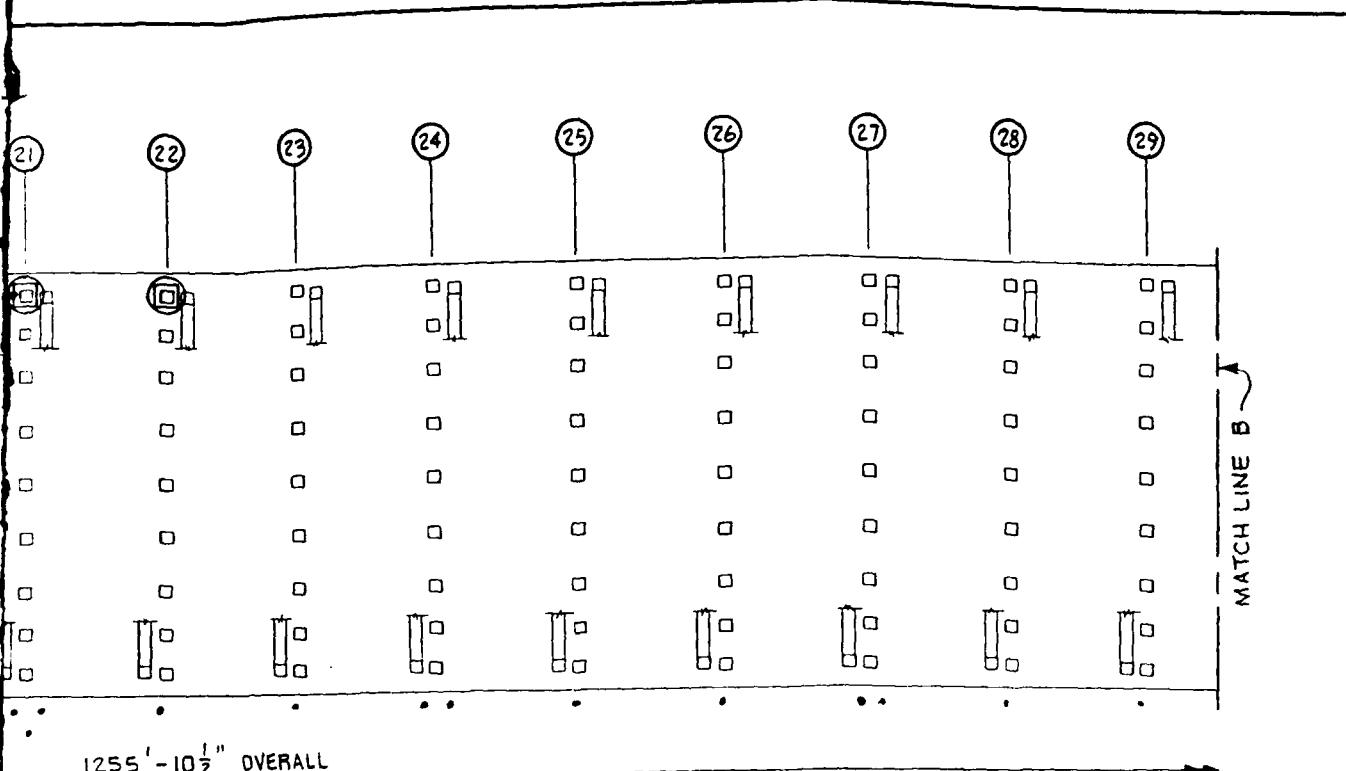
LEVELS OF INSPECTION

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

NOTE:

REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4050661 THRU 4050665.

5 (



PLAN

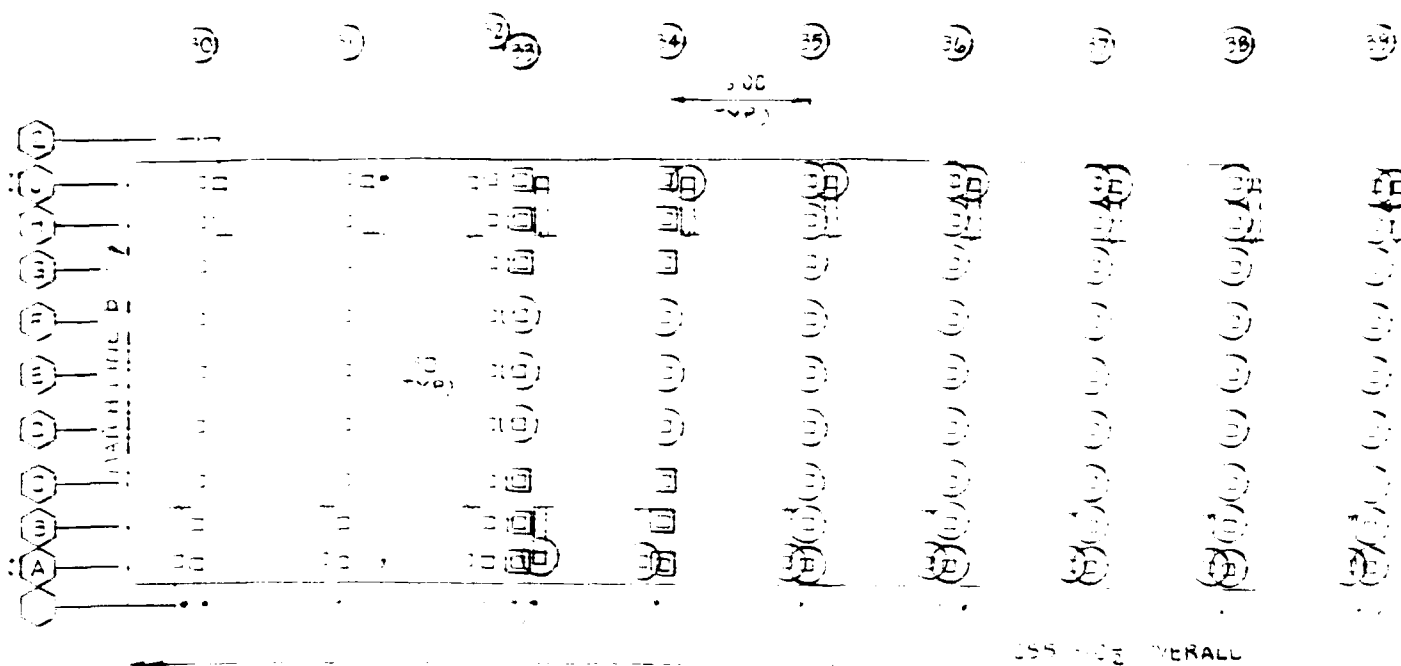
SCALE AS SHOWN



LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
5	0	5	10
20	30	NAVAL STATION	FIG NO
CHILD'S ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		PIER 23	11B



USS 1003 OVERALL

PLAN
SCALE AS SHOWN

LEGEND

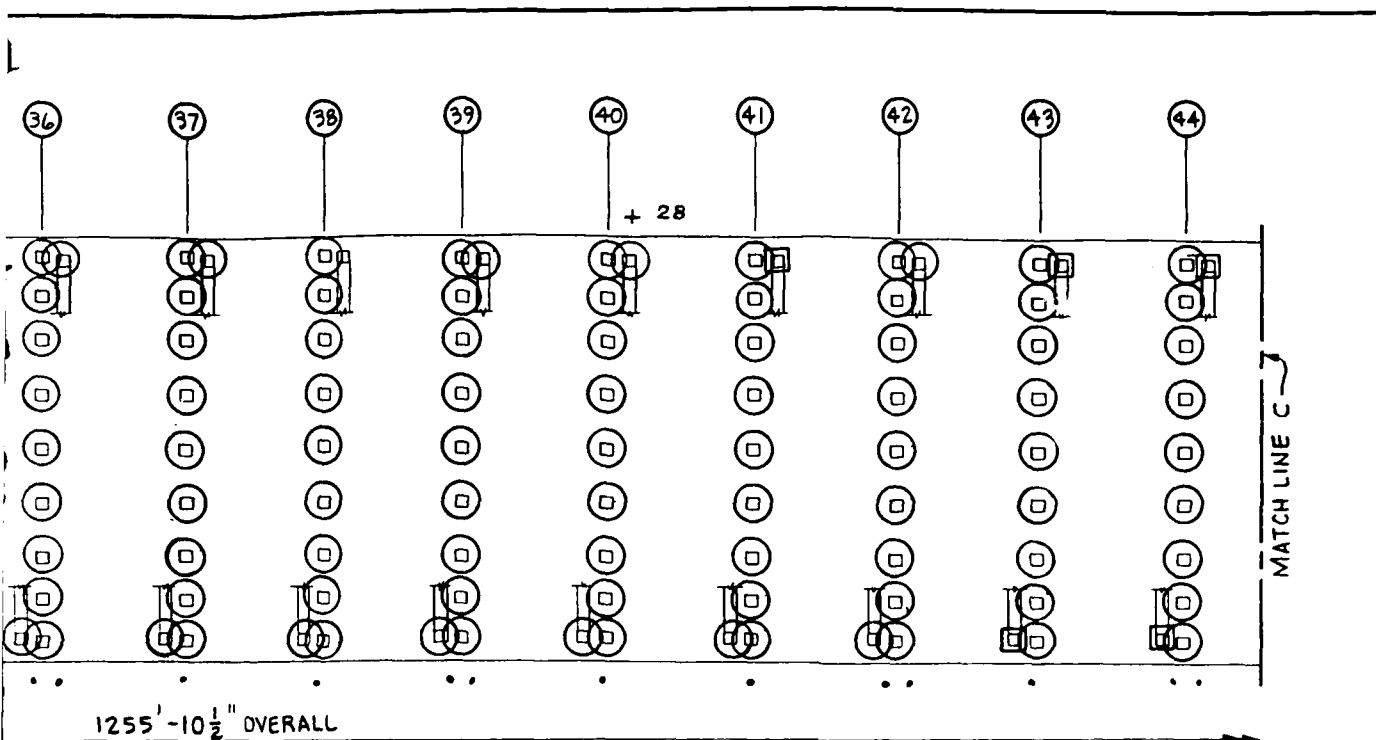
- SEVERE DAMAGE (REQUIRES REPLACEMENT)
- HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- LIGHT SPALLING
- SOUNDING IN FEET BELOW MLW

LEVELS OF INSPECTION

- MODIFIED LEVEL
- LEVEL I
- LEVEL II

NOTE:

REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4050661 THRU 4050665.



PLAN
SCALE AS SHOWN

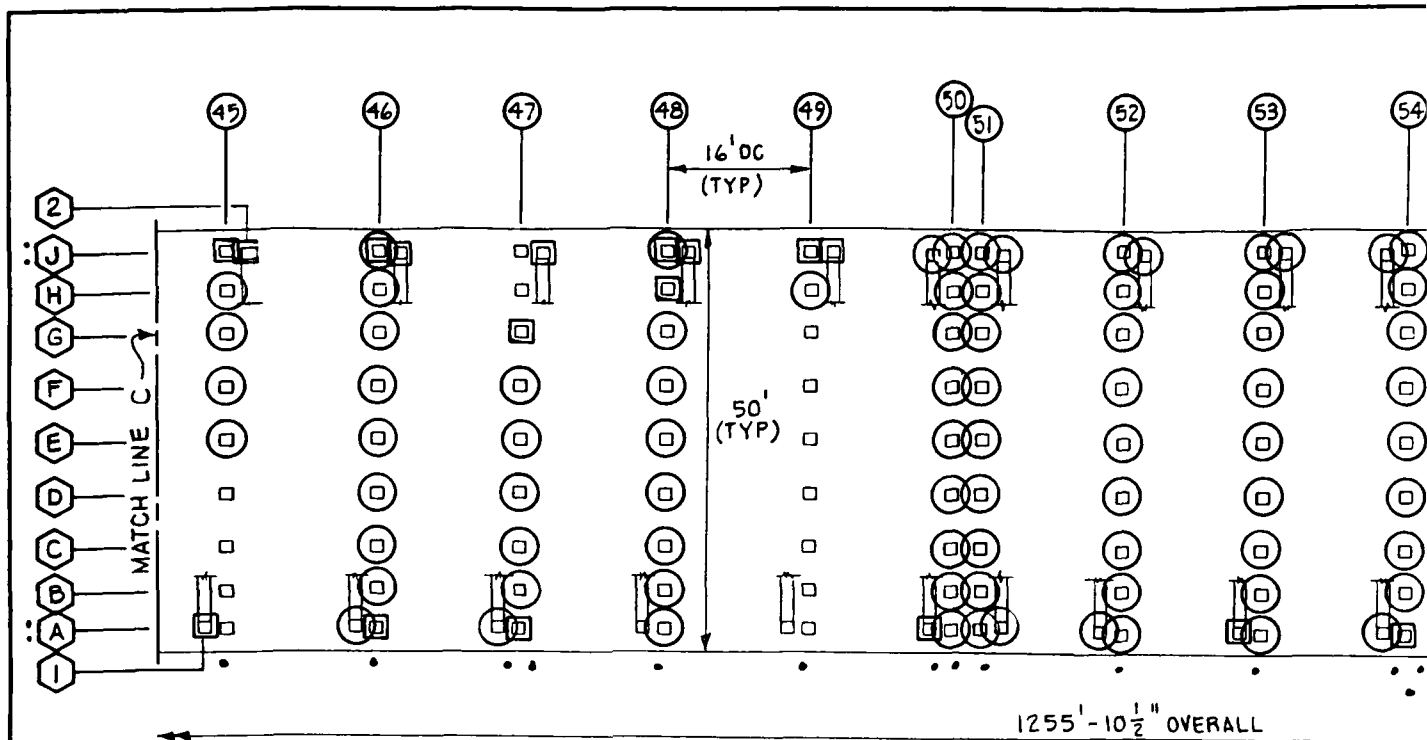


LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- .. LEVEL II

2

GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D C	
5	0 5 10 20 30	NAVAL STATION	FIG NO
		NORFOLK, VA	11C

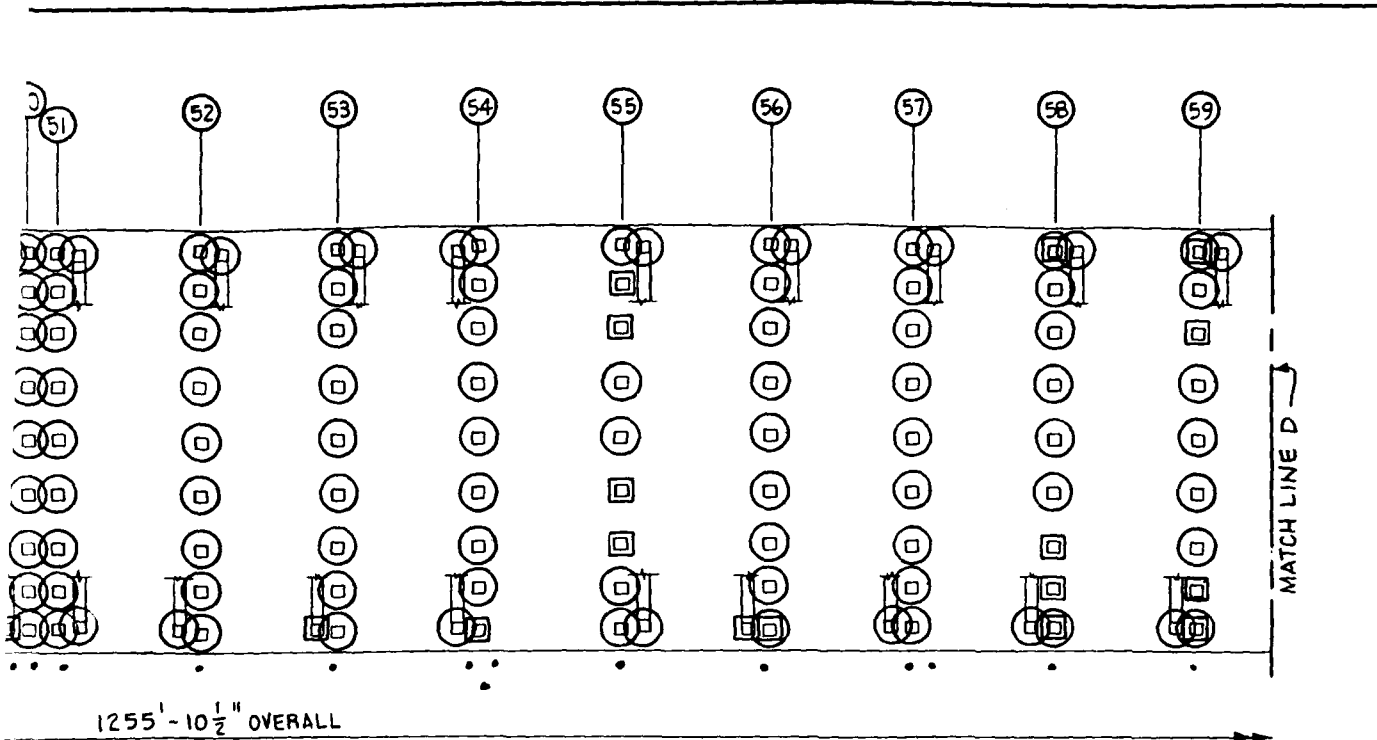


PLAN
SCALE AS SHOWN

- LEGEND**
- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
 - ◻ HEAVY SPALLING, REBAR EXPOSED
 - HEAVY SPALLING, NO REBAR EXPOSED
 - △ LIGHT SPALLING
 - + SOUNDING IN FEET BELOW MLW

- LEVELS OF INS**
- MODIFIED LEVEL
 - .. LEVEL I
 - ∴ LEVEL II

NOTE:
REFERENCES TAKEN FROM NAVFAC
DWG NOS. 4050661 THRU 4050665.



PLAN

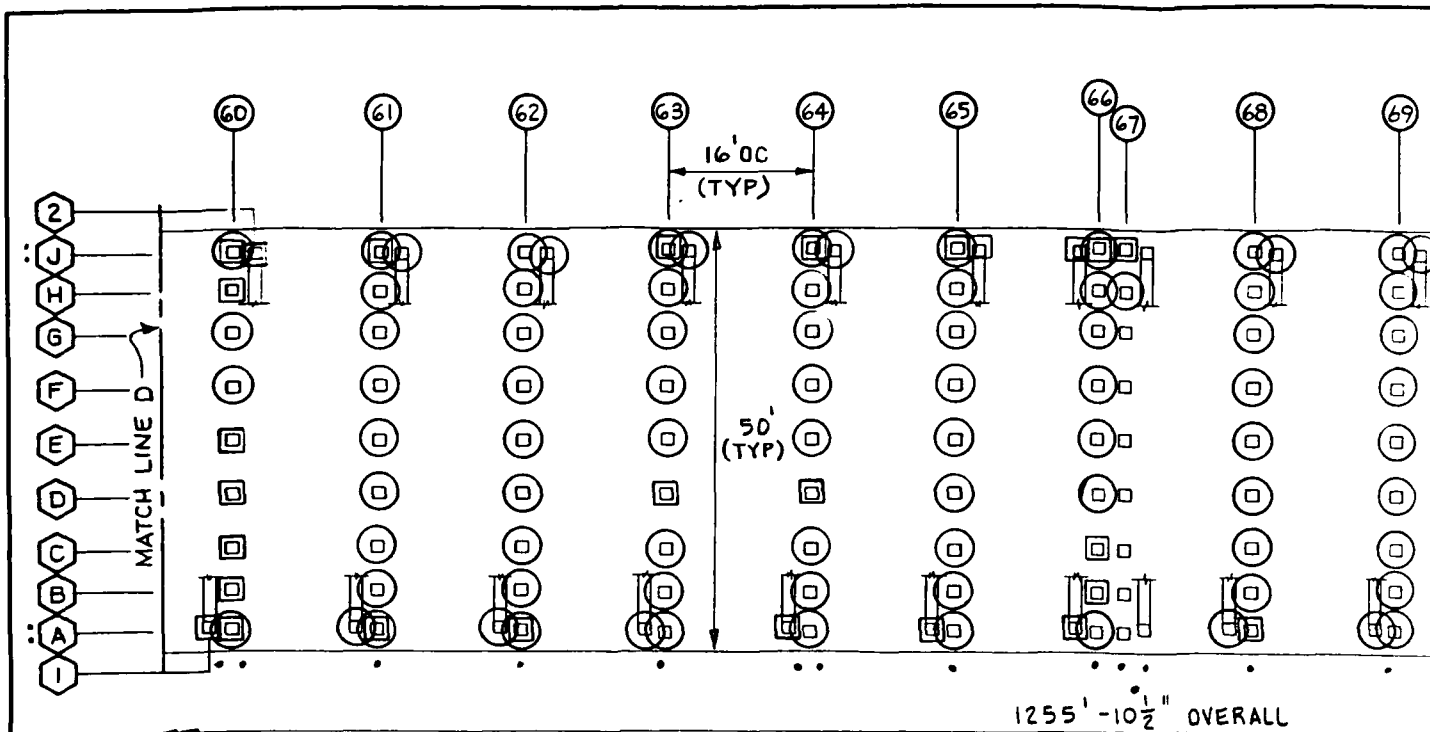
SCALE AS SHOWN



LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

GRAPHIC SCALE		CHESAPEAKE DIVISION	
5 0 5 10 20 30		NAVAL FACILITIES ENGINEERING COMMAND	
CHILD'S ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		WASHINGTON D.C.	
		NAVAL STATION	FIG NO
		PIER 23	11D



PLAN
SCALE AS SHOWN

LEGEND

- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

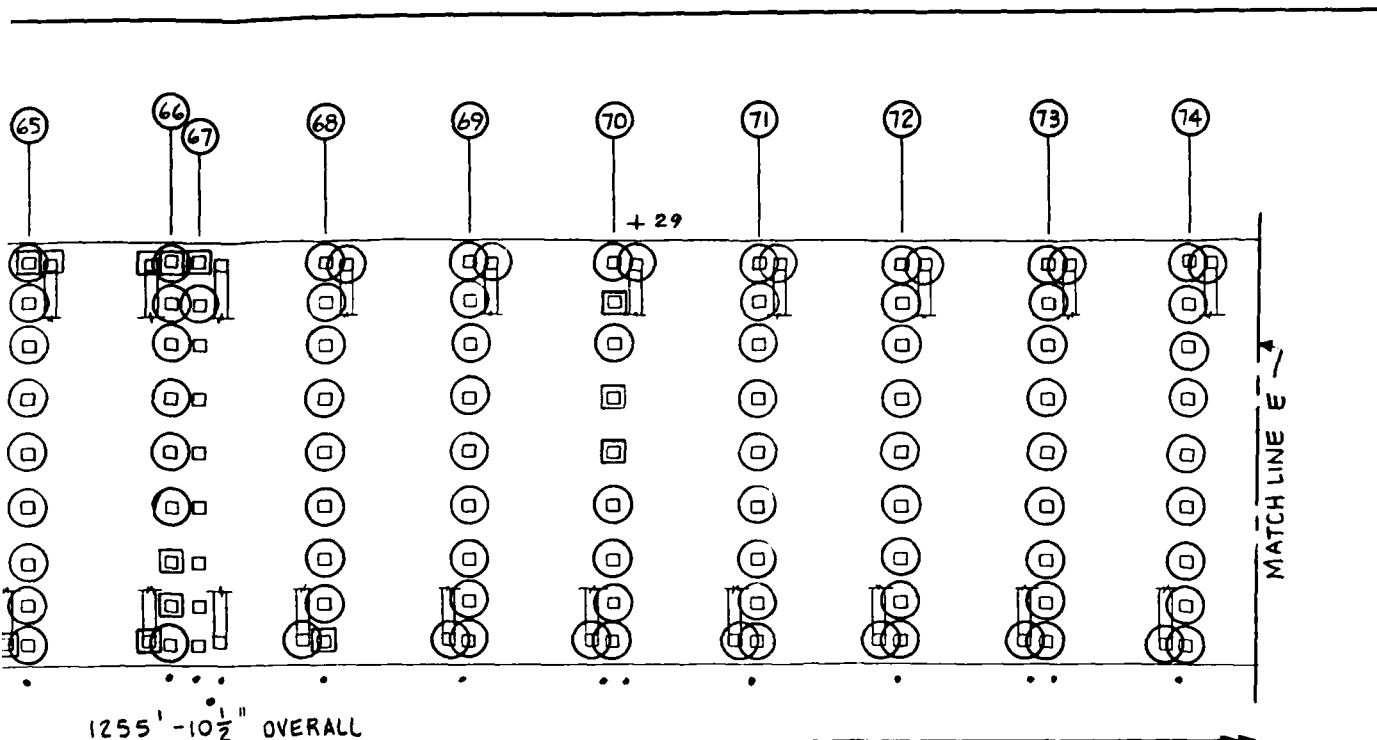
LEVELS OF INSPECTION

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

NOTE:

REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4050661 THRU 4050665.

5 0
11111



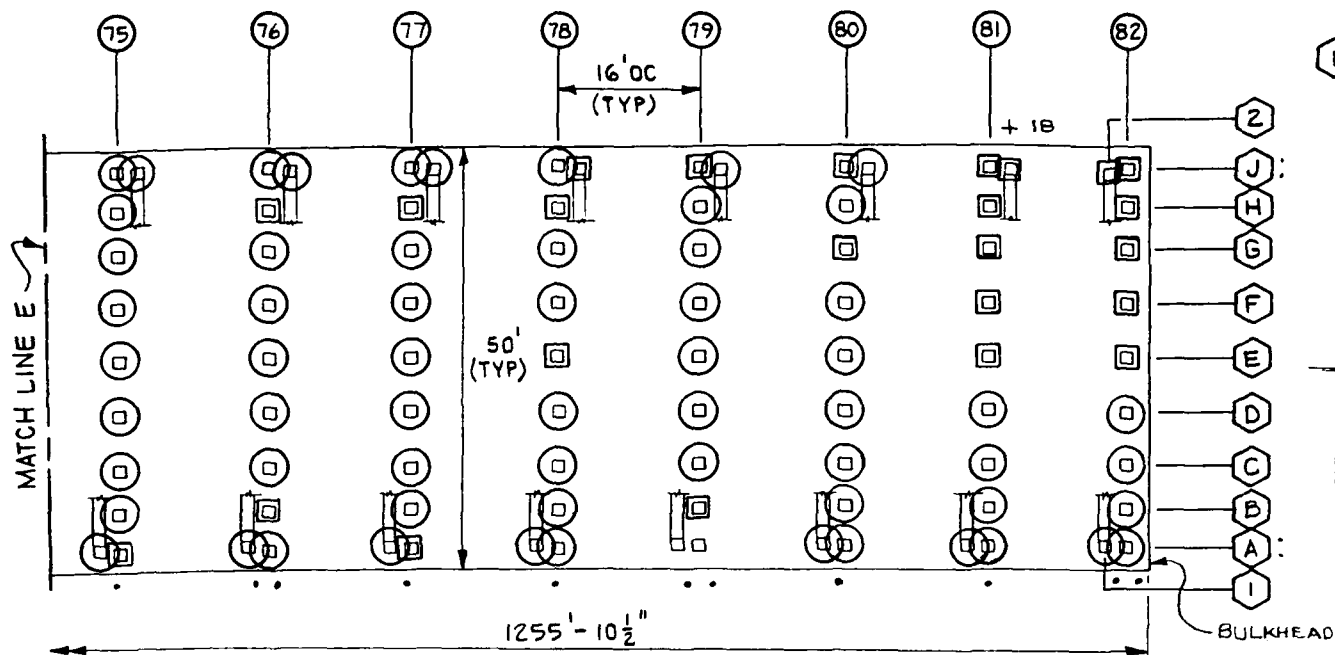
PLAN

SCALE AS SHOWN

LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

GRAPHIC SCALE		CHESAPEAKE DIVISION	
5	0	NAVAL FACILITIES ENGINEERING COMMAND	
5	10	WASHINGTON D.C.	
20	30	NAVAL STATION	NORFOLK, VA
		PIER 23	
		FIG NO 11E	



PLAN

SCALE AS SHOWN

LEGEND

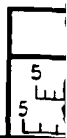
- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

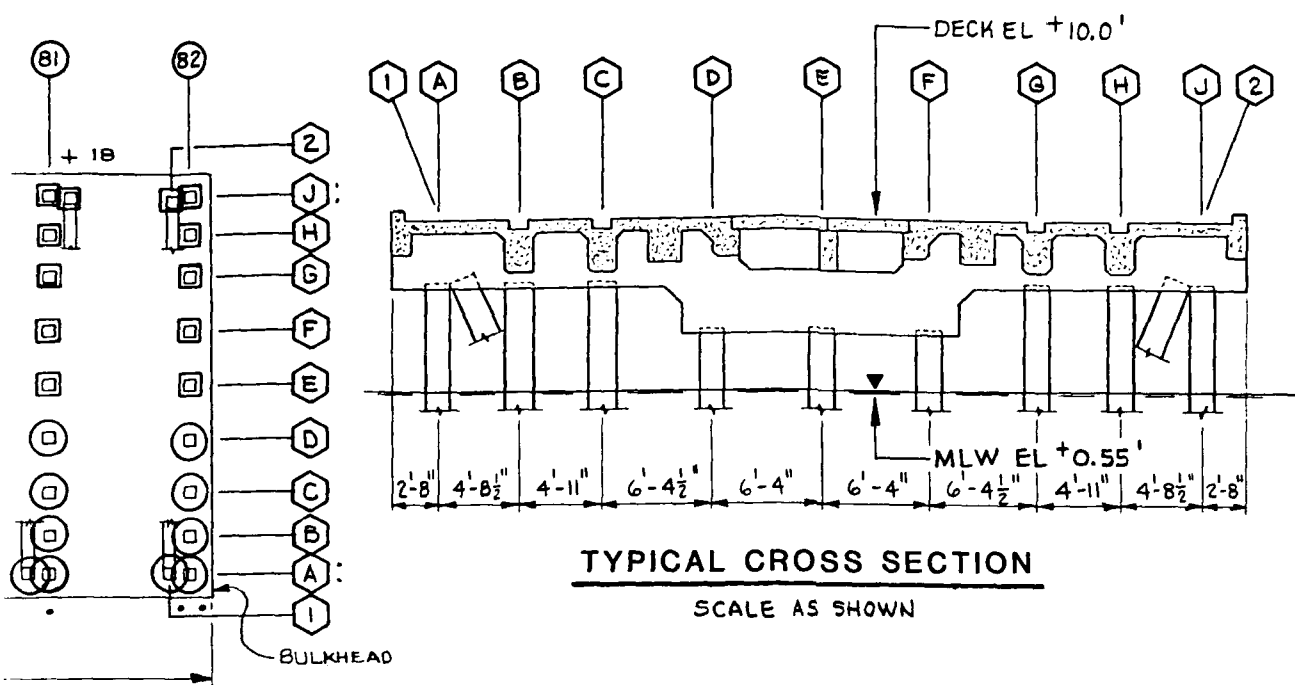
LEVELS OF INSPECT

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

NOTE:

REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4050661 THRU 4050665
1035013.





LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

GRAPHIC SCALE		CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
5	0	5	10	20	30
5	0	5	10	15	
NAVAL STATION				NORFOLK, VA	FIG NO.
PIER 23					11F

4.2.2 OBSERVED INSPECTION CONDITIONS

Severely damaged piles were noted throughout the pier (see Photo 8). A list of piles that exhibit the conditions described as severely damaged in Section 4.0 follows:

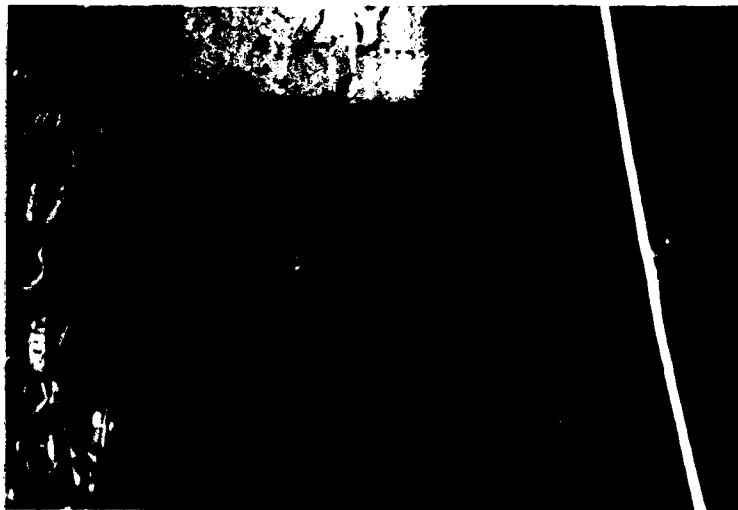
<u>Bent #</u>	<u>Pile</u>	<u>Bent #</u>	<u>Pile</u>
66	J	56	A
65	J	48	J
64	J	46	J
63	J	22	J
62	A	21	J
61	A,J	18	J
60	A,J	17	J
59	A,J	13	J
58	A,J		

The description of general conditions found will be divided into two parts, one for the old section of the pier and one for the new. This procedure was adopted due to the diversity of conditions found in the two sections. Bent numbering starts outshore with #1 and ends with #82 at the bulkhead.

General conditions noted in the new section (Bents 1-32 are as follows:

- 1) Typical spalling of the piles in this section was observed to be 0" to 1" deep and 0" to 3" long. This spalling is located in the area of mean low water. This could be described as cosmetic spalling.
- 2) 24% of the piles exhibited hairline cracking in the tidal zone on one or more faces.
- 3) A cursory inspection of the superstructure of the pier revealed good conditions. Although some caps and beams were exhibiting cracking,

PHOTO #8: Pier 23, Bent 66, Pile J, example
of severely damaged pile.



repairs have been made using pneumatically placed concrete and injection grouting. A more detailed inspection of this area should be conducted by the Naval Station.

General conditions noted in the old section (Bents 33-82) are as follows:

- 1) Heavy spalling, which is described in Section 4.0, is found in the tidal zone on 98% of the piles.
- 2) Heavy spalling is accompanied by exposed rebar on 17% of the piles (see Photo 9).
- 3) Minor cracking along the corners of the piles is associated with the heavy spalling. Cracks range in size from hairline to 3/8" wide. Most cracking is limited to the tidal zone, but 36% of the piles exhibit cracking below the tidal zone, occasionally reaching the mudline (see Photo 10).
- 4) A cursory inspection of the superstructure showed that repairs had been made using pneumatically placed concrete. Repaired and non-repaired areas were exhibiting some hairline cracking. This area should be examined in more detail by the Naval Station.
- 5) Light spalling, which is described in Section 4.0, could be found on 2% of the piles in the tidal zone. This is considered cosmetic spalling with no structural significance.



PHOTO #9: Pier 23, Bent 64, Pile J, shows severely damaged pile at El -05, heavy spalling and rebar partially cleaned of corrosion and biofouling. The tie wire is exposed horizontally.

PHOTO #10: Pier 23, Bent 66, Pile G, at El -7.0 shows crack and area of soft concrete (1") chipped away by diver on corner of pile.



4.2.3 STRUCTURAL CONDITION ASSESSMENT

In Bents 1-32, the new section, the general condition of the pier is excellent. The cosmetic spalling observed, at this time, poses no threat to the structural integrity of the pier. The hairline cracking noted on some of the piles is probably due to one of two reasons; possibly the cracks could have originated from the construction process of the pier (driving the piles), or possibly from the manufacture of the piles. In any case, the cracks are not in need of repair.

In Bents 33-82, the old section, the piles have suffered major deterioration in the tidal zone. A structural analysis of the heavily spalled piles (see Appendix) indicates that this condition has not reduced the original design capacity of the piles, but if the deterioration is allowed to continue, a re-assessment of the capacity of the piles will have to be made. To stop the decaying process, repairs will have to be made.

The light spalling noticed on some of the piles has no significant effect on the capacity of the piles, although attention should be paid to the continued deterioration of these piles.

4.2.4 RECOMMENDATIONS

For Pier 23, it is recommended that all the severely damaged and heavily spalled piles be repaired as soon as possible.

The superstructure, in areas where there is severe damage to structural piles, has limited capability to carry its designed live loading. Moderate live loading, such as imposed presently, will be transmitted through the superstructure to adjacent piles. Capacity loading should be restricted in these areas until repairs have been made.

We recommend that the severely damaged piles be repaired by driving two piles on either side of the damaged pile and pouring a new cap over the two new piles to support the old cap. The estimated cost to repair one damaged pile is \$5,307 (see Appendix). In Pier 23 there are 21 piles that need to be repaired in this manner. The total estimated cost for this repair is \$111,447.

Heavily spalled piles should be repaired. Soft concrete should be chipped away to sound concrete and the rebars should be cleaned or replaced if necessary. It is recommended that the piles be jacketed in concrete from El +5.0 to El -5.0. If a fabric form is used the cost per pile is estimated to be \$1,320 (see Appendix). There are 497 piles that need to be repaired; the total cost estimate is \$656, 040.

All repairs should be inspected after completion. The entire pier should be inspected in 5 years. The immediate inspection will insure that the repairs have been properly constructed. The follow-up inspection will determine the change of conditions with respect to time.

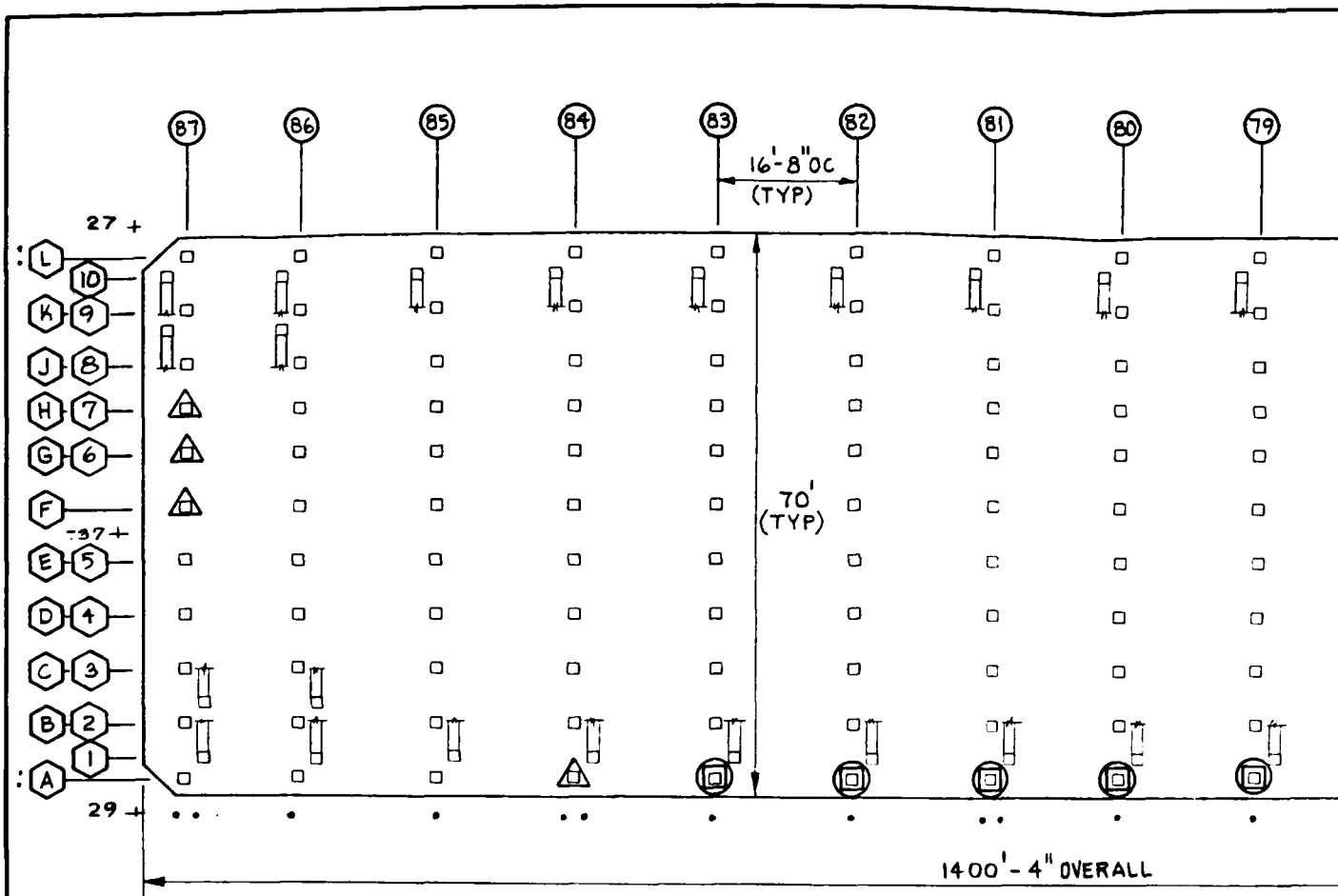
4.3 PIER 25

4.3.1 DESCRIPTION

Pier 25 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station, Norfolk, Virginia (see Figure 4). During the inspection period this pier was functioning as a berthing area for DD's, DDG's, CG's and FF's. Pier 25 is perpendicular to Bulkhead 175.

