(2)

RAPID BAY JETTY

STRUCTURAL CONDITION REPORT

FINAL REPORT

December 2004

Department of Transport and Urban Planning

Government of South Australia

EXECUTIVE SUMMARY

The Structures Group, Pavements and Structures, have been engaged by Marine Facilities to provide an assessment of the structural condition of the Rapid Bay Jetty. The assessment included a site inspection of the Jetty, a review of previous engineering condition reports and a desktop analysis of the pile condition data.

Overwhelming evidence now exists to close the Jetty from bent 26 onwards as it poses an unacceptable risk to users. This section of the jetty has major structural defects arising from a lack of maintenance with the condition of various sections of the structure being very poor bordering on unsafe.

The original timber piles from bents 1 to 6 are in a satisfactory condition as are the steel box piles between bents 7 and 26. However, 69% of the original timber piles between bents 27 and 79 are heavily necked or completely severed and are classified as Poor or Very Poor.

The superstructure steelwork is generally in a poor condition with substantial amounts of flaking and delamination corrosion resulting in large amounts of section loss with holes in both the webs and flanges of the girders not uncommon.

Conclusions / Recommendations

Bents 27 to 79

- The risk of a two span collapse for this part of the structure has been determined as **EXTREME**. Risk mitigation options necessitate immediate action and require the development and implementation of a specific risk management plan.
- The condition of the jetty has deteriorated to the extent that maintenance is no longer an option with the replacement of the majority of structural elements now required OR the construction of a new jetty on an alternative alignment.
- The closure of the Jetty from bent 26 is recommended **immediately.**

Start of Jetty to Bent 26

- The risk of a two span collapse for this part of the structure has been determined as **MODERATE**. Risk mitigation should include a regular inspection program and periodic monitoring (by measurement) of the residual steel thicknesses of both the girders and crossheads at a number of locations.
- The section of jetty up to bent 26 could remain open but given that doubts exist about its future serviceability there appears to be little benefit in attempting to keep it open. This section is tidal with generally low water depth and therefore would not appeal to users for fishing or diving purposes if left open.

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1 INTRODUCTION

1.1 Brief

The Structures Group, Pavements and Structures, have been engaged by Marine Facilities to undertake a desktop audit of previous engineering reports and provide a final assessment of the current structural condition of the Rapid Bay Jetty. This report assesses the extent of risk to users, the condition of critical elements and investigates possible maintenance options.

1.2 Methodology

A site inspection was undertaken in September 2004 to establish an initial visual assessment of the structure. Following the initial site inspection, an audit of the previous engineering condition reports and a desktop analysis of pile condition data was undertaken. This audit enabled trends in the deterioration rate of critical elements of the structure to be re-assessed. A subsequent site inspection was undertaken to focus on critical elements of the structure in order to form an overall assessment of the structures integrity. There was sufficient historical condition information available and visual evidence was such that detailed inspection and physical material testing was considered not necessary at this stage.

1.3 Structure History

The Rapid Bay Jetty is located at the township of Rapid Bay, approximately 100 kms to the south of Adelaide on the Fleurieu Peninsula. The jetty was constructed in 1941 by BHP Proprietary Limited for the purpose of shipping limestone from the adjacent quarry and supported a significant conveyor system. Adelaide Brighton Cement later used the jetty for the same purpose, with the last shipment occurring in 1991. The conveyor system along the western side of the structure was dismantled in 1998. Ownership of the jetty was transferred to the Department of Marine and Harbors in 1982. The jetty is now exclusively used by recreation fisherman and divers.

1.4 Structure Description

The jetty is T-shaped in plan and is approximately 470 metres in length. The jetty can be separated into 2 sections – the approach jetty and the T-head. The approach jetty section consists of 80 bents at 4.5 metre centres with the T-head (bent 80 onwards) consisting of a number of bents at various centres with an overall length of approximately 200 metres. The approach jetty section typically comprises 4 No. 13" x 5" x 40.53 lb/ft rolled steel girders, 3 of which support timber crossbeams and decking, spanning longitudinally between bents. The girders in turn are supported by a pair of 12" x 3-1/2" x 34.33 lb/ft steel channel crossheads bolted to 3 No. 450 mm diameter timber piles (photo 2).

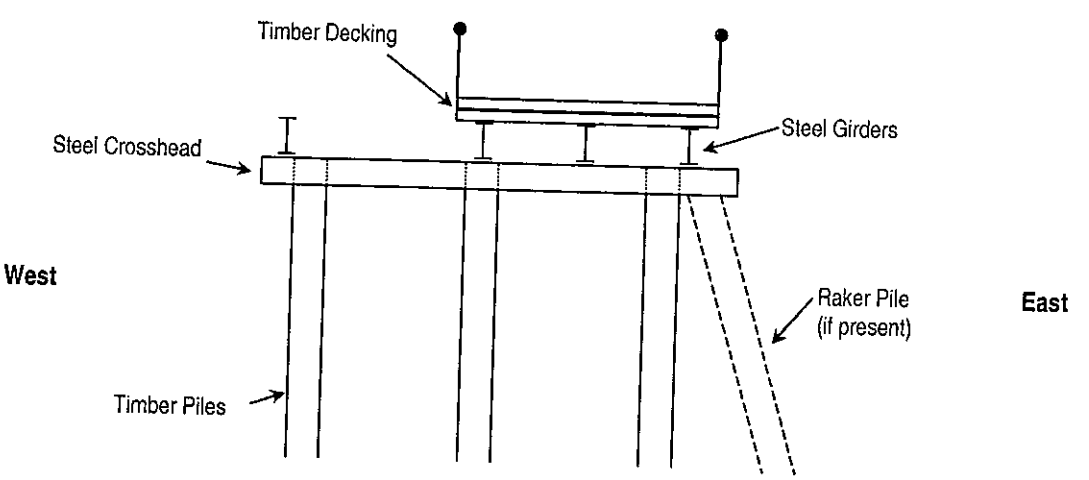


Figure 1.1 – Typical Approach Jetty Cross-Section

The remaining girder, on the western side, previously supported the conveyor equipment that was removed in the late 1990's (photo 3). The girders are 2 span continuous, that is spanning across intermediate bents, and are joined to the girders in the adjoining spans with bolted splice plates on the webs (photo 4). The original drawings indicate that the girders and channels are thickened sections indicating a level of corrosion allowance in the design.

During its life, sections of the jetty have been rebuilt, with the most notable work involving the reconstruction of the T-Head in 1968. The T-head section has a similar arrangement to that of the approach jetty, with the exception being that the bents consist of deep I - section crossheads supported on steel box piles.

On the approach jetty, all piles between bents 7 and 26 have been replaced with steel box piles. A number of failed timber piles between bents 27 and 79 have also been replaced by either steel H piles or steel box piles. The timber decking on the T-Head section is in a dilapidated state resulting in this section being closed to the public in June 2003. This was achieved by the installation of a large security fence with appropriate signage at bent 75 as well as removal of sections of decking immediately past this point to further discourage would-be trespassers (photo 5)

Vehicular access to the jetty has been restricted by means of a physical barrier at the start of the jetty.

2 PREVIOUS INVESTIGATIONS

A number of investigations into the condition of the jetty have been undertaken in the last 20 years. These include the following:

- Report by (then) Civil Engineering Branch, Department of Marine & Harbors, 1987
- Rapid Bay Jetty, Update Assessment, Department of Marine & Harbors, May 1992
- Underwater Inspection of Piles, Seacon Australia Pty Ltd, October 1998
- Rapid Bay Jetty, Structural Assessment Report, June 1998, Maunsell Pty Ltd
- Report on the Testing of Timber Piles to the Rapid Bay Jetty, Integrity Testing Pty Ltd, November 2000
- Rapid Bay Pile Inspection, Seacon Australia Pty Ltd, July 2003

A copy of the 1987 report by the then Civil Engineering Branch could not be obtained however this is referenced to a large extent by the 1992 report by the Department of Marine and Harbors. The key points from these reports are summarised below in order to gain an understanding of the work already undertaken and get a representation of the rate of deterioration of the structure.

Report by (then) Civil Engineering Branch, 1987 (extracted from 1992 report)

- Superstructure steelwork in poor condition with up to 50% loss of section
- Timber piles and decking in poor condition
- Measurements of remaining pile percentages (see Appendix B)

Rapid Bay Jetty, Update Assessment, Department of Marine & Harbors, May 1992

- Timber decking and bearers seawards of Bent 28 are in poor condition and will require total replacement (completed)
- All timber piles between bents 26 – 79 recommended for replacement with steel piles
- Recommends the replacement of the majority of structural elements – all piles from bents 26 to 79 (not done), Timber decking from bent 28 to 79 (done), 80 % of girders to be replaced and remainder to be grit blasted and painted (not done)
- Steel crossheads and bracing to be grit blasted and painted (not done)
- Estimates of remaining pile percentage based on 1987 values extrapolated using an assumed deterioration rate
- Necking of some piles so extreme that collapse likely within 5 years
- Estimated cost of repairs $2.53M

The following is an extract from the Recommendations in this report:

"The Approach Jetty (Bents 0 – 79) is now approximately 50 years old and has clearly reached the end of its economic life. The condition of the structure now is such that routine maintenance is no longer feasible, and replacement of the majority of structural elements is the only option available to extend its working life"

Underwater Inspection of Piles, Seacon Australia Pty Ltd, October 1998

- Measurements of remaining pile percentages (see Appendix B)
- Extensive Teredo Worm infestation throughout timber piled sections (see Appendix E for article on Teredo Worms)
- The concrete encasement has failed on the majority of the piles

Rapid Bay Jetty, Structural Assessment Report, June 1998, Maunsell Pty Ltd

- For bents 27 and 32 (where the western piles are missing), gives an allowable axle wheel load of 1 tonne.
- For bents 29 to 80, indicates an allowable wheel load of 2.2 tonnes based upon the capacity of the piles using a reduced pile diameter of 200 mm (20% section area based upon 450 mm dia full section), 2.7 tonne allowable wheel load based upon the decking, and an allowable girder wheel load of 4.5 tonnes including section loss.
- Flange thicknesses of girders and crossheads appear to be reduced to less than half of original dimensions and most of the pile bracing has rusted away
- At bent 17 the seriously corroded crossheads are twisted with the western girder detached.