The pier was constructed in 1977 and is 1400' long and 70' wide. There are 1131 bearing piles supporting the reinforced concrete deck of the pier (See Figure 12A-12G). The piles are all prestressed precast reinforced concrete 16" square. The design bearing capacity of each pile is 47.5 tons.

Reference: Department of the Navy, Naval Facilities Engineering Command, NAVFAC Drawings Nos. 4050666 through 4050675.



PLAN

SCALE AS SHOWN

LEGEND

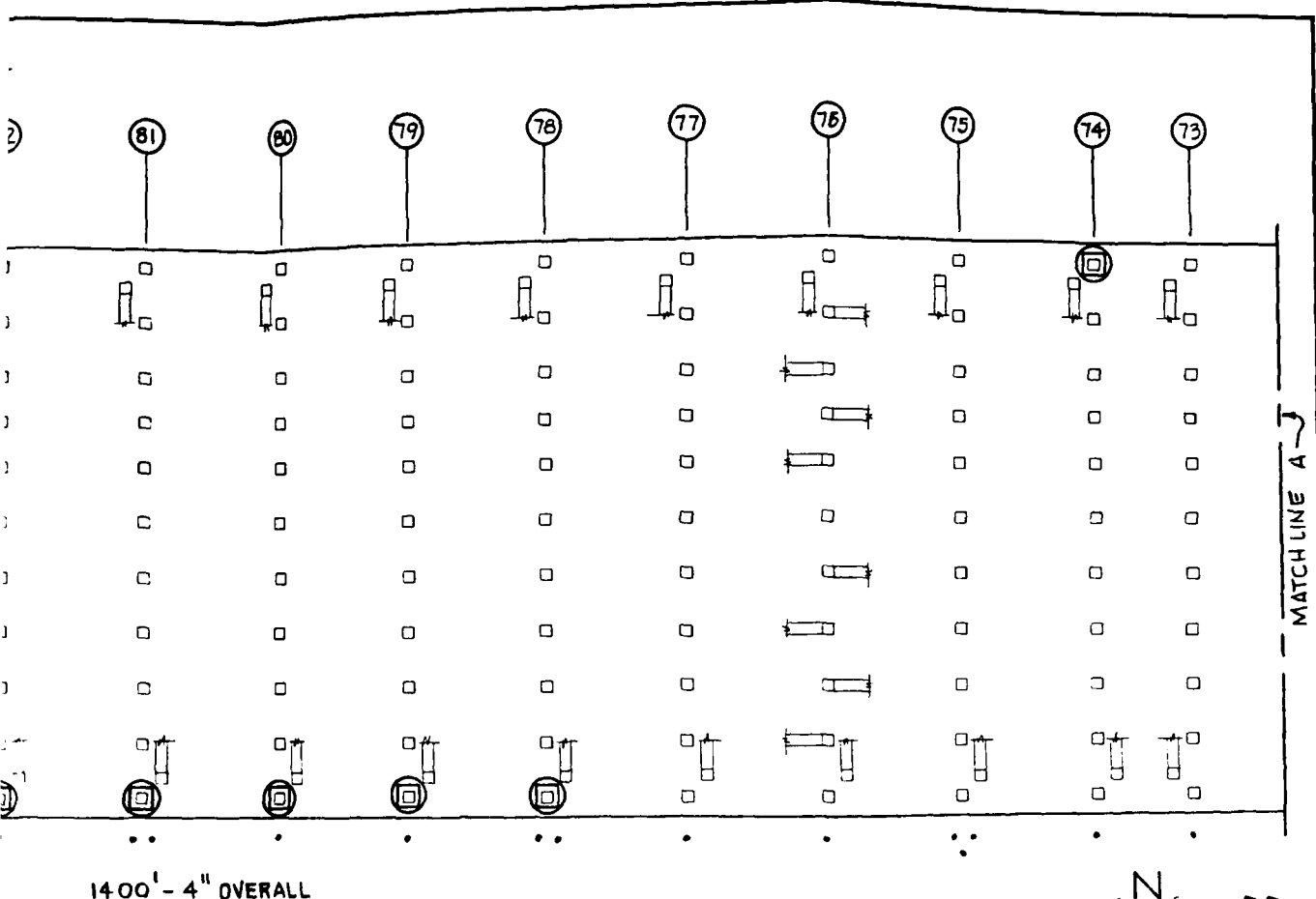
- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- + SOUNDING IN FEET BELOW MLW

LEVE
• MODII
.. LEVE
.. LEVE

NOTE :

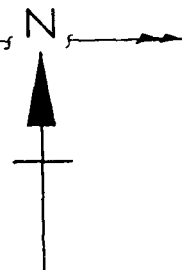
REFERENCES TAKEN FROM NAVFAC
DWG NOS. 5050666 THRU 5050675.

5
W



1400' - 4" OVERALL

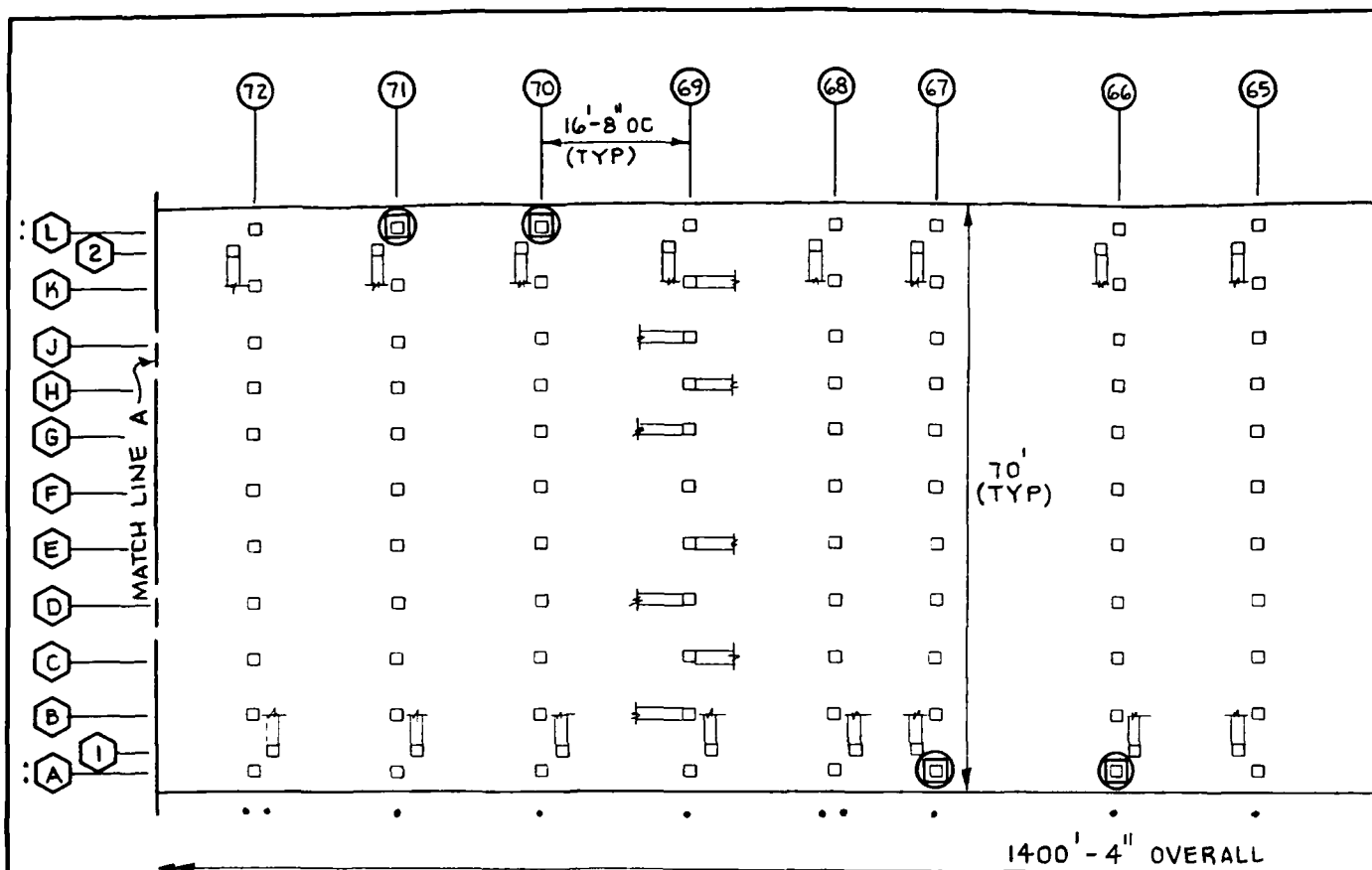
PLAN
SCALE AS SHOWN



LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

GRAPHIC SCALE		CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D C	
5	0	5	10	20	30
NAVAL STATION		PIER 25		NORFOLK, VA	
				FIG NO	
				12A	



PLAN

SCALE AS SHOWN

LEGEND

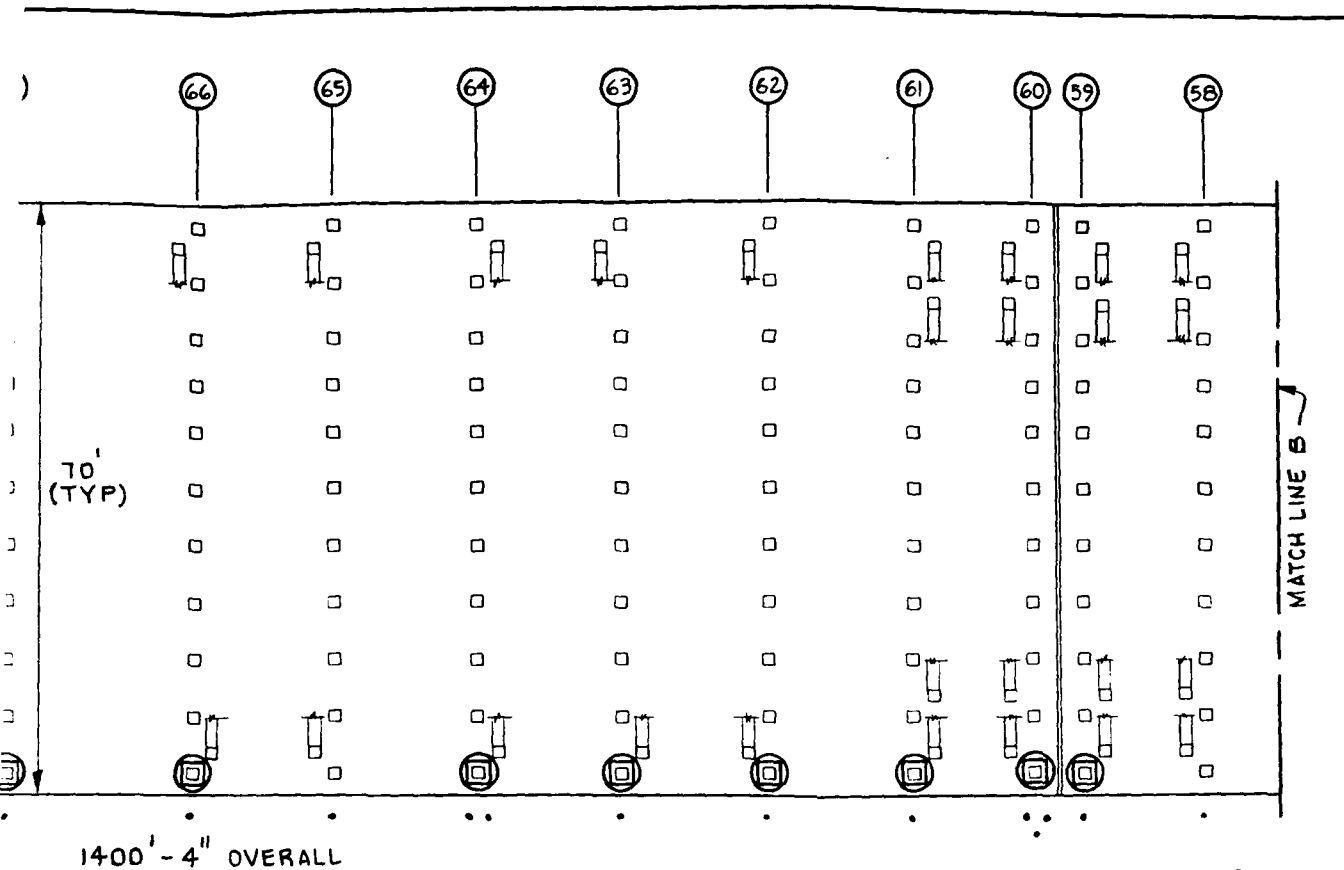
- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 75 SOUNDING IN FEET BELOW MLW

LEVELS (

- MODIFIED L
- .. LEVEL I
- ∴ LEVEL II

NOTE:

REFERENCES TAKEN FROM NAVFAC
DWG NOS. 5050666 THRU 5050675.



PLAN

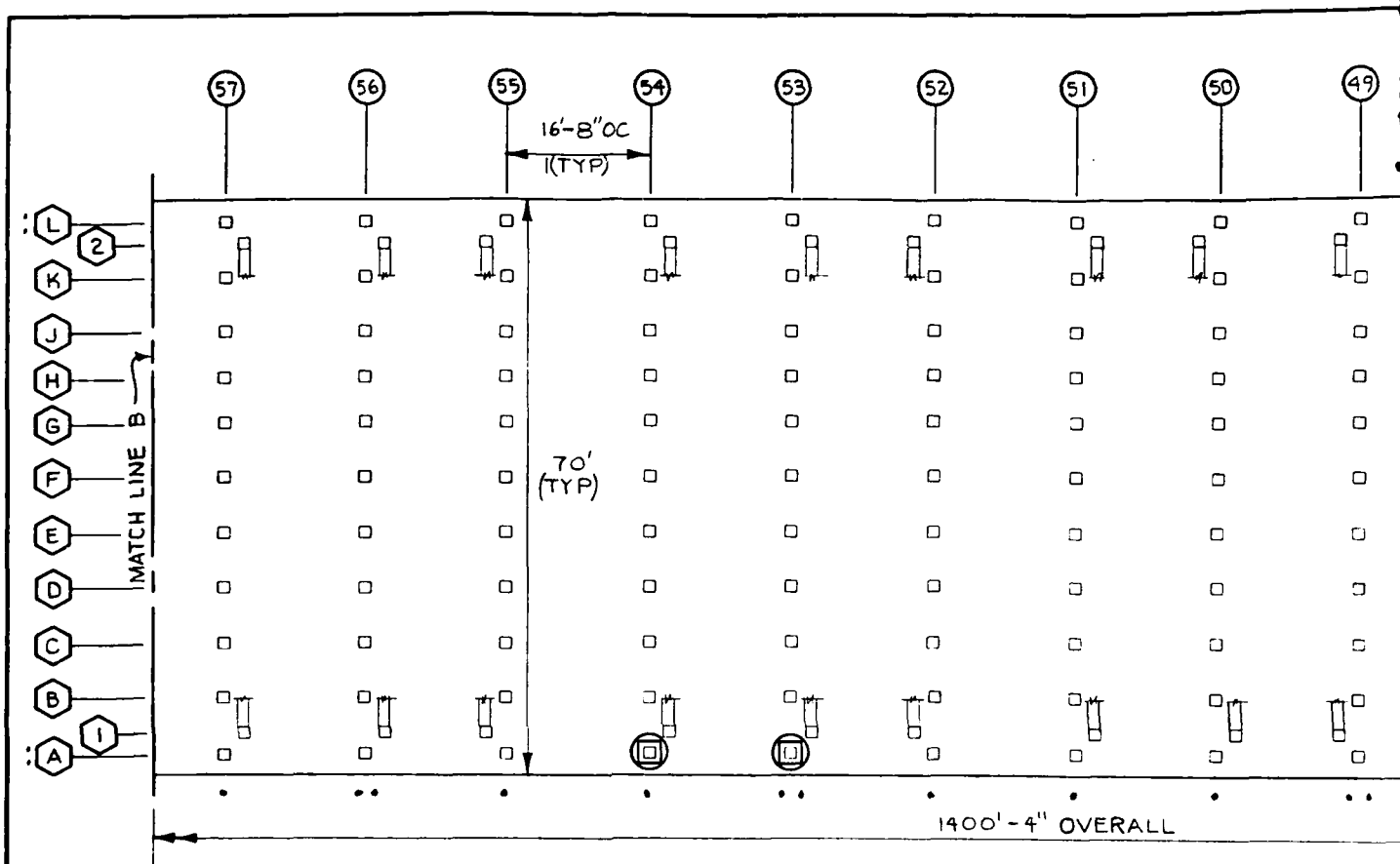
SCALE AS SHOWN

LEVELS OF INSPECTION (ALL PILES WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II



GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D C	
5 0 5 10 20 30 		NAVAL STATION PIER 25	NORFOLK, VA FIG NO. 12B



PLAN
SCALE AS SHOWN

LEGEND

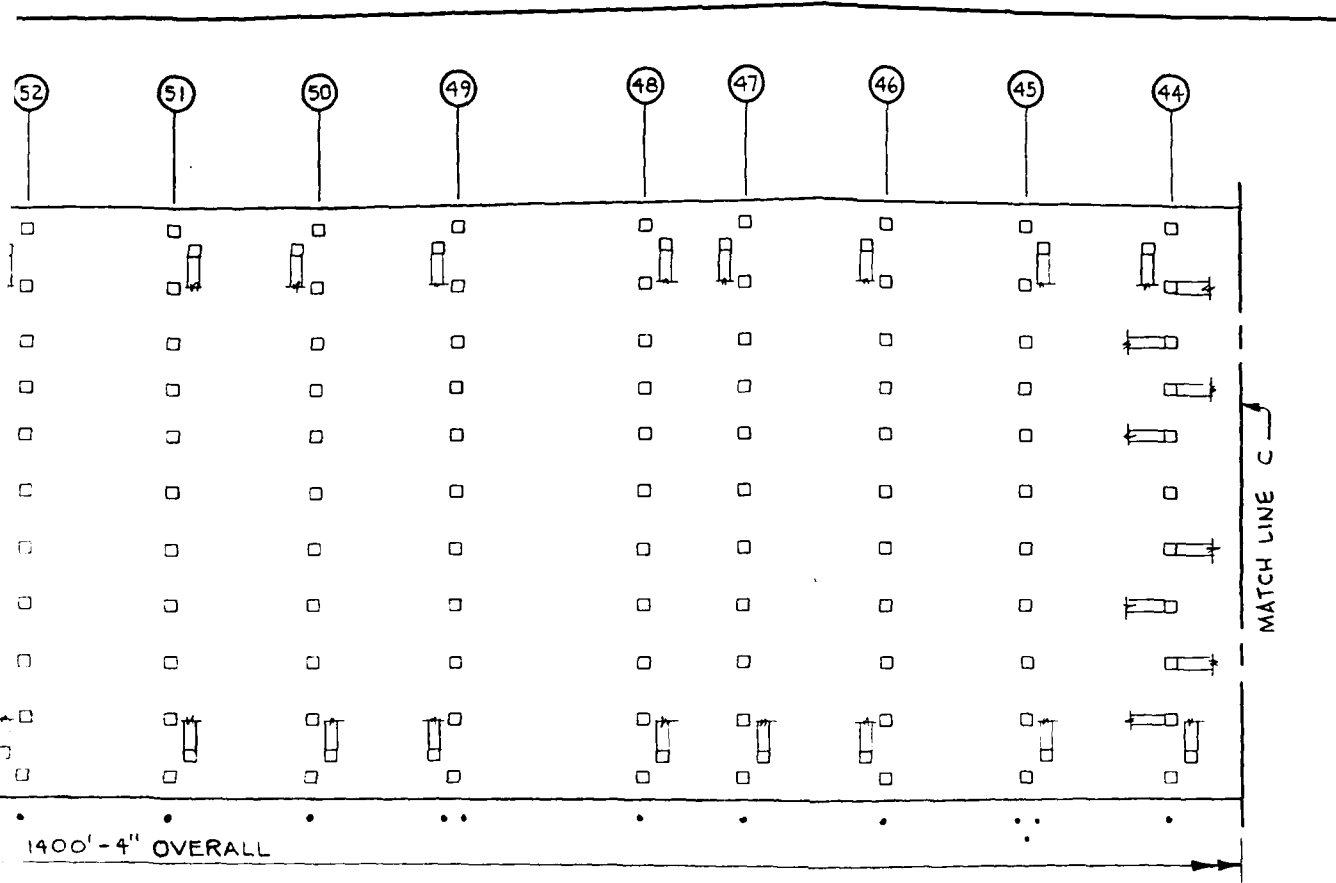
- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊡ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

LEVELS

- MODIFIED
- .. LEVEL I
- ∴ LEVEL II

NOTE:
REFERENCES TAKEN FROM NAVFAC
DWG NOS. 5050656 THRU 5050675

5 0
1111



PLAN

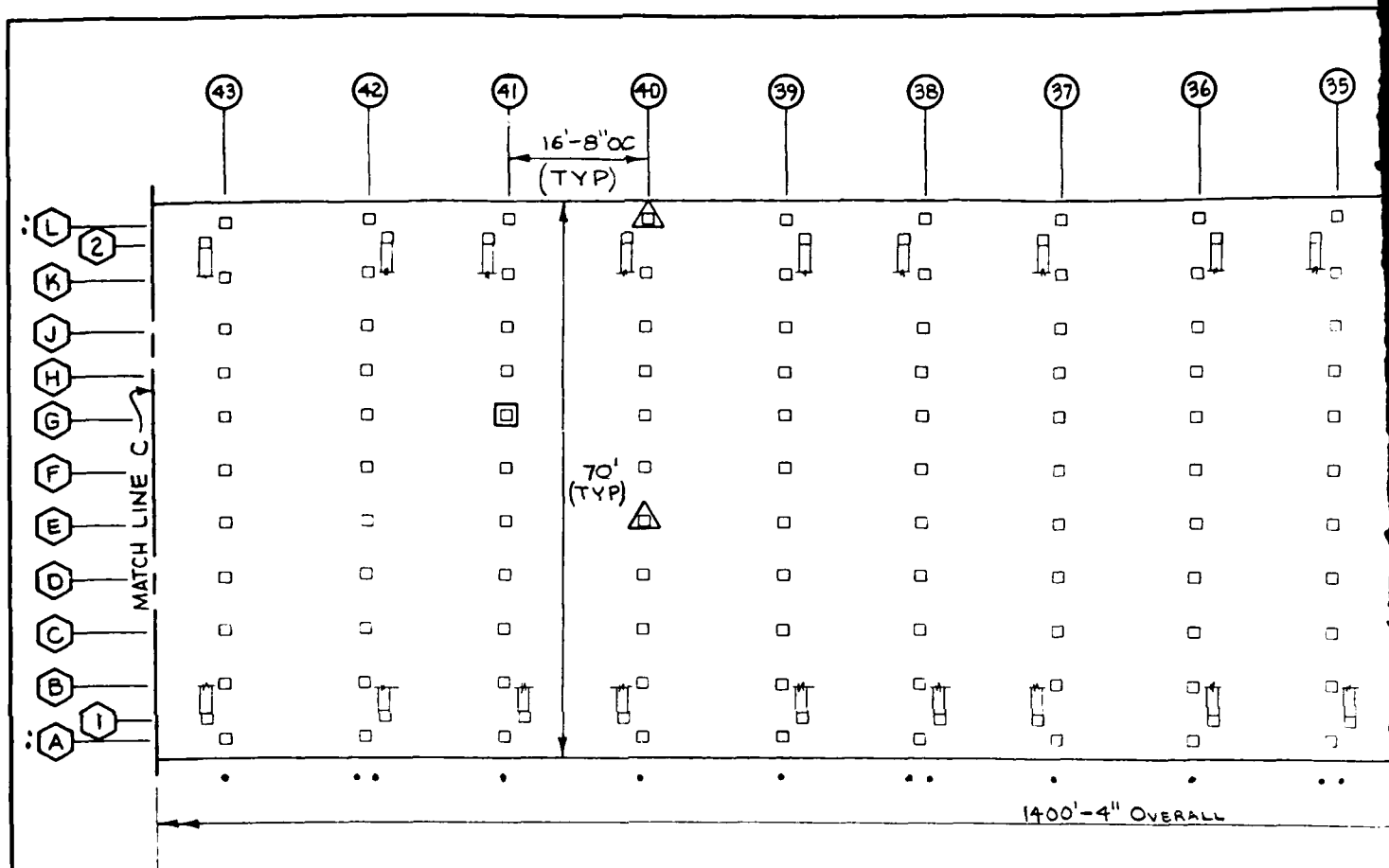
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- LEVEL II



GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D C	
5	0 5 10 20 30	NAVAL STATION PIER 25	FIG NO 12C
CHILD'S ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		NORFOLK, VA	



PLAN
SCALE AS SHOWN

LEGEND

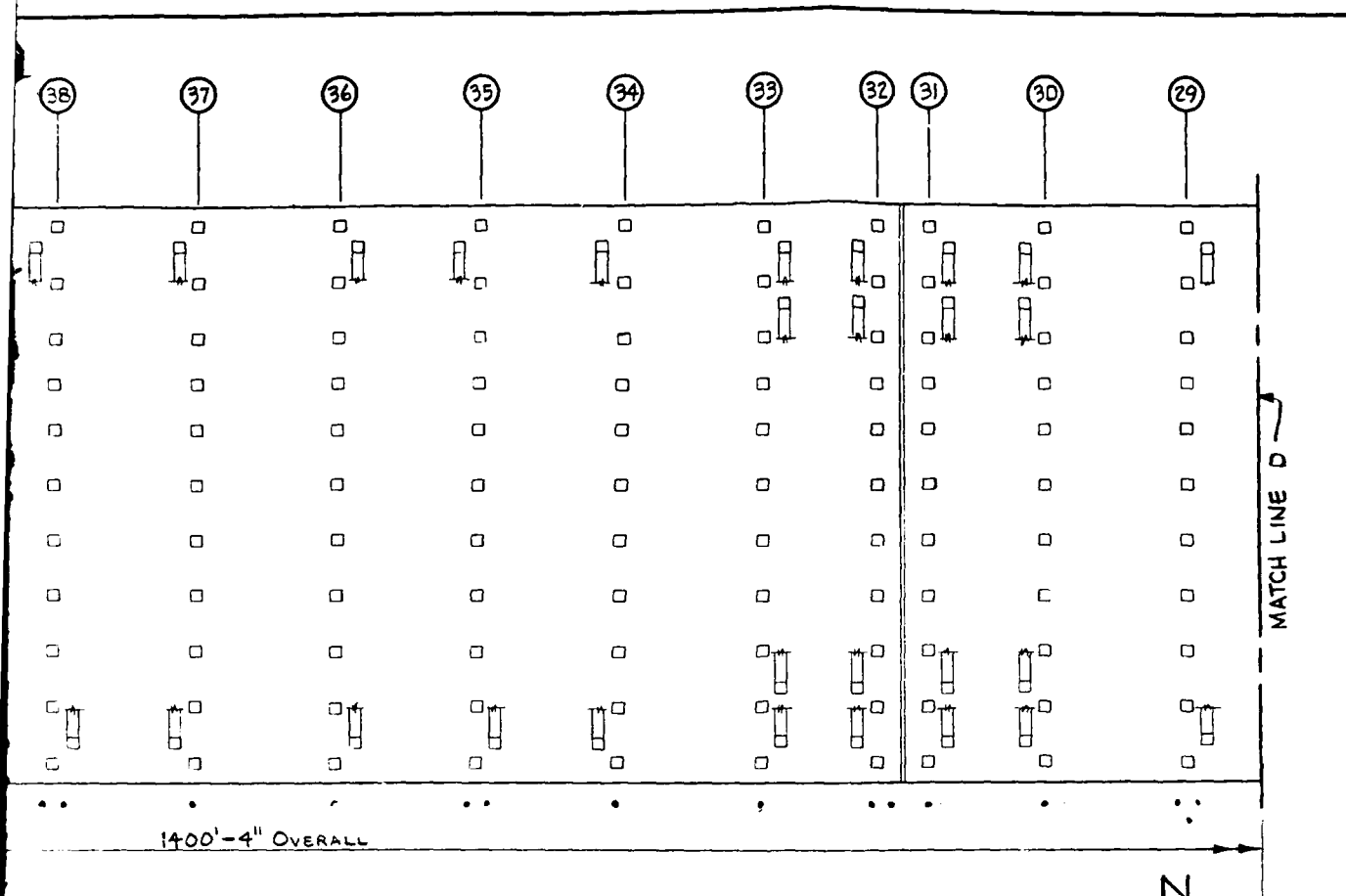
- ⊖ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

LEVEL
• MODI
.. LEVE
.. LEVE

NOTE:

REFERENCES TAKEN FROM NAVFAC
DWG NOS. 5050656 THRU 5050675

5 0
WUL



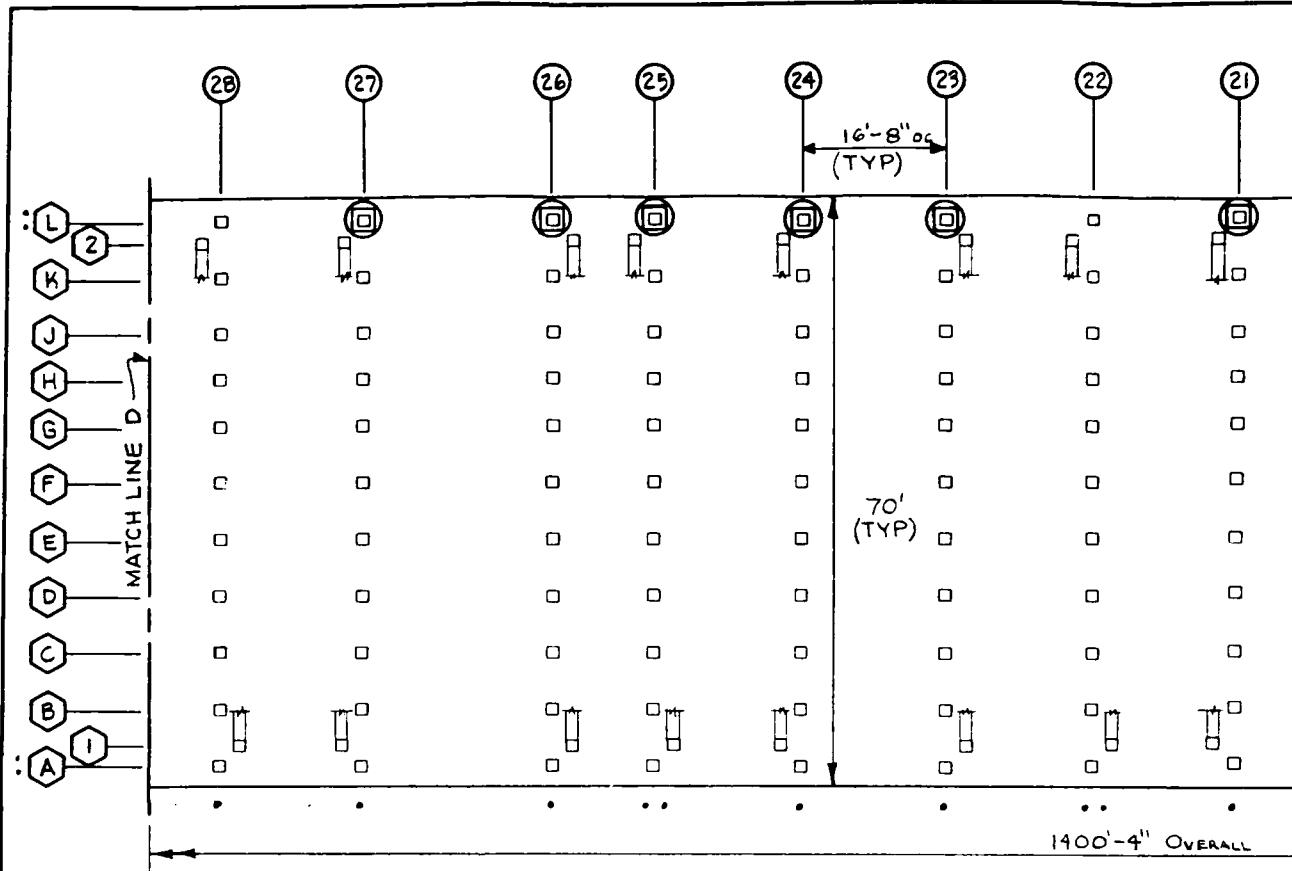
PLAN
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II



GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D.C.	
5	0	NAVAL STATION	FIG. NO.
5	10	NORFOLK, VA	12D
20	30	PIER 25	

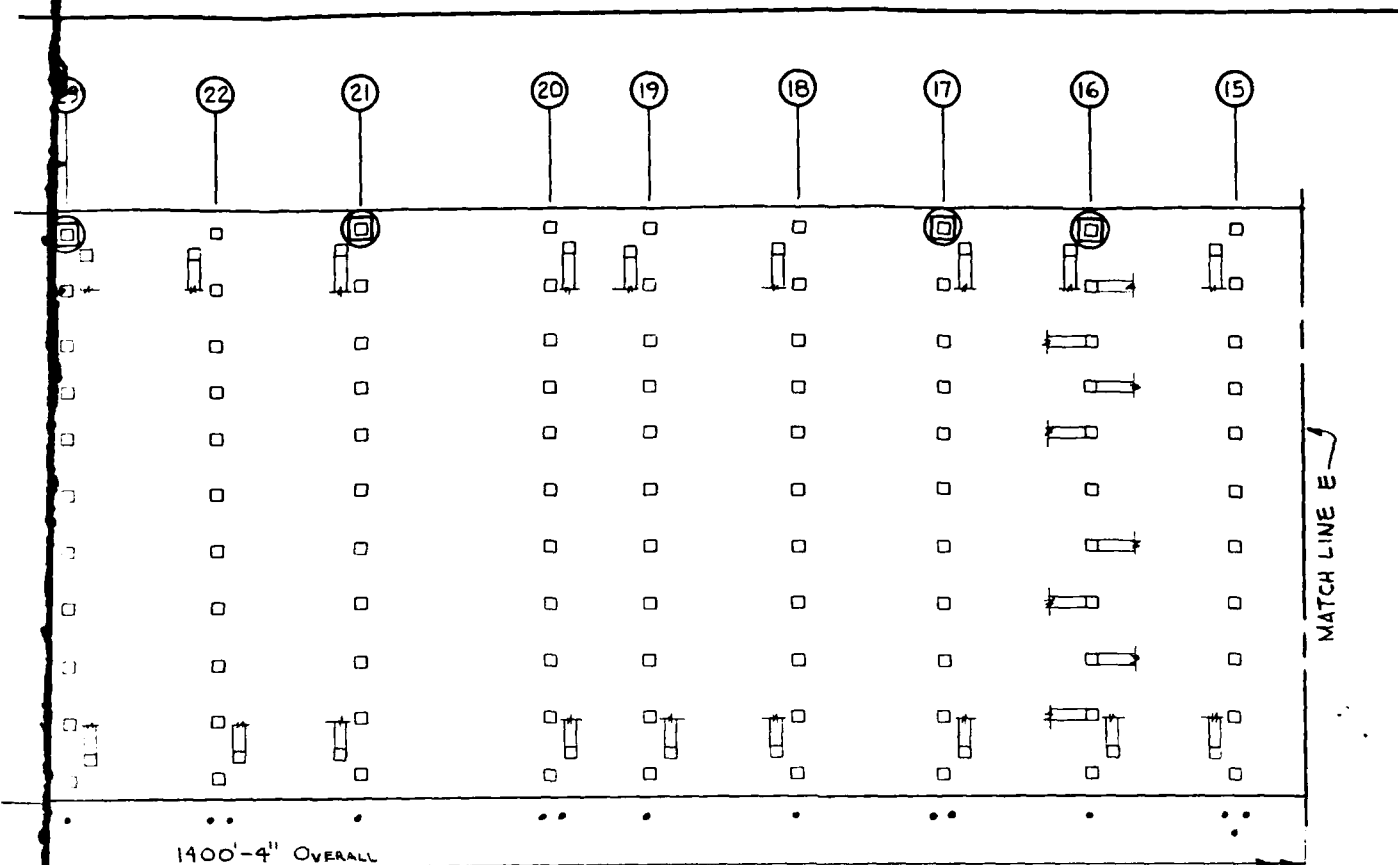


PLAN
SCALE AS SHOWN

LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊡ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

NOTE:
REFERENCES TAKEN FROM NAVFAC
DWG Nos. 5050656 THRU 5050675

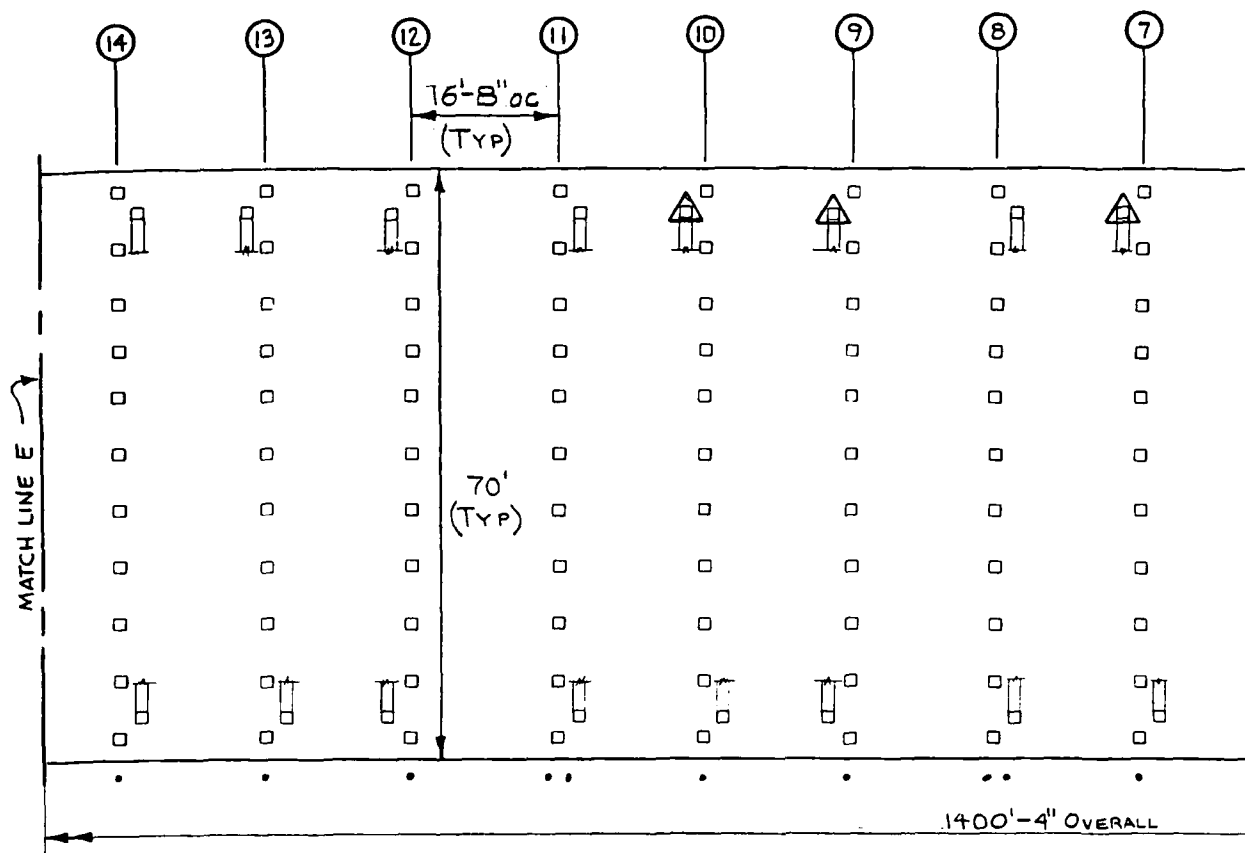


PLAN
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

GRAPHIC SCALE	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
5 0 5 10 20 30 		NAVAL STATION NORFOLK, VA	FIG. NO.
		PIER 25	12E



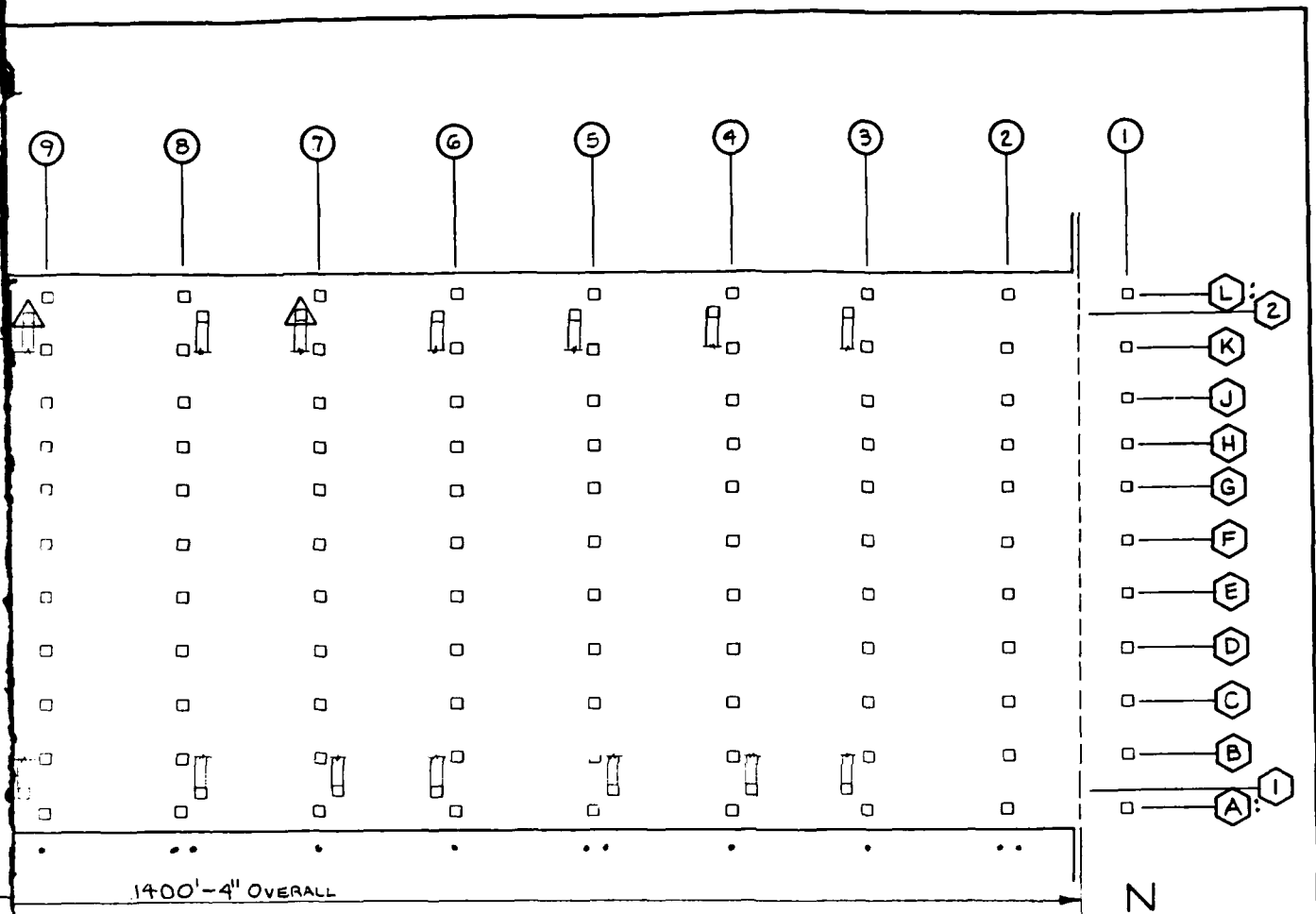
PLAN
SCALE AS SHOWN

LEGEND

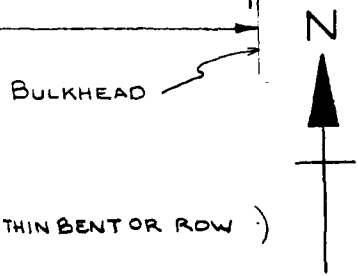
- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊞ HEAVY SPALLING, REBAR EXPOSED
- ⊡ HEAVY SPALLING, NO REBAR EXPOSED
- ⊠ LIGHT SPALLING
- ⊞ SOUNDING IN FEET BELOW MLW

NOTE:

REFERENCES TAKEN FROM NAVFAC
DWG Nos. 5050656 THRU 5050675



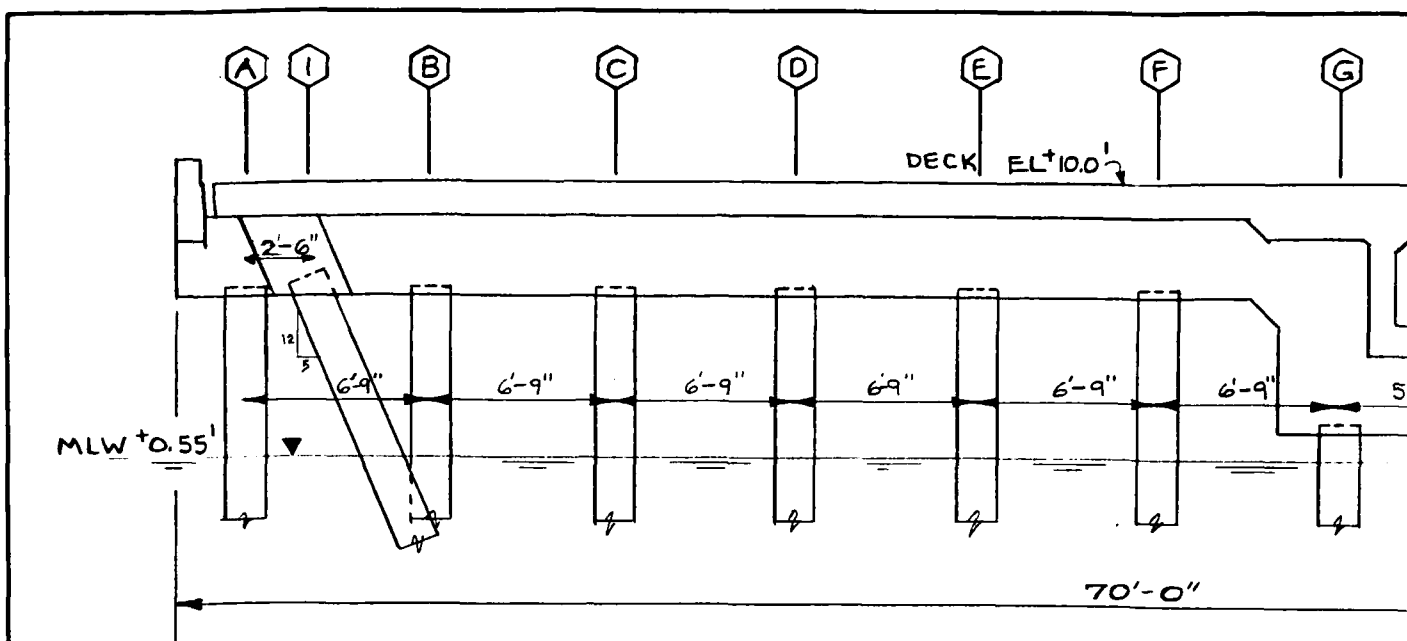
PLAN
SCALE AS SHOWN



LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

GRAPHIC SCALE 5 0 5 10 20 30	CHILOS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. NAVAL STATION NORFOLK, VA PIER 25	FIG NO 12F
--	--	---	------------------------------

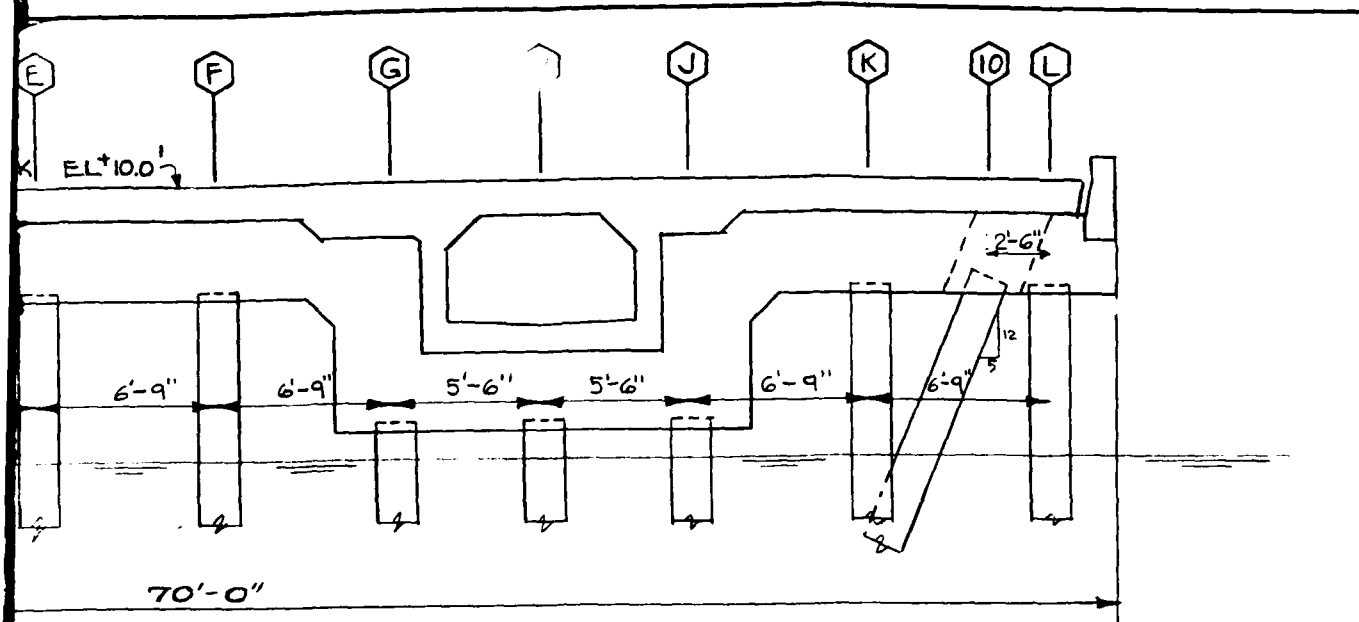


TYPICAL CROSS SECTION

SCALE AS SHOWN

NOTE:

REFERENCES TAKEN FROM NAVFAC
DNG No. 4015036



TYPICAL CROSS SECTION

SCALE AS SHOWN

GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND	
5 0 5		WASHINGTON D C	FIG. NO.
CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		NAVAL STATION PIER 25	NORFOLK, VA 12G

4.3.2 OBSERVED INSPECTION CONDITION

A condition affecting 16% of the perimeter piles is noted as severely damaged (see Photo 11). The condition is described in detail in Section 4.0.

A list of piles that exhibit these conditions is as follows:

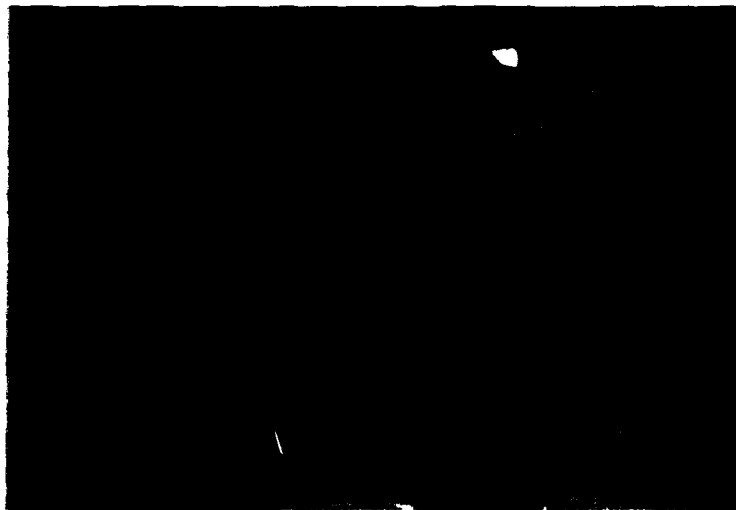
<u>Bent #</u>	<u>Pile</u>	<u>Bent #</u>	<u>Pile</u>
83	A	61	A
82	A	60	A
81	A	59	A
80	A	54	A
79	A	53	A
78	A	27	L
74	L	26	L
71	L	25	L
70	L	24	L
67	A	23	L
66	A	21	L
64	A	17	L
63	A	16	L
62	A		

Bent numbering begins at the bulkhead with No. 1 and ends out-shore with No. 87.

General and typical conditions noted throughout the pier:

- 1) A cursory inspection of the superstructure reveals that it is in good condition. Hairline cracking and calcareous deposits are noted throughout the underside of the deck supporting structure.
- 2) The caps, adjacent to the perimeter piles that have suffered severe damage, have received some abrasive damage, i.e., corners are chipped.
- 3) Minor spalling of the pile cap around the piles supporting the utility trench is typical but not structurally significant.
- 4) Typically, the piles are in good to excellent condition. Typical conditions are defined as 0" to 1" of spalling in the tidal zone. 98% of the piles exhibit this typical spalling.

PHOTO #11: Pier 25, Bent 23, Pile L,
severely damaged pile, at El 0.0
shows pre-stressing strands and
tie wire.



4.3.3 STRUCTURAL CONDITION ASSESSMENT

The hairline cracking of the pile cap and deck beams is not structurally significant at this time. This condition should be under observation to determine further deterioration.

The severely damaged piles are a serious problem. It is advisable to repair the severely damaged piles immediately. It is noted that many of these piles have the same pile letter designation and are in consecutive bents.

4.3.4 RECOMMENDATIONS

For Pier 25, it is recommended that all severely damaged piles be repaired as soon as possible.

The superstructure, in areas where there is severe damage to structural piles, has limited capability to carry its designed live loading. Moderate live loading, such as imposed presently, will be transmitted through the superstructure to adjacent piles. Capacity loading should be restricted in these areas until repairs have been made.

We recommend that the severely damaged piles be repaired by driving 2 piles on either side of the damaged pile and pouring a new cap over the new piles to support the old cap. The estimated cost to repair one damaged pile is \$5,307. There are 27 piles in need of this type of repair. This would cost an estimated \$143,289 (see Appendix).

There is one heavily spalled pile that should be repaired, sound concrete should be exposed and the rebar should be cleaned. It is recommended that this pile be jacketed from El +5.0 to El -2.0. If a fabric form is used the cost is estimated to be \$924.00 (see Appendix).

All repairs should be inspected after completion. The entire pier should be re-inspected in 5 years. The immediate inspection will insure that the repairs have been properly constructed. The follow-up inspection will determine the change of conditions with respect to time.

4.4 PIER 2

4.4.1 DESCRIPTION

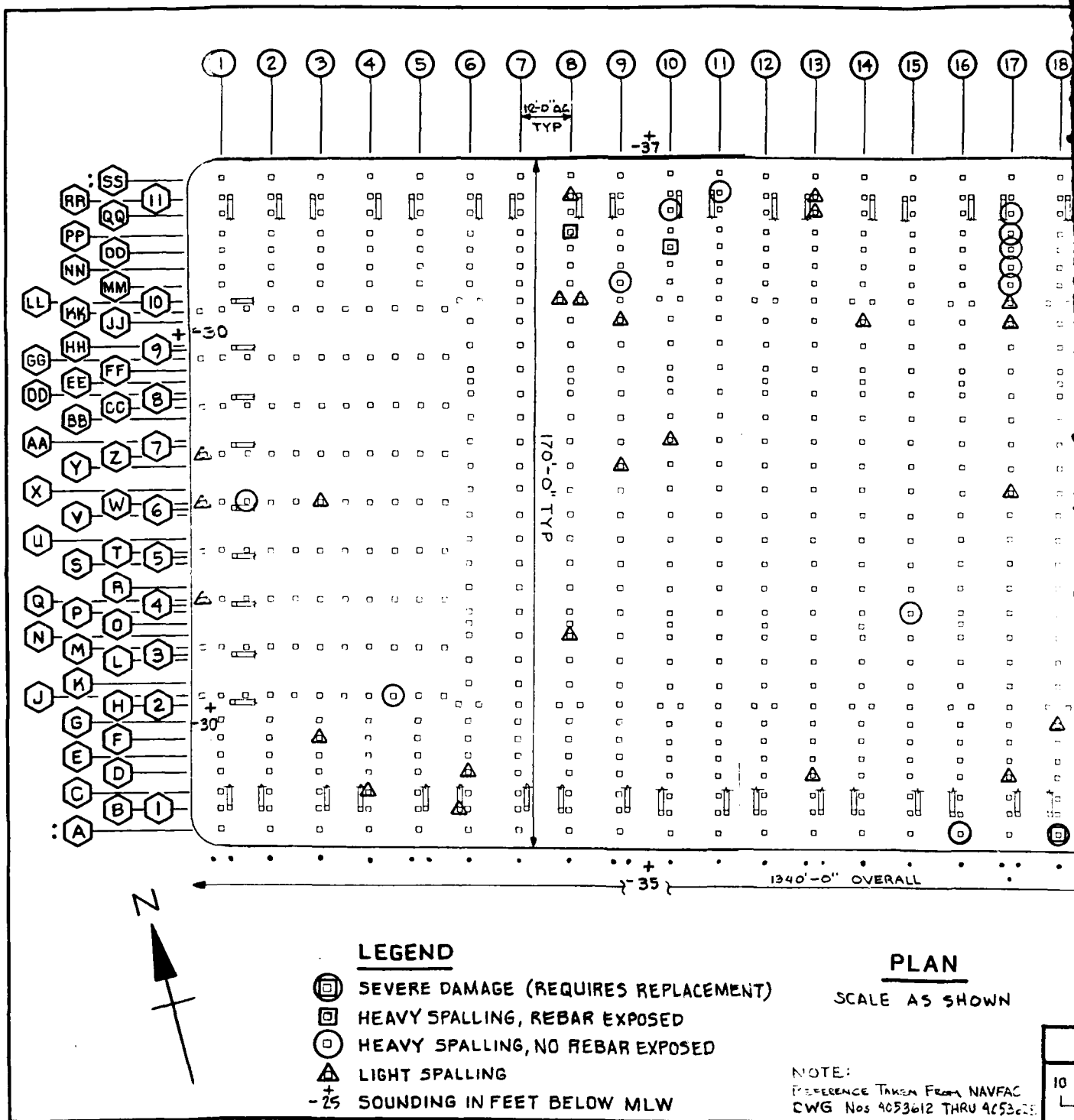
Pier 2 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station (see Figure 4). The northeastern corner of the pier intersects Bulkhead Y307, and the southeastern corner of the pier intersects Bulkhead Z308, (see Photo 12).

The pier was constructed in 1943 and is 1340' long and 170' wide. There are 4250 bearing piles supporting the reinforced concrete deck of the pier (see Figures 13A-13E). All piles are 18" square precast concrete. The design bearing capacity of each pile is 40 tons.

Reference: Department of the Navy, Naval Facilities Engineering
Command - NAVFAC Drawings Nos. 4053612 to 4053629

PHOTO #12: Pier 2, Overview of south side
of pier looking west.





AD-A167 551

UNDERWATER FACILITIES INSPECTIONS AND ASSESSMENTS AT
NAVAL STATION NORFOLK VIRGINIA (U) CHIEF ENGINEERING
CORP MEDFIELD MA JUL 82 CHES/NAUFAC-PRO-1-82 (13)
F/G 13/2

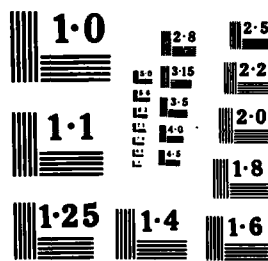
UNCLASSIFIED

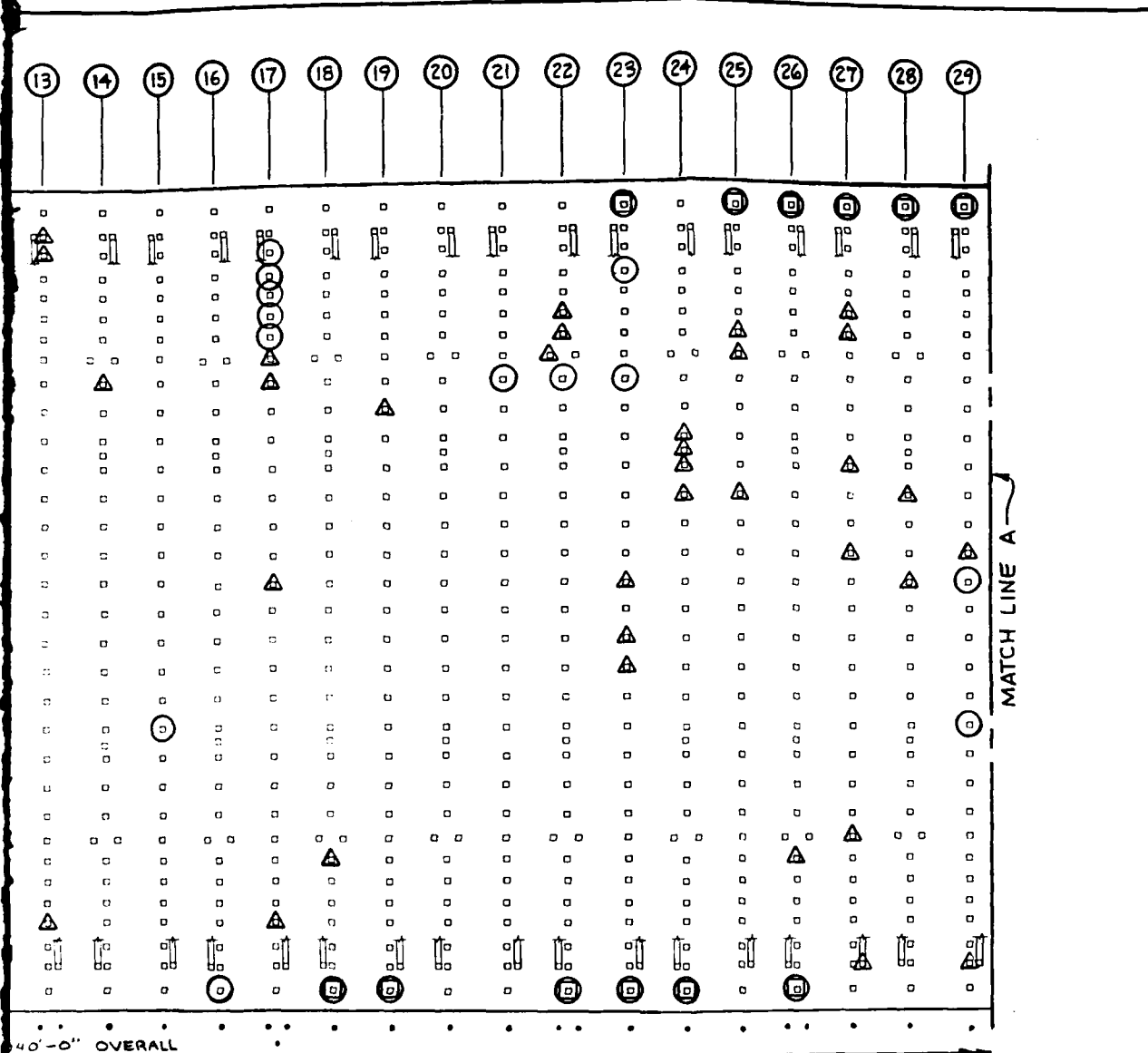
NS2477-81-C-8448

2/2

ML

END
DATE
SEP
86
(11)





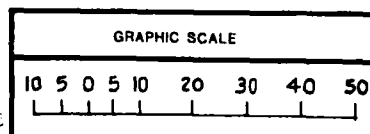
PLAN

SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

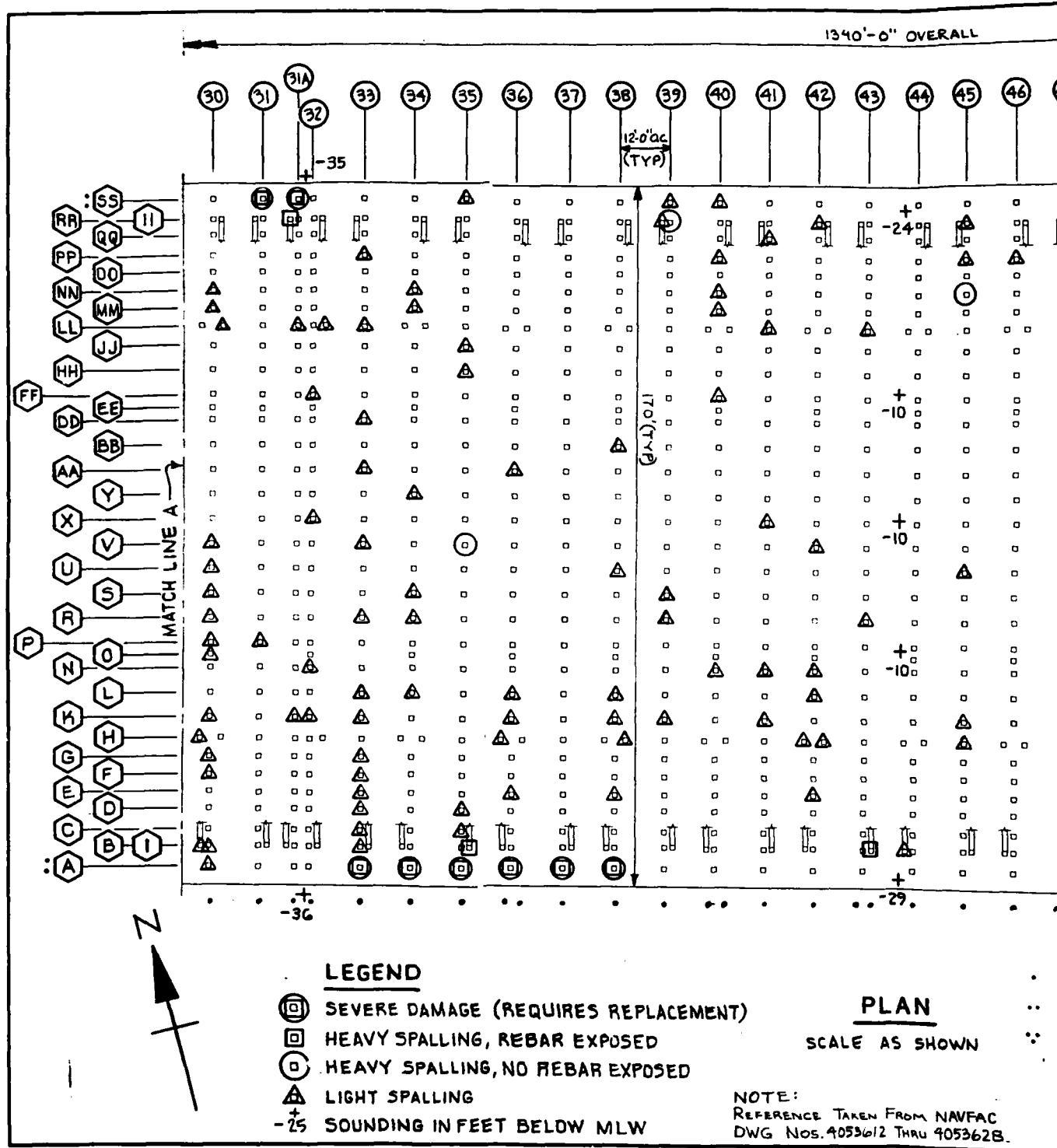
- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

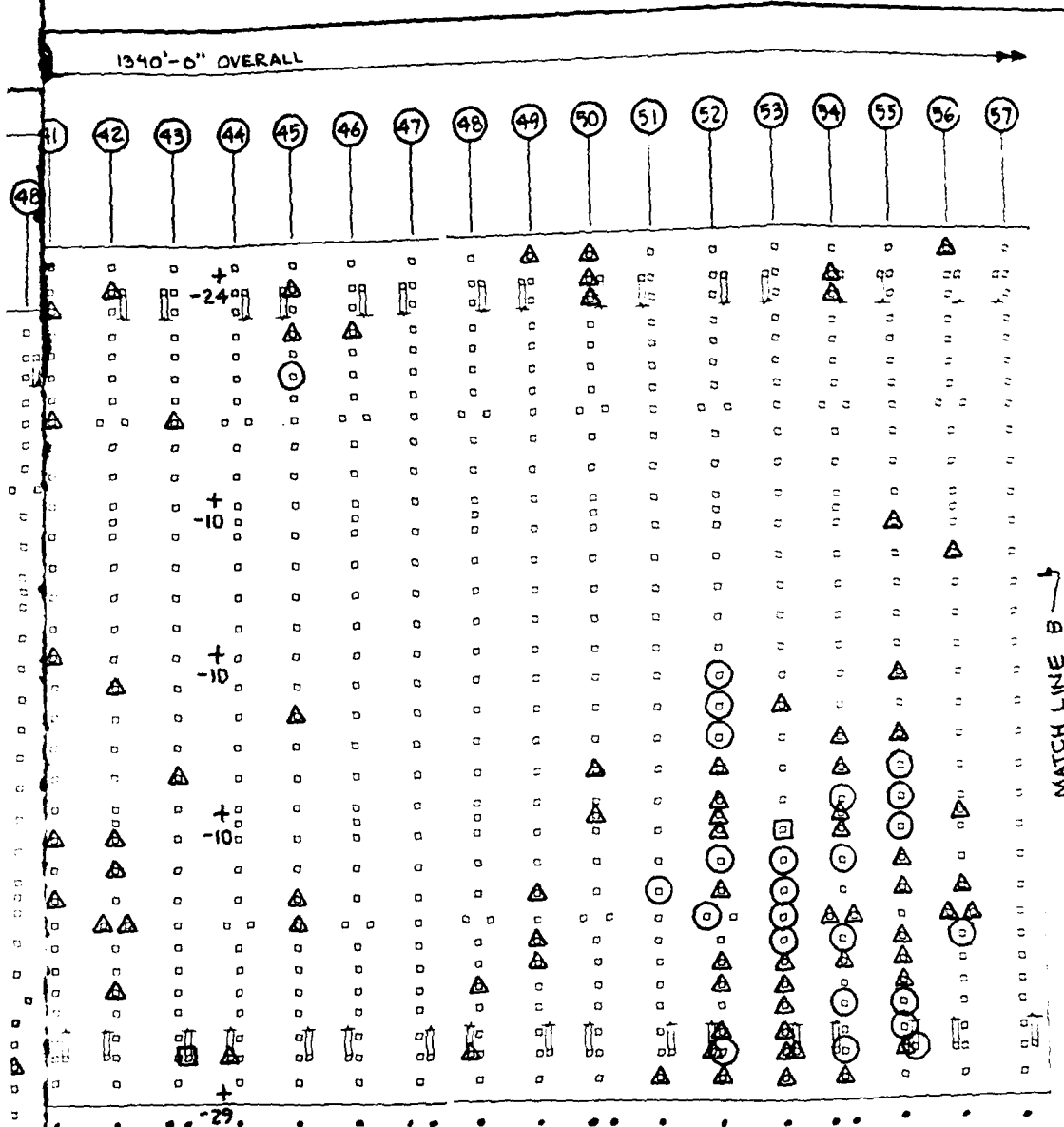
NOTE:
REFERENCE TAKEN FROM NAVFAC
CWG Nos 4053612 THRU 4053625



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON D C
NAVAL STATION: NORFOLK, VA
PIER 2
FIG NO
13A





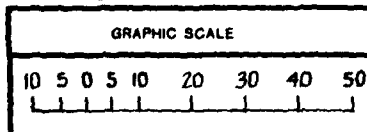
LEVELS OF INSPECTION (WITH IN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

PLAN

SCALE AS SHOWN

NOTE: REFERENCE TAKEN FROM NAVFAC
WG NOS. 4053612 THRU 4053628.



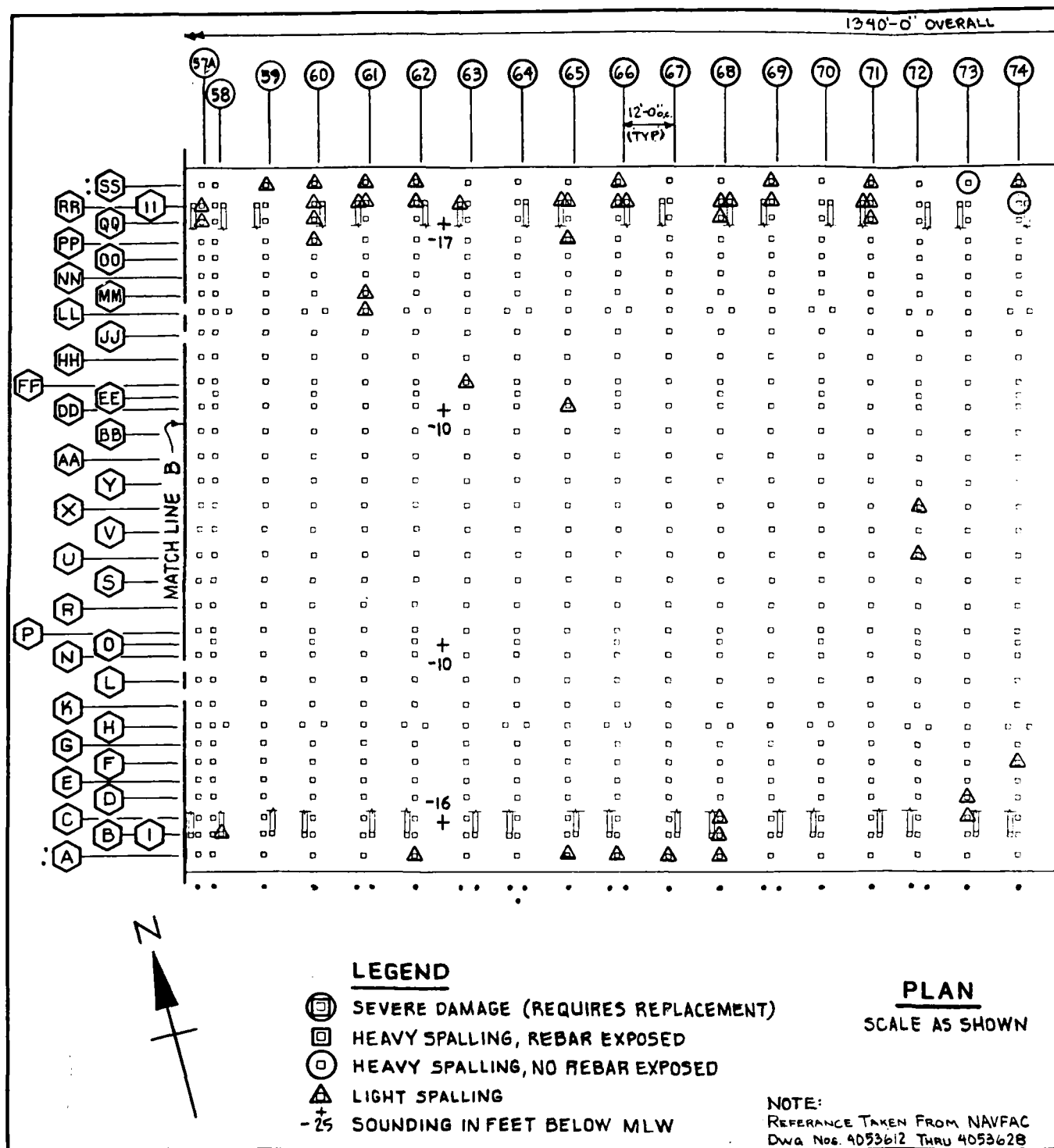
CHILDS ENGINEERING
CORPORATION
BOX 233
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON D C

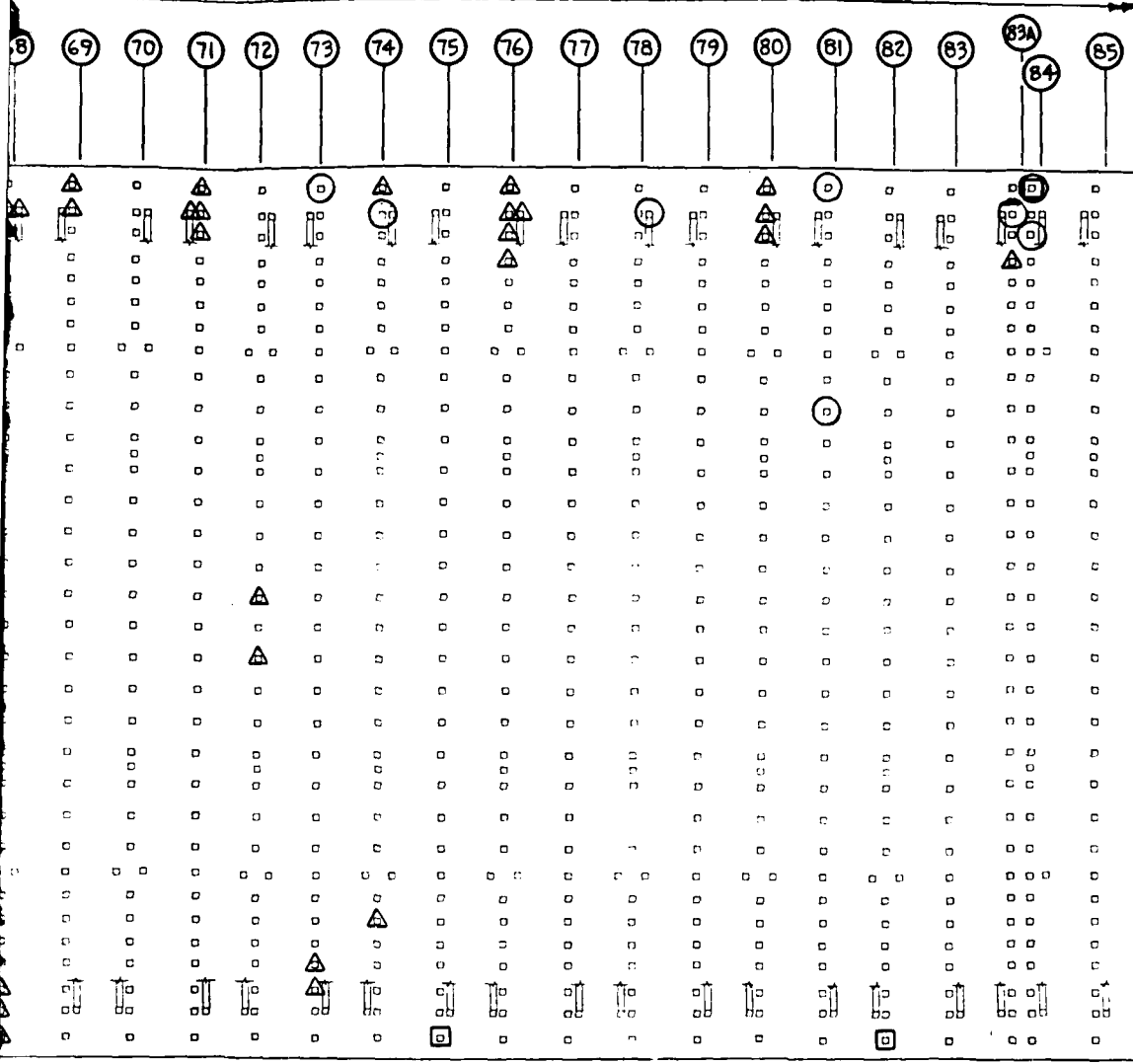
NAVAL STATION NORFOLK, VA

PIER 2

FIG NO
138



1340'-0" OVERALL



170'-0" (TYP)