Report on the Testing of Timber Piles to the Rapid Bay Jetty, Integrity Testing Pty Ltd, November 2000

- Measurements of remaining pile percentages based upon Modified Shock Testing (a method involving striking the pile with a hammer and measuring the seismic wave)
- 124 Piles were tested (mostly western side and centre piles) with 50 being listed as Category 3 (defective piles with repairs required in next 2 – 3 years) and 64 Category 4 piles (either structurally redundant or with sufficient defects to the pile to be replaced immediately)

The following is an extract from the Conclusion in this report:

"It is our considered opinion that the majority of the piles are in need of repairs or replacement or serious redundancy of the jetty could occur in the near future"

Rapid Bay Pile Inspection, Seacon Australia Pty Ltd, July 2003

- Measurements of remaining pile percentages (see Appendix B)
- Only piles at bent 27 have concrete encasement remaining above waterline with remainder damaged or missing

3 STRUCTURAL CONDITION

The jetty has major structural defects with the condition of various sections of the structure very poor bordering on unsafe. The condition assessment of the Jetty was based on site inspections and previous engineering reports. For the purpose of this report the substructure incorporates all piles, pile bracing and crossheads and the superstructure incorporates everything above this level, i.e. the girders, girder bracing and timber decking.

Although the T-head section has been closed to the public, the major structural elements on this section are believed to be in a reasonably good condition as it was essentially re-built in 1968. This section was closed in June 2003 following damage to the timber decking during a storm. The T-head section of the jetty has not been inspected as a part of this report.

3.1 Superstructure

The timber decking and timber cross girders have been progressively replaced within the last decade and are generally in a good condition.

The condition of the girders and bracing ranges from fair to very poor. The steelwork from bents 1 to 10 was grit blasted and repainted during the 1980's however corrosion is again onset with flaking and section loss present.

The steelwork on bents 11 to 75 ranges from poor to very poor with substantial amounts of flaking and delamination corrosion resulting in large amounts of section loss with holes in both the webs and flanges of the girders not uncommon (photos 6-10, 12). The steelwork on the western side that previously supported the conveyor system and is exposed (ie, does not support decking) is in very poor condition. There are numerous corrosion holes in the both the girders and bracing, with a number of bracing connections having failed (photos 11, 13). Likewise the steelwork supporting the timber decking is in very poor condition. It is important to note that the original design incorporated extra thickness sections to act as a corrosion allowance. Although no definitive measurements have been undertaken in this review, the level of corrosion is much greater that the initial corrosion allowance and generally appears greater than 50% of section.

3.2 Substructure

The substructure consists of twin steel channel crossheads supported on either timber or steel piles. The original timber piles remain from bent 1 to 6 whilst the piles between bents 7 to 26 have been replaced with steel box piles. The majority of the piles from bents 27 to bent 79 are the original timber piles with steel box or H piles at a few locations where the timber piles have failed.

The timber piles from bents 1 to 6 are on the shoreline and are in good condition. The steel piles from bents 7 to 26 and at various locations from bents 27 to 79 are also in a good condition, however they exhibit areas of surface corrosion and minor flaking, but are within acceptable levels.

The steel crossheads are heavily corroded with large areas of flaking corrosion and section loss. Holes in the webs and flanges of the crossheads are not uncommon (photo 12).

The original timber piles from bents 27 to 79 are in a very poor condition with numerous heavily necked piles, especially at bents 28, 29, 41 and 42 (photos 14-19). The piles on the western side of the structure are generally the worst as the swell predominantly comes from a north-westerly direction (see Location Plan, Appendix A). A number of piles on the western side have necked to the extent that they have broken off and now "hang" from the superstructure steelwork. These 'hanging' piles are supported by the girders spanning between two bents and by the steel crosshead cantilevering from the central pile. At bents 11 and 15 the wave action acting on the "hanging" pile on the western side has resulted in the pile twisting and breaking the twin steel channel crosshead and falling off (photo 13). It is

fortunate that the majority of the failed piles have occurred at the intermediate supports of the girders and not at the ends where the bolted splice plates are located, allowing the girders to span between 2 bents. The exception is at bent 32 where the pile has failed at the girder splice location, which results in the pile purely relying on the support of the crosshead cantilevering from the central pile.

Concrete encasing of the timber piles to above high water level has been used as a repair method since the 1970's to increase their life. The 2003 report by SEACON indicated however that only 2 of these encasings were still sound to above water level indicating that this method has been rather unsuccessful in being an effective long term repair at this location. It also highlights the amount of energy that is exerted on the piles from wave action.

A desktop analysis of the pile condition data for bents 27 to 79 (piles up to bent 26 are all in a serviceable condition) has been undertaken (see Appendix B) and is summarised in Table 3.1 below:

	West Pile			Centre Pile			East Pile		
	1987	1998	2004	1987	1998	2003	1987	1998	2003
Satisfactory	25	24	8	49	44	23	49	48	17
Poor	21	11	21	3	7	24	3	5	29
Very Poor	7	18	24	1	2	6	1	0	7

Table 3.1 – Breakdown of Pile Condition by Year
2004 values assessed from visual inspection 12/11/2004
There are 159 piles between bents 27 and 79

Pile assessments for similar structures have been based on previous criteria used by the then Department of Marine and Harbours and are defined as follows:

- **Satisfactory** - greater than 50% of remaining pile cross-sectional area.
- **Poor** – between 50% and 30% of the remaining pile cross-sectional area, with maintenance/repairs required.
- **Very Poor** - less than 30% of remaining pile cross-sectional area and beyond repair with replacement necessary.

Table 3.1 highlights that the condition of the piles has decreased rapidly between 1998 and 2003/4. By extrapolation of individual pile condition to 2007, a rapid shift from satisfactory into the poor and very poor categories is predicted. This rapid deterioration is graphically represented in Figure 3.1 below.

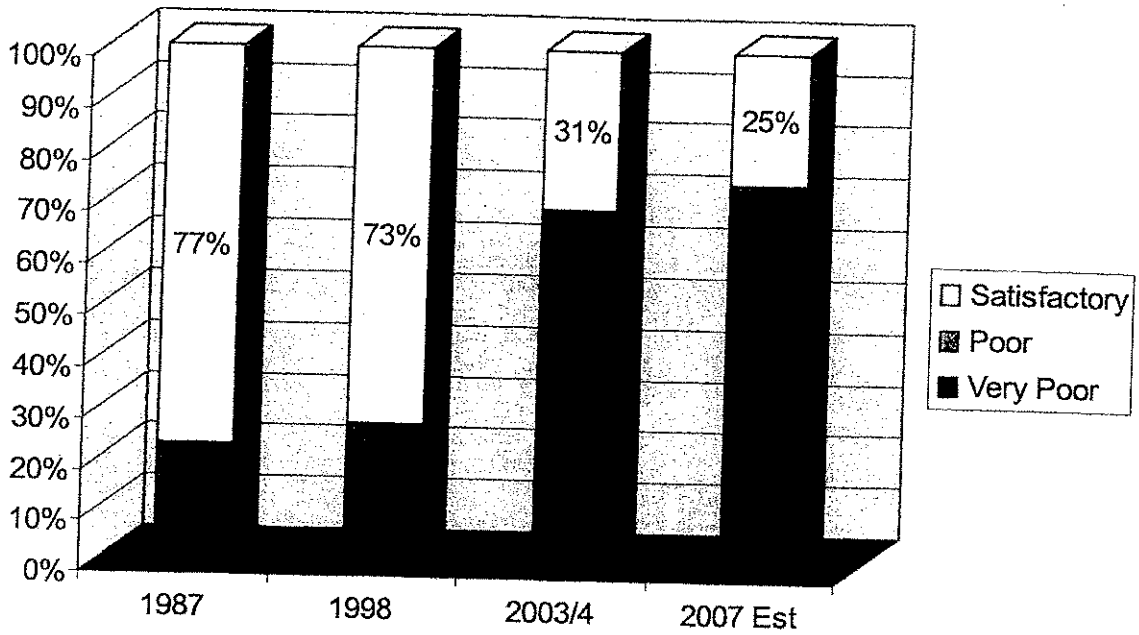


Figure 3.1 –Breakdown of Pile Condition – All Piles from Bent 27 to 79

This deterioration rate is of concern given that all timber piles between bents 27 and 79 were recommended for replacement as far back as 1992 and it is obvious that further deterioration has occurred since this time.

The distribution of pile condition (by satisfactory, poor and very poor) along the structure is depicted in Appendix B. This provides a virtual plan assessment of pile condition along the structure and highlights the clustered zones of poor pile condition that exist.

Piles on the western side are in a worse condition than the central and eastern piles. As the conveyor system previously located along the western side has been removed, the western piles only support the self-weight of the remaining steelwork along this edge of the structure. The loadings from the timber decking are almost entirely taken by the eastern and central piles. This results in the western piles being somewhat redundant, however at the locations where they have necked to the extent that they have failed, additional load is placed upon the remaining piles from the self-weight of the steelwork and the remaining "hanging" section of piles. The "hanging" piles also exert large twisting forces on the crosshead channels during rough seas.

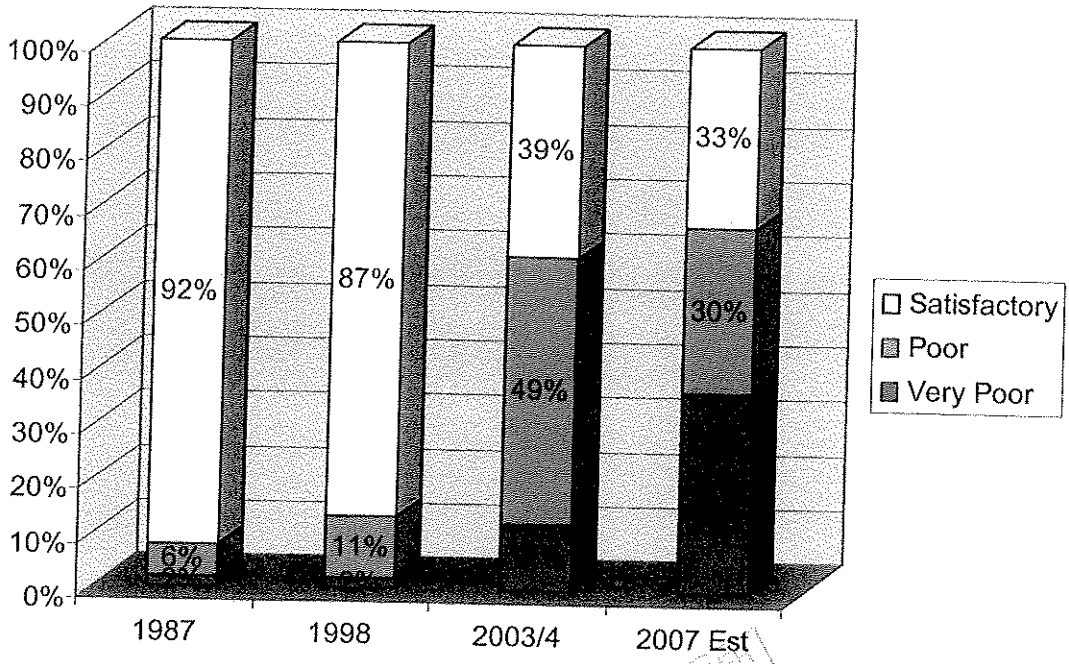


Figure 3.2 –Breakdown of Pile Condition – Central and Eastern Piles Only from Bent 27 to 79

Figure 3.2 indicates that if the western piles are ignored, there will still be more than two thirds of the remaining piles in a poor or very poor condition by 2007.