MATCH LINE C

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

PLAN
SCALE AS SHOWN

NOTE:
REFERENCE TAKEN FROM NAVFAC
Dwg. Nos. 4053612 THRU 4053628

GRAPHIC SCALE

10 5 0 5 10 20 30 40 50

CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

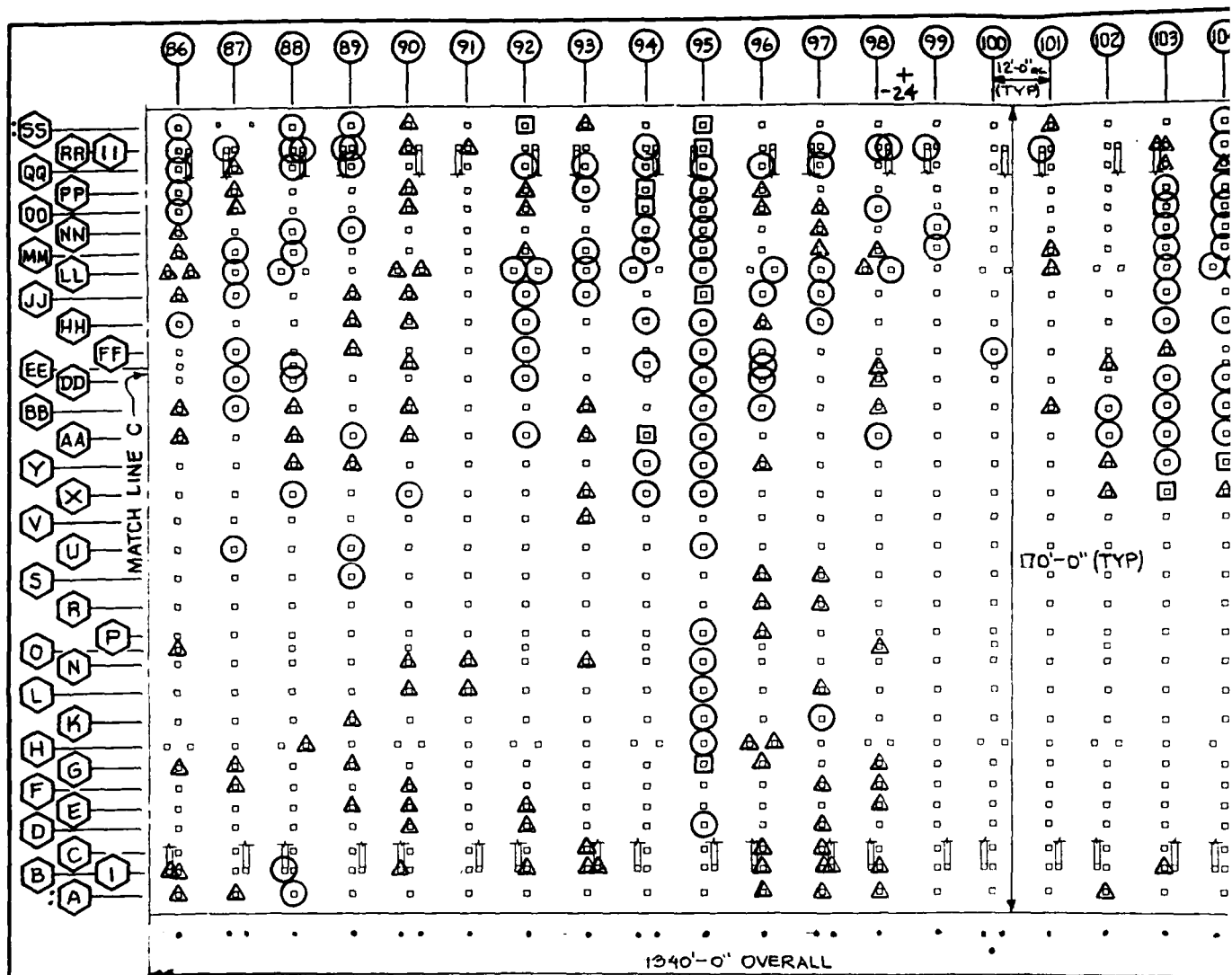
NAVAL STATION

PIER 2

NORFOLK, VA

FIG NO

13C



PLAN

SCALE AS SHOWN

LEVELS OF INSPECT

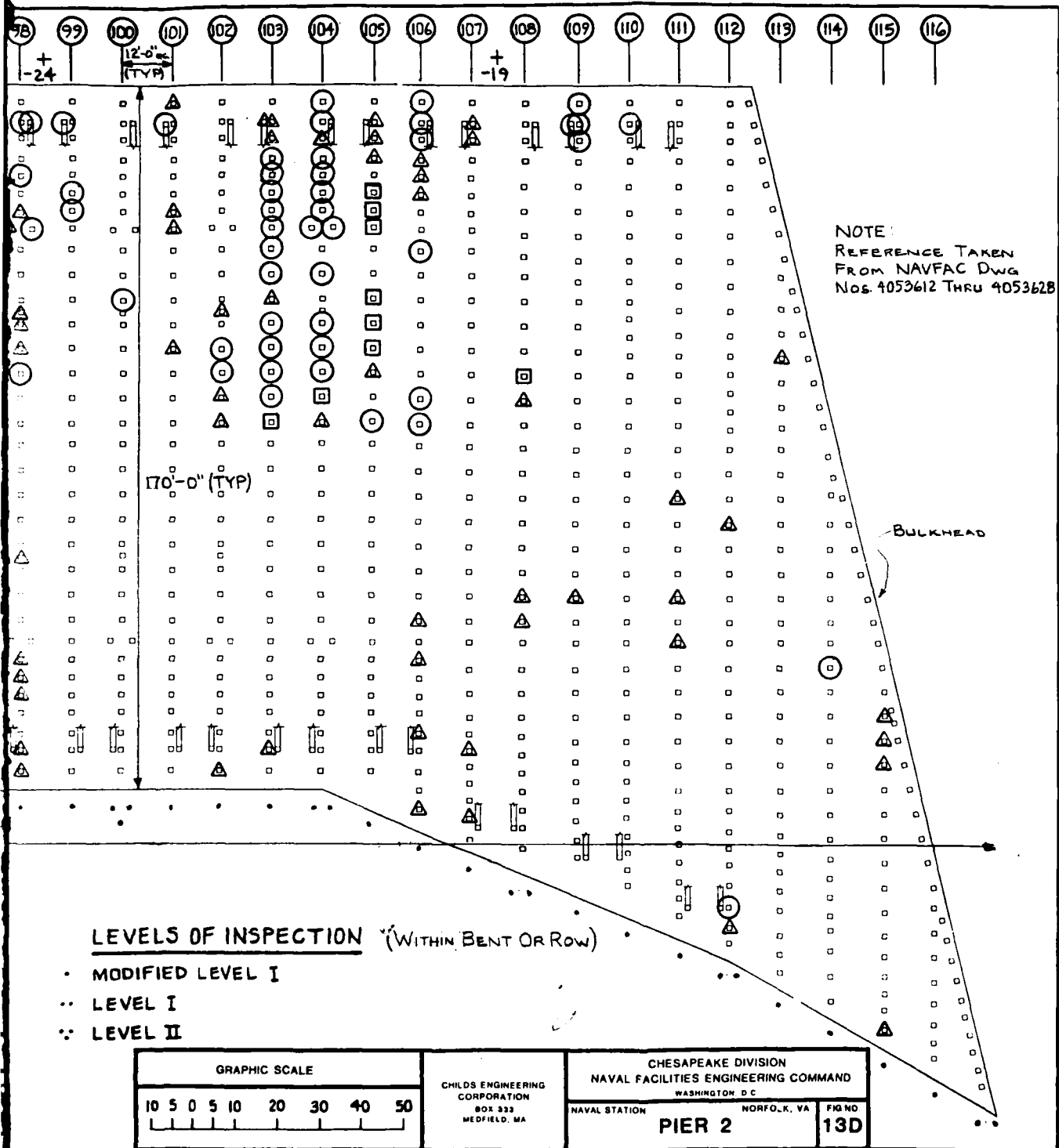
- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

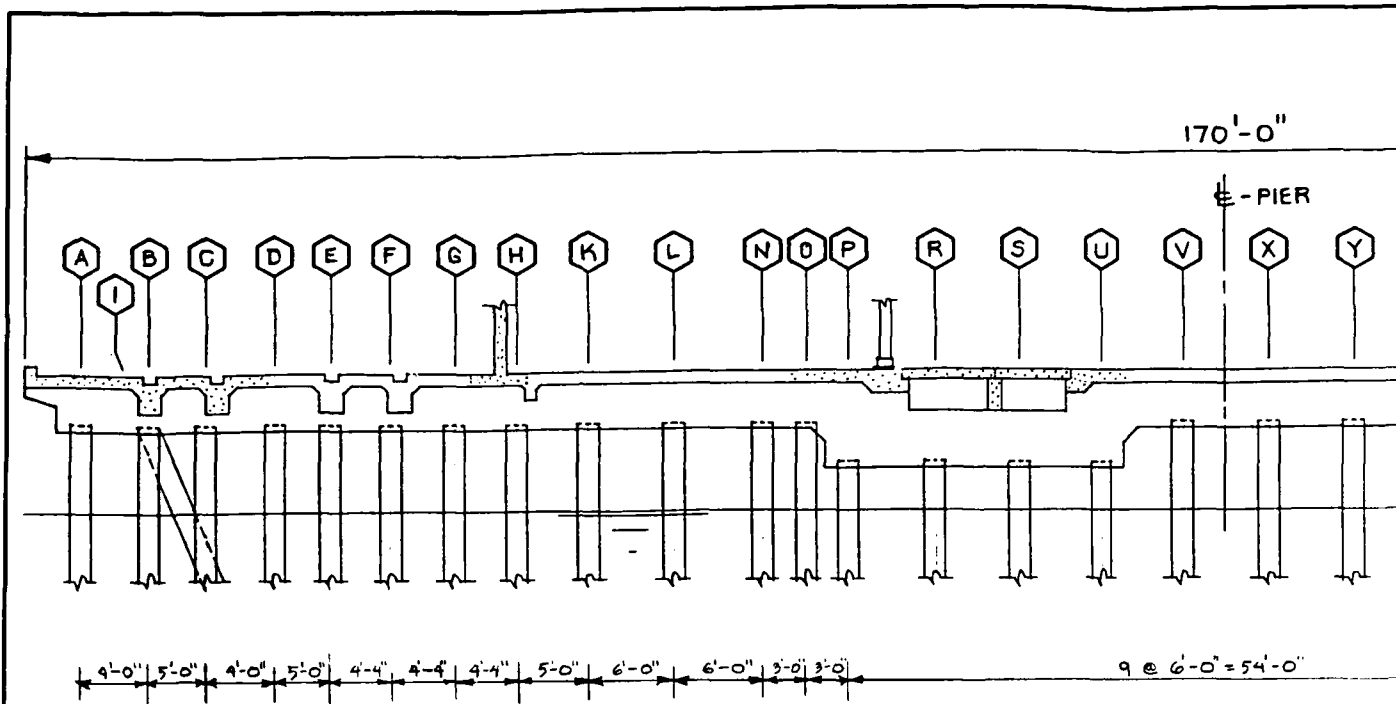
LEGEND

- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- ⊕ SOUNDING IN FEET BELOW MLW

GRAPHIC SCALE

10 5 0 5 10 20 30

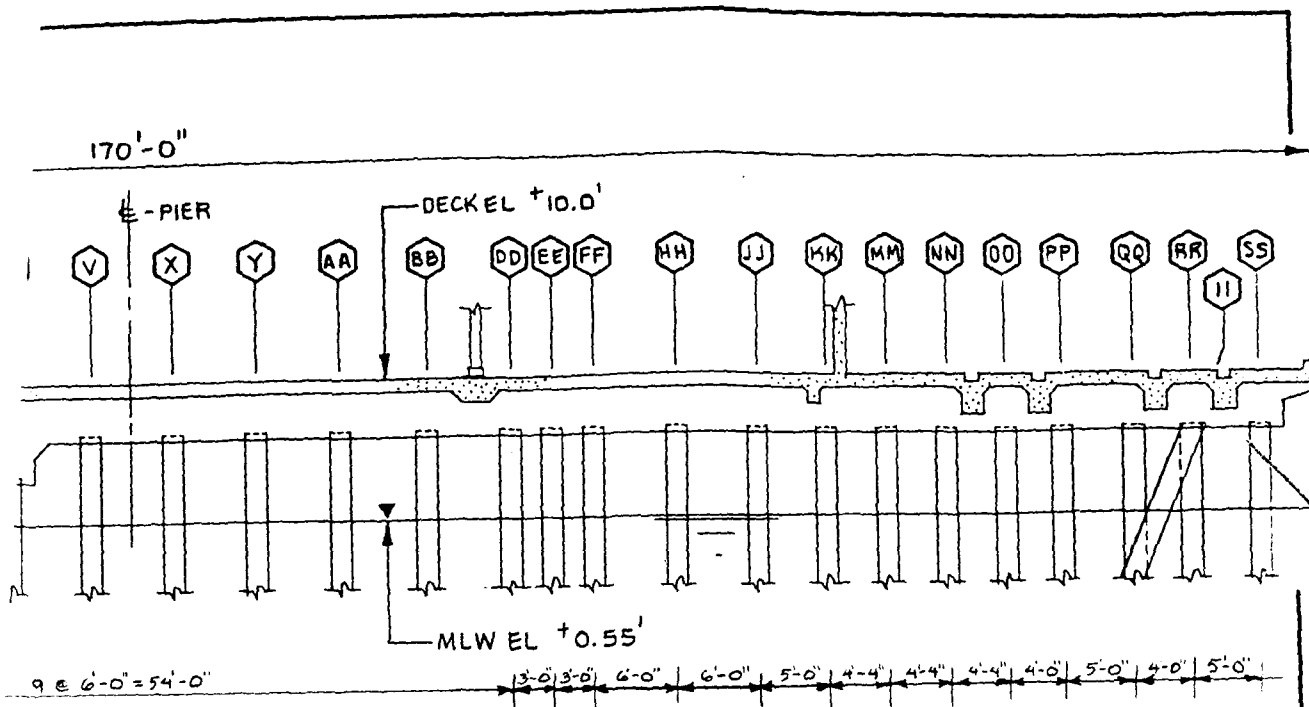




TYPICAL CROSS SECTION

SCALE : $\frac{3}{32}$ " = 1'-0"

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG No. 4053660



L CROSS SECTION

SCALE: $\frac{3}{32}'' = 1'-0''$

GRAPHIC SCALE 5' 0 5' 10' 15'	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. NAVAL STATION PIER 2 NORFOLK, VA FIG. NO. 13E
---	--	--

4.4.2 OBSERVED INSPECTION CONDITIONS

Generally, the overall condition of the structural piles is good. Some piles are severely damaged. In Section 4.0 variations of this condition are explained in detail.

A list of piles that exhibit severe structural damage is as follows:

<u>Bent #</u>	<u>Pile</u>
18	A
19	A (Being repaired)
22	A " "
23	A, SS " "
24	A " "
25	SS
26	A, SS (A being repaired)
27	SS
28	SS
29	SS
31	SS (Being repaired)
31A	SS " "
33	A " "
34	A " "
35	A " "
36	A " "
37	A " "
38	A " "
84	SS

Bent numbering begins outshore with No. 1 and ends at the bulkhead with No. 116.

General and typical conditions noted throughout the pier are as follows:

- 1) A cursory inspection of the superstructure indicates that it has been repaired using pneumatically-placed concrete. These repairs are exhibiting hairline cracking. Unrepaired areas are also showing deterioration in the form of hairline cracking (see Photos 13 and 14). Some of these cracks are leaching rust. A detailed examination should be carried out by the

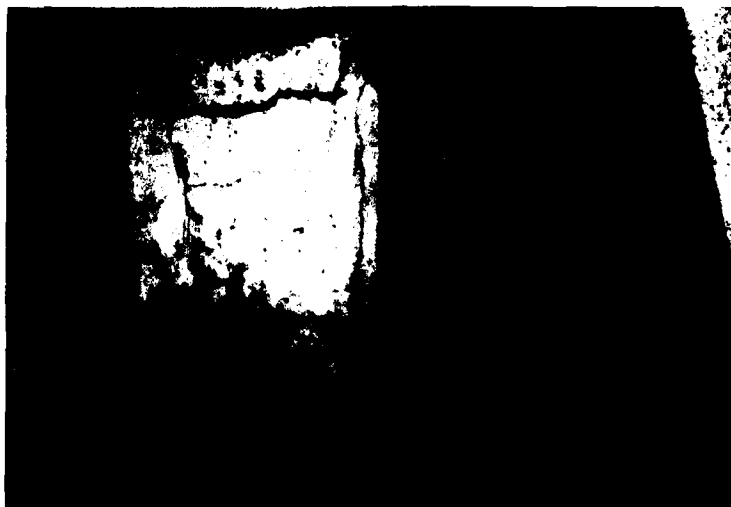


PHOTO #13: Pier 2, Bent 82, Pile A, pile cracked and spalled with rebar exposed at El +5.0.

PHOTO #14: Pier 2, Bent 84, Pile B, example of cracking of a pile at El +6.



Naval Station in this area.

- 2) The tops of the piles occasionally exhibit minor hairline cracking and spalling, (see Photos 13 and 14). In some cases there are rust stains at these cracks. Frequently, these cracks have been included in the pneumatically-placed concrete repairs.
- 3) Observing the overall condition of the pier, the percentages indicate that 9% of the piles are heavily spalled, in the tidal zone, 15% of the piles are lightly spalled in the tidal zone and 76% of the piles are in excellent condition. Heavy spalling and light spalling are described in detail in Section 4.0, (see Photos 15 and 16).
- 4) When localized conditions are considered, the percentages change significantly. This is exemplified in Bents 50 to 57, on the south side, Piles A through W), 22% of the piles are heavily spalled and 30% are lightly spalled. On the north side (Piles X through SS) there are no heavily spalled piles and 9% are lightly spalled. In another case, Bents 85-107, on the north side (Piles X through SS) 37% of the piles exhibit heavy spalling and 27% show light spalling. On the south side (Piles A through W), 4% of the piles are heavily spalled, and 13% are lightly spalled. In all cases, along with the heavy spalling condition, is a cracking of the corners similar to that found on Piers 22 and 23. (All spalling described above is in the tidal zone.)

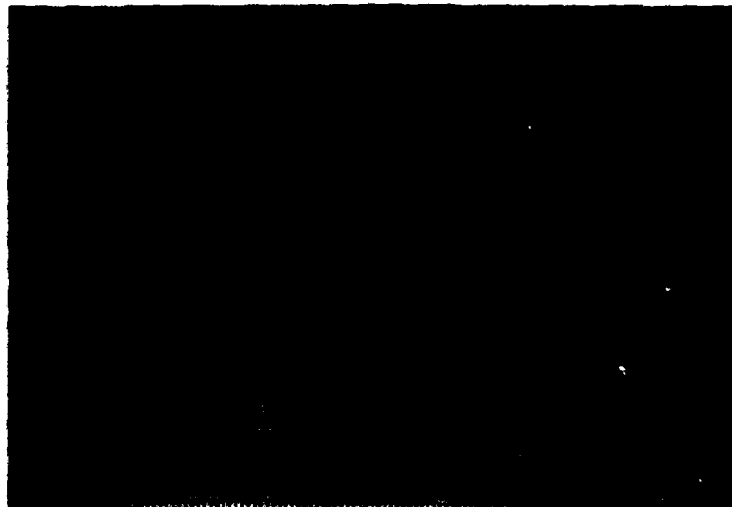
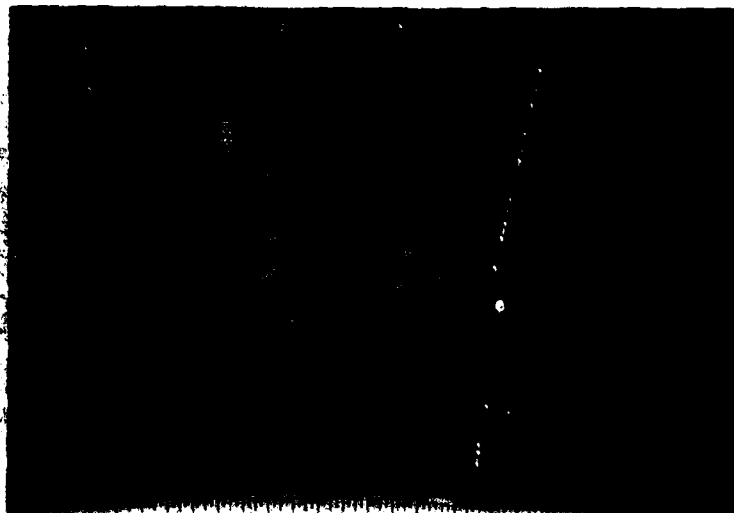


PHOTO #15: Pier 2, Bent 53, Pile N, at El -1.0, heavy spalling with rebar exposed. The concrete and rebar have been cleaned of biofouling and corrosion.

PHOTO #16: Pier 2, Bent 58, Pile 1, shows light spalling in the tidal zone to a depth of 2".



4.4.3 STRUCTURAL CONDITION ASSESSMENT

The overall condition of Pier 2 is good. Concern and attention should be given to the severely damaged piles. These piles are not functioning and are not contributing to the support of the pier.

Heavily spalled piles have undergone a significant loss of cross-sectional area; in particular, piles that have exposed rebar exhibit the greatest loss of cross-sectional area. A structural analysis of this condition indicates that the piles are capable of carrying their original design load. However, if deterioration is allowed to continue, reconsideration of the capacity of the damaged piles will have to be made.

Light spalling is cosmetic with no structural significance. The hairline cracking at the top of some piles seems to originate from the process of driving the piles. This condition is not structurally significant at this time.

4.4.4 RECOMMENDATIONS

For Pier 2, it is recommended that all the severely damaged and heavily spalled piles be repaired as soon as possible.

The superstructure, in areas where there is severe damage to structural piles, has limited capability to carry its designed live loading. Moderate live loading, such as imposed presently, will be transmitted through the superstructure to adjacent piles. Capacity loading should be restricted in these areas until repairs have been made.

We recommend that the severely damaged piles be repaired by driving two piles on either side of the damaged pile and pouring a new cap over the two new piles to support the old cap. The estimated cost to repair one damaged pile is \$5,307. On Pier 2 there are 7 piles that need to be repaired in this fashion. The majority of the piles in this condition are in the process of being repaired. The total estimated cost is \$37,149.

Heavily spalled piles should be repaired by concrete jacketing to prevent further loss of cross-sectional area. The soft concrete should be chipped away from the spalled area to sound concrete. If there is exposed rebar, it should be cleaned and if there is significant loss to cross-sectional area of the steel, they should be replaced. The jacket should cover the area between El +5.0 and El -5.0. If a fabric form is used, the estimated cost per pile is \$1,320. In this pier there are 215 piles that need this repair. The total estimated cost would be \$283,800.

All repairs should be inspected after completion. The entire pier should be re-inspected in 5 years. The immediate inspection will insure that the repairs have been properly constructed. The follow-up inspection will determine the change of conditions with respect to time.

4.5 PIER 3

4.5.1 DESCRIPTION

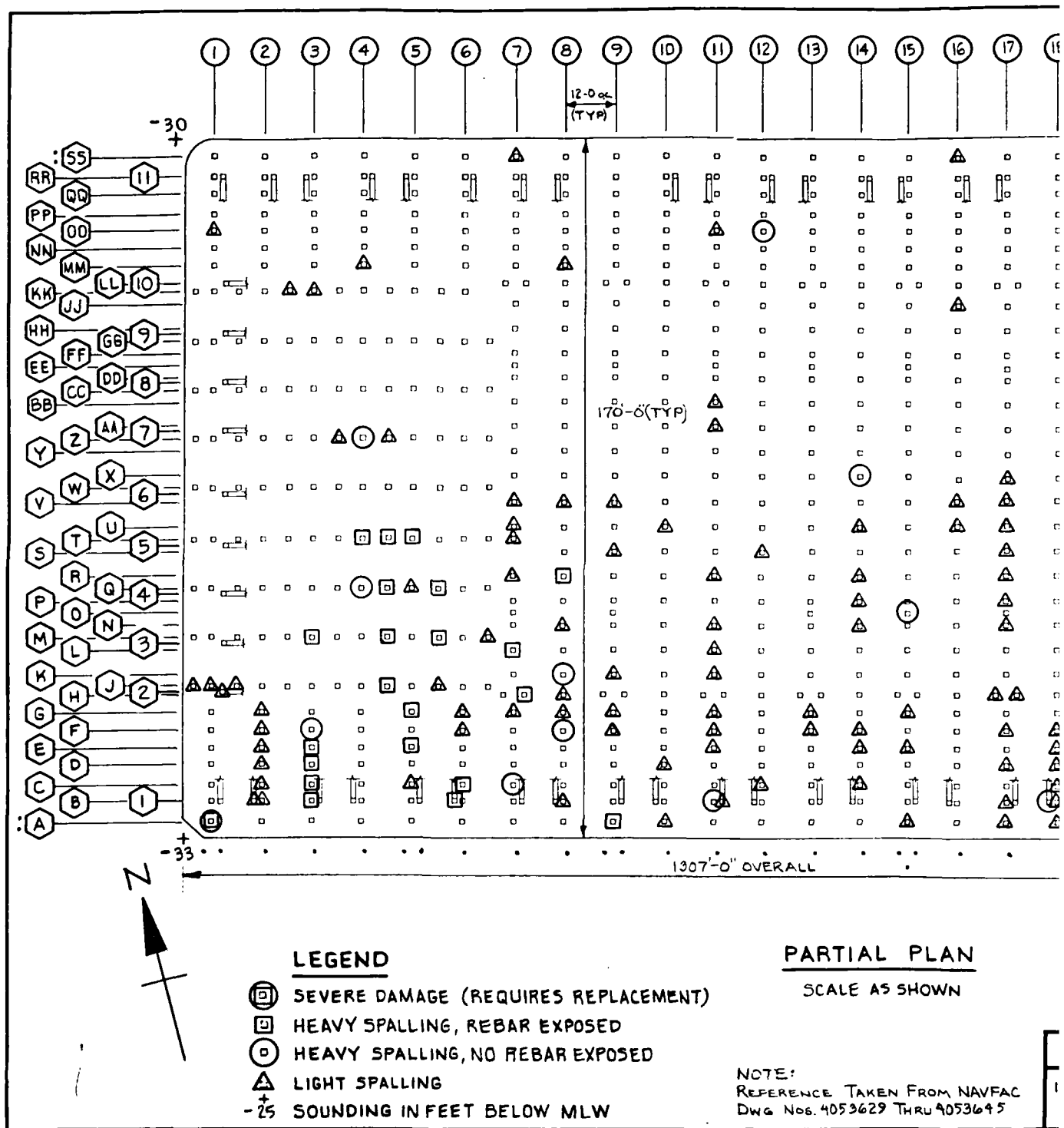
Pier 3 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station (see Figure 4). The northeastern corner of the pier is adjacent to Bulkhead W306 and the southeastern corner of the pier is adjacent to Pier 4; to the south it is adjacent to Pier 2. During the period of inspection, Pier 3 was functioning as a general purpose berthing pier and was being used by DD's, and AOR's, (see Photo 17).

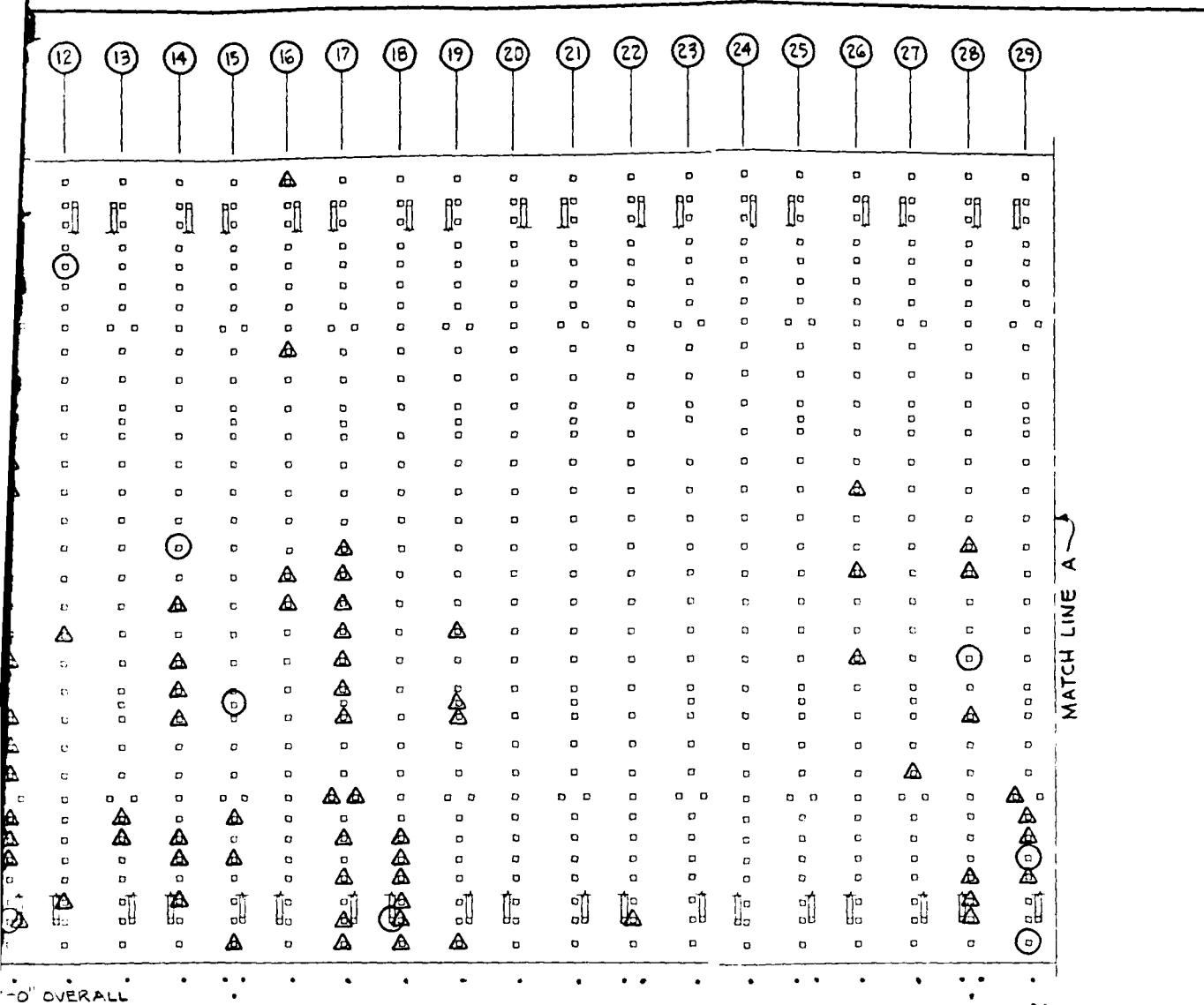
The pier was constructed in 1942 and is 1307' long and 170' wide. There are 4300 bearing piles supporting the pier (see Figures 14A-14E). All piles are 18" square precast concrete. The design bearing capacity of each pile is 40 tons.

Reference: Department of the Navy, Naval Facilities Engineering Command - NAVFAC Drawings Nos. 4053629 to 4053645

PHOTO #17: Pier 3, overview of south side of
pier looking west.







PARTIAL PLAN

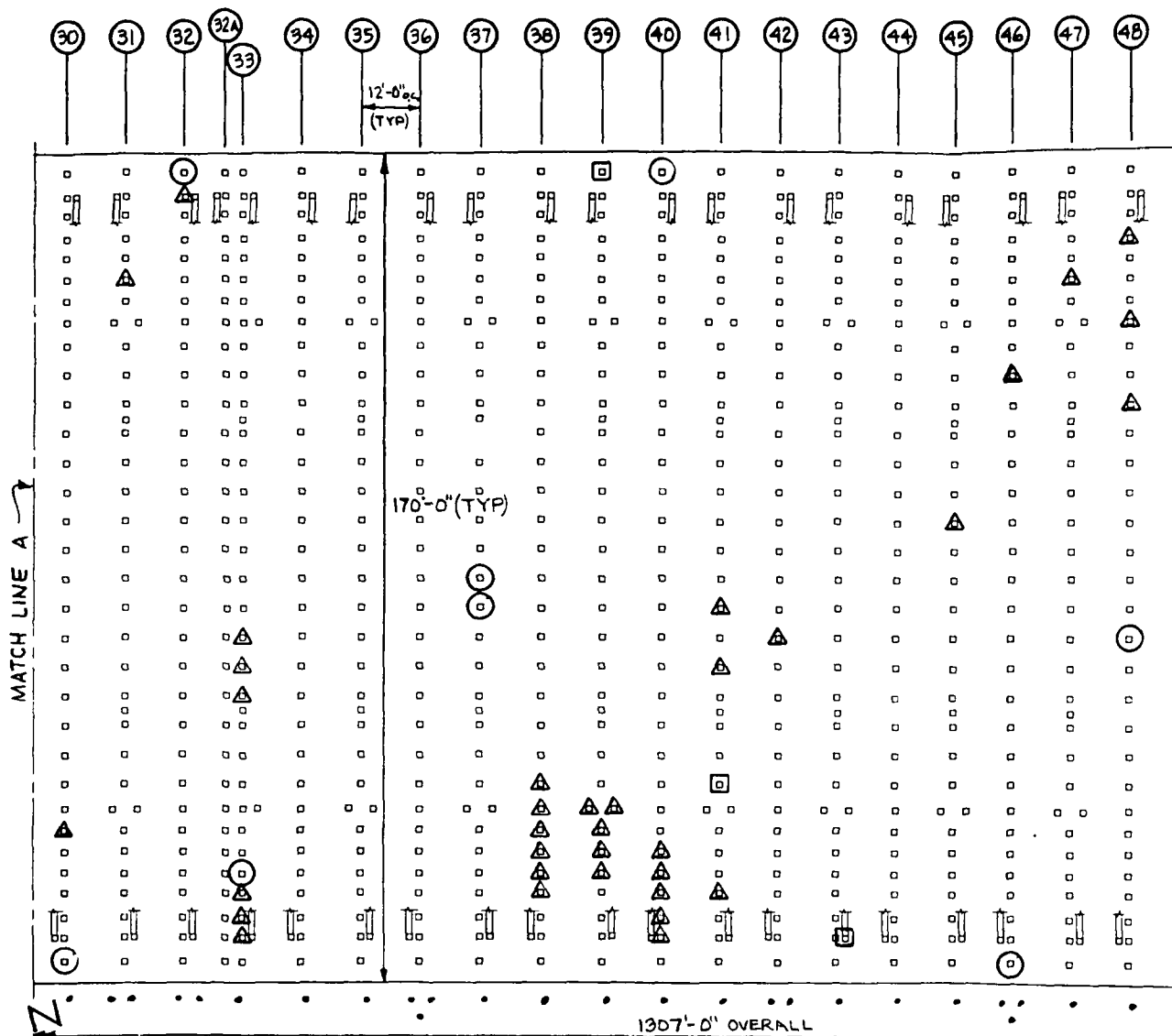
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG NO. 4053629 THRU 4053645

GRAPHIC SCALE		CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
10	5	0	5	10	20
30	40	50			
				NAVAL STATION	NORFOLK, VA
				PIER 3	FIG NO
					14A



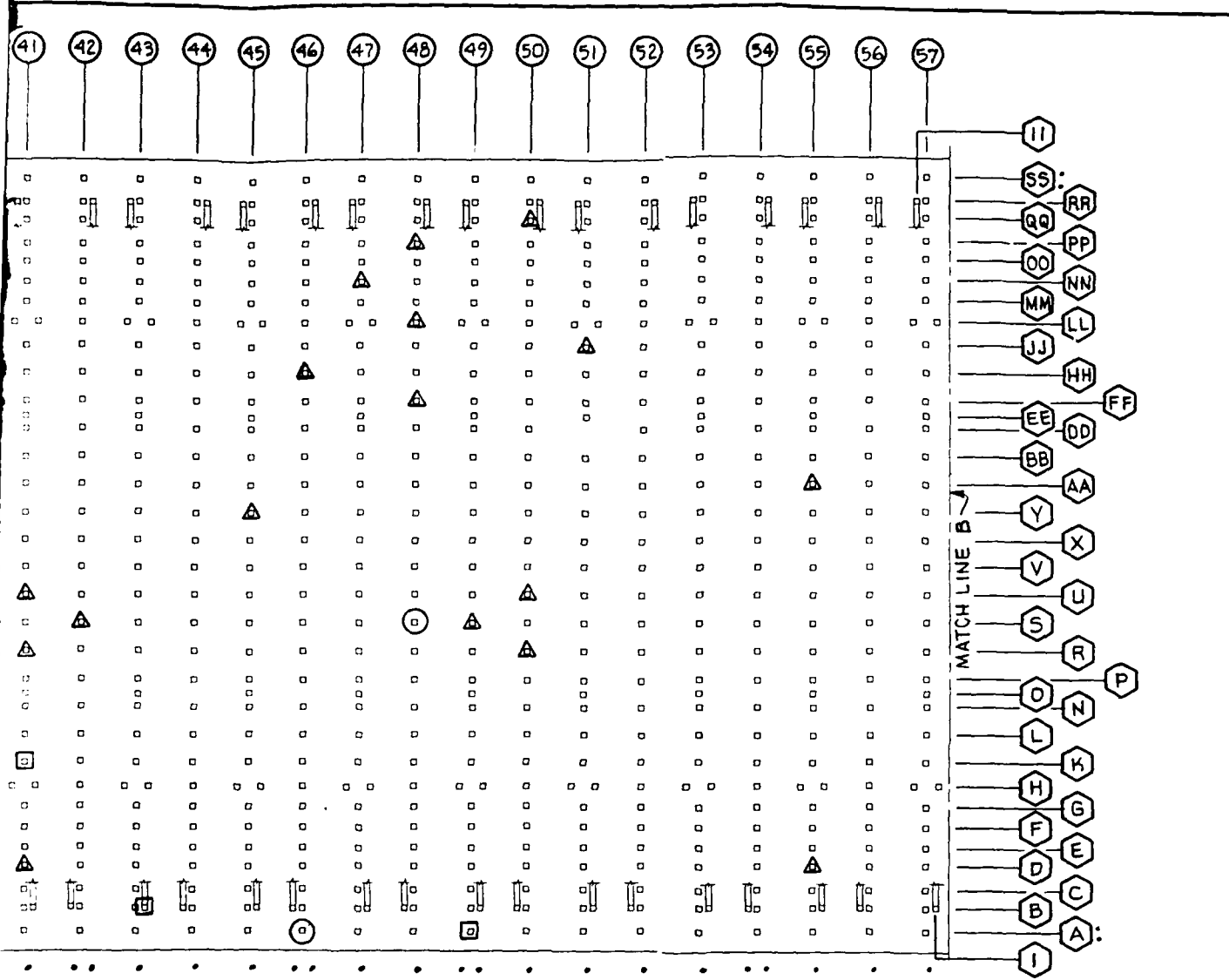
LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊡ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