Regardless, there are still deficiencies in lateral stability due to the absence of raker piles and ineffective steel crossbracing between piles and bents. Although lateral loads (from wind) would have reduced since the dismantling of the conveyor system, there are concerns about the lateral stability of the structure between bents 38 and 79 due to loss of a number of the original timber raking piles. The overall lateral stability is also compromised at the locations where the western pile has failed. The raking piles at bents 54, 56, 60, 64, 66, 70 and 72 have failed (photo 20 typical). This requires the lateral wind or wave loads being taken by "frame action" of the bents, which greatly increases the chance of the piles failing in bending at the necking locations. If the piles at one bent were to fail, the most likely failure mechanism is that 2 spans of the jetty will collapse. It is unlikely that progressive collapse of the entire structure will occur simultaneously.

The 1998 report by SEACON and the 2000 report by Integrity Testing indicated that a large number of piles are suffering from Teredo Worm infestation. Teredo worms, or 'shipworms" are also known as the "termites of the sea". The worms invade the timber when they are tiny larvae and once inside they quickly grow. Teredo worms create a honeycomb of holes in wood. The wood may look fine externally except for a few small holes, but be entirely eaten away inside (an article on Teredo Worms is provided in Appendix E).

4 RISK ASSESSMENT

A qualitative risk assessment has been undertaken (excluding T-head) in order to determine the risk of this facility to users and the Agency. This risk assessment has been based on AS 4360 – Risk Management and DTUP in-house literature and procedures. This process establishes a "Likelihood" and "Consequence", from which the risk rating can be determined and then mitigation options considered. The template used for this Risk Assessment is provided in Appendix D for reference purposes. The risk has been evaluated on the event of two spans collapsing.

This assessment has been separated into two sections (start to bent 26 and bents 27 to 79) as each segment is sufficiently different (steel to timber piles) to warrant a separate risk analysis.

4.1 Bents 27 to 79

Likelihood

This has been assessed as *POSSIBLE.*

Should occur at some time. A 25 – 75% chance of occurring within a 12 month.period and may arise at least once in a 5-year period.

This Likelihood appears consistent with the probability of a storm event causing the heavily necked piles to fail, and hence result in the collapse of 2 (or more) spans of the Jetty. The next scale down represents a likelihood occurrence during the next 5 – 20 years, which is considered to be too lenient considering the poor condition of the structure.

Consequence

This has been assessed as *MAJOR*

Serious injuries, major component failure, severe disruptions and economic uncertainty.

It could be argued that loss of life may occur during the collapse of the Jetty during a storm event, hence resulting in a consequence of CATASTROPHIC. However it was deemed that MAJOR was the more appropriate consequence, as "total destruction" was unlikely. For this section of the jetty, the timber piles would fail in a brittle manner without prior warning.

Risk Rating

Computed as EXTREME

The combined effect of the above Likelihood and Consequence gives the Jetty from bents 27 to 79 an overall risk rating of ***EXTREME***. Risk mitigation options necessitate immediate action (i.e. closure) and requires the development and implementation of a specific risk management plan. This would include designing, constructing and maintaining a suitable physical barrier in order to prevent access to this part of the structure (i.e. managing the consequence).

4.2 Start of Jetty to Bent 26

A similar exercise has been done for this section, with "Likelihood" reducing to UNLIKELY and "Consequence" reducing to MODERATE. This computed an overall risk of MODERATE (two levels down from EXTREME).

As the piles in this section are in a serviceable condition, the failure mechanism would be the yielding of the steel girders which would most likely occur in a ductile fashion, thus providing sufficient warning for users to take evasive action. It is considered that failure is unlikely in the next 5 years.

Risk mitigation options necessitate the development and implementation of a specific risk management plan. This should include a regular inspection program and periodic monitoring (by measurement) of the residual steel thicknesses of both the girders and crossheads at a number of locations.

Based on this risk assessment, the section of jetty up to bent 26 could remain open but given that doubts exist about its future serviceability there appears to be little benefit in attempting to keep it open. This section is tidal with generally low water depth and therefore would not appeal to users for fishing or diving purposes if left open.

5 MAINTENANCE OPTIONS

5.1 Option 1 – Maintenance/Repair

The current condition of the structure is such that maintenance is not an option. Any repairs from bent 27 onwards would in effect default to "reconstruction" of the jetty. The piles have deteriorated to the extent that new piles are required. In any event, the existing girders and crossheads have corroded to such an extent that structural connectivity to new piles would prove to be ineffective.

The section loss of the superstructure steelwork has advanced to the state that grit blasting and painting would also be ineffective.

The existing piles up to bent 27 are in a serviceable condition.

5.2 Option 2 – Reconstruction

Reconstruction of the jetty along the same alignment would prove complex, environmentally sensitive, extremely costly and a waste of taxpayers money.

Alternatively, a smaller (modest in comparison) recreational type jetty can be constructed closer to the township and could be carried out at less cost.

The construction of a 200m long, 3m wide steel piled, timber deck jetty is anticipated to cost in the range of $1.5 to 2.0 million (subject to design and final estimates).

6 CONCLUSION / RECOMMENDATIONS

6.1 Start of Jetty to Bent 26

This section of the jetty is in a better condition than the rest of the structure, primarily because the majority of the timber piles have been replaced with steel piles. The risk of a structural failure has been determined as **MODERATE.**

It is strongly recommended that Materials Technology, Transport SA be engaged to measure the residual thicknesses of both the girders and crossheads at a number of locations. This will allow the degree of corrosion to be measured and hence determine the remaining life for this section of the structure.

This section of the jetty could remain open but given that doubts exist about its future serviceability, there appears to be little benefit in attempting to keep this section of the jetty open.

6.2 Bent 27 to Bent 79

The condition of this section of the jetty has now reached the stage where it poses an unacceptable risk to users. The risk of a two span collapse has been determined as **EXTREME**. The timber piles have deteriorated to the extent that they could fail during rough seas or collapse simply as a result of total section loss.

The collapse of a pile in the centre or on the eastern side of a bent would possibly result in the collapse of two spans of the jetty. The replacement of these timber piles has been recommended as far back as 1992 and their poor condition can no longer be ignored. Numerous piles are also suffering from Teredo Worm infestation, which may result in the timber appearing fine, but being entirely eaten away inside.

Pile deterioration rates between 1998 and 2003 (bents 27 to 79) predict that by 2007 42% of all piles will be in a very poor condition requiring replacement

The superstructure steelwork is also in a very poor condition.

It is recommended that due to the poor condition of the piles and superstructure steelwork that this section of the jetty immediately be closed to public access.

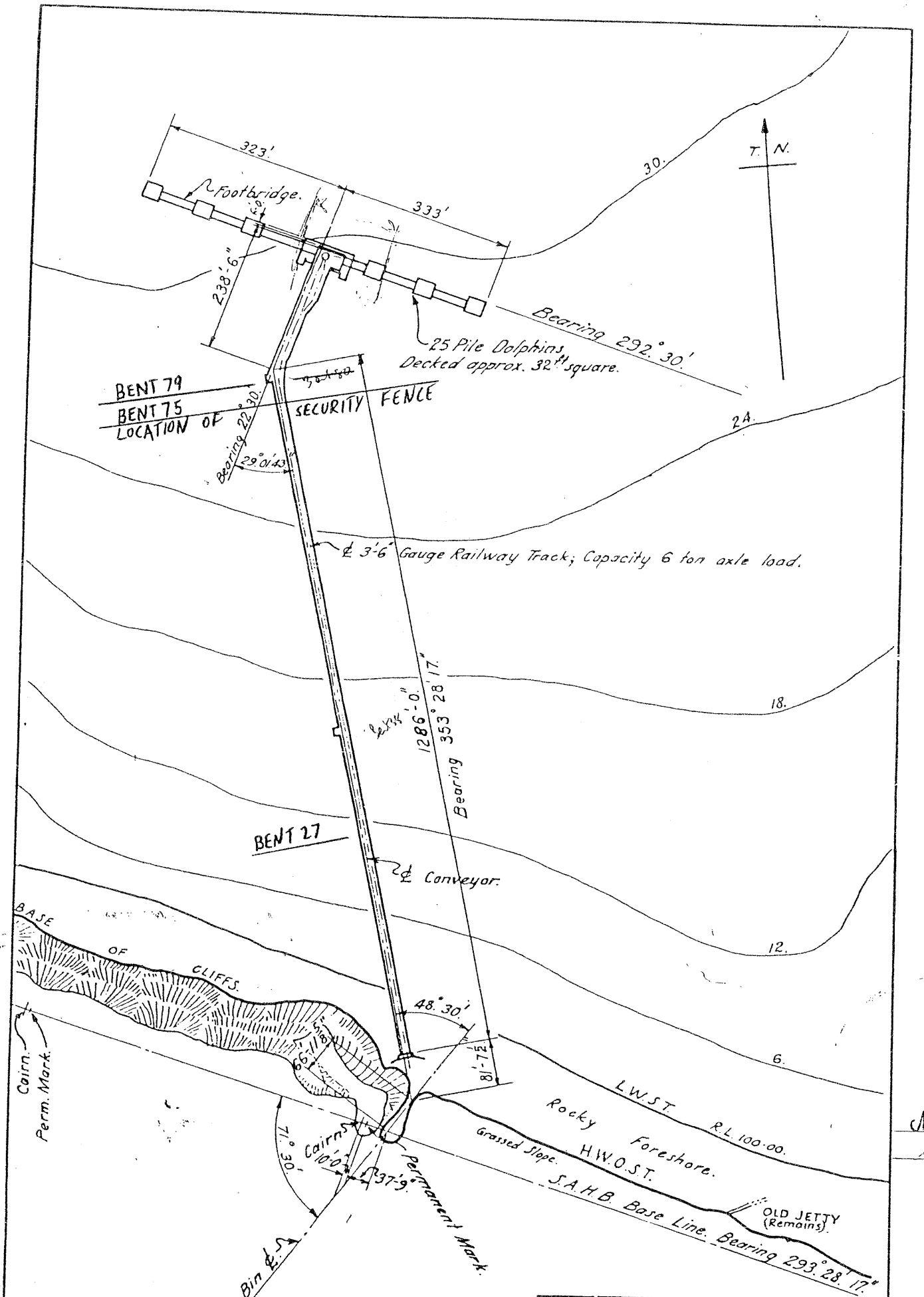
G. W. Chaplin.