PARTIAL PLAN

SCALE AS SHOWN

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4053629 THRU 4053645



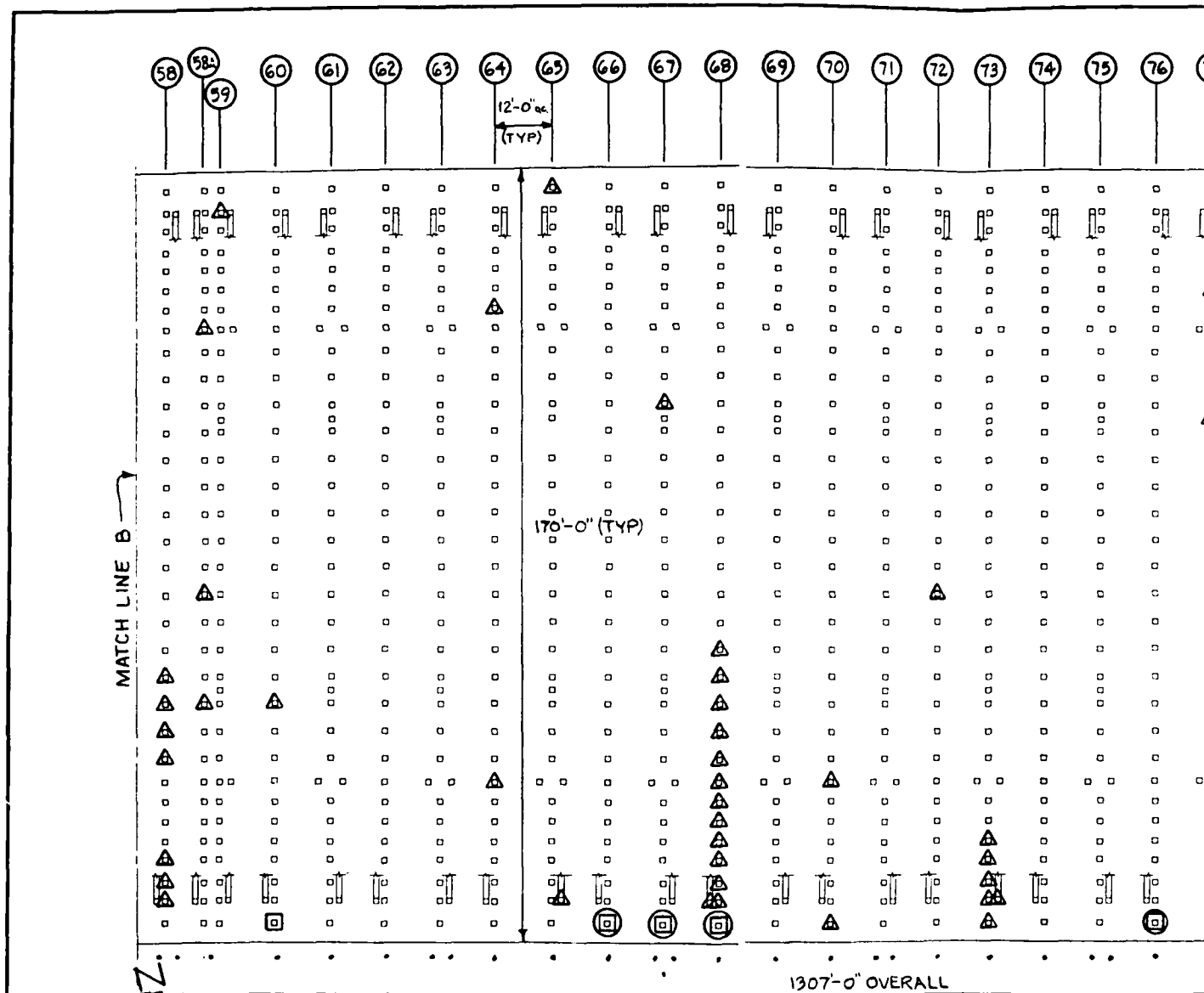
PARTIAL PLAN
SCALE AS SHOWN

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4053629 THRU 4053645

GRAPHIC SCALE 10 5 0 5 10 20 30 40 50	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. NAVAL STATION NORFOLK, VA PIER 3 FIG. NO. 14B
---	--	---



LEGEND

- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- 25 SOUNDING IN FEET BELOW MLW

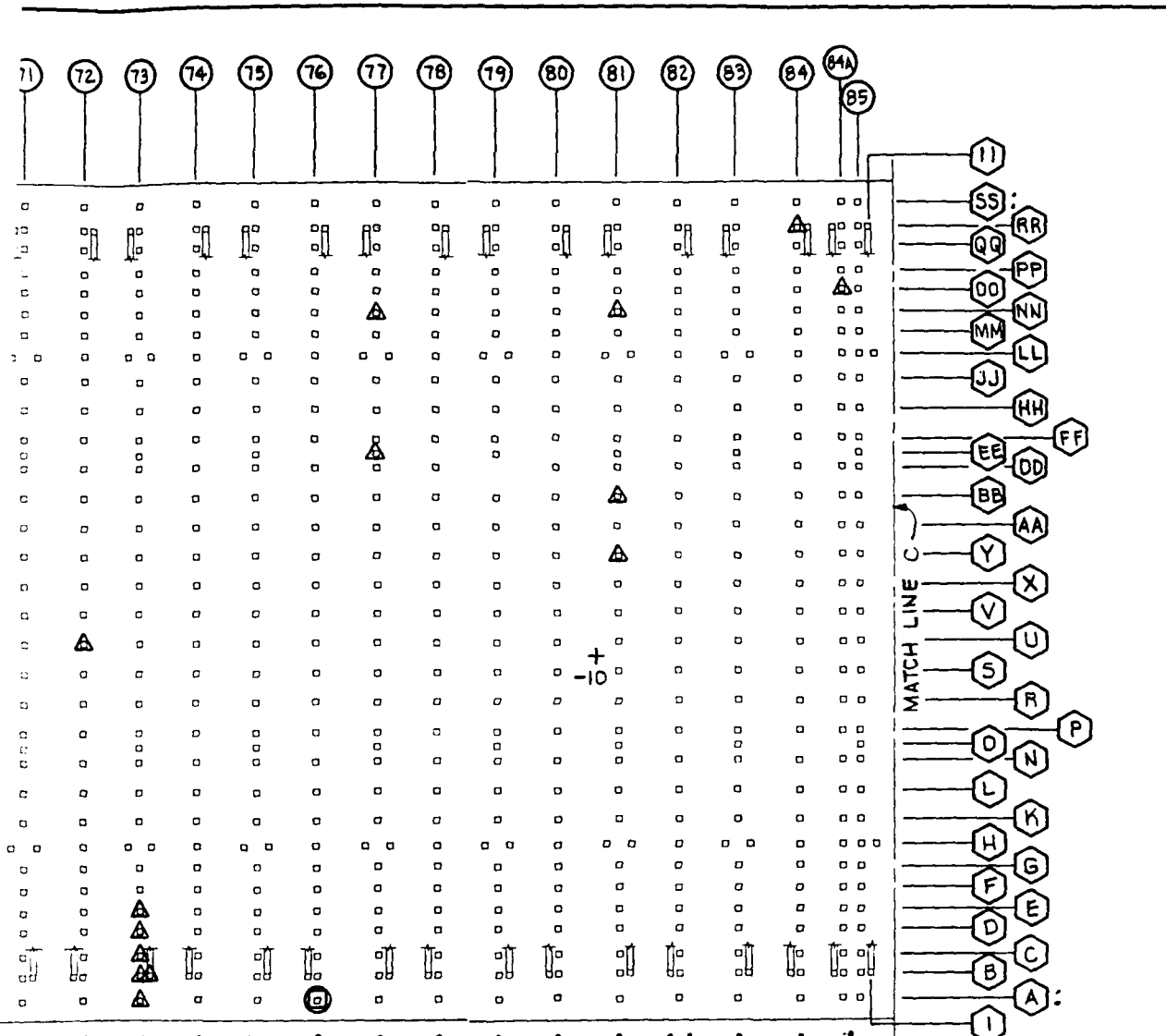
PARTIAL PLAN

SCALE AS SHOWN

NOTE:

REFERENCE TAKEN FROM NAVFAC
DWG Nos. 4053629 THRU 4053629

10 5
L L



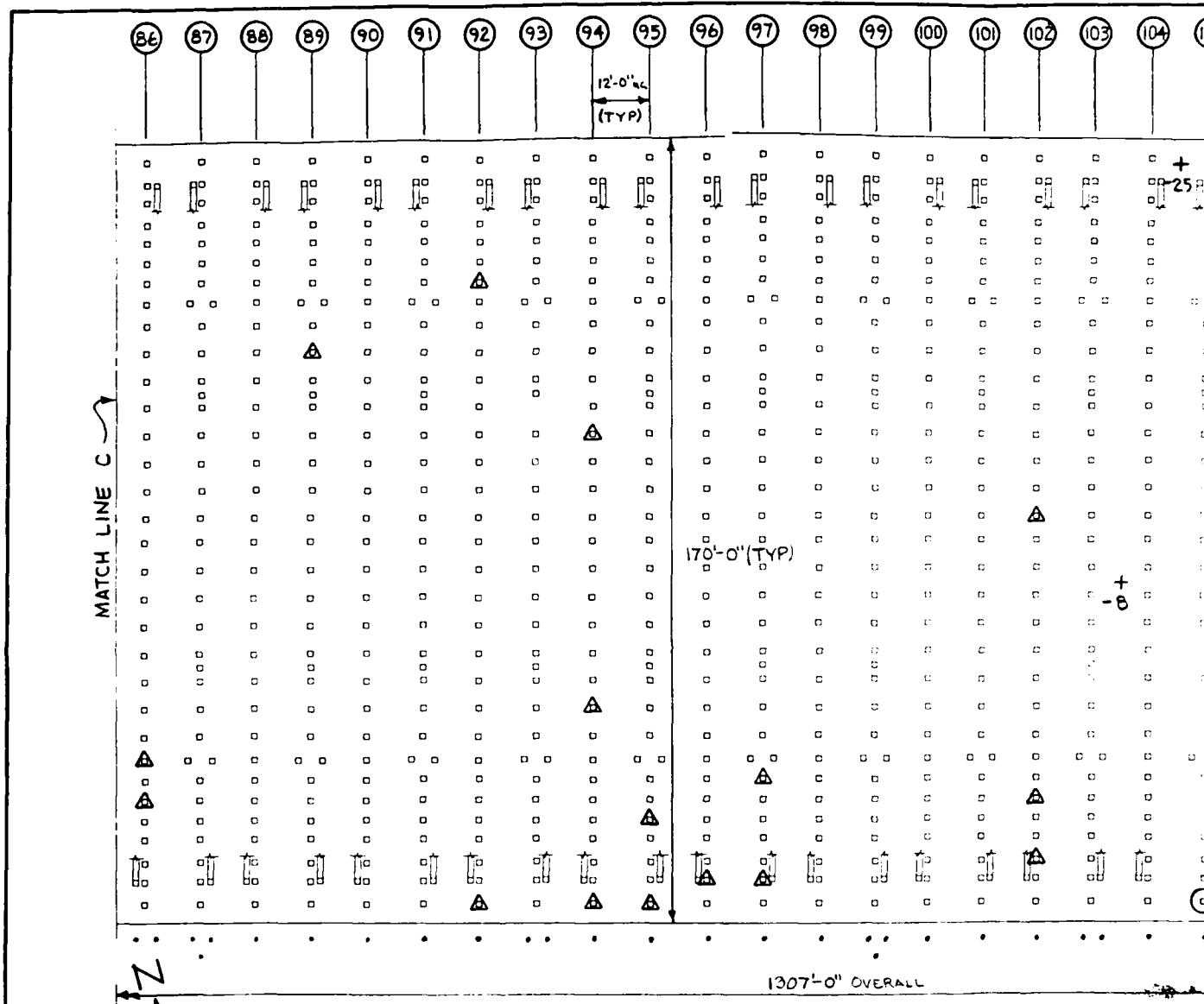
LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II

L PLAN
S SHOWN

ENCE TAKEN FROM NAVFAC
Nos 4053629 THRU 4053629

GRAPHIC SCALE 10 5 0 5 10 20 30 40 50	CHILDS ENGINEERING CORPORATION 801 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D C NAVAL STATION NORFOLK, VA PIER 3	FIG NO 14C
---	--	--	-----------------------



LEGEND

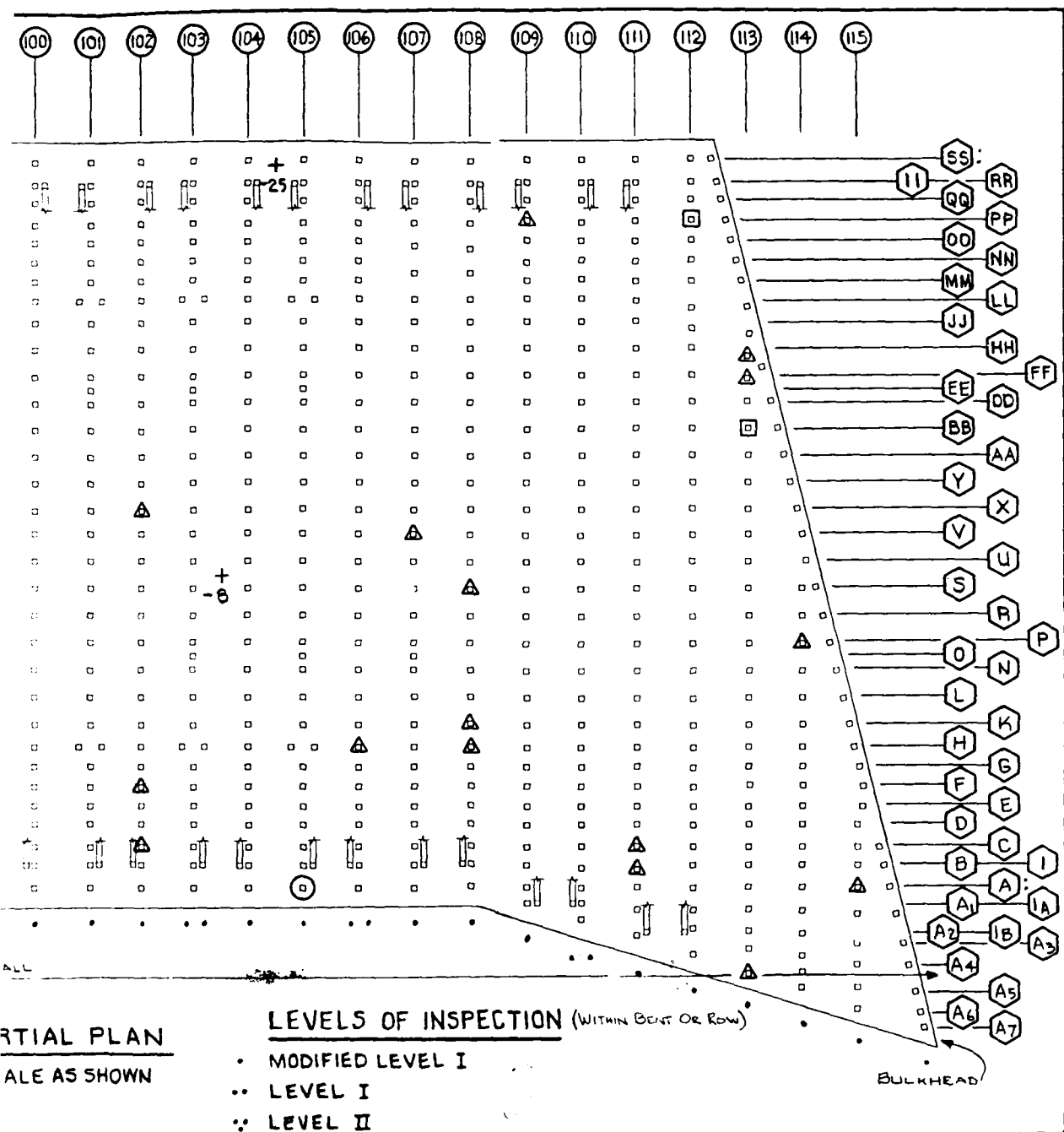
- ⊗ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊠ HEAVY SPALLING, REBAR EXPOSED
- ◻ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

PARTIAL PLAN

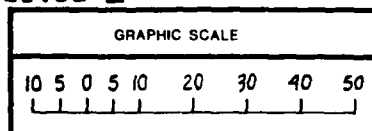
SCALE AS SHOWN

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG Nos. 4053629 THRU 4053645

LE
• MO
.. LE
∴ LE
10
L

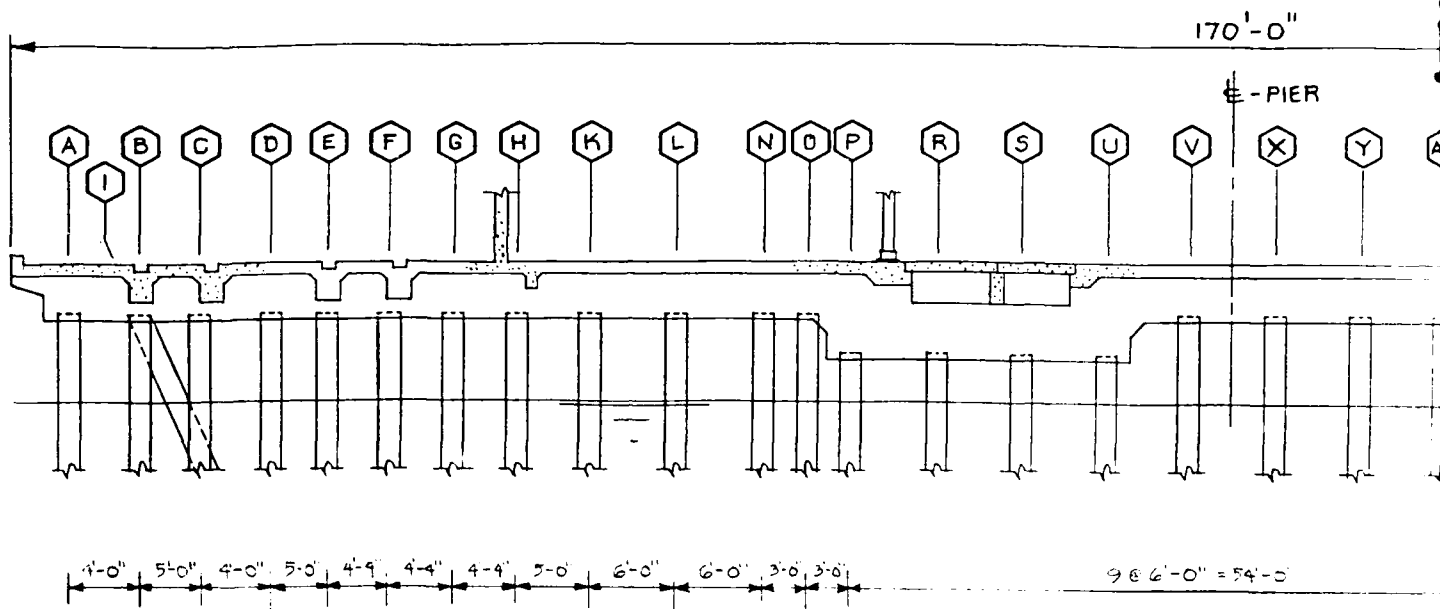


REFERENCE TAKEN FROM NAVFAC
NOS. 4053629 THRU 4053645



CHILDS ENGINEERING
CORPORATION
BOX 939
MEDFIELD, MA

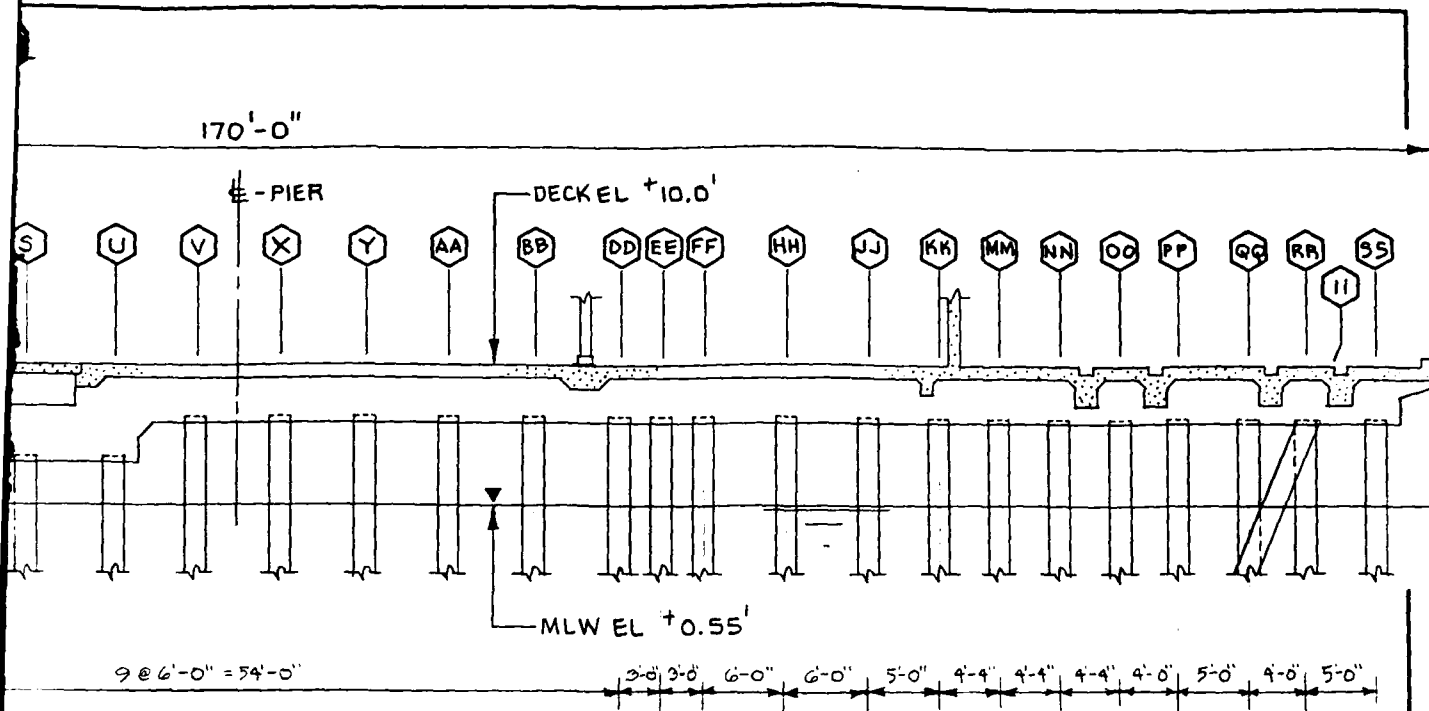
CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.		
NAVAL STATION	NORFOLK, VA	FIG NO
PIER 3		14D



TYPICAL CROSS SECTION

SCALE : $\frac{3}{32}$ " = 1'-0"

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG No. 4053660



TYPICAL CROSS SECTION

SCALE : $\frac{3}{32}" = 1'-0"$

GRAPHIC SCALE 5 0 5 10 15	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
	CHILDS ENGINEERING CORPORATION BOX 533 MEDFIELD, MA	NAVAL STATION PIER 3 NORFOLK, VA FIG. NO. 14E

4.5.2 OBSERVED INSPECTION CONDITIONS

The overall condition of this pier is excellent. Conditions found here can be classified into three groups as defined in detail in Section 4.0.

The severely damaged piles are not carrying a load at this time. A list of these piles follows:

<u>Bent #</u>	<u>Pile</u>
1	A
66	A
67	A
68	A
76	A

Bent numbering begins outshore with No. 1 and ends at the bulkhead with No. 115.

General and typical conditions noted throughout the pier:

- 1) The comprehensive study of the structural integrity of the pier shows that 1% of the piles are heavily spalled, 5% are lightly spalled, (see Photo #18). The rest are in excellent condition. 28% of the heavily spalled piles have rebar exposed. There is one occurrence of a localized condition. Between Bents 1-9 of the south side of the pier (Piles A-W and 1-6), 16% are heavily spalled with 65% of these having rebar exposed; 21% are lightly spalled. (All spalling is located in the tidal zone.)
- 2) A cursory inspection of the superstructure indicates that there is hairline cracking present. Although some repairs have been made employing pneumatically-placed concrete, there are hairline cracks on unrepaired and on repaired areas. A more detailed inspection of this area should be conducted by the Naval Station.

PHOTO #18: Pier 3, Bent 5, Pile C, example
of light spalling in the tidal
zone on the corner of the pile
(2" deep).



4.5.3 STRUCTURAL CONDITION ASSESSMENT

The overall structural integrity of the piles is excellent. A specific anomaly that should be considered immediately is that of the severely damaged piles. The piles in this state have no load-bearing capacity. Piles in this condition should be repaired immediately.

Heavily spalled piles are suffering a significant loss in cross-sectional area in the tidal zone. A structural analysis of the heavily spalled piles (see Appendix) indicates that at this time there is no reason to revise the capacity of these piles. It should be noted that if the deterioration is allowed to continue, it will have an effect on the capacity of the piles. Piles that have exposed rebar are experiencing the most cross-sectional loss.

Light spalling is considered cosmetic and has no structural significance.

4.5.4 RECOMMENDATIONS

For Pier 3, it is recommended that all the severely damaged and heavily spalled piles be repaired as soon as possible.

The superstructure, in areas where there is severe damage to structural piles, has limited capability to carry its designed live loading. Moderate live loading, such as imposed presently, will be transmitted through the superstructure to adjacent piles. Capacity loading should be restricted in these areas until repairs have been made.

We recommend that the severely damaged piles be repaired by driving two piles on either side of the damaged pile and pouring a new cap over the two new piles to support the old cap. The estimated cost to repair one damaged pile is \$5,307 (see Appendix). On Pier 3 there are 5 piles that need to be repaired in this fashion. The majority of the piles in this condition are in the process of being repaired. The total cost is estimated at \$26,535.

Heavily spalled piles should be repaired by concrete jacketing to prevent further loss of cross-sectional areas. The soft concrete should be chipped away to sound concrete. If there is exposed rebar, it should be cleaned and if there is significant loss to cross-sectional area of the steel, they should be replaced. The jacket should cover the area between El +5.0 to El -5.0. If a fabric form is used, the estimated cost per pile is \$1,320 (see Appendix). In this pier, there are 51 piles that need this repair. The total estimated cost would be \$67,320.

All repairs should be inspected after completion. The entire pier should be re-inspected in 5 years. The immediate inspection will insure that the repairs have been properly constructed. The follow-up inspection will determine the change of conditions with respect to time.

4.6 PIER 4

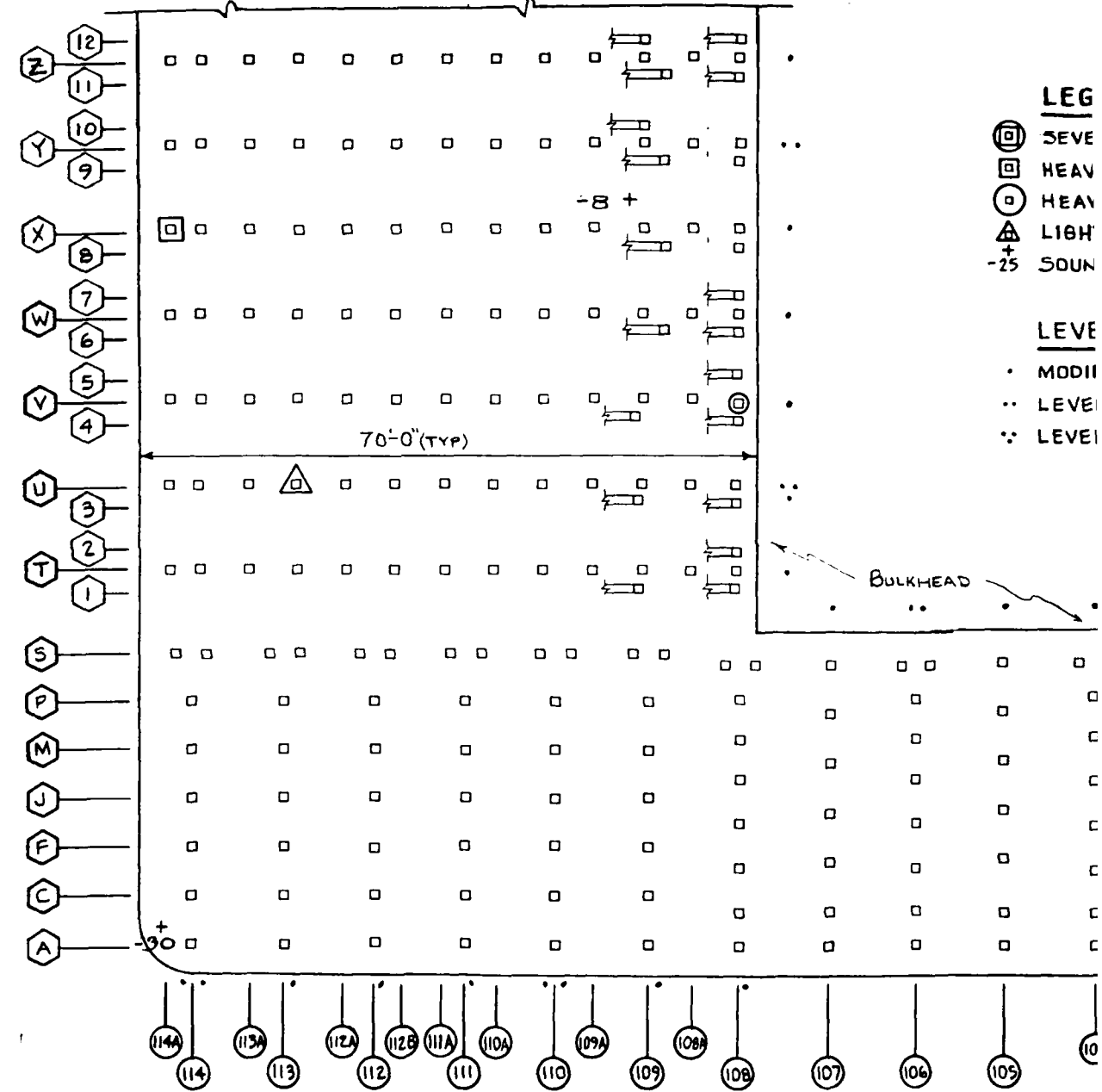
4.6.1 DESCRIPTION

Pier 4 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station, (see Figure 4). The pier is perpendicular to Bulkhead W306 and just south of Pier 5 and north of Pier 3. During the period of inspection the pier was being used as a general purpose berthing pier and was being utilized by Military Sealift Command AOR's.

Pier 4 was constructed in 1942 and is 1346' long and 250' wide. The center of the pier is solid fill retained by a steel sheet pile bulkhead. There is a warehouse on the pier used to store freight. The reinforced concrete apron and outside building columns are supported by 2100 bearing piles and there is 2760 linear feet of steel sheet pile bulkhead. The steel sheet piles are protected by a face of reinforced concrete (see Figures 15A-15H). All piles are 18" square pre-cast concrete. The design bearing capacity of each pile is 40 tons.

Reference: Department of the Navy, Naval Facilities Engineering
Command - NAVFAC Drawings Nos. 4053646 to 4053655

1346'-0" OVERALL



- LEG**
- ⊖ SEVE
 - ⊖ HEAV
 - ⊖ HEAV
 - △ LIGH
 - +25 SOUN

- LEVE**
- MODII
 - .. LEVEI
 - ∴ LEVEI

NOTE:
REFERENCE TAKEN FROM NAVFAC DWG Nos. 4053646 THRU 4053655

PLAN
SCALE AS SHOWN

1346'-0" OVERALL

LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊡ HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- .. LEVEL I
- .. LEVEL II



BULKHEAD

46'-0" (TYP)

12'-0" o.c.
(TYP)

MATCH LINE A

R
Q
N
K
G
D
B
A

PLAN

SCALE AS SHOWN

GRAPHIC SCALE

5 0 5 10 20 30

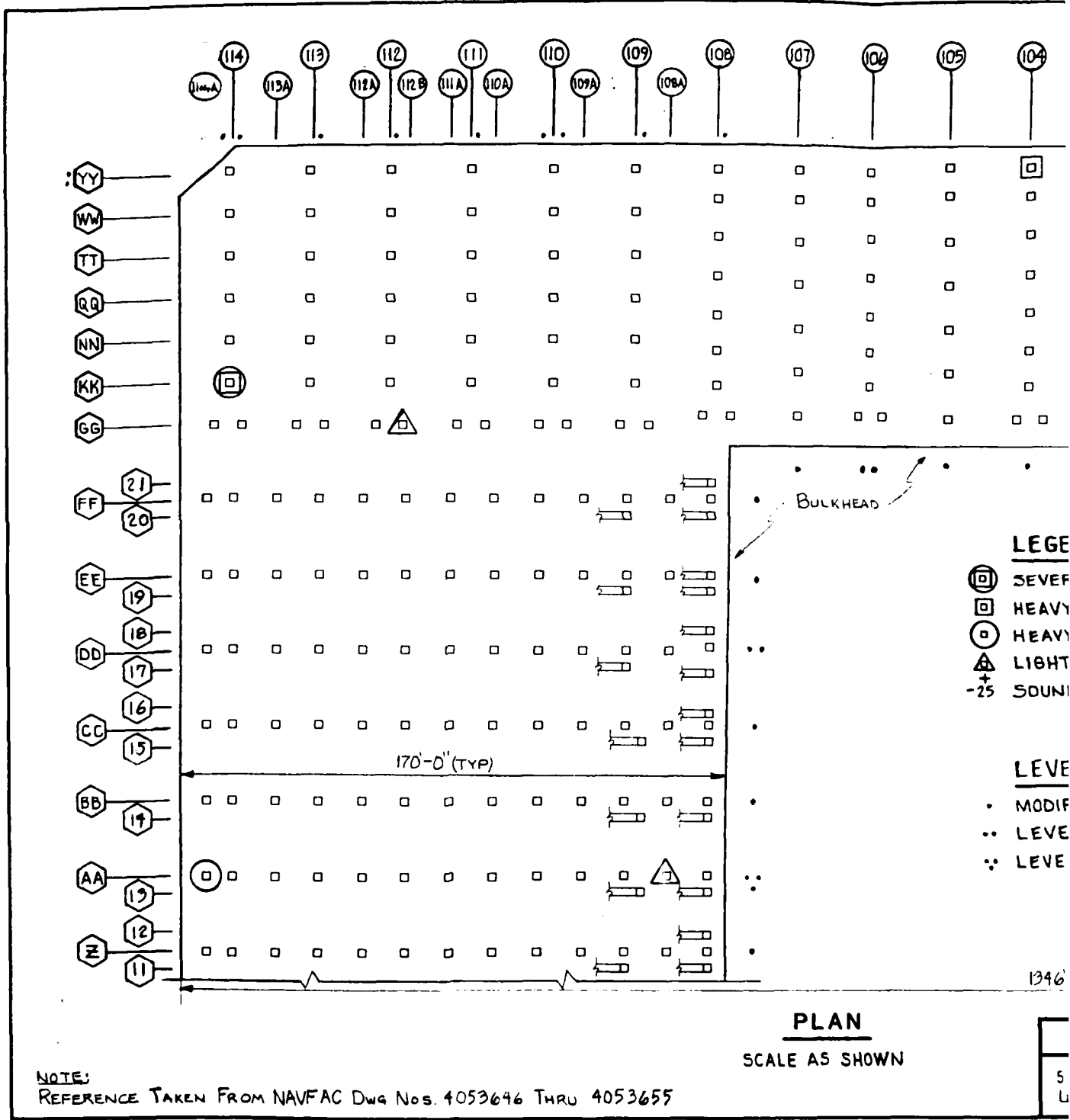
CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD MA

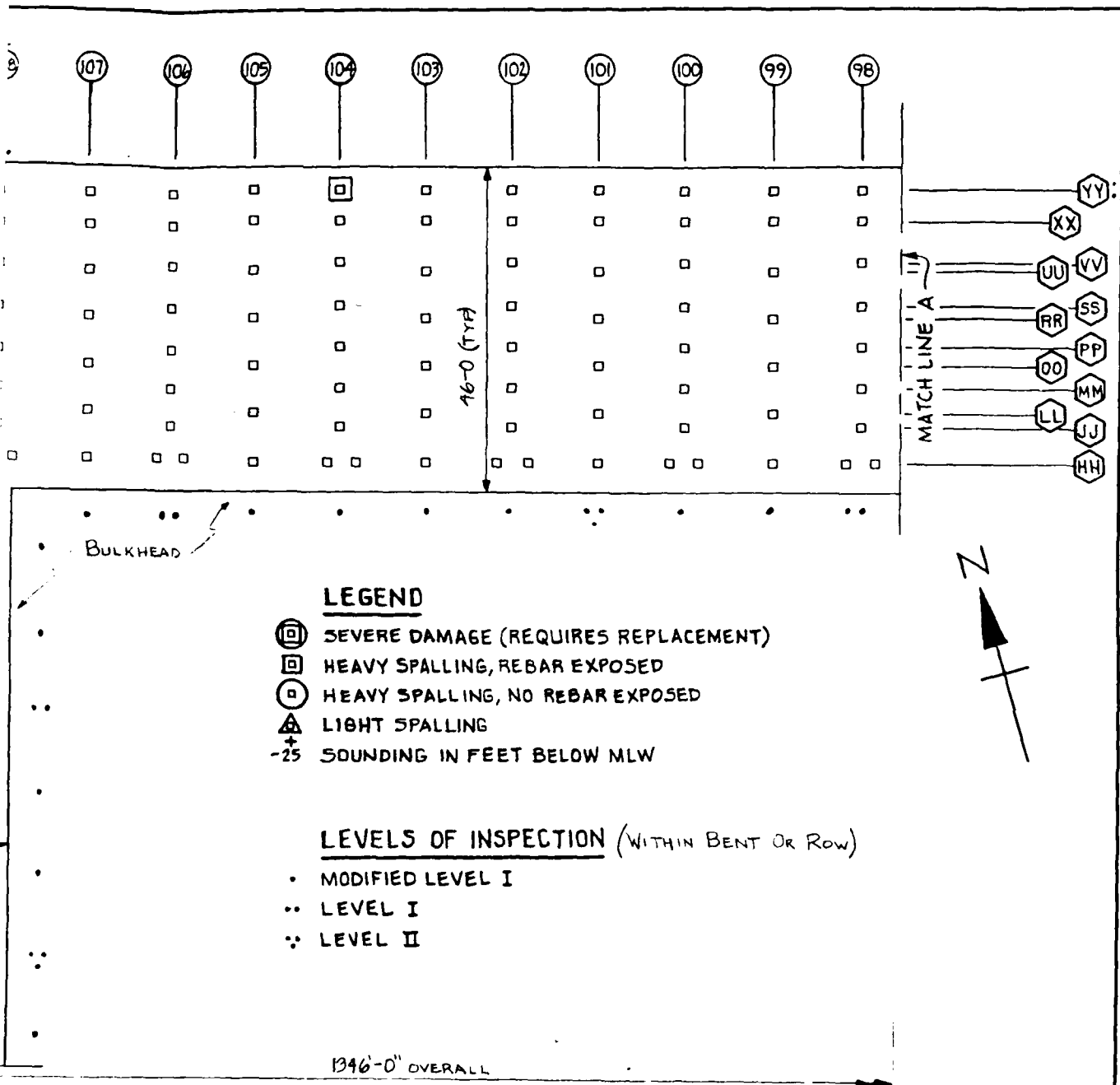
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON D.C.

NAVAL STATION NORFOLK, VA

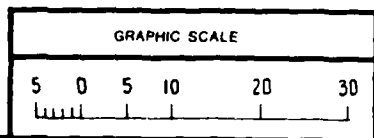
PIER 4

FIG NO
15A

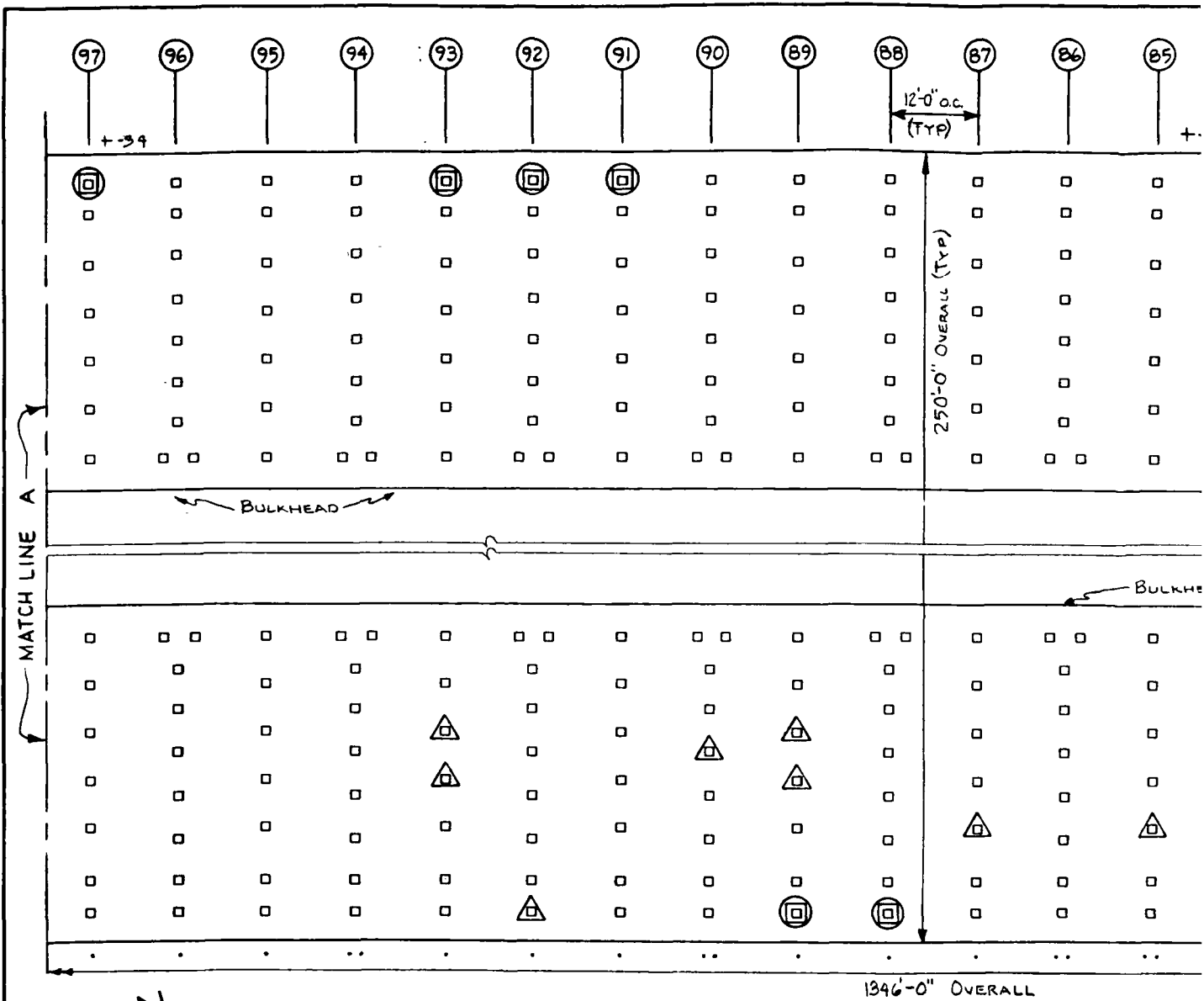




PLAN
SCALE AS SHOWN



CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION	
	NAVAL FACILITIES ENGINEERING COMMAND	
	WASHINGTON, D.C.	
NAVAL STATION	NORFOLK, VA	FIG. NO.
PIER 4		15B



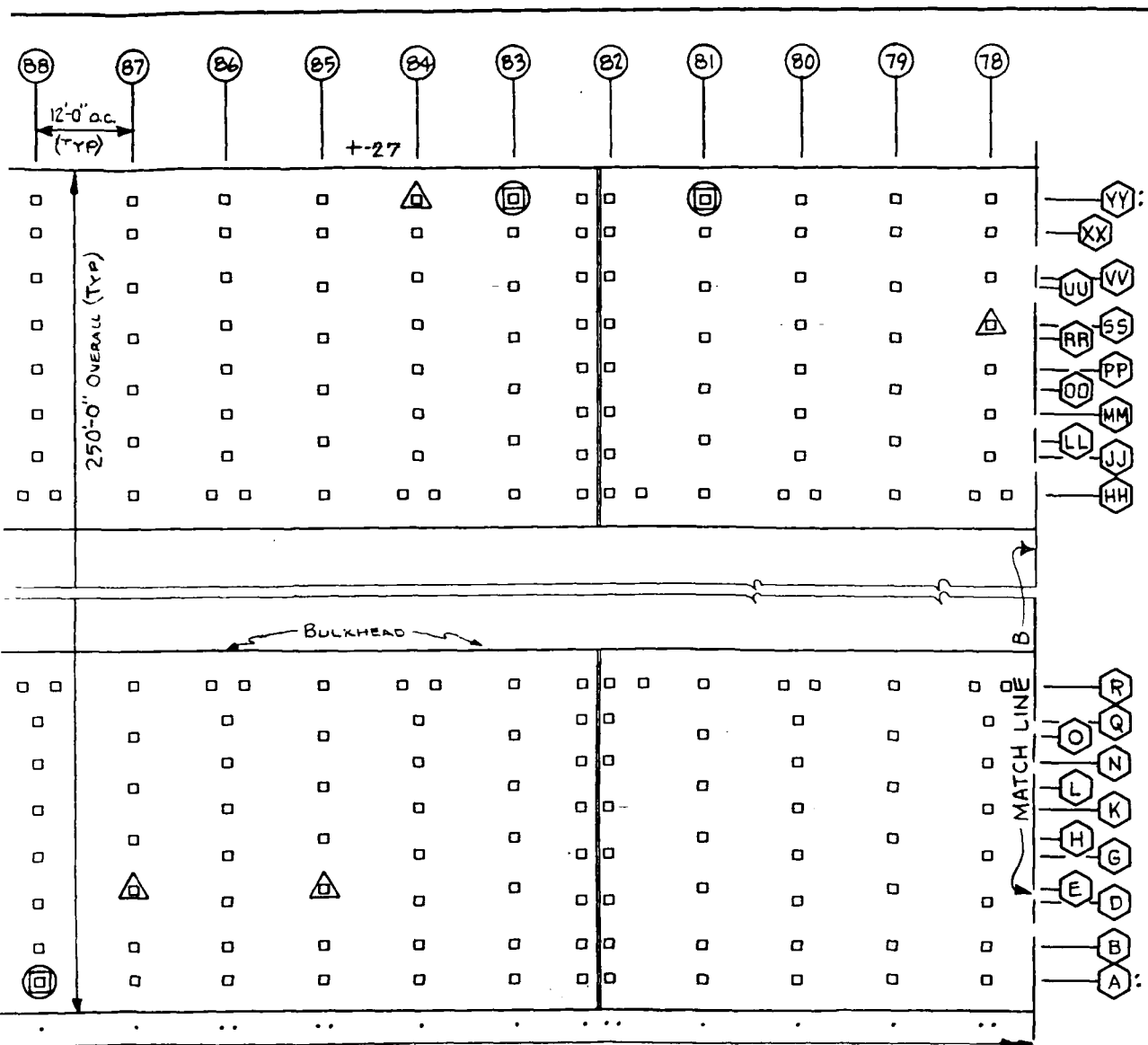
LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊡ HEAVY SPALLING, REBAR EXPOSED
- ⊙ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- ± SOUNDING IN FEET BELOW MLW

LEVELS OF INSPECTION (W)

- MODIFIED LEVEL I
- .. LEVEL I
- .. LEVEL II

5 0
11111



1346'-0" OVERALL

PLAN

NOTE:
REFERENCE TAKEN FROM
NAVFAC DWG NOS
4053646 THRU 4053655

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

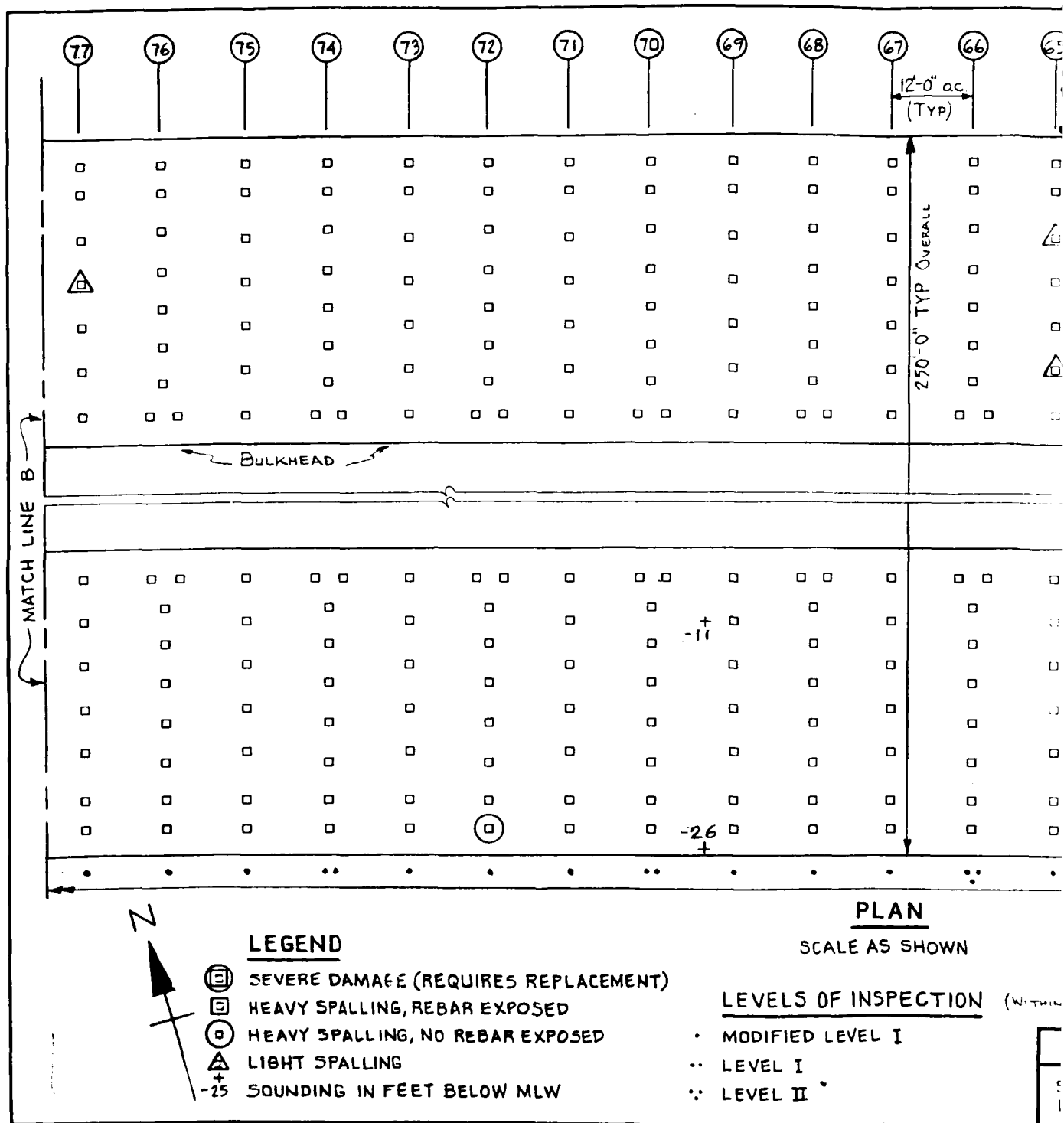
SCALE AS SHOWN

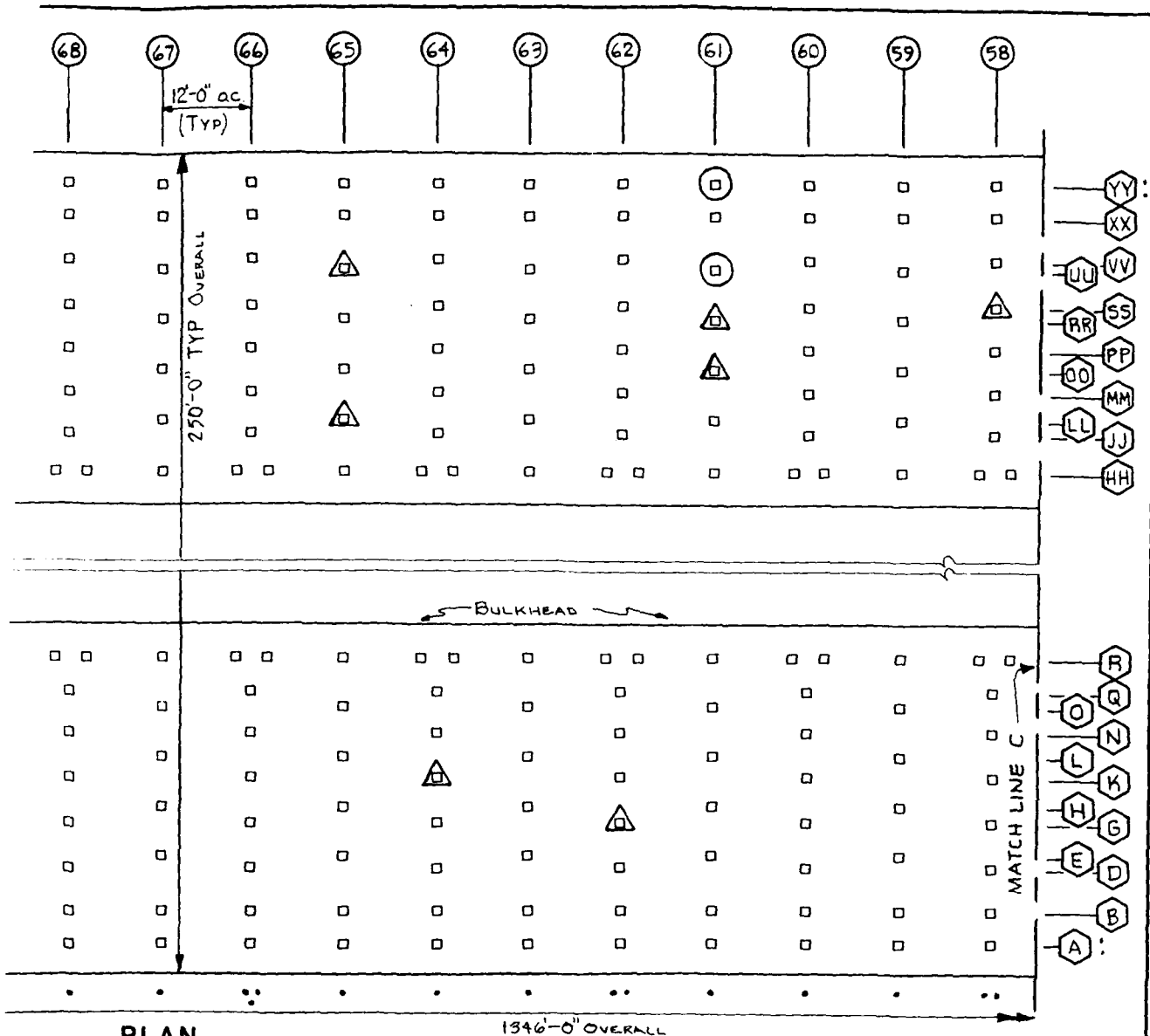
MODIFIED LEVEL I

LEVEL I

LEVEL II

GRAPHIC SCALE 5 0 5 10 20 30	CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA	CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C. NAVAL STATION NORFOLK, VA PIER 4 FIG NO 15C
--	--	---





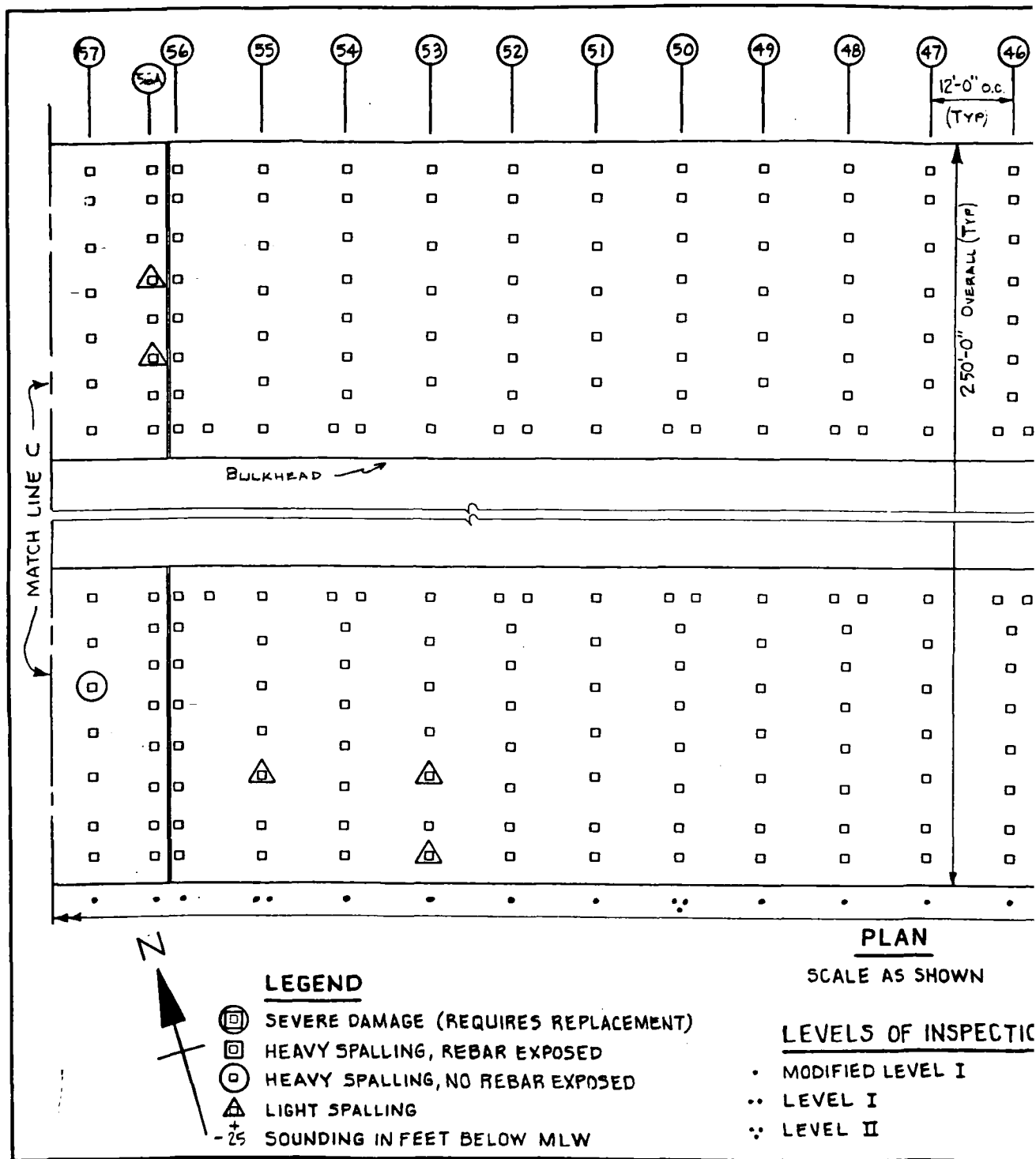
LEVELS OF INSPECTION (WITHIN BENT OR ROW)

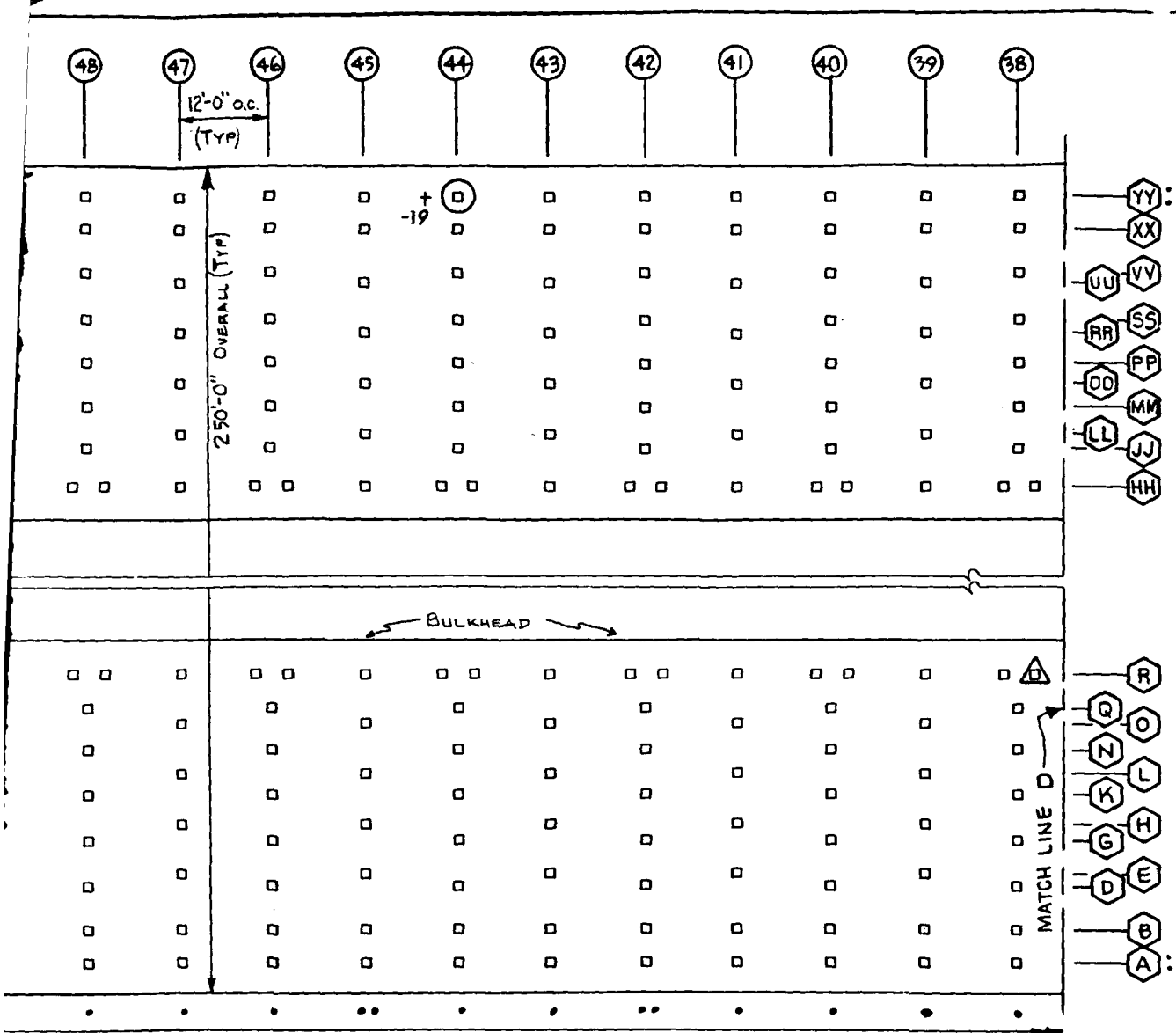
MODIFIED LEVEL I

LEVEL I

LEVEL II

GRAPHIC SCALE		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
5	0	NAVAL STATION	FIG NO
5	10	PIER 4	150
20	30		





PLAN

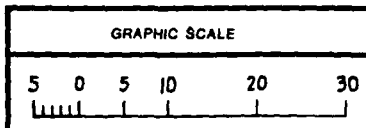
1346'-0" OVERALL

SCALE AS SHOWN

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4053646 THRU 4053655

LEVELS OF INSPECTION (WITHIN BENT OR ROW)

MODIFIED LEVEL I
LEVEL I
LEVEL II



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

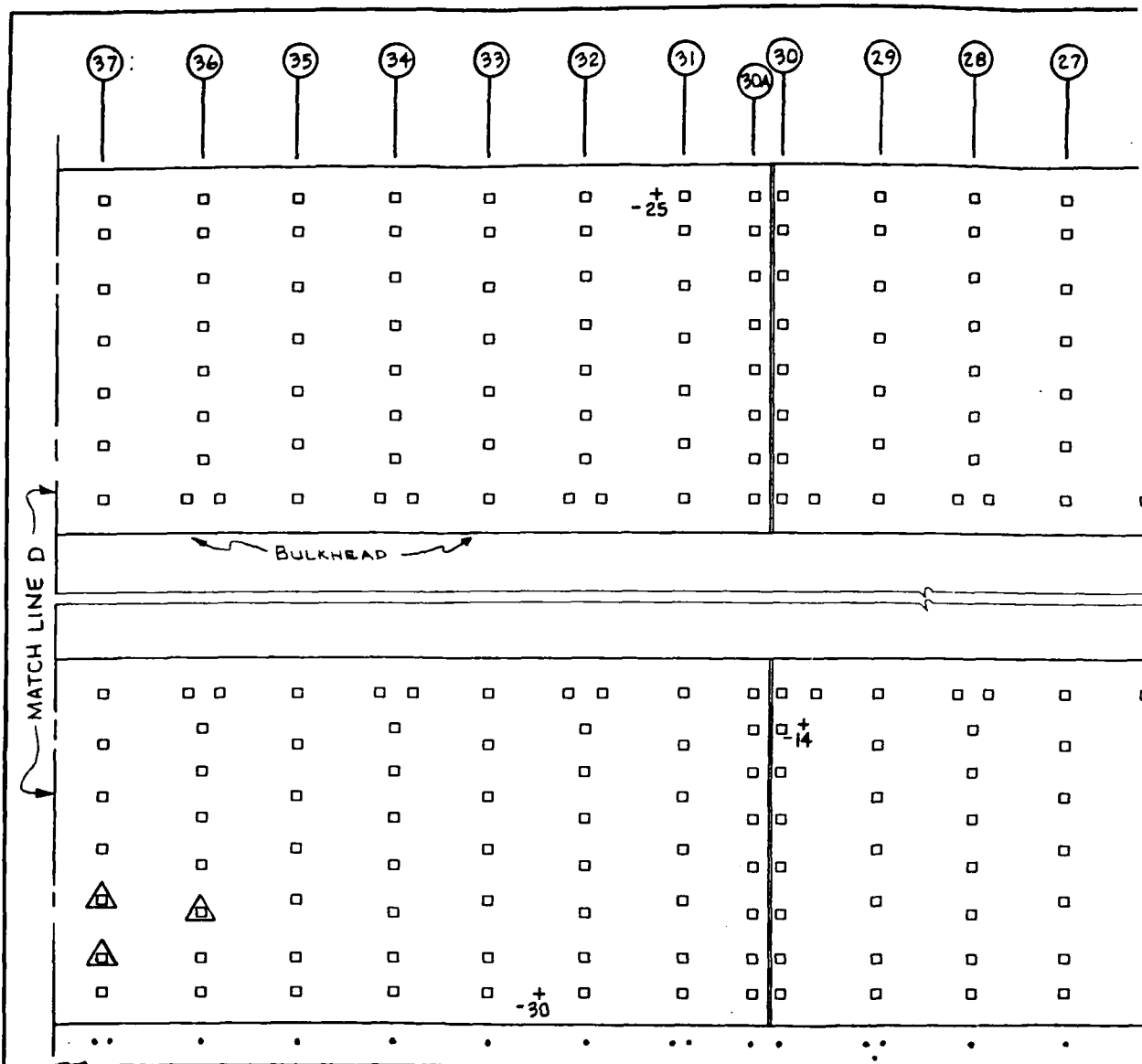
NAVAL STATION

NORFOLK, VA

FIG. NO.

PIER 4

15E



LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ◻ HEAVY SPALLING, REBAR EXPOSED
- ◻ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- + SOUNING IN FEET BELOW MLW

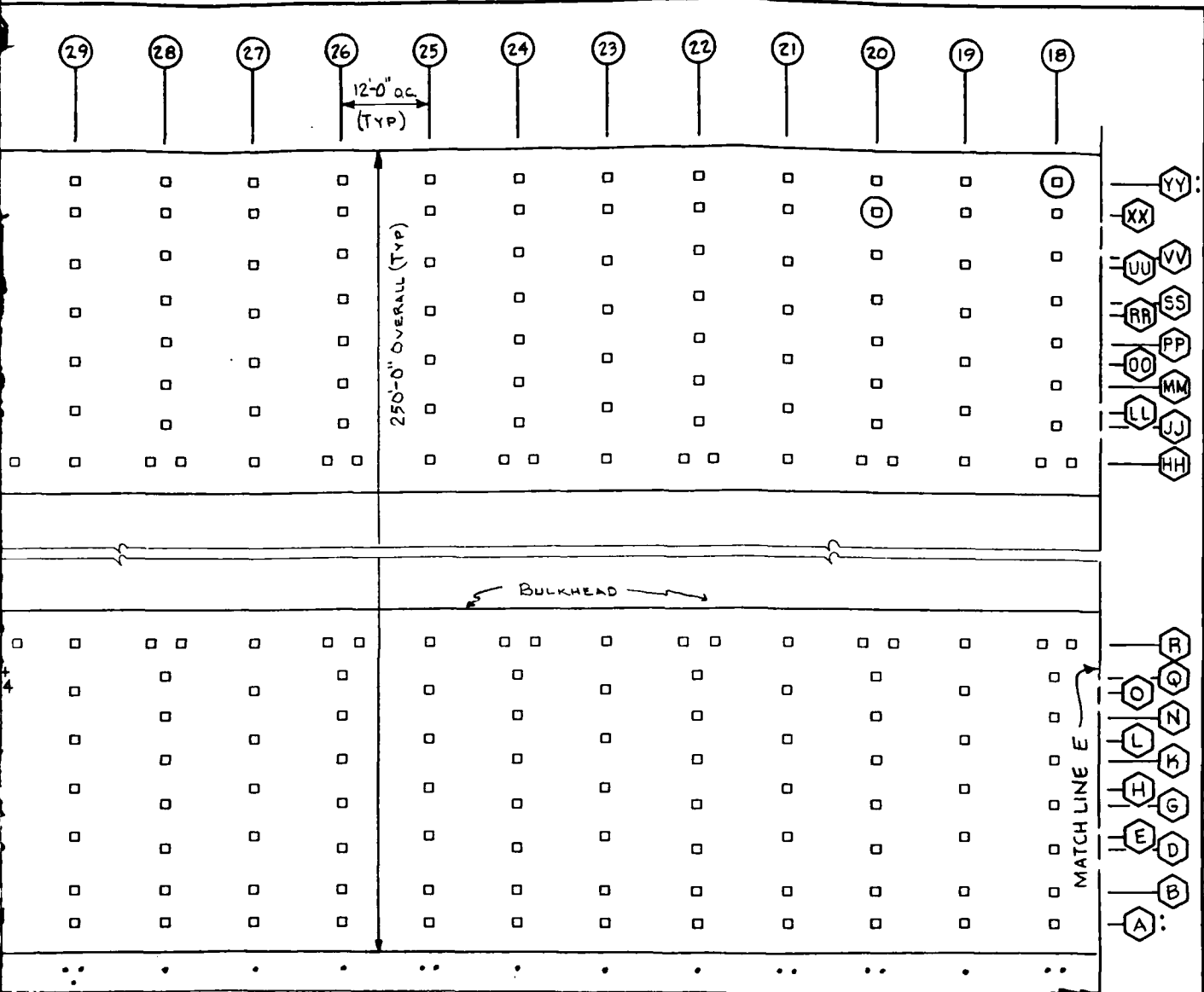
PLAN

SCALE AS SHOW

LEVELS OF INSPECT

- MODIFIED LEVEL I
- .. LEVEL I
- .. LEVEL II

2-0
TY



PLAN

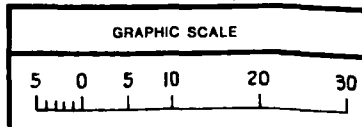
SCALE AS SHOWN

1346'-0" OVERALL

NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG NOS. 4053646 THRU 4053655

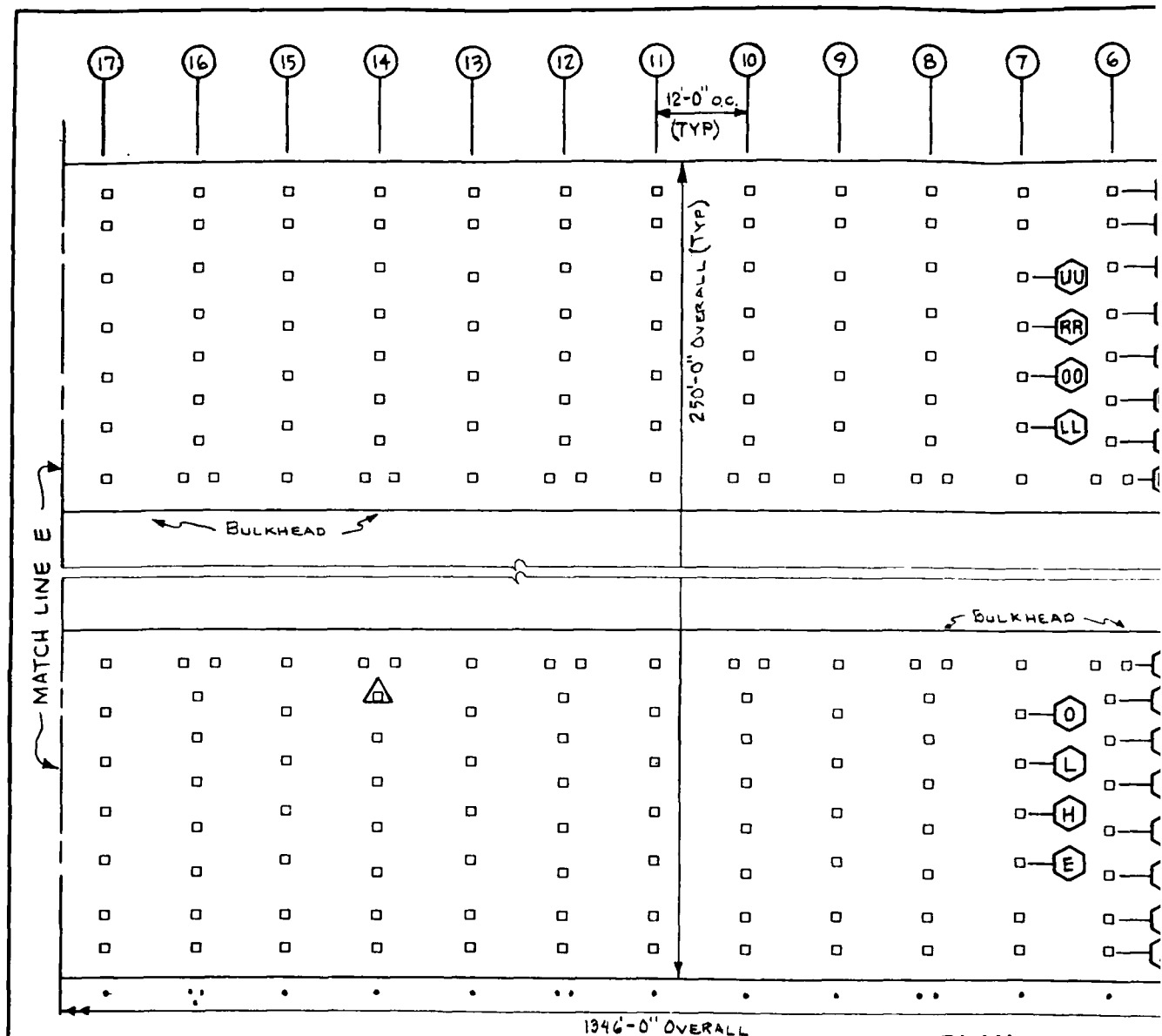
LEVELS OF INSPECTION (WITHIN BENT OR ROW)

- MODIFIED LEVEL I
- LEVEL I
- LEVEL II



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.
NAVAL STATION NORFOLK, VA
PIER4
FIG. NO. **15F**



LEGEND

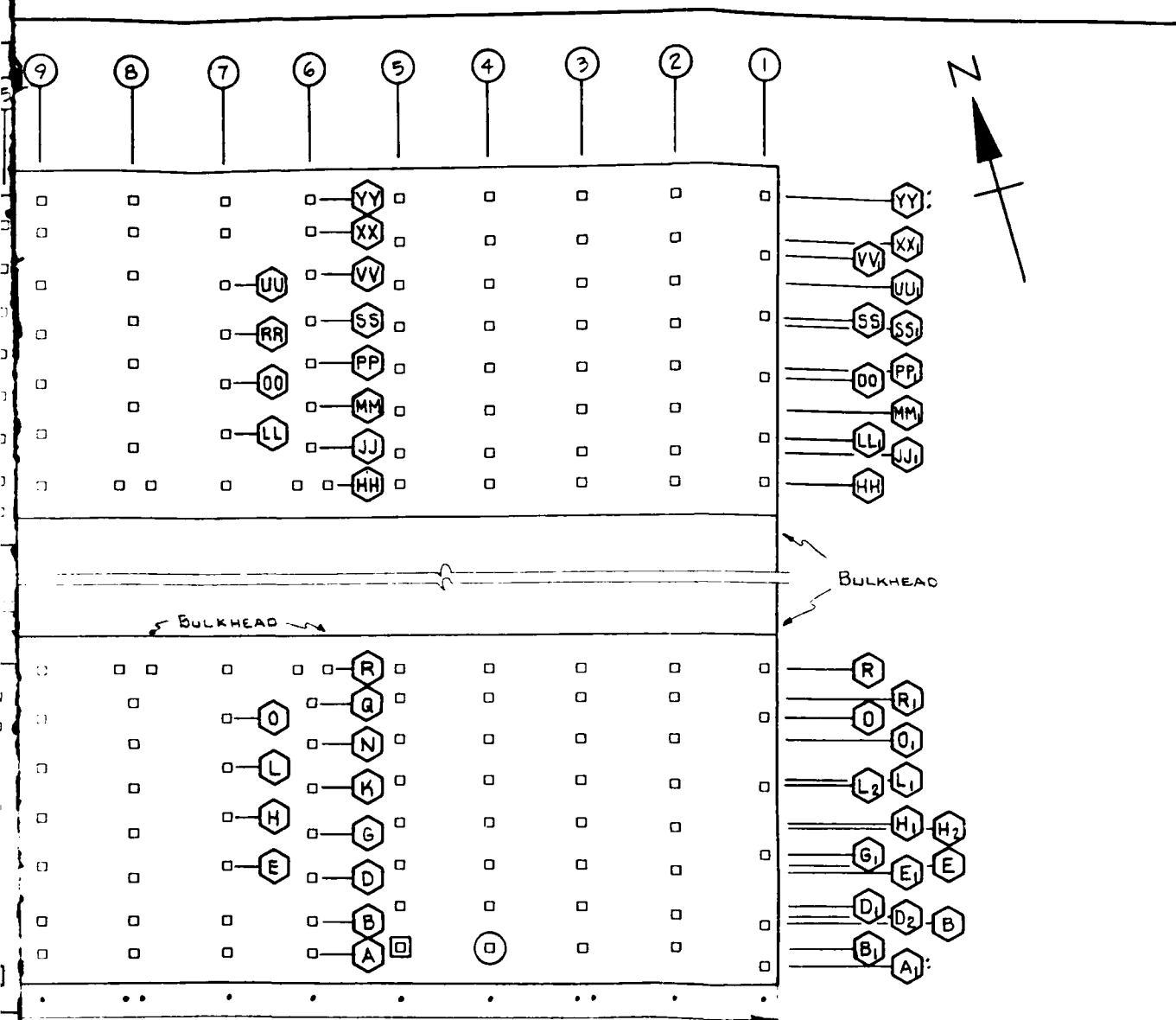
- ⊞ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- ⊞ HEAVY SPALLING, REBAR EXPOSED
- ⊞ HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +
-25 SOUNDING IN FEET BELOW MLW

PLAN

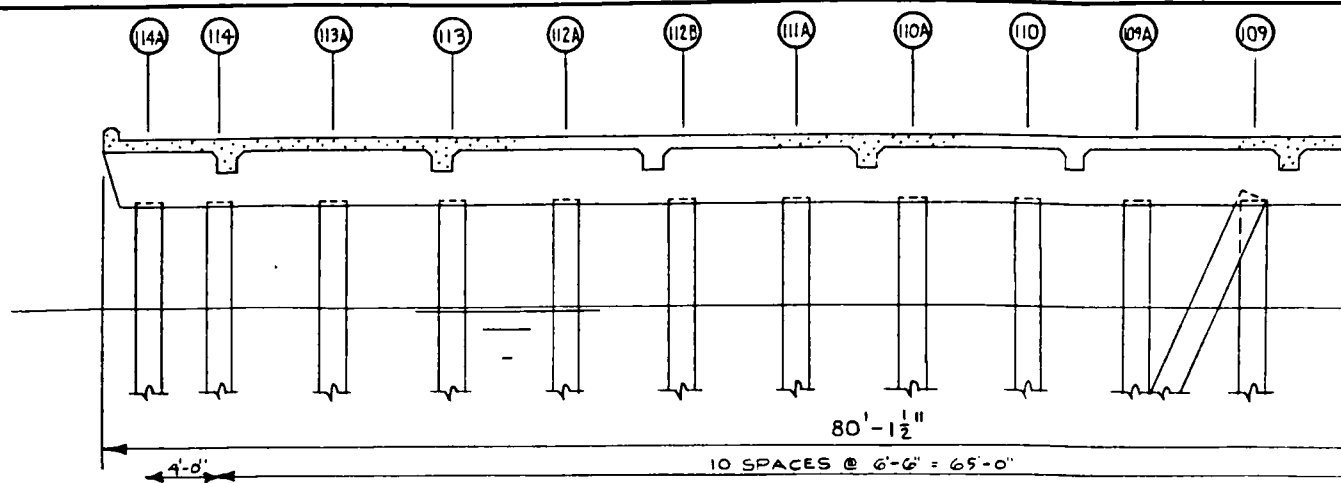
SCALE AS SHOWN

LEVELS OF INSPECTION

- MODIFIED LEVEL I
- .. LEVEL I
- ∴ LEVEL II

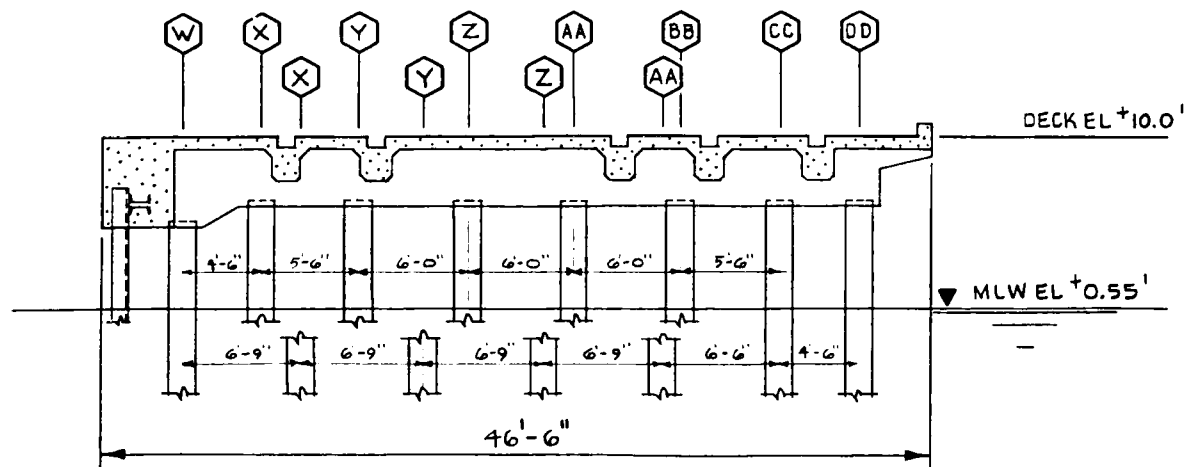


NOTE:
REFERENCE TAKEN FROM NAVFAC
DWG Nos. 4053646 THRU 4053655



CROSS SECTION AT END OF PIER

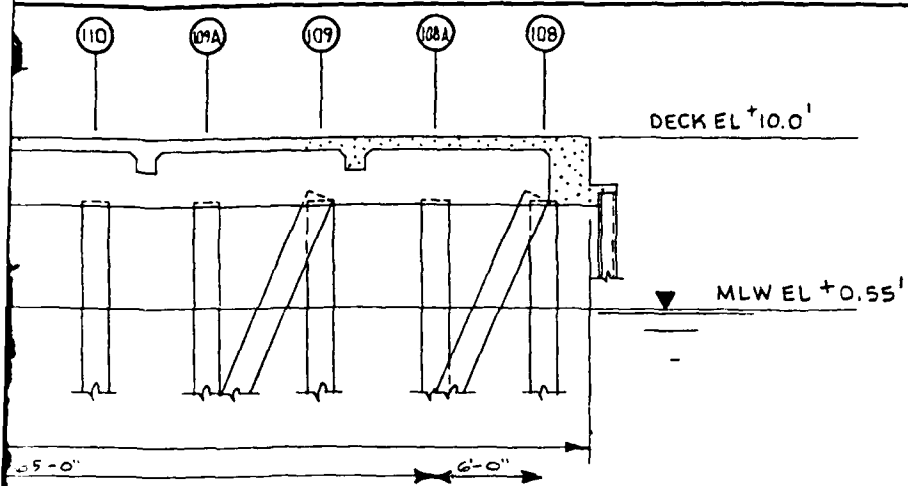
SCALE AS SHOWN



TYPICAL CROSS SECTION

SCALE AS SHOWN

NOTE:
REFERENCE TAKEN FROM NAVFAC DWG No. 4058660



OF PIER

DECK EL +10.0'

MLW EL +0.55'

GRAPHIC SCALE				CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON D C		
5	0	5	10	CHILD'S ENGINEERING CORPORATION BOX 323 MEDFIELD, MA	NAVAL STATION	FIG NO
					PIER 4	15H

4.6.2 OBSERVED INSPECTION CONDITIONS

The explanation of observed conditions will be divided into two parts; one concerning the structural piles, the other dealing with the bulkhead. Severely damaged piles can be described as piles that are not performing their original design function, (see Photos 19 and 20).