G CHAPLIN
MANAGER, STRUCTURES

01/12/2004

S DIMAS
MANAGER, MARINE FACILITIES

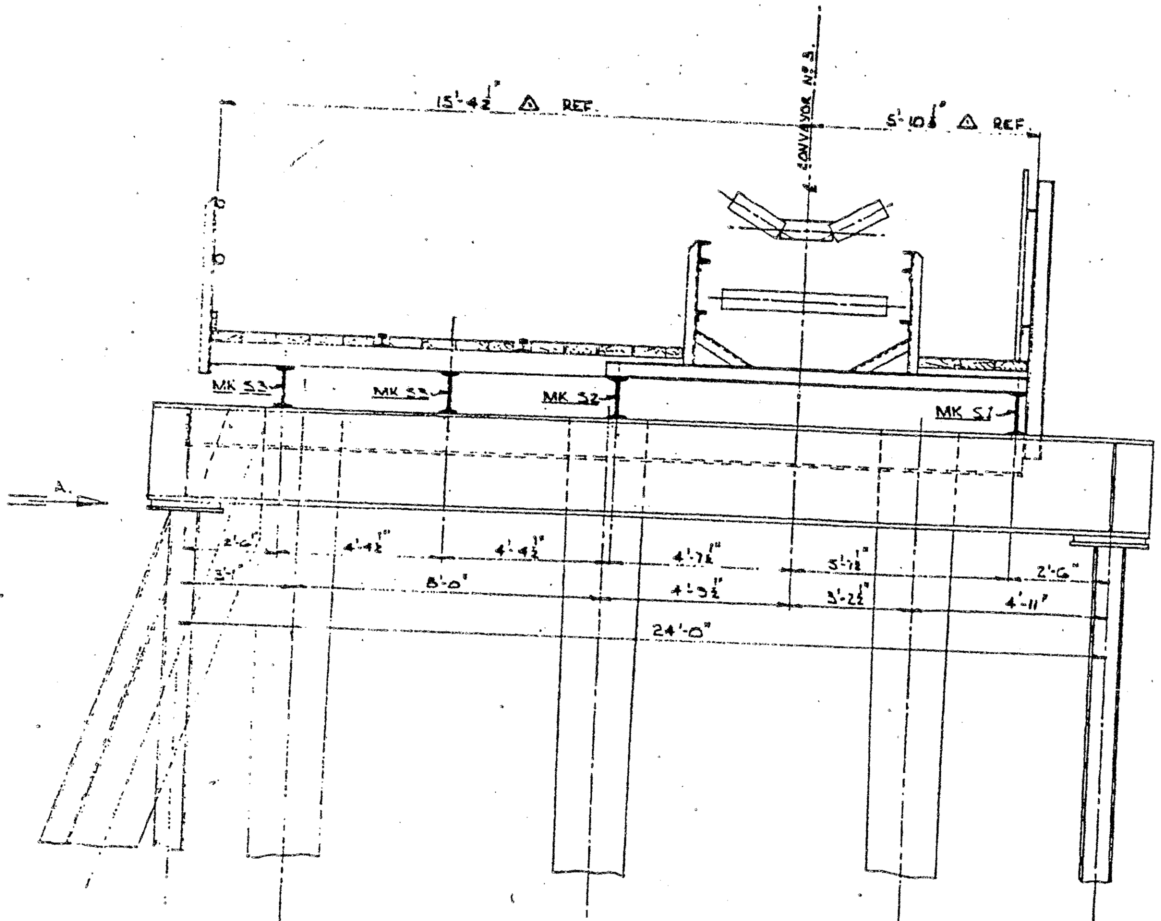
01/12/2004



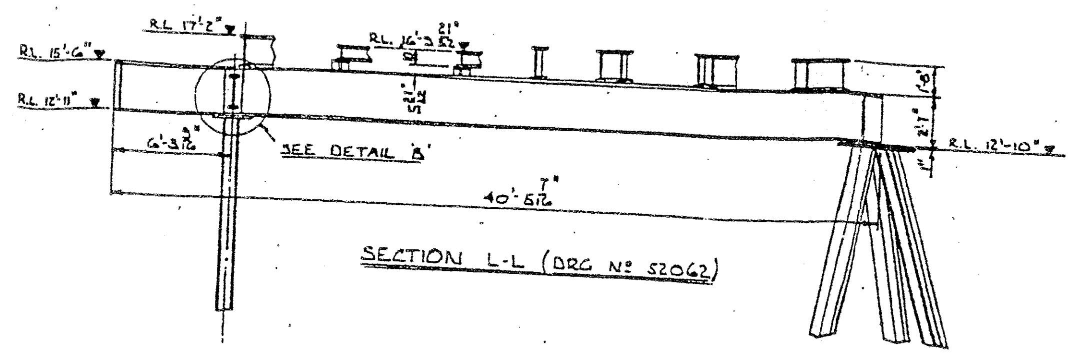
NAVIGATION AIDS
Consist of one red light to each dolphin.

NOTE: Read in conjunction with S.A. Harbours Board Drawg 8904 PH20.

JETTY: RAPID BAY.	
LOCATION PLAN.	
B.H.P. Co. Ltd. WHYALLA. S.L	
Drawn: A.J.W.	C.D. SKETCH
Scale: 200'-1"	



SECTION K-K (DRG Nº 52062)



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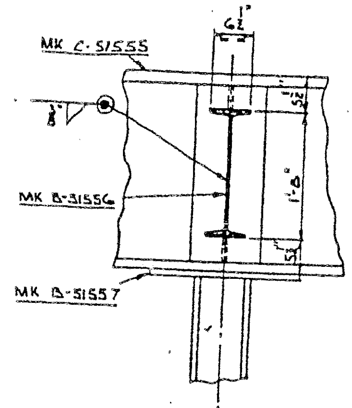
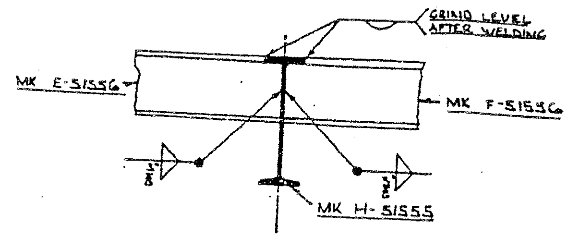


DETAIL 'B'



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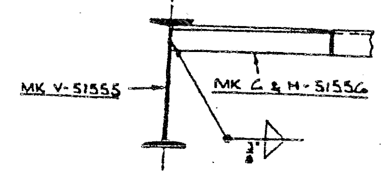
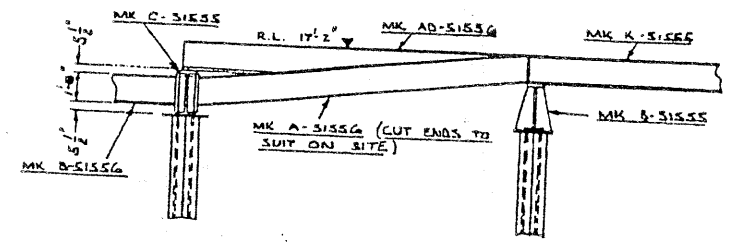
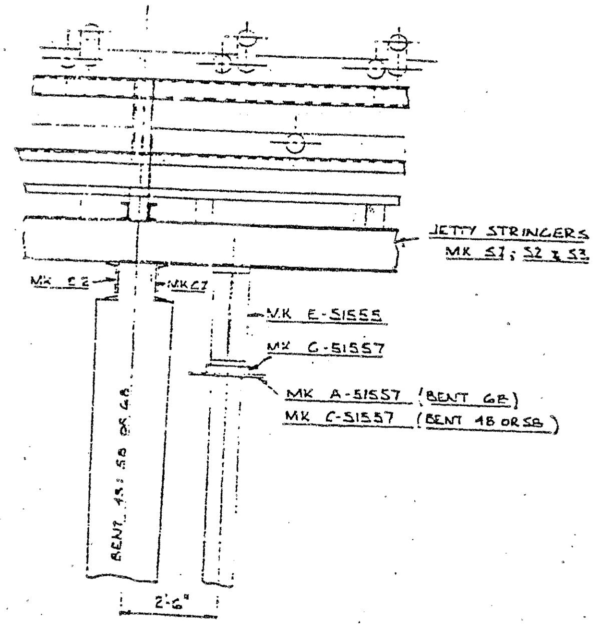


SECTION N-N (DRG Nº 52062) △



SECTION P-P (DRG Nº 52062) △

FOR PLAN SEE DRG Nº 3764



VIEW 'A'

(SAFETY RAILS & FENCING OMITTED)

PROCEDURE:—

BENTS 48; 58 & 68 PLUS 2'-6"

1. REMOVE EXISTING JETTY BRACING MK B1 & B2 FROM BETWEEN BENTS 48-49; 58-59 & 68-69
2. DRIVE PILES & CUT OFF AT R.L. 13'-4" (SEE PILING NOTES 1; 11 & 12 DRG Nº 51554
3. WELD PILE CAPS MK A-51557 (BENT 68) & MK C-51557 (BENT 48 & 58) IN POSITION
4. SLIDE CROSS HEADS MK E-51555 UNDER JETTY AND PACK UP UNTIL WEIGHT OF JETTY STRINGERS IS TAKEN UP BY THE CROSS HEADS (APPROX 2")
5. WELD EXISTING JETTY STRINGERS MK S1; S2 & S3 TO CROSS HEADS MK E-51555.

NOTES:—

1. DIMET COATING DAMAGED BY SITE WELDING ETC. MUST BE REPAIRED.
2. ADDITIONAL STRUCTURE ALL WELDED, ALL WELDS 3/8 CONTINUOUS FILLET UNLESS OTHERWISE NOTED.
3. ALL FLAME CUT SURFACES MUST BE UNIFORM, SMOOTH AND FREE OF ALL LOOSE SCALE & SLAG BEFORE WELDING.
4. THIS DRAWING TO BE READ IN CONJUNCTION WITH DRG Nºs 51560 & 52062

REFERENCE DRAWINGS:—

51554 CROSS HEADS & STRINGERS
51557 PILE CAPS & SPACERS
51560 CROSS HEAD DETAILS BENT 48; 58 & 68
52062 STEEL MARKING PLAN BENT 37 TO 88

COLOR CODE:—

EXISTING STEELWORK.