A list of severely damaged piles follows:

<u>Bent #</u>	<u>Piles</u>
89	A
88	A
114	KK
93	YY
92	YY
91	YY
83	YY
81	YY
97	YY

Bent numbering begins at the bulkhead with No. 1 and ends out-shore with No. 114A.

General conditions noted throughout the pier are as follows:

- 1) Heavy spalling was observed on less than 1% of the piles. Light spalling was noted on 2% of the piles. General condition of piles is excellent, (see Photo 21). Spalling is typically found in the tidal zone.
- 2) In conjunction with hairline cracking is a rust stain.
- 3) Two localized conditions in the pier were noted; in Bents 114 to 108, Piles T to FF and 1 to 21, 50% of the piles are exhibiting hairline cracking



PHOTO #19: Pier 4, Bents 92, 93, Pile DD,
shows 2 consecutive perimeter
piles severely damaged.

PHOTO #20: Pier 4, Bent 93, Pile DD, at E1
-2.0, shows rebar (partially
cleaned) of broken pile entering
concrete.

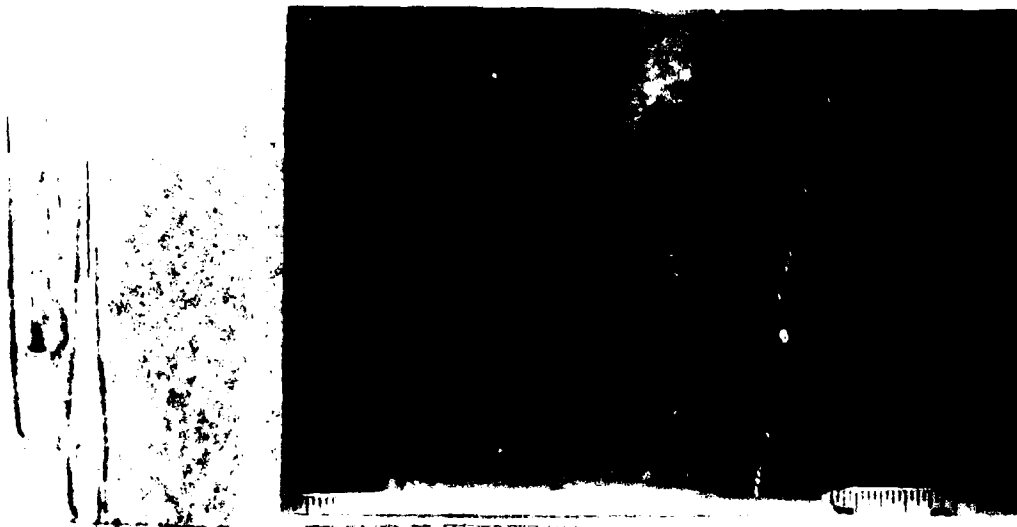


PHOTO #21: Pier 4, Bent 110, Pile DD looking
at the corner of the pile at
El +0.0, shows pile in good
condition.



from the pile cap down 14-16 inches. 75% of the piles that are cracked exhibit rust stains. In Bents 30A to 64, Piles HH to YY, 60% of the piles exhibited hairline cracking on one or more faces about 12" long, in the tidal zone.

- 4) The steel sheet pile bulkhead is protected by a reinforced concrete wall. In some locations, the wooden formwork was left in place. Voids at the mudline were common; along 25% of the concrete wall the voids or gaps could be found. The gaps varied in size from 2" x 3" holes at the mudline to larger holes, 12" square, exposing the sheet pile and rebar (see Photo 22). Cold joint lines were found periodically along the wall running horizontally and vertically.

PHOTO #22: Pier 4, on north face of bulkhead,
between Bents 84 and 85, example
of void in the concrete face
exposing rebar and steel sheet
pile at El -8, (approximate
dimensions 2' x 1').



4.6.3 STRUCTURAL CONDITION ASSESSMENT

The overall condition of the structural piles on Pier 4 is excellent. Concern and attention should be given to the severely damaged piles. Repairs should be made immediately to return them to their original design capacity.

Heavily spalled piles have undergone a significant loss in cross-sectional area, particularly the piles with exposed rebar. A structural analysis of this condition (see Appendix), indicates that the piles are capable of carrying imposed loads, although if deterioration is allowed to continue, the load-carrying capacity of the damaged piles will have to be recalculated.

The localized hairline cracking at the top of some piles seems to originate from the process of driving the pile. This condition is not structurally significant at this time.

Voids in the concrete face of the sheet pile wall could have been caused by a number of reasons:

- a) Poor control or method of placement resulting in trapped water.
- b) The sediment could be shifting due to dredging or possibly prop wash from tugboats, therefore lowering the mudline.

The steel sheet piles do not seem to be effected structurally by voids or other irregularities in the concrete face.

4.6.4 RECOMMENDATIONS

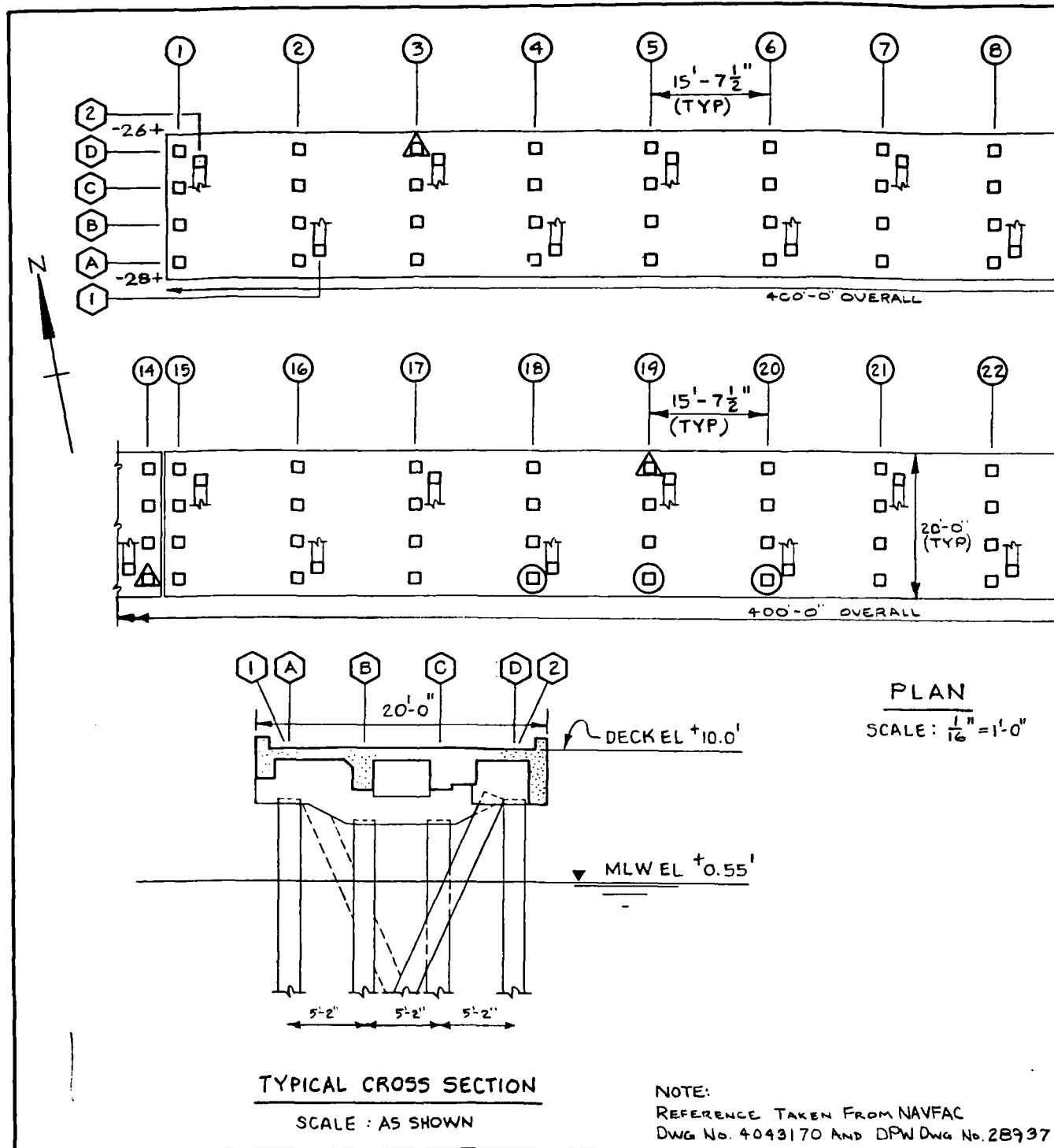
For Pier 4, it is recommended that all the severely damaged and heavily spalled piles be repaired as soon as possible.

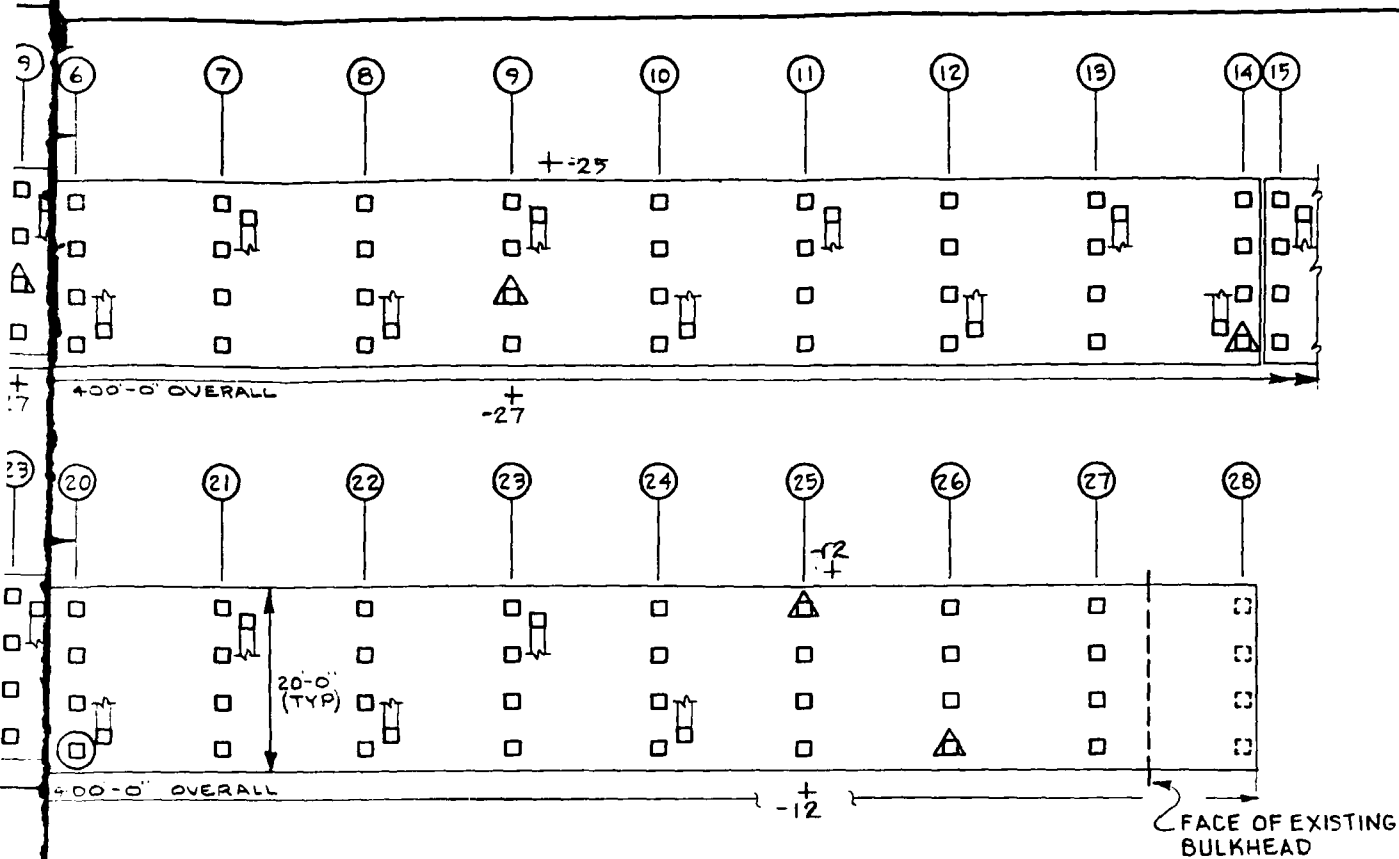
The superstructure, in areas where there is severe damage to structural piles, has limited capability to carry its designed live loading. Moderate live loading, such as imposed presently, will be transmitted through the superstructure to adjacent piles. Capacity loading should be restricted in these areas until repairs have been made.

We recommend that the severely damaged piles be repaired by driving two piles on either side of the damaged pile and pouring a new cap over the two new piles to support the old cap. The estimated cost to repair one damaged pile is \$5,307 (see Appendix). On Pier 4 there are 9 piles that need to be repaired in this fashion. The majority of the piles in this condition are in the process of being repaired. The total estimated cost is \$47,763.

Heavily spalled piles should be repaired by concrete jacketing to prevent further loss of cross-sectional area. The soft concrete should be chipped away to sound concrete. If there is exposed rebar, it should be cleaned and if there is significant loss to cross-sectional area of the steel, it should be replaced. The jacket should cover the area between El +5.0 and El -5.0. If a fabric form is used, the estimated cost per pile is \$1,320 (see Appendix). In this pier there are 13 piles that need this repair. The total estimated cost would be \$17,160.

All repairs should be inspected after completion. The entire pier should be re-inspected in 5 years. The immediate inspection will insure that the repairs have been properly constructed. The follow-up inspection will determine the change of conditions with respect to time.





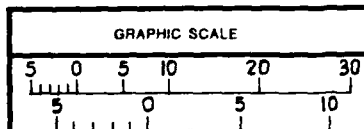
PLAN
SCALE: $\frac{1}{16}" = 1'-0"$

LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- +25 SOUNDING IN FEET BELOW MLW

NOTE: LEVEL II INSPECTION PERFORMED ON ALL PILES

CE TAKEN FROM NAVFAC
4043170 AND DPW DWG No. 28937



CHILDS ENGINEERING
CORPORATION
BOX 535
MEDFORD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.
NAVAL STATION NORFOLK, VA
PIER C
FIG NO
16

4.7.2 OBSERVED INSPECTION CONDITIONS

1. The general condition of Pier C is excellent. We found little heavy spalling and no severe damage. Light spalling is noted on 7% of the piles.
2. A condition of abrasion is found in Bents 18, 19 and 20 on Pile A. This abrasion was across the face of the pile beginning at El 0.0 and running down to El -2.0. In Bent 19, Pile A, the spalling occurred again at El -10.0.
3. In a cursory inspection of the superstructure, we noticed that there is deterioration. Horizontal cracking of the caps and beams is accompanied by some spalling. The cracking is mostly hairline, but some cracks are up to 1/2" wide. An estimated 90% of the superstructure has some form of cracking. Because the superstructure was beyond the scope of this project, we advise an examination of greater detail conducted by the Naval Station.

4.7.3 STRUCTURAL CONDITION ASSESSMENT

The condition of the structural piles in Pier C is excellent. The localized condition found in Bents 18 to 20 seems to originate from abrasion caused by a pipe hanger that has broken loose. This damage does not pose a threat to the structural integrity of the pier.

4.7.4 RECOMMENDATIONS

For Pier C, there are no structural elements in need of repair at this time. The condition of the structural piles is excellent.

We recommend that the pipe hangers that have broken loose in Bents 18, 19 and 20 be secured so that further abrasive action does not occur.

A follow-up inspection is recommended in 5 years to observe change in conditions.

4.8 PIER D

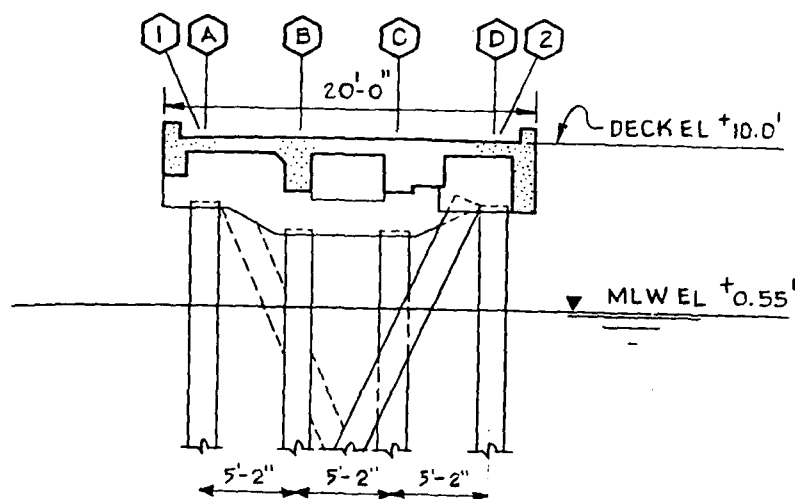
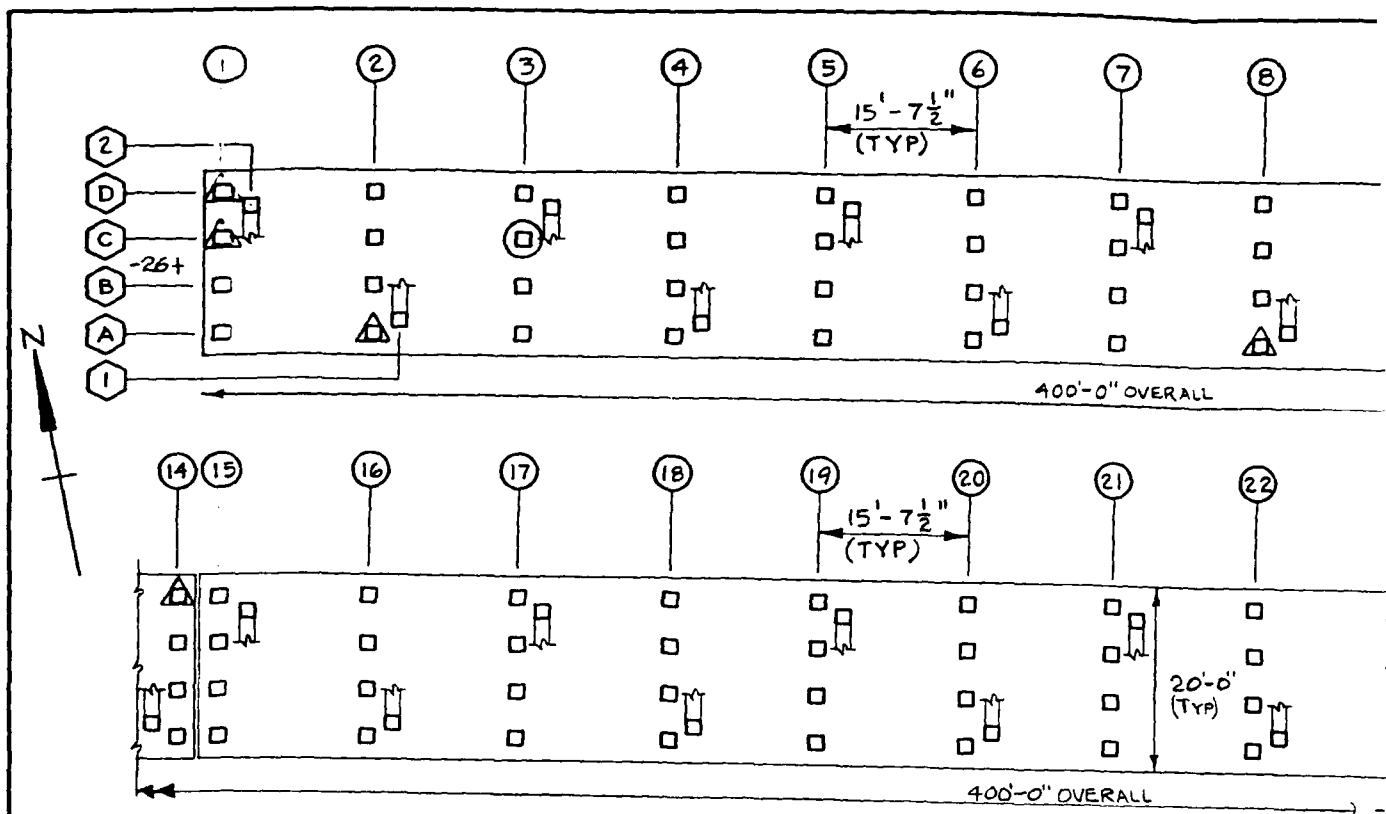
4.8.1 DESCRIPTION

Pier D is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station (see Figure 4). The pier is perpendicular to Bulkhead 306 and just south of Pier E. During the inspection period the pier was being used as a small boat berthing pier and was being utilized by small craft.

The pier was constructed in 1952 and is 400' long and 20' wide. The pier is supported by 140 bearing piles arranged in 28 bents (see Figure 17). All piles are 18" square pre-cast concrete. The design bearing capacity of each pile is 40 tons.

Bent numbering begins outshore with No. 1 and ends at the bulkhead with No. 28.

Reference: Department of Public Works, Naval Station Norfolk
DPW Drawing No. 28937



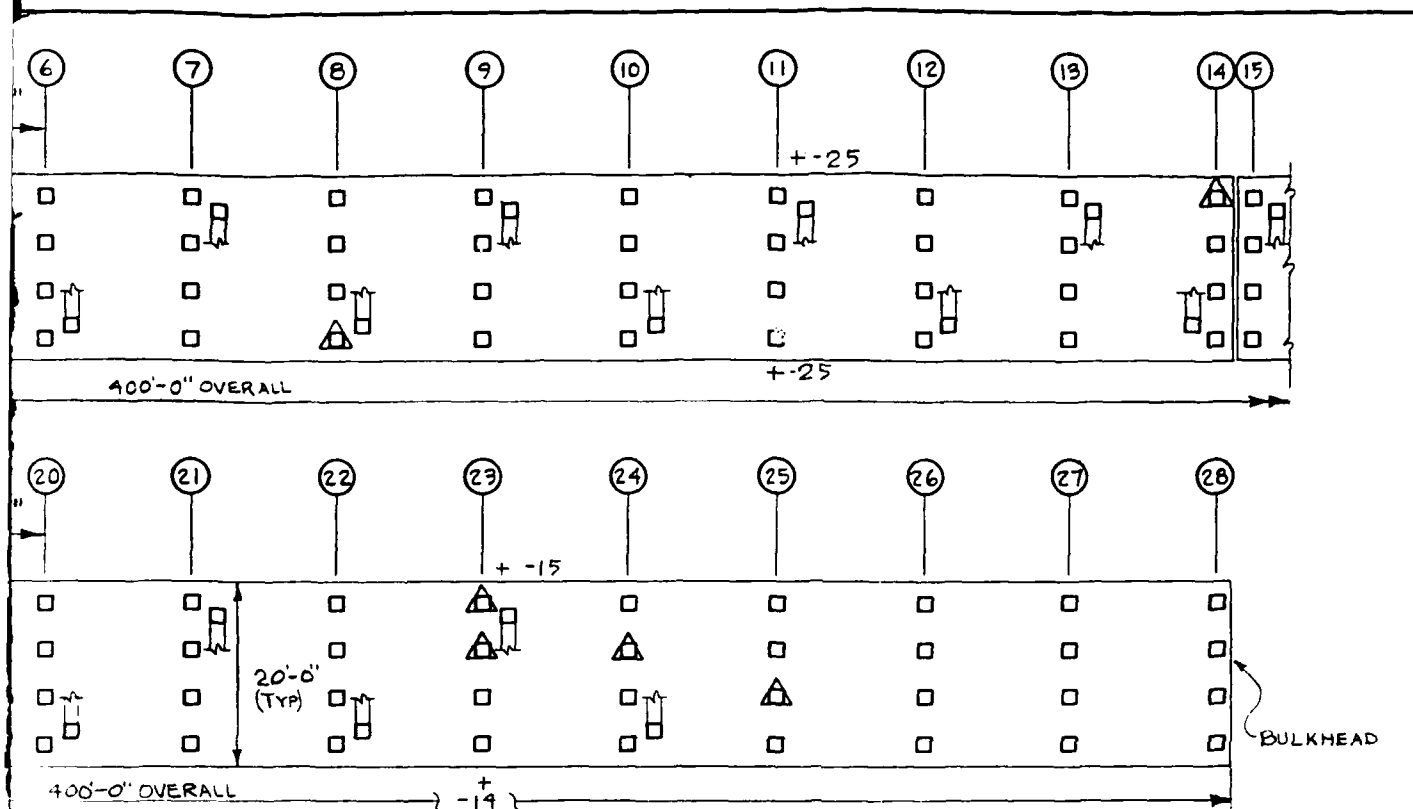
TYPICAL CROSS SECTION

SCALE AS SHOWN

PLAN

SCALE: 1/16" = 1'-0"

NOTE:
REFERENCE TAKEN FROM NAVFAC DWG.
NO. 4043170 AND DPW DWG NO. 2B937



PLAN

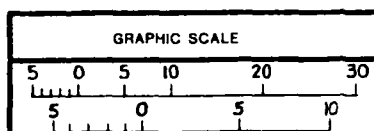
SCALE: $\frac{1}{16}'' = 1'-0''$

LEGEND

- ⊠ SEVERE DAMAGE (REQUIRES REPLACEMENT)
- HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- △ LIGHT SPALLING
- + SOUNDING IN FEET BELOW MLW

NOTE: LEVEL II INSPECTION PERFORMED ON ALL PILES

TAKEN FROM NAVFAC DWG.
AND DPW DWG No. 28937



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.		
NAVAL STATION	NORFOLK, VA	FIG. NO.
PIER D		17

4.8.2 OBSERVED INSPECTION CONDITIONS

1. The overall condition of the pier is excellent. There was no heavy spalling found and light spalling was noticed on 7% of the piles in the tidal zone (see Photo 23). There were no structural anomalies observed.
2. In a cursory inspection of the superstructure, we noticed that there is deterioration. Horizontal cracking of the caps and beams is accompanied by some spalling. The cracking is mostly hairline, but some cracks are up to 1/2" wide. An estimated 90% of the superstructure has some form of cracking. Because the superstructure was beyond the scope of this project, we advise an examination of greater detail conducted by the Naval Station.

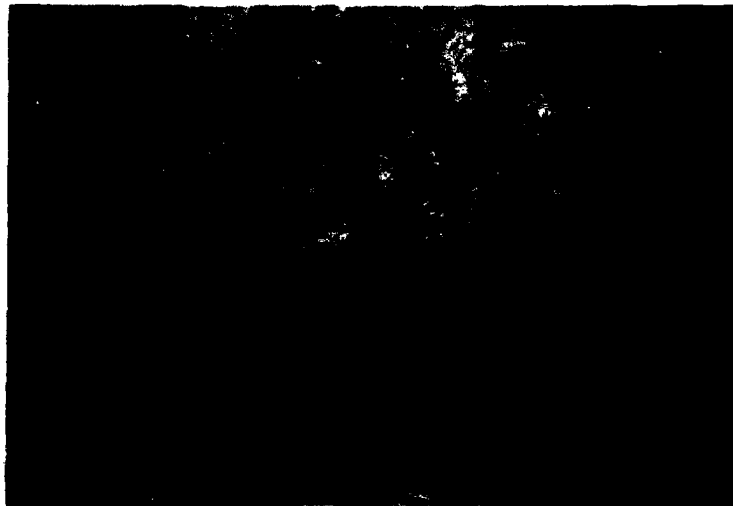
4.8.3 STRUCTURAL CONDITION ASSESSMENT

The condition of the structural piles in Pier D is excellent. The light spalling found has no structural significance at this time.

4.8.4 RECOMMENDATIONS

For Pier D, the structural piles are not in need of repair at this time. The piles inspected were in excellent condition. However, subsequently there should be an inspection of the same caliber in 5 years to determine if deterioration has become a problem.

PHOTO #23: Pier D, Bent 10, Pile A, shows a
pile at El 0.0 with spalling of
less than 1" on the corner.



4.9 PIER E

4.9.1 DESCRIPTION

Pier E is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station (see Figure 4). The pier is perpendicular to Bulkhead 306 and just south of Pier F. During the inspection period the pier was being used as a small boat berthing pier and was being utilized by small craft (see Photo 24).

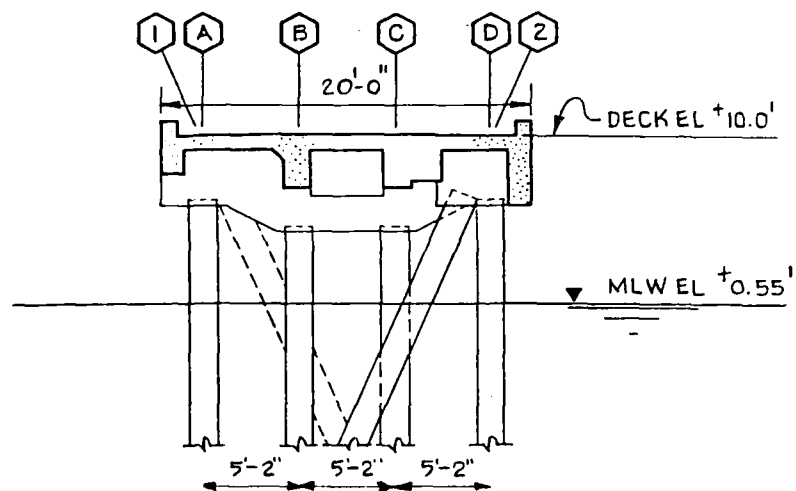
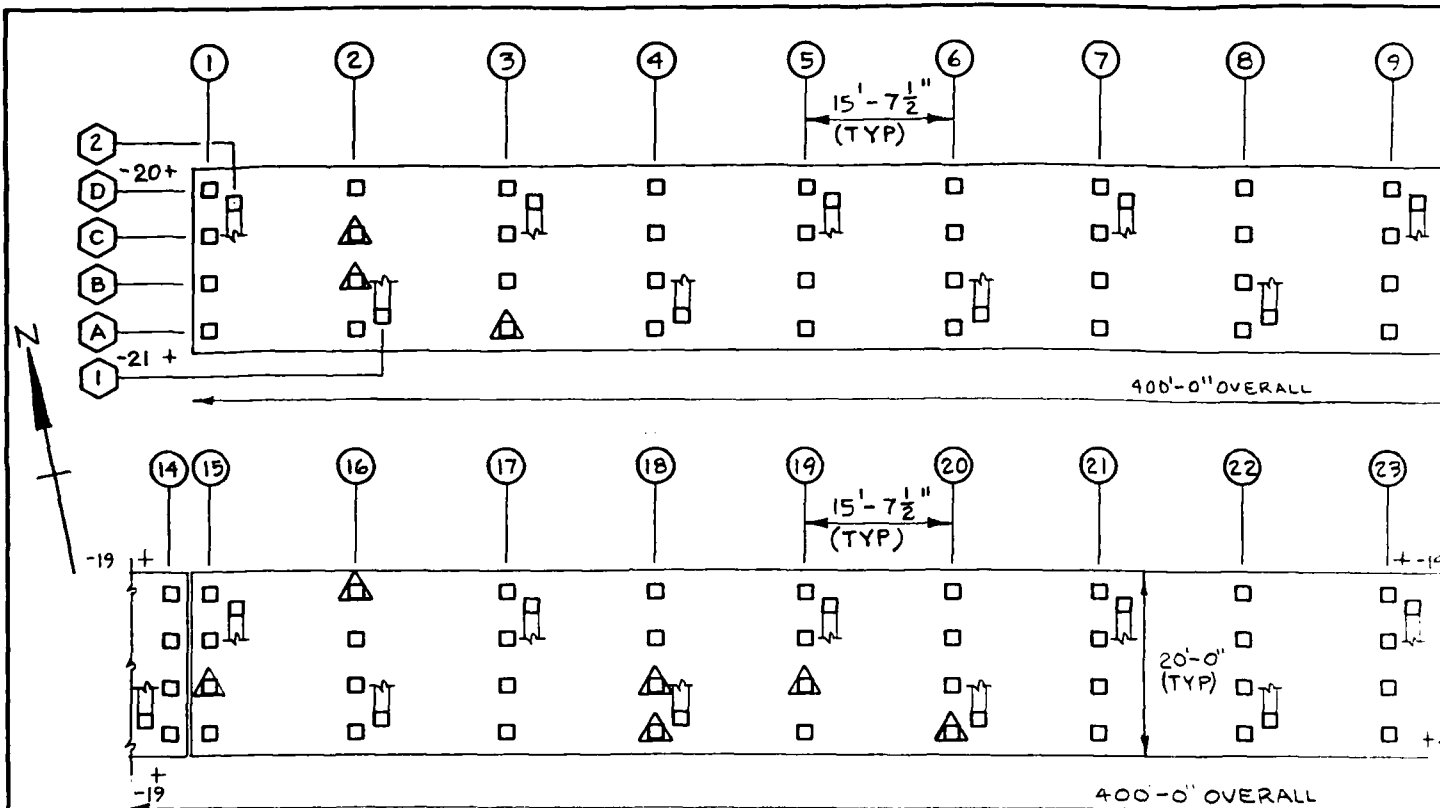
The pier was constructed in 1952 and is 400' long and 20' wide. The pier is supported by 140 bearing piles arranged in 28 bents (see Figure 18). All piles are 18" square precast concrete. The design bearing capacity of each pile is 40 tons.

Bent numbering starts outshore with No. 1 and ends at the bulkhead with No. 28.

Reference: Department of Public Works, Naval Station, Norfolk
DPW Drawing No. 28937.

PHOTO #24: Pier E, overview of pier looking west.