STEELWORK TO BE ADDED.

No. Off	Mark No.	Description	Material	Wt./unit
383/15/-	Job No.	JETTY – RAPID BAY JETTY SECTION & DETAILS		

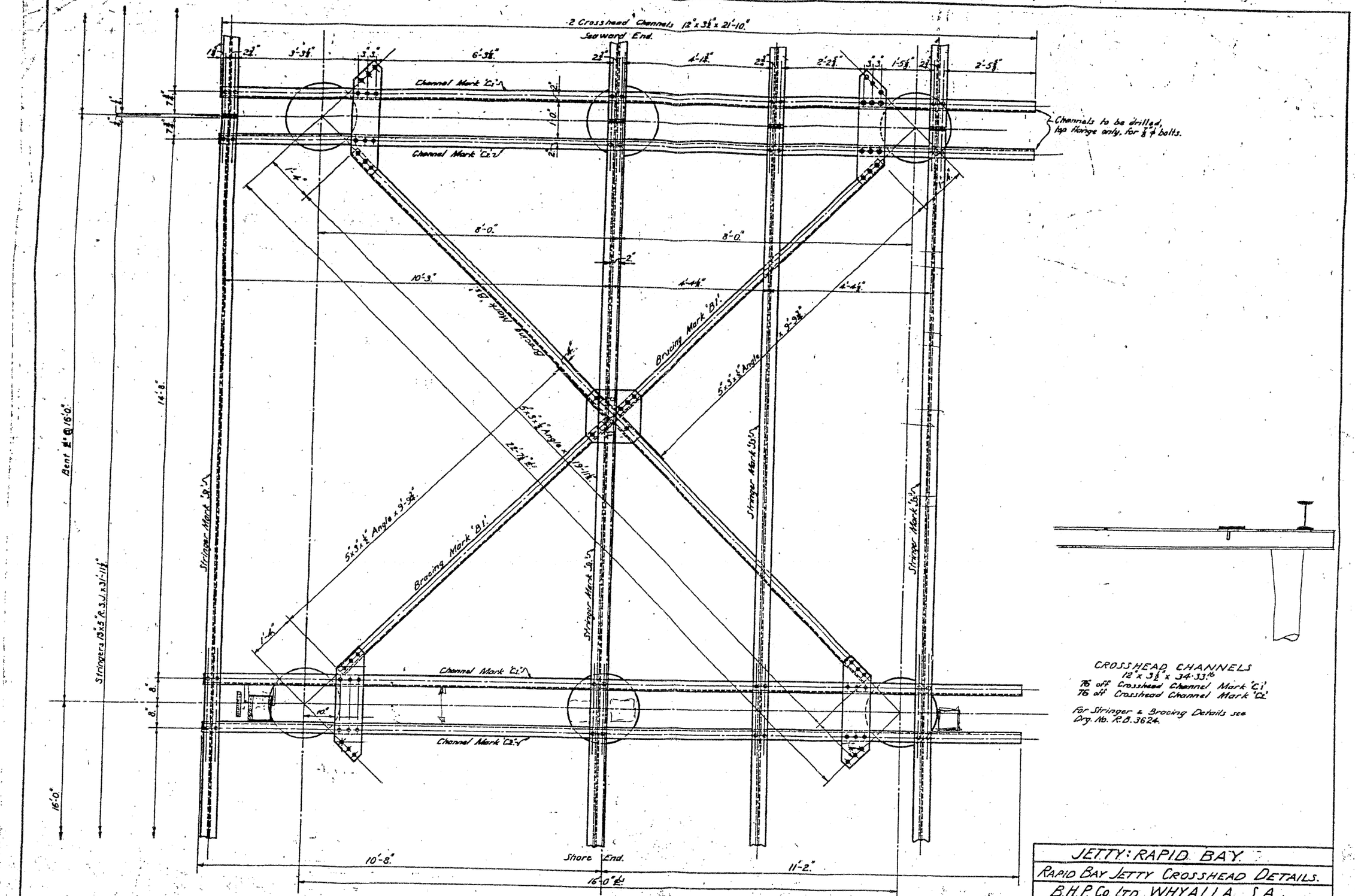
Revision		
3. SECTION P-P ADDED (DRG Nº 52062) 30-7-68 H.C.H.	2 SECTION N-N ADDED (DRG Nº 52062) 21-5-68 H.C.H.	1 REF DIMNS ADDED SECTION K-K (52062) 18-4-68 H.C.H.

DATE 15th FEBRUARY 1968		SCALE ¼ ; ½ & 1" = 1'-0"
DR. H.C.H.	CH. P.E.K.	DRG. No.
TR.	TR. CH.	51558C
S.D.E.		
C.D.E.	C.E.	

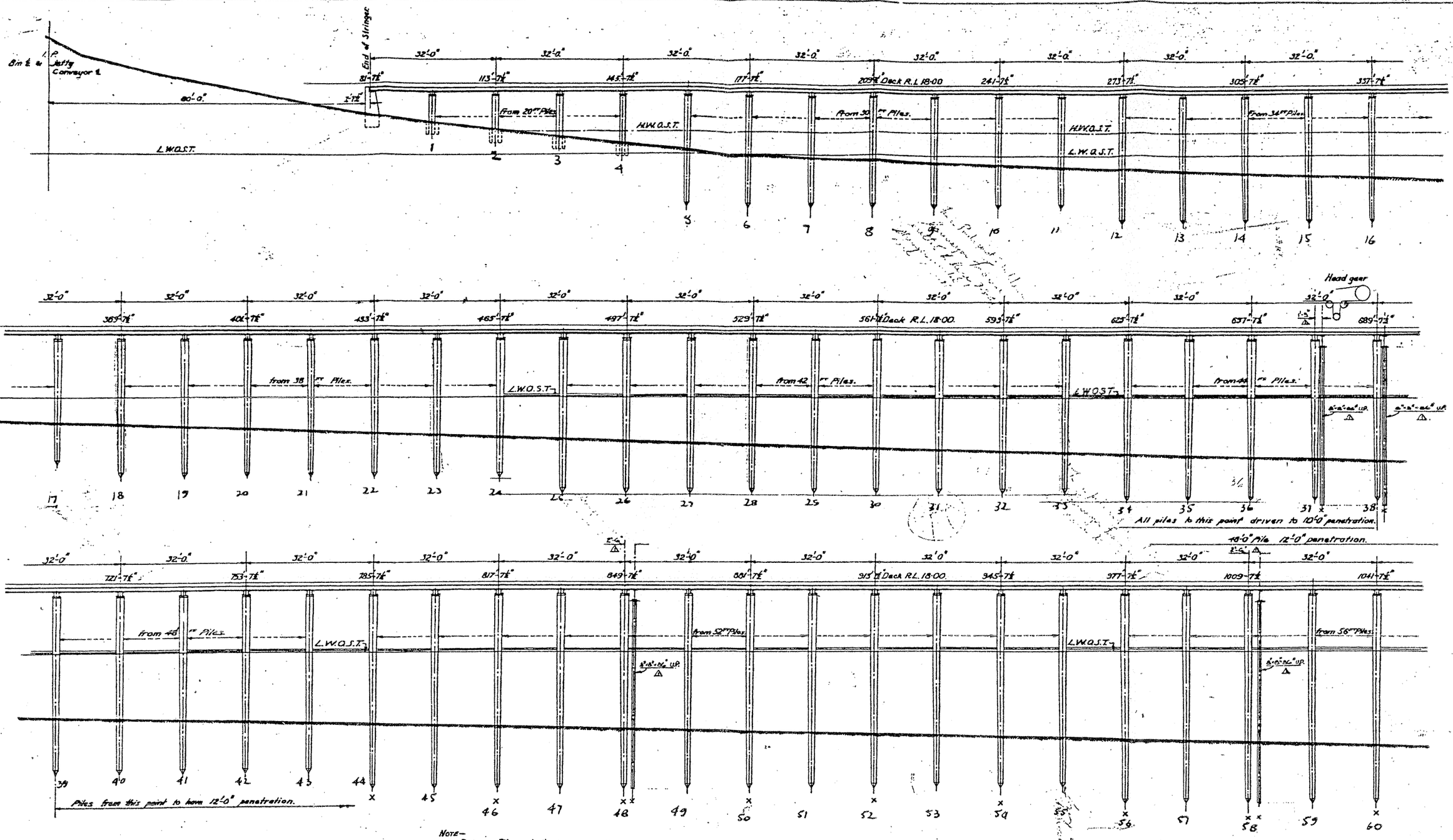
THE B.H.P. CO. LTD., WHYALLA, S.A.

51558

22 21 20 19 18 17 16 15 14 13 12 11 10



JETTY: RAPID BAY.	
RAPID BAY JETTY CROSSHEAD DETAILS.	
B.H.P. Co. LTD., WHYALLA, S.A.	
Drawn : A.J.W.	Scale : ½"=1'
Traced : A.J.W.	DRG No R.B. 3622
Checked :	
Approved :	
Date : 19·6·40.	



NOTE—
Raking Piles indicated thus X
8'×8'×60" UNIVERSAL PILE SECTION ARE SINGLE SECTION PILES ONLY ON THIS DRAWING.

38'

1. ADDED 6'-8"-60" U.P. 4 PILE BENTS REMOVED. 26-2-40 H.C.H. R.B.R.	REVISION.	JETTY - RAPID BAY
		PROFILE ON CENTRE LINE — SHORE END
		B. H. P. Co. LTD., WHYALLA, S.A.
		Drawn: A.W. — Scale: 10'-1"
		Traced: H.D.L.
		Checked: W.B.
		Approved:
		Date: 25·4·40

DRG. No. 3603C
RB

3E27 3E23 3E19 3E15 3E11 3E7

3E28 3E24 3E20 3E16 3E12 3E8

3E29 3E25 3E21 3E17 3E13 3E9

3E30 3E26 3E22 3E18 3E14 3E10

4 @ 7'-6" = 30'-0"

29'-3" FENDER LINE

3 @ 10'-6" = 32'-0"

No 3 EAST DOLPHIN

PILE CUT-OFF HEIGHTS

No. 3E1 – 3E7 = RL 16·98'

No. 3E8 – 3E30 = RL 15·38'

No 3 WEST DOLPHIN
STEEL PILES AS FOR No 3 EAST DOLPHIN

No 2 WEST DOLPHIN
STEEL PILES AS FOR No 3 EAST DOLPHIN

No 1 WEST DOLPHIN
STEEL PILES AS FOR No 3 EAST DOLPHIN

TRUE NORTH

JETTY

℄ GULLET CONVEYOR

℄ JETTY CONVEYOR

℄ BENT 95 1582'–11"

℄ BENT 94 1582'–11"

STEEL RAKING PILES INDICATED THUS

℄ OF FRONT JETTY HEAD COLUMNS

No 1 EAST DOLPHIN
STEEL PILES AS FOR No 3 EAST DOLPHIN

No 2 EAST DOLPHIN
STEEL PILES AS FOR No 3 EAST DOLPHIN

No 3 EAST DOLPHIN
STEEL PILES — SEE ENLARGED DETAIL

TIMBER RAKING PILES INDICATED THUS.

1 VERTICAL
19 RAKERS NEEDED

1 vert 2 rake

1 vert 10 rake

SEE DRAWINGS

JETTY – RAPID BAY – STEEL PILES

3846 " – PILING LAYOUT AT JETTY HEAD

7821 CRUSHING PLANT – RAPID BAY – GEN ARRGT OF JETTY HEAD

13571 STEEL DOLPHIN ARRGT & MARKING PLAN

13632 PIVOTED WALKWAYS BETWEEN DOLPHINS. LOCATION PLAN & DETAILS.

13640 FIXED WALKWAYS BETWEEN DOLPHINS. LOCATION PLAN & DETAILS.

⚠ 13074 ARRGTS WALKWAYS BETWEEN DOLPHINS. 32°-23½" WEST

15075 " " " " 32°-23½" EAST

15076 " " " " 7 EAST & 1 WEST

NOTE

JETTY, BRIDGE AND DOLPHIN PILES CUT WITH TOPS AT R.L. 6·1" SHEWN THUS

SPRING PILES CUT WITH TOPS AT RL 14'-3 SHEWN THUS + (TIMBER PILES ONLY)

POSITION OF LIGHTING POINTS ON MAIN JETTY AND JETTY HEAD OF TRACK LEVEL SHEWN THUS — L.P.

JETTY & JETTY HEAD PILES (TIMBER) 322

JETTY RAKING PILES 23 TIMBER & 8 STEEL

JETTY HEAD SPRING PILES 4 (TIMBER)

DOLPHIN WALKWAY PILES 15 (TIMBER)

DOLPHIN PILES STEEL DOUBLE 10"x8"x81" RSB 138

" " STEEL SINGLE 10"x8"x81" RSB 42

⚠ DOLPHIN WALKWAY PILES 38 STEEL DOUBLE 10"x8"x8" Is

" " SINGLE 10"x8"x81" Is RAKING PILES

DOLPHIN WALKWAY PILES RELOCATED	24-8-66	4-4-68	W.F.D.	H.D.M.
No 3 WEST DOLPHIN MOVED 14' WEST 3 PILES 20'-0" BETWEEN No 2 & No 3 WEST DOLPHINS	12-1-1404	1153	J.W.S.	W.R.
POSITION OF No 1 EAST, Nos 2 & 3 WEST DOLPHINS CHANGED. PILE LAYOUTS AS AS No 3 EAST	24-9-69	4059	W.F.D.	H.D.M.
POSITION OF No 2 EAST DOLPHIN CHANGED	5-3-69	3826	W.F.D.	D.W.I.
ALTERATION TO No 3 EAST DOLPHIN PILE LAYOUT	1-10-68	3648	E.R.S.	
No 3 EAST DOLPHIN MOVED & CHANGED	15-5-68	3631	E.R.S.	
MODIFIED TO SUIT PLANT AS ERECTED AH	23-1-68			
Revisions	Date	C.S.E.	Surv'd.	Cklsd.

THE B.H.P. CO. LTD., WHYALLA, S.A.

JETTY RAPID BAY

JETTY AND DOLPHINS PILE LAYOUT

Scale 1" = 32'-0"

DRN. R.M.C. CH. J.L.M.

TR. R.KNIBBS TR. SUP. J.L.M.

C.S. APP'D C.E.

Dwg. No. RB4295 J

APPENDIX B

Pile Percentages

Pile Condition Data
Remaining Pile Area Percentages

	West				Centre				East			
Bent No.	1987	1998	2004	Ass. 2007	1987	1998	2003	Ass. 2007	1987	1998	2003	Ass. 2007
79	65	70			0	0	0	0	70	70	50	38
78	65	70	51	48	70	75	40	19	70	65	50	41
77	65	65	31	24	75	75	60	51	75	75	60	51
76	60	65	47	45	75	75	60	51	75	80	50	32
75	55	15	20	13	70	70	50	38	75	75	70	67
74	55	40	39	39	75	75	40	19	75	75	60	51
73	50	45	36	34	70	65	55	49	75	75	65	59
72	60	60	20	13	75	65	55	49	60	40	35	32
71	65	65	51	48	70	70	60	54	75	75	70	67
70	5	100	100	100	75	75	35	11	70	70	30	6
69	40	0	0	0	70	70	60	54	70	60	40	28
68	65	65	20	12	70	70	50	38	65	100	100	100
67	65	60	20	13	75	65	50	41	75	70	50	38
66	50	55	31	27	65	60	40	28	65	70	35	14
65	60	70	33	26	70	70	50	38	70	65	35	17
64	55	5	20	23	60	65	40	25	60	65	40	25
63	55	60	47	45	60	55	45	39	50	60	35	20
62	45	0	0	0	65	70	40	22	65	60	40	28
61	55	60	47	45	70	75	65	59	75	75	60	51
60	55	40	44	45	70	65	35	17	75	75	45	27
59	50	50	14	7	70	75	70	67	55	55	40	31
58A			100	100							100	100
58	45	30	44	40	70	65	65	65	65	100	50	20
57	40	20	0	0	60	30	40	35	60	70	35	14
56	35	20	22	20	70	75	60	51	55	65	40	25
55	55	65	50	47	65	75	55	43	60	60	35	20
54	20	25	10	7	65	65	60	57	70	70	45	30
53	45	55	36	32	70	75	65	59	65	65	50	41
52	75	65	44	40	75	75	50	35	75	75	45	27
51	45	45	39	38	65	50	40	34	75	75	55	43
50	65	50	24	19	70	75	55	43	60	65	45	33
49	45	55	24	18	60	65	35	17	60	70	50	38
48	40	100	100	100	50	50	35	26	70	65	100	100
47	40	30	36	35	70	65	60	57	30	35	15	3
46	60	50	24	19	60	50	30	18	65	65	50	41
45	75	75	51	47	65	70	50	38	70	70	55	46
44	20	15	15	15	60	65	60	57	60	65	60	57
43	70	65	22	14	65	70	45	30	55	55	30	15
42	70	70	44	39	65	65	40	25	40	35	15	3
41	45	35	47	49	55	35	15	3	60	55	30	15
40	40	35	10	5	55	60	35	20	60	65	50	41
39	60	60	39	35	65	70	60	54	65	60	55	52
38	45	100	100	100	45	40	0	0	65	100	100	100
37	40	100	100	100	65	60	60	60	75	100	100	100
36	45	15	5	3	80	75	65	59	60	65	60	57
35	50	0	0	0	70	60	70	65	75	75	80	75
34	55	40	39	35	60	60	50	44	75	60	45	36
33	50	30	36	35	100	100	100	100	70	65	45	33
32	5	0	0	0	70	55	60	55	70	60	50	44
31	30	0	0	0	75	45	20	6	75	65	60	57
30	60	45	33	31	65	60	35	20	55	55	50	47
29	15	0	0	0	60	65	30	9	55	40	25	16
28	50	5	10	10	100	100	100	100	65	60	20	0
27	30	0	0	0	45	45	45	45	50	50	50	50

Note: Timber piles on shoreline bents 1 - 7 and in good condition.
Piles on Bents 7 to 26 replaced with Steel Box Piles

Denotes this section closed
Steel Piles
Satisfactory Condition - Pile Area >50%
Poor Condition - Pile Area >30% <50%
Very Poor Condition Pile Area <30 %

1987: Report by then Civil Engineering Branch
1998: Underwater Inspection by SEACON Australia
2003: Underwater Inspection by SEACON Australia
2004: Inspection by Structural (2003 Values updated)
2007: Estimated values based on deterioration between 1998 and 2003 inspections