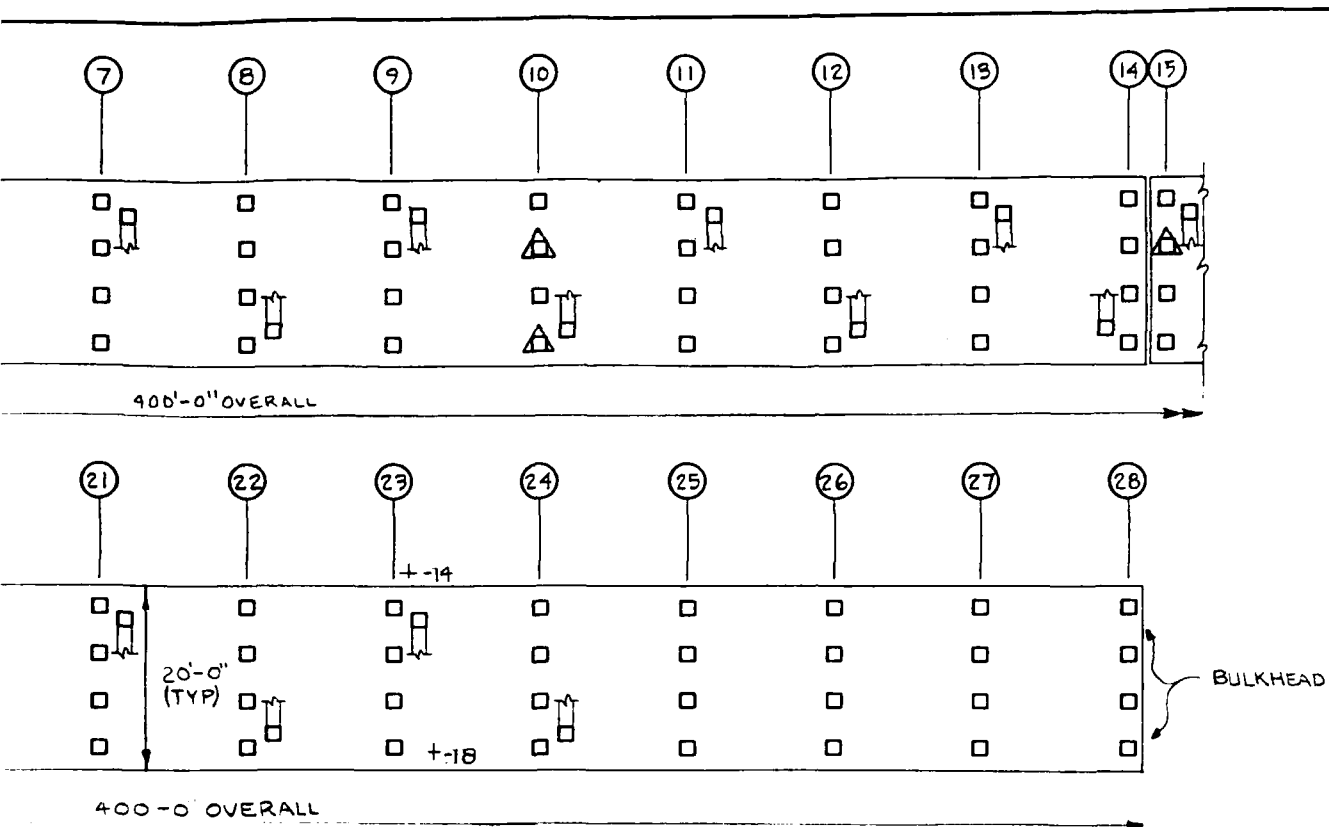
TYPICAL CROSS SECTION

SCALE AS SHOWN

PLAN
SCALE: $\frac{1}{16}" = 1'-0"$

NOTE:
REFERENCE TAKEN FROM NAVFAC DWG
NO. 4093170 AND DPW DWG NO 28937

5
LL
5
L



PLAN

SCALE: $\frac{1}{16}'' = 1'-0''$

LEGEND

- SEVERE DAMAGE (REQUIRES REPLACEMENT)
- HEAVY SPALLING, REBAR EXPOSED
- HEAVY SPALLING, NO REBAR EXPOSED
- LIGHT SPALLING
- $\pm$ SOUNDING IN FEET BELOW MLW

NOTE: LEVEL II INSPECTION PERFORMED ON ALL PILES

FROM NAVFAC DWG
NO DPW DWG NO 28937

GRAPHIC SCALE		CHILDS ENGINEERING CORPORATION BOX 333 MEDFIELD, MA		CHESAPEAKE DIVISION NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON, D.C.	
5	0	5	10	20	30
5	0	5	10	NAVAL STATION NORFOLK, VA	
PIER E					FIG NO 18

4.9.2 OBSERVED INSPECTION CONDITIONS

The overall condition of the pier is excellent. There is no heavy spalling and light spalling was noted on 7% of the piles in the tidal zone (see Photo 25). There were no structural anomalies observed.

In a cursory inspection of the pile caps and deck beams, we noticed that significant deterioration has started. Horizontal cracking of the caps and beams is accompanied by some spalling in the cracked area. The cracking is mostly hairline, but some cracks are up to 1/2" wide. An estimated 90% of the superstructure has some form of cracking.

Because the superstructure was beyond the scope of this project, we advise an examination of greater detail conducted by the Naval Station.

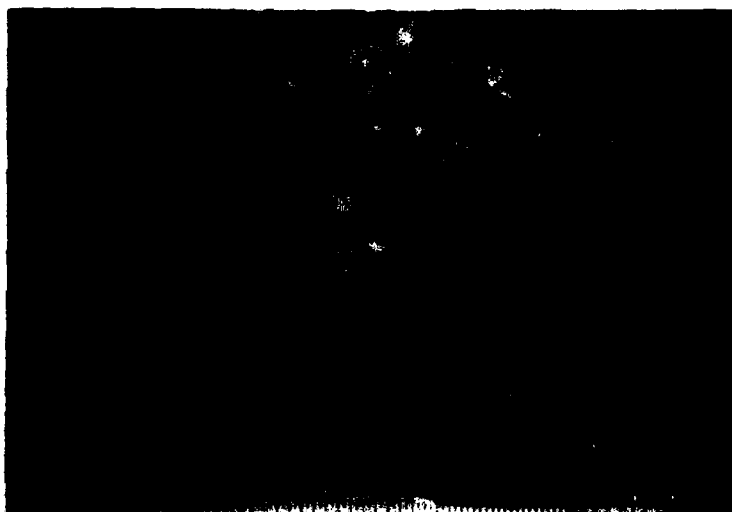
4.9.3 STRUCTURAL CONDITION ASSESSMENT

The condition of the structural piles in Pier E is excellent. The light spalling found has no structural significance at this time.

4.9.4 RECOMMENDATIONS

For Pier E, the structural piles are not in need of repair at this time. The piles inspected were in excellent condition. However, subsequently there should be an inspection of the same caliber in 5 years to determine if deterioration has become a problem.

PHOTO #25: Pier E, Bent 16, Pile D, example of light spalling on a corner in the tidal zone. A straight edge is representing the original pile dimension.



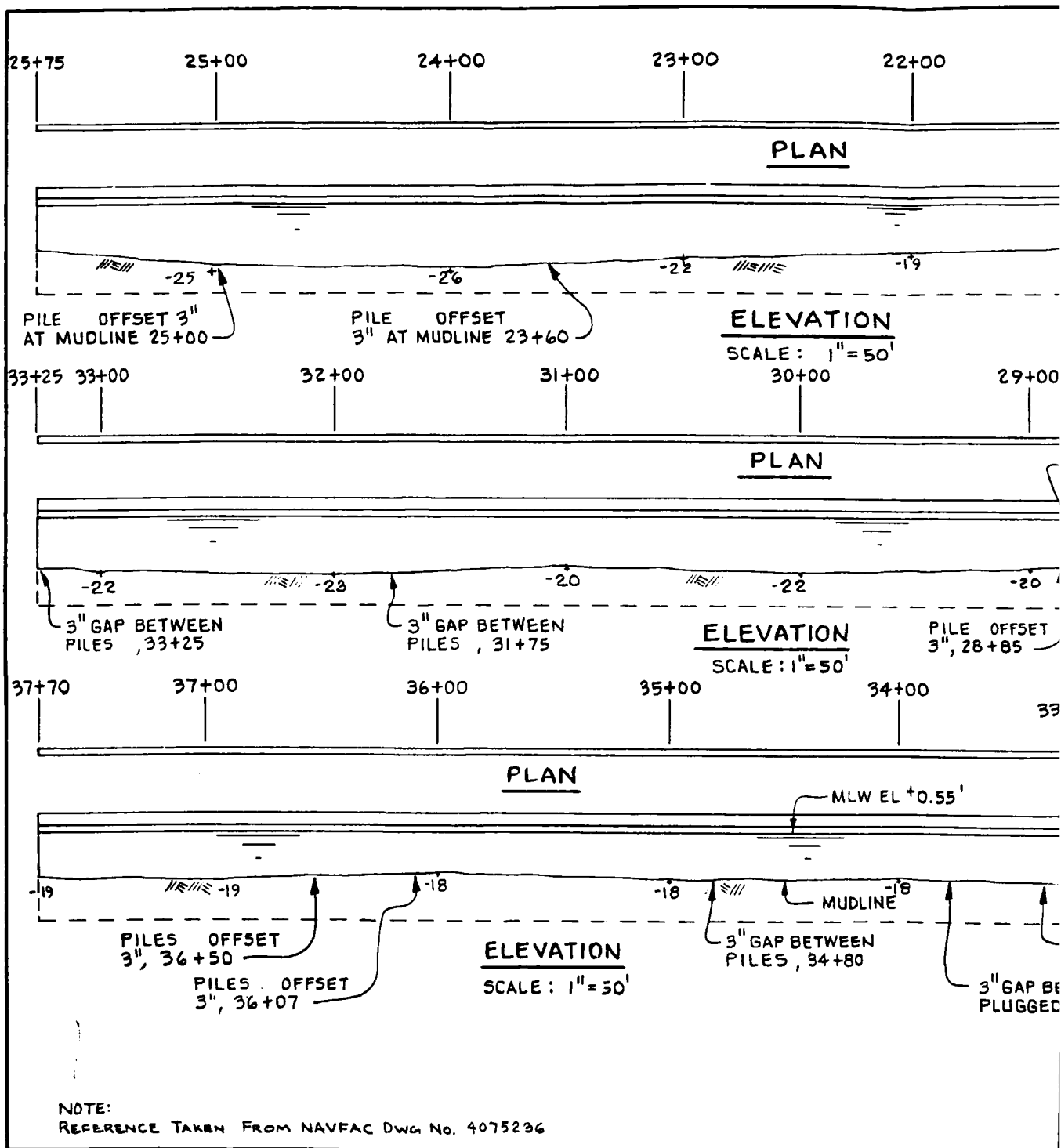
4.10 BULKHEAD CEP-102

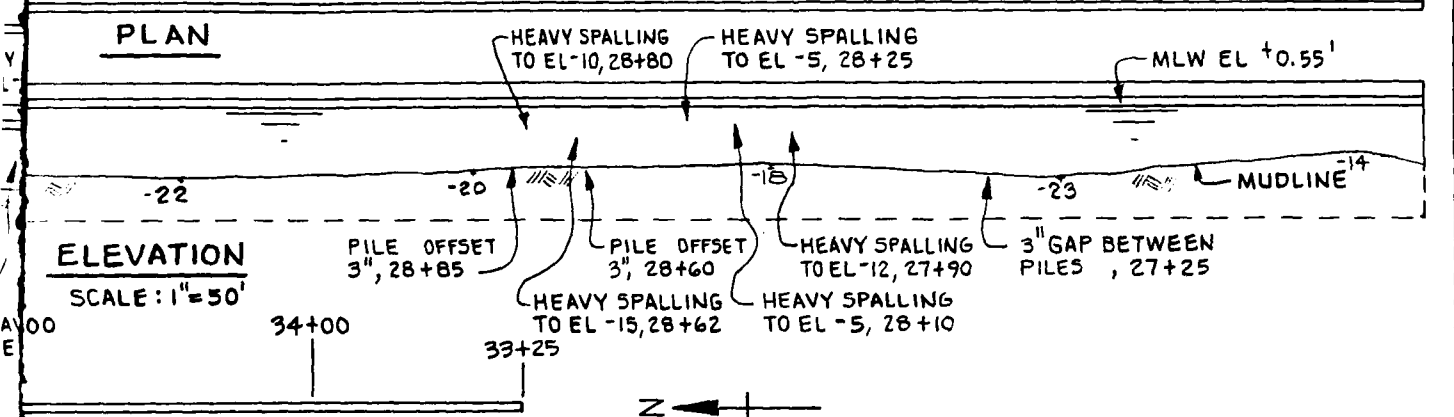
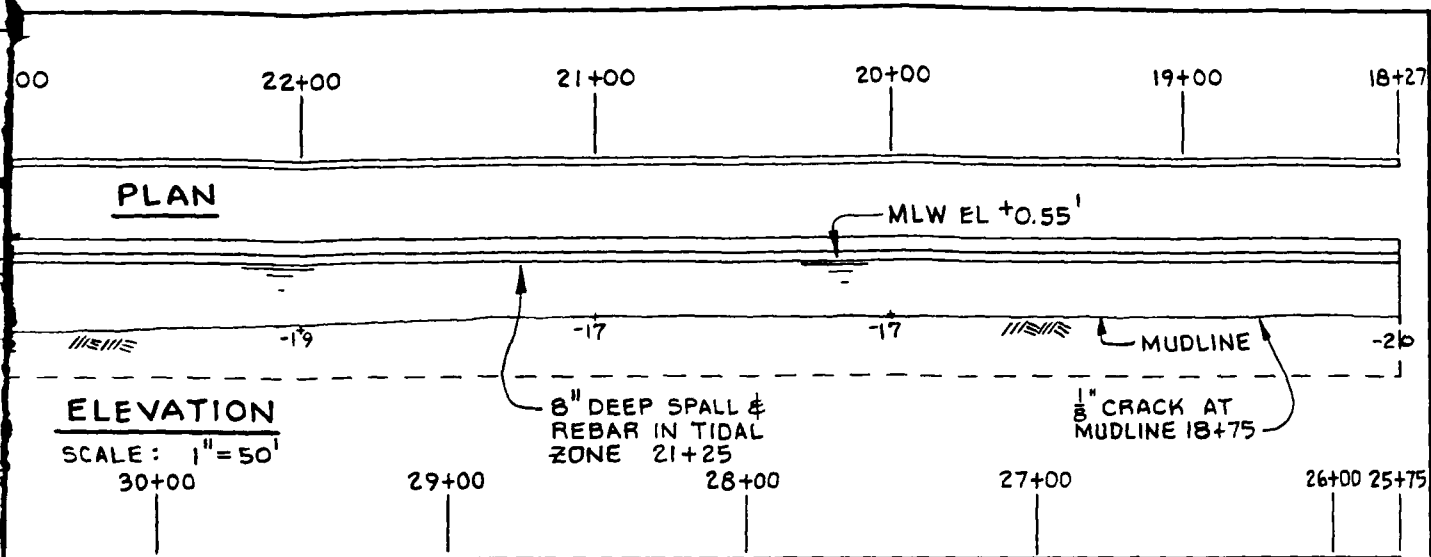
4.10.1 DESCRIPTION

Bulkhead CEP-102 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station (see Figure 4). This is functioning as the bulkhead about Piers 20 to 23.

This facility was constructed in 1943 and is 1750' long. The bulkhead consists of 2' wide precast concrete sheet piles (see Figure 19).

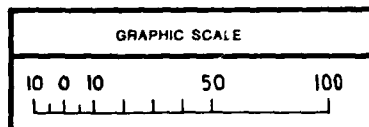
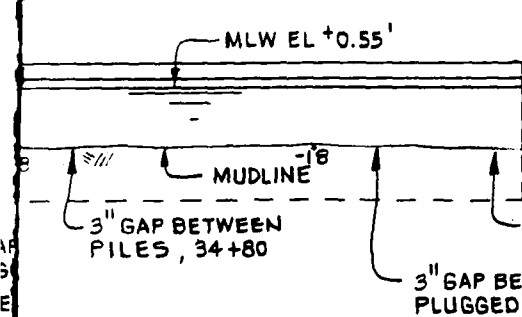
Reference: Department of the Navy, Naval Facilities Engineering Command - NAVFAC Drawing No. 4075236





LEGEND

25+75 STATION Nos.
-25 SOUNDINGS IN FEET FROM MLW



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

NAVAL STATION NORFOLK, VA FIG. NO.

CEP 102 19

4.10.2 OBSERVED INSPECTION CONDITION

The soundings along the concrete sheet pile bulkhead indicate that the depth of water along the wall varies from 16' to 25'. The general condition of the bulkhead seems to be good. The most damage occurs in the tidal zone. Deterioration of the concrete in the form of spalling and cracking along the corners of the individual piles was noted (see Photo 26). Up to 4" of the concrete is spalled from some corners. This occurs from the cap, El +2.5 to El -3.0. The spalling typically was exemplified by a loss of concrete down to the tongue or groove, on the edge of the pile (see Figure 20). There did not seem to be direct access to the fill material, although there could be infiltration of water through the joints of the piles. Accompanying the spalling at mean low water, there was occasional cracking along the corners of the pile reaching from the spalled area to El -10.0 (see Photo 26). Gaps of 1" to 2" between the outer edges of the piles were common. Infrequently, there were gaps of up to 3" between the piles. In the presence of a large gap, the tongue was visible. Access past the tongue was not possible. A condition of an offset of an individual pile to the wall was noted occasionally. This offset was usually about 2" to 3" and occurred at the mudline. Following the offset up the pile revealed that it would taper down to zero at El -5.0. There was no detectable batter in the bulkhead and there were no obvious structural defects.

Although we did not see any indication of fill leaching out, discussions with base personnel lead us to believe that recently there had been sinkholes behind the wall. This is a result of the loss of fill.

PHOTO #26: Bulkhead CEP-102, Station 21+50,
at the mudline (El -17) shows
cracking of corner and light
spalling.



4.10.3 STRUCTURAL CONDITION ASSESSMENT

Generally, the structural condition of the wall is good. The various sized gaps between the piles is a condition which has been present since the construction of the bulkhead. This is also true of the occasional offset of an individual pile. These conditions have no bearing on the structural integrity of the bulkhead.

The spalling in the area of mean low water seems to be caused by wave action. This does not structurally seem to be a problem. The concern involving this condition is the leaching out of the fill behind the piles. There are no obvious signs of this happening, such as an irregular build-up of silt along the wall or any conspicuous openings or breaks in the wall.

4.10.4 RECOMMENDATIONS

Our recommendation is to take some sort of action to alleviate the problem of loss of fill. This could be done in any number of ways. Base personnel indicated that there had been a contract previously let to study the problem and design repairs. The proposed method of repair chosen uses wooden planking fastened to the outside of the sheet piles. The planking will cover the pile joints, thus closing access to the fill behind the sheet pile wall. This will stop the flow of water and keep fill from leaching out from between the piles. The pertinent drawings include repairs to the topside cap, along with existing conditions and repair designs.

We concur that the proposed technique will alleviate the problem of loss of fill. We direct reference to the contract, Repairs to Bulkheads CEP-102, CEP-176 and Quaywall CEP-111, (NAVFAC Drawing Nos. 4075236 to 4075254) for further or more detailed information.

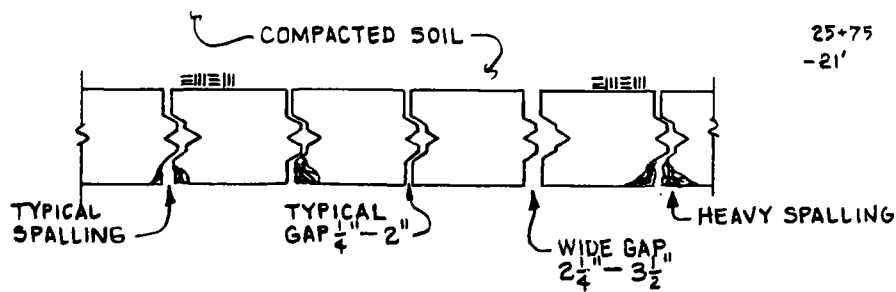
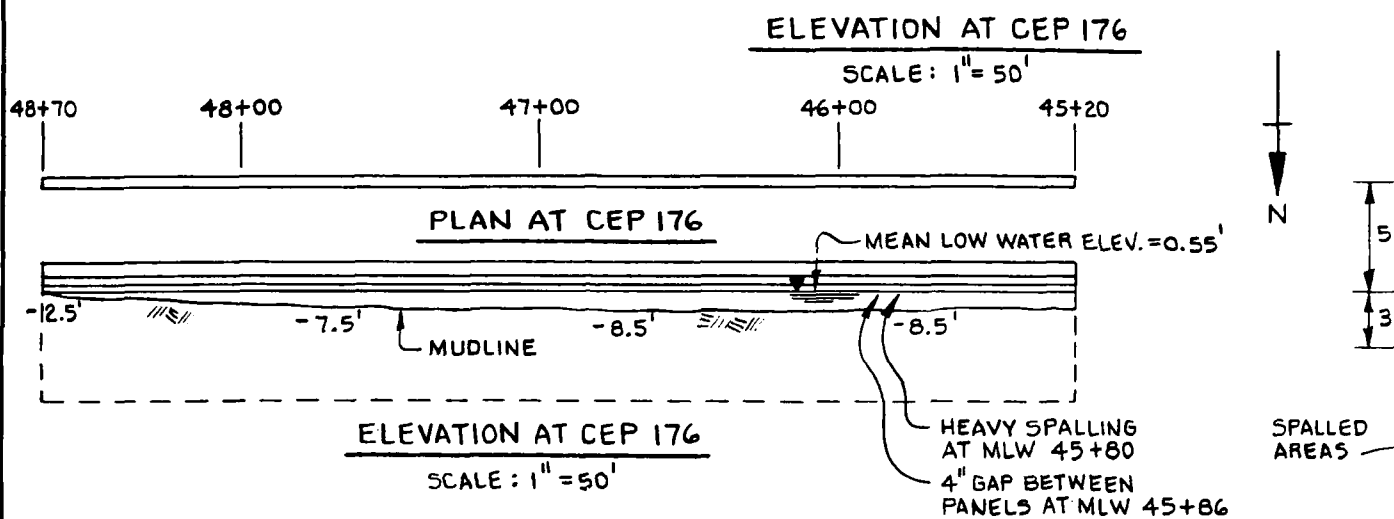
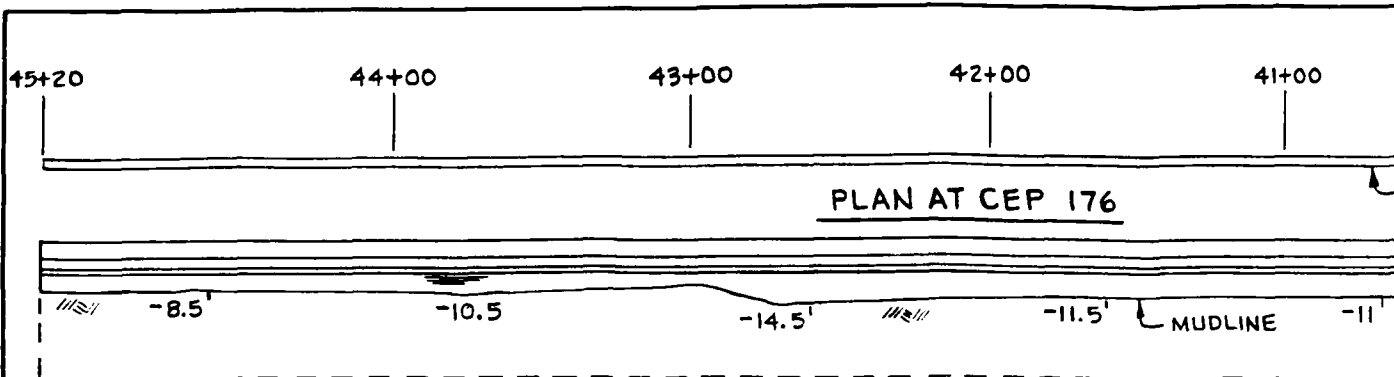
4.11 BULKHEAD CEP-176

4.11.1 DESCRIPTION

Bulkhead CEP-176 is located on the eastern shore of Hampton Roads in the westernmost portion of the Naval Station, (see Figure 4). During the inspection period, the bulkhead was functioning as an AFDM-7 mooring facility.

This facility was constructed in 1943. The bulkhead consists of 2' wide precast concrete piles and is 900' long (see Figure 20).

Reference: Department of the Navy, Naval Facilities Engineering
Command
NAVFAC Drawing No. 4075236



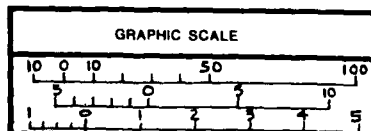
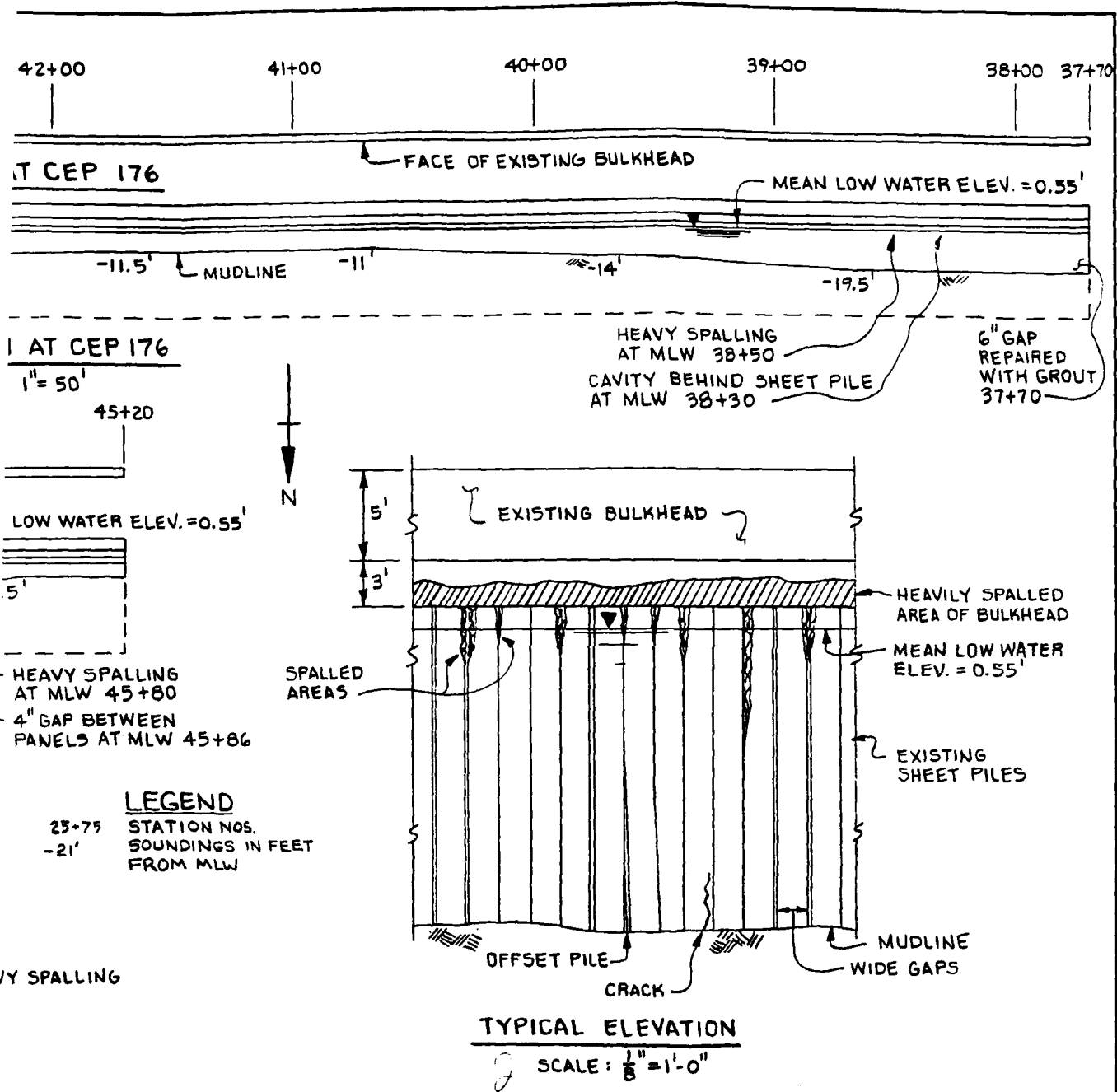
TYPICAL PLAN VIEW AT MLW

SCALE: $\frac{3}{8}$ " = 1'-0"

LEGEND

25+75 STATION NOS.
-21' SOUNDINGS IN FEET
FROM MLW

NOTE:
REFERENCE TAKEN FROM NAVFAC DWG No. 4075236



CHILDS ENGINEERING
CORPORATION
BOX 333
MEDFIELD, MA

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D.C.

NAVAL STATION NORFOLK, VA

CEP 176

FIG NO 20

4.11.2 OBSERVED INSPECTION CONDITION

Soundings indicate that the depth of water ranges from 18' at the west end to 1' at the east end. The general condition of the wall seems to be good. The most damage occurs in the tidal zone. In this area, spalling appears on the corners of the piles to a depth of 4". The damage is located from the cap, El +2.5 to El -2.0; to elucidate: the groove section of the pile is typically spalled to the adjacent tongue (see Photo 27).

At Station 38+30, damage to the bulkhead is noted. A gap reaching to El -3 was found in the piles in conjunction with a section of the cap that is severely damaged. This damage reveals an open space behind the piles.

An overall condition noted along the bulkhead indicates that the severity of the spalling decreases while moving east along the wall.

The piles were typically spaced with gaps of 1" to 2" between the outer edges of the piles. Infrequently, there were gaps of up to 3" between the piles. In the presence of a large gap, the tongue was visible. Access past the tongue was not possible. A condition of an offset of an individual pile to the wall was noted occasionally. This offset was usually about 2" to 3" and occurred at the mudline. Following the offset up the pile revealed that it would taper down to zero at El -5.0.

PHOTO #27: Bulkhead CEP-176, Station 39+45,
at El -4.0, shows spalling on
edges of 2 piles.



4.11.3 STRUCTURAL CONDITION ASSESSMENT

The structural condition of the bulkhead is good. On the western end of the bulkhead there is some spalling in the area of mean low water. The severity of the spalling decreases while moving easterly along the bulkhead. This could be due to the fact that the eastern end of the bulkhead is protected from wave action.

The void in the fill behind the piles at Station 38+30 was caused by the large opening in the cap. This opening allows wave action to erode the fill, therefore eventually creating a sink hole.

General condition of Bulkhead CEP-176 is better than the condition of Bulkhead CEP-102.

4.11.4 RECOMMENDATIONS

Our recommendation is to take some sort of action to alleviate the problem of loss of fill. This could be done in any number of ways. Base personnel indicated that there had been a contract previously let to study the problem and design repairs. The proposed method of repair chosen uses wooden planking fastened to the outside of the sheet piles. The planking will cover the pile joints, thus closing access to the fill behind the sheet pile wall. This will stop the flow of water and keep fill from leaching out from between the piles. The pertinent drawings include repairs to the topside cap along with existing conditions and repair designs.

We concur that the proposed technique will alleviate the problem of loss of fill. We direct reference to the contract, Repairs to Bulkheads CEP-102, CEP-176 and Quaywall CEP-111 (NAVFAC Drawing Nos. 4075236 to 4075254) for further or more detailed information.

TABLE OF CONTENTS FOR APPENDIX

<u>TITLE</u>	<u>PAGE</u>
Repair Cost Estimates	A-1
Required Pile Capacity	A-2
Remaining Pile Capacity	A-7

REPAIR COST ESTIMATE

1) Cost to Replace Severely Damaged Piles:

Recommended technique is to drive (2) 14" square piles on either side of the pile cap in the area of the broken pile, then pour a new cap to support the old cap, across the 2 new piles.

Cost of Repair:

- A. 14" square pile @ \$25/Lf (installed)
x 60' = \$1,500/pile
\$1500 x 2 piles = \$3,000.
- B. To cut holes in deck: \$ 500.
- C. To cast a new cap:
9' x 3.5' x 1.5' = 47.29 Ft³ = 1.75 Yd³
reinforced concrete in place: \$1,000/Yd³
1.75 Yd³ @ \$1000/Yd³ = \$1,750.
- D. To patch hole in deck:
Area of holes = 24.5 Ft²
1' depth of slab @ 24.5 Ft² = .91 Yd³
.91 Yd³ @ \$75/Yd³ = \$68.

Total cost to repair 1 pile:

2 piles installed	\$3,000	
cut holes in deck	500	
cast new cap	1,750	
repair holes in deck	57	
		\$5,307

2) Cost to Repair Heavily Spalled Piles:

Recommended technique of repair is to jacket the damaged pile with concrete. Using a fabric form, the cost would be \$132/Lf. The area to be jacketed would be El +5.0 to El -5.0. The price per pile is \$1,320.

For piles that are 16" square, a 34" diameter jacket would be needed to provide proper coverage. An 18" square pile would need a 37" diameter jacket.

Note: If there are less than 20 piles to be repaired, there will be a mobilization/demobilization cost of \$5,000.

Cost estimate dollar amounts are based on current local prices with reference to Survey of Techniques for Underwater Maintenance/Repair of Waterfront Structures, Report Number CR81.009 by Childs Engineering Corporation.

CHILDS ENGINEERING CORPORATION

Box 333
MEDFIELD, MA 02052

JOB 498-82

SHEET NO

OF

CALCULATED BY CDS

DATE 7-28-82

CHECKED BY DLP

DATE 9/82

SCALE

REQUIRED PILE CAPACITY

PIERS #22 + #23 -

DEAD LOAD: A) DECK + AREA = $16' \times 6.33' = 101.28 \text{ ft}^2$
DEPTH OF SLAB 8"
VOLUME OF CONCRETE
 $(.66 \text{ ft}) \times (101.3 \text{ ft}^2) = 67.5 \text{ ft}^3$

B) CAP - DEPTH 3.25 ft
WIDTH 1.83 ft
LENGTH 6.33 ft
VOLUME $37.6 \text{ ft}^3 \approx 38 \text{ ft}^3$

TOTAL VOLUME OF CONCRETE = 106 ft^3

$$(106 \text{ ft}^3) (150 \text{ lb/ft}^3) = 16 \text{ K}$$

LIVE LOAD:

DECK AREA = 101.3 ft^2

$$(101.3 \text{ ft}^2) (600 \text{ lb/ft}^2) = 61 \text{ K}$$

DEAD LOAD 16 K

LIVE LOAD 61 K

TOTAL LOAD/PILE 77 K = 38.5 TONS

CHILDS ENGINEERING CORPORATION

Box 333
MEDFIELD, MA 02052

JOB 498-82

SHEET NO _____

OF _____

CALCULATED BY CDS

DATE 7-27-82

CHECKED BY DLP

DATE 9/82

SCALE _____

REQUIRED PILE CAPACITY

PIER #4

DEAD LOAD: DECK - AREA 81 ft²
DEPTH OF SLAB 8"
VOLUME 54.27 ft³

$$(54.27 \text{ ft}^3) (150 \text{ lb/ft}^3) = 8.14 \text{ K}$$

CAP - AREA 15.72 ft²
DEPTH 3.33 ft
VOL 52.15 ft³

$$(52.15 \text{ ft}^3) (150 \text{ lb/ft}^3) = 7.85 \text{ K}$$

DECK LOAD 8.14 K
CAP LOAD 7.85 K
TOTAL DEAD LOAD 15.99 K

LIVE LOAD:

$$(81 \text{ ft}^2) (600 \text{ lb/ft}^2) = 48.6 \text{ K}$$

DEAD LOAD 15.99 K
LIVE LOAD 48.6 K
TOTAL LOAD / PILE 64.59 K = 32.3 TONS/PILE

CHILDS ENGINEERING CORPORATION

Box 333
MEDFIELD, MA 02052

JOB 498-PZ

SHEET NO

OF

CALCULATED BY CDS

DATE 7-26-82

CHECKED BY DLB

DATE 9/82

SCALE

REQUIRED PILE CAPACITY

PIERS 2 + 3

DEAD LOAD:

DECK -

AREA 72 ft²

DEPTH OF SLAB .83 ft

VOLUME 59.76 ft³

$$(59.76 \text{ ft}^3) (150 \text{ lb/ft}^3) = 8.96 \text{ K}$$

CAP -

AREA 13.98 ft²

DEPTH 3.25 ft

VOLUME 45.44 ft³

$$(45.44 \text{ ft}^3) (150 \text{ lb/ft}^3) = 6.8 \text{ K}$$

DECK LOAD 8.96 K

CAP LOAD 6.8 K

TOTAL DEAD LOAD 15.76 K

LIVE LOAD:

$$(72 \text{ ft}^2) (600 \text{ lb/ft}^2) = 43.2 \text{ K}$$

DEAD LOAD 15.76 K

LIVE LOAD 43.2 K

TOTAL LOAD / PILE 58.96 K = 29.48 TONS/PILE

CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

JOB 498-82
SHEET NO _____ OF _____
CALCULATED BY CDS DATE 7-26-82
CHECKED BY DLP DATE 9/82
SCALE _____

REQUIRED PILE CAPACITY

PIER # 25

DEAD LOAD :

DECK -

AREA 111.37 ft^2
DEPTH OF SLAB 1.25 FT
VOLUME 139.2 ft^3

$$(139.2 \text{ ft}^3) (150 \text{ lb/ft}^3) = 20.88 \text{ K}$$

CAP -

AREA 15.7 ft^2
DEPTH 2.83 FT
VOLUME 44.5 ft^3

$$(44.5 \text{ ft}^3) (150 \text{ lb/ft}^3) = 6.7 \text{ K}$$

DECK LOAD 20.88 K

CAP LOAD 6.7 K

TOTAL DEAD LOAD 27.58 K

LIVE LOAD !

$$(111.37 \text{ ft}^2) (600 \text{ lb/ft}^2) = 66.8 \text{ K}$$

DEAD LOAD 27.58 K

LIVE LOAD 66.8 K

TOTAL LOAD / PILE 94.38 K = 47.19 Tons/pile

CHILDS ENGINEERING CORPORATION
Box 333
MEDFIELD, MA 02052

JOB 498-82
SHEET NO _____ OF _____
CALCULATED BY CDS DATE 7-26-82
CHECKED BY DLP DATE 9/82
SCALE _____

REQUIRED PILE CAPACITY

PIERS C, D, E

DEAD LOAD :

DECK - AREA 81 ft^2
DEPTH OF SLAB .75 ft
VOLUME 60.75 ft^3

$$(60.75 \text{ ft}^3) (150 \text{ lb/ft}^3) = 9.1 \text{ K}$$

CAP - AREA 10.34 ft^2
DEPTH 3.5 ft
VOLUME 36.19 ft^3

$$(36.19 \text{ ft}^3) (150 \text{ lb/ft}^3) = 5.4 \text{ K}$$

DECK LOAD 9.1 K
CAP LOAD 5.4 K
TOTAL DEAD LOAD 14.5 K

LIVE LOAD :

$$(81 \text{ ft}^2) (600 \text{ lb/ft}^2) = 48.6 \text{ K}$$

DEAD LOAD 14.5 K
LIVE LOAD 48.6 K
TOTAL LOAD / PILE 63.1 K = 31.6 TONS / PILE

CHILDS ENGINEERING CORPORATION

Box 333
MEDFIELD, MA 02052

JOB 408-82 NAUSTA NORFOLK VA
SHEET NO 1 OF 2
CALCULATED BY CDS DATE 9/7/82
CHECKED BY DLP DATE 9/82
SCALE _____

REMAINING CAPACITY OF HEAVILY SPALLED PILE

16" SQUARE CONCRETE PILE -

LONG COLUMN CONSIDERATION:

$$P' = \left[.8 A_g (.225 f'_c + f_s P_g) \right] \left(1.3 - \frac{.03L}{t} \right)$$

WHERE ;
P' = ALLOWABLE LOAD
A_g = GROSS AREA OF CONCRETE PILE
f'_c = 28 DAY STRENGTH OF CONCRETE
f_s = ALLOWABLE STRESS OF STEEL
P_g = RATIO OF EFFECTIVE AREA OF
VERTICAL REINFORCEMENT TO THE
GROSS AREA (A_g). $\frac{A_s}{A_g}$
L = EFFECTIVE LENGTH
t = LEAST DIMENTION.

$$P' = (.8) 256 \text{ in}^2 \left[.225 (4000 \text{ psi}) + (20,000 \text{ psi}) .02 \right] \left(1.3 - \frac{.03 (480 \text{ in})}{16 \text{ in}} \right)$$

$$(204.8 \text{ in}^2) \quad [1300 \text{ psi}] \quad (.4)$$

$$P' = 106 \text{ K} = 53 \text{ TONS}$$

SHORT COLUMN CONSIDERATION:

$$P_R = .8 A_g (.225 f'_c + f_s P_g) \quad \text{USE REVISED } A_g$$

$$P = 80 \text{ TONS}$$

CHILDS ENGINEERING CORPORATION

Box 333
MEDFIELD, MA 02052

JOB _____

SHEET NO. 2 OF 2

CALCULATED BY CDS DATE 9/7/82

CHECKED BY DLP DATE 9/82

SCALE _____

18" SQUARE CONCRETE PILE -

LONG COLUMN CONSIDERATION:

$$P' = [.8 A_g (.225 F'_c + F_s P_g)] (1.3 - \frac{.03 L}{L})$$

$$P' = (.8) 324 (.225(4000) + (20000)(.02)) (1.3 - \frac{.03 \times 480}{18})$$

$$P' = 259.2 [900 + 400] .5$$

$$P' = 168 K = 84.24$$

SHORT COLUMN CONSIDERATION:

USE REVISED A_g

$$P' = .8 A_g (.225 F'_c + F_s P_g)$$

$$P' = .8 (201) (.225(4000) + (20000)(.02))$$

$$P' = 104 \text{ TONS}$$

END

DATE
FILMED

6 - 86

DTIC