APPENDIX C

Photographs

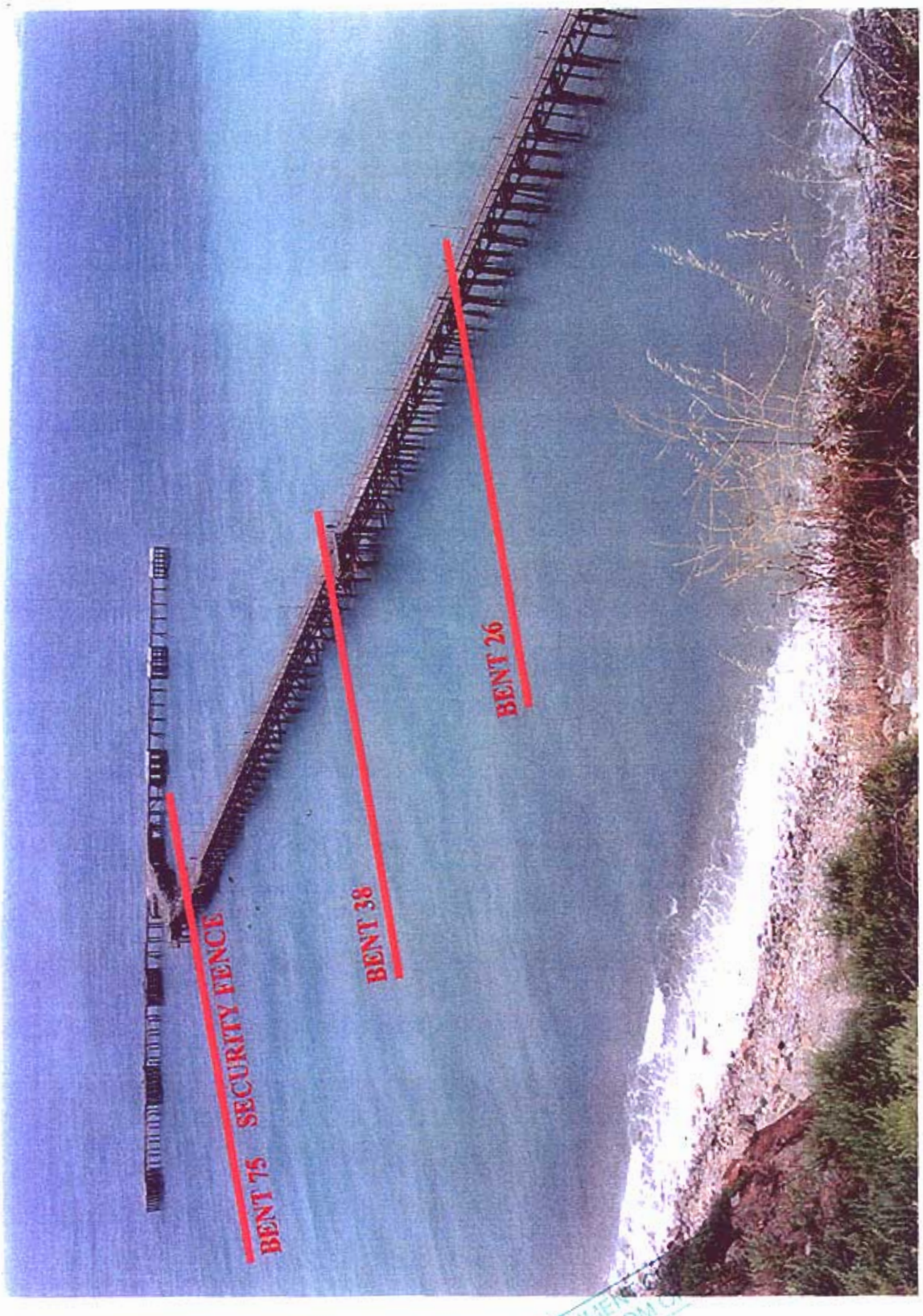


Photo 1 – Rapid Bay Jetty Layout

Photo 2 – General Underside of Approach Jetty (new steel piles adjacent to existing timber piles)

Photo 3 – Western Side of Jetty Looking South

Photo 4 – Typical Detail at Bent at Ends of Girders

Photo 5 – T-head Section With Decking Removed

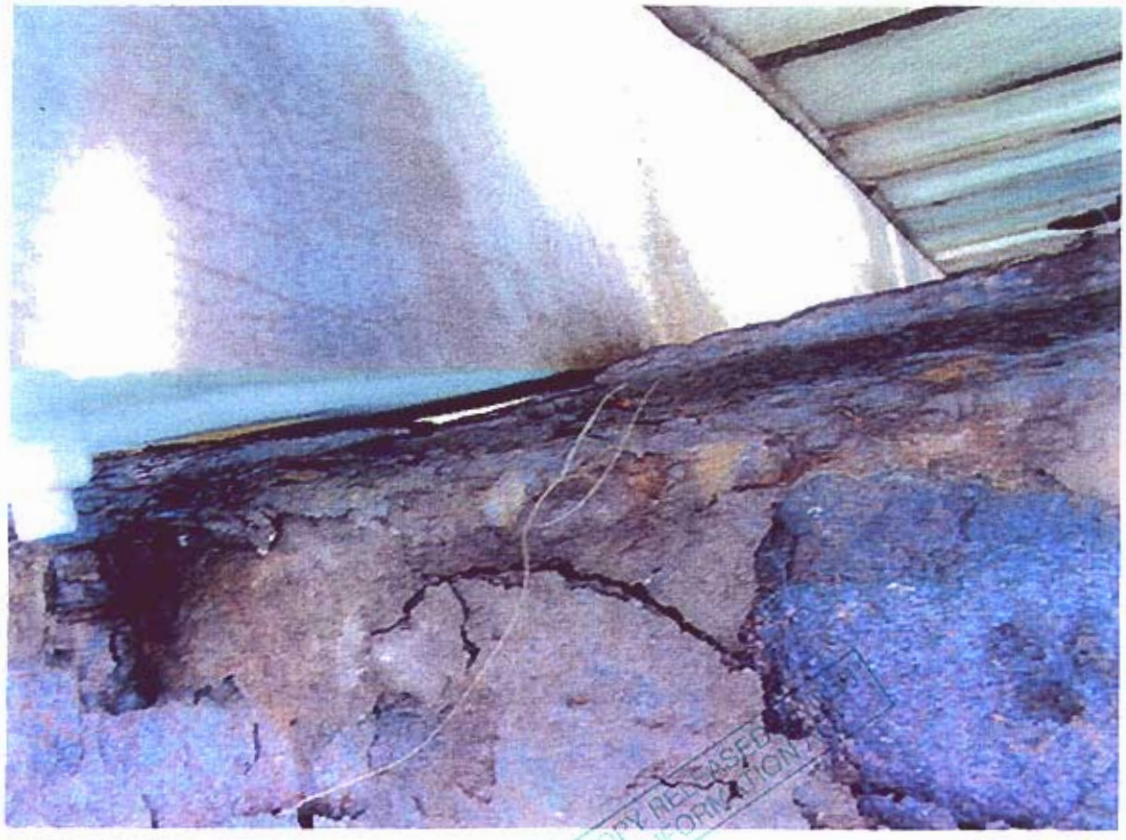


Photo 6 – Hole in Girder Top Flange

Photo 7 – Jacking Corrosion of Girder Top Flange

Photo 8 – Typical Girder Corrosion

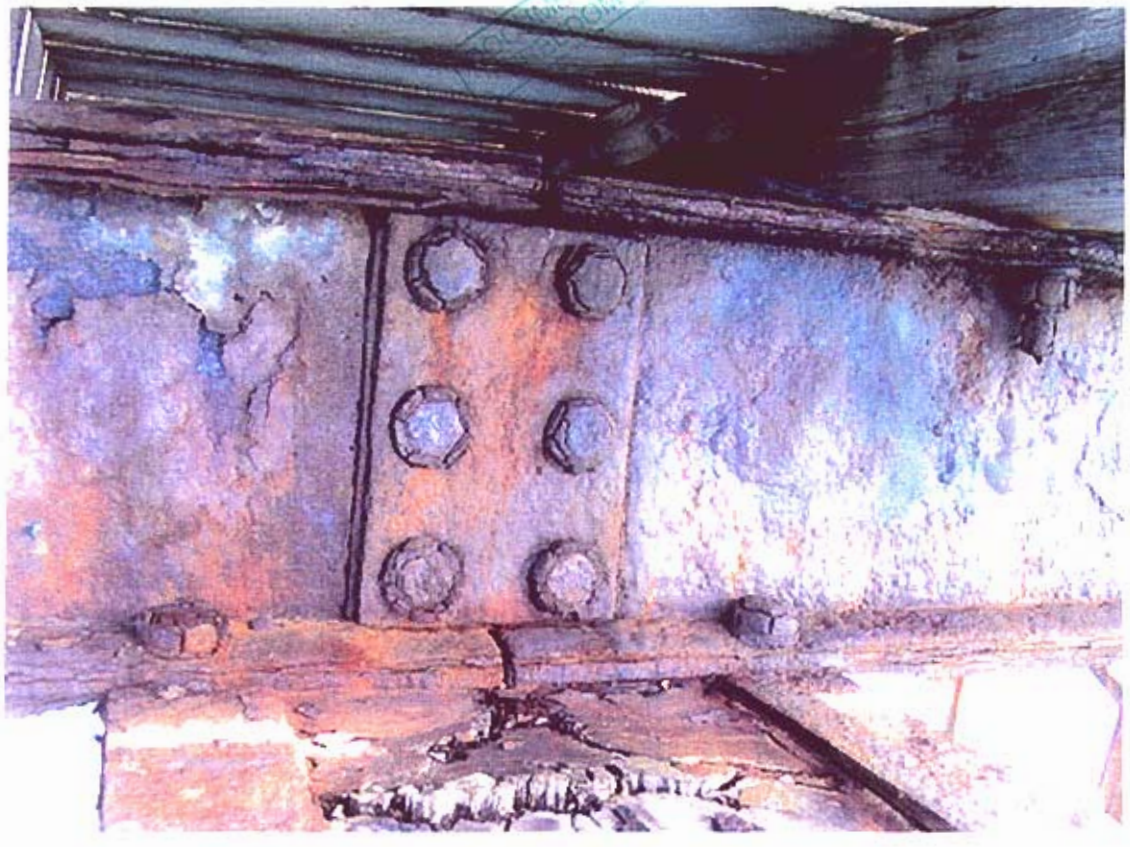


Photo 9 – Typical Girder Corrosion

Photo 10 – Girder Corrosion – Hole in Bottom Flange

Photo 11 – Steelwork Corrosion, Bent 16 - Western Side

Photo 12 - Hole in Crosshead Web – Bent 19, Western Side

Photo 13 – Pile Missing, Crosshead Broken – Bent 11, Western side

Photo 14 – Typical Pile "Necking"

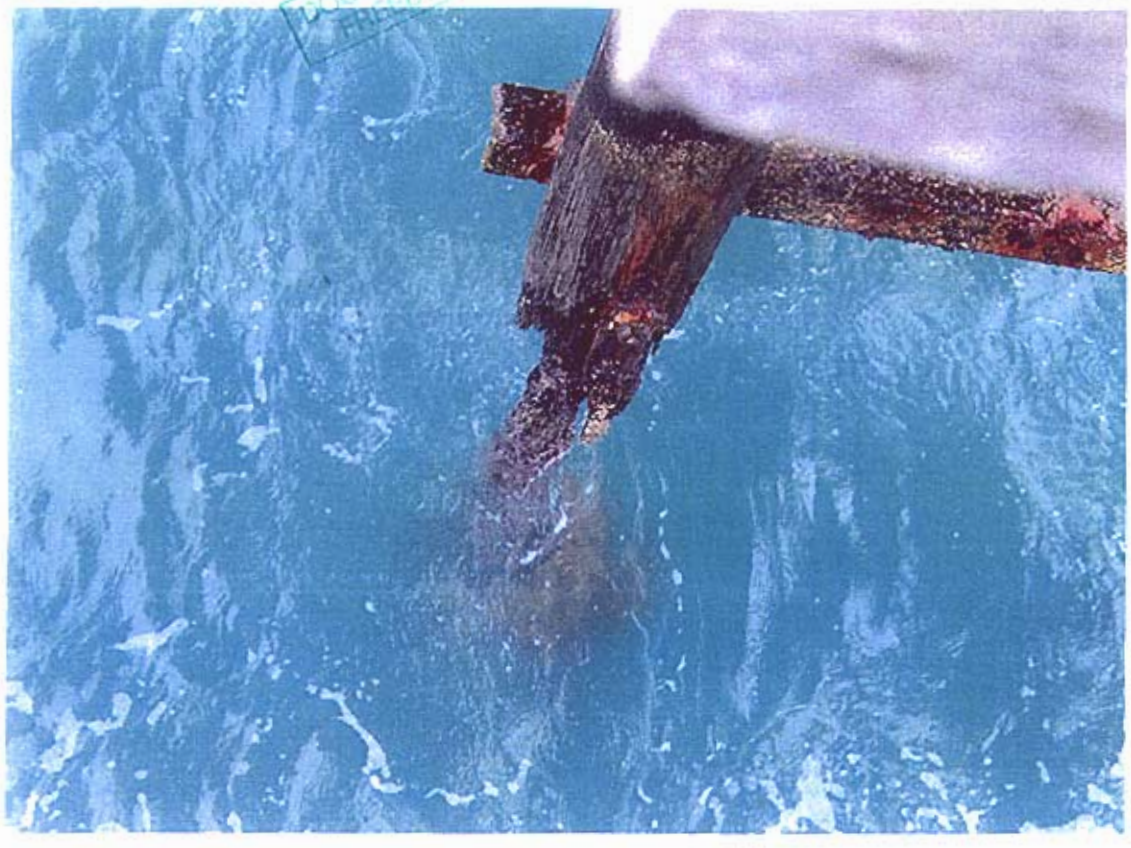


Photo 15 – Heavy Pile "Necking" – Bent 47, Eastern Side

Photo 16 – Heavy Pile "Necking" – Bent 47, Eastern Side

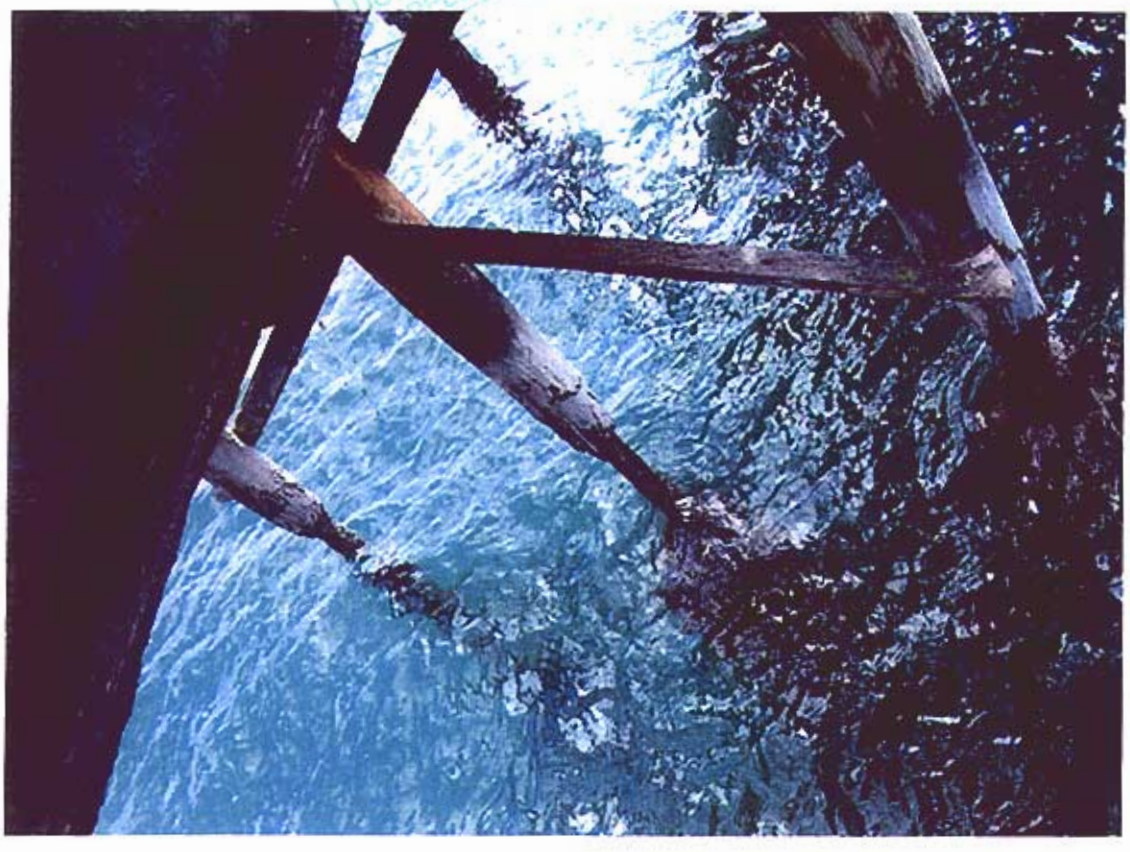


Photo 17 – Pile "Necking" – Bent 46

Photo 18 – Typical Pile "Necking"

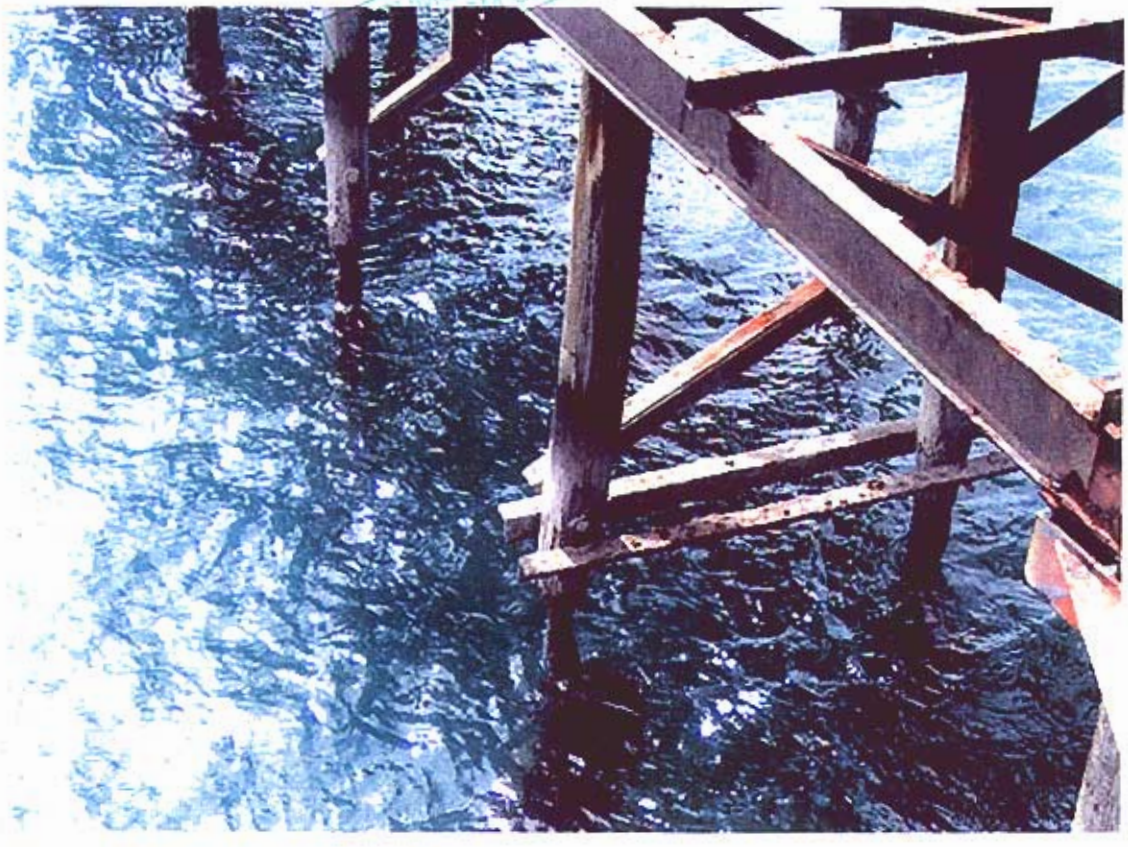


Photo 19 – Typical Pile "Necking" – Bents 40 & 41

Photo 20 – Broken Raking Pile, Bent 64, Eastern side

Photo 21 – Typical Bracing Corrosion

APPENDIX D

Risk Assessment Template

Risk Template to AS 4360

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	High	High	Extreme	Extreme	Extreme
Likely	Moderate	High	High	Extreme	Extreme
Possible	Slight	Moderate	High	Extreme	Extreme
Unlikely	Low	Slight	Moderate	High	Extreme
Rare	Low	Low	Moderate	High	High

Definitions

Likelihood	
Almost Certain	Expected to occur. Greater than 95% chance of occuring within a 12 month period and will occur at least several times a year.
Likely	Will probably occur. A 75 - 95% chance of occuring within a 12 month period and will occur once in a year.
Possible	Should occur at some time. A 25 - 75% chance of occuring within a 12 month period and may arise at least once in a 5-year period.
Unlikely	Could occur. A 5 - 25% chance of occuring within a 12 month period. May occur during the next 5-20 year period.
Rare	Will only occur in exceptional circumstances. Less than 5% chance of occuring within a 12 month period. Very unlikely to occur during the next 20 years.

Consequence	
Insignificant	No real consequences
Minor	No injuries, disruptions or economic loss but may have some short term effect on tourism / "image"
Moderate	Minor injuries, some dirsuption and economic lossses that can be recovered in a short period (up to 6 months)
Major	Serious injuries, major component failiure, severe disruptions and economic uncertainty
Catastrophic	Loss of life, total destruction, cessation of operations of facility, economic hardship

Risk	
Extreme	Immediate action required. Develop and implement specific risk management plan.
High	Develop and implement a specific risk management plan.
Moderate	Either accept and manage or develop and implement a specific risk management plan.
Low	Accept and manage by routine procedures.

APPENDIX E

Article on Teredo Worms

Teredo navalis

Size: to 5 "

This worm-like creature is actually a bivalve mollusk with a greatly reduced shell, which it uses to bore tunnels into wood. They typically spend their entire lives in a tunnel in a single piece of wood. In addition to feeding off the wood, they can also filter-feed like ordinary bivalves.

In the age of wooden ships, teredos and other wood-borers were a tremendous problem. In our area, more wood boring is done by crustaceans than Teredos.

more

'Termites' of Sea Tell Rotten Tale

Shipworms, Gribbles Devour Bulkheads At Alarming Rate

By Ana M. Alaya - Star-Ledger January 27, 2004

For decades, the Hudson River and the waters of the metropolitan area ran thick with the contaminants of industry and the piers and wharves reeked of the foul fumes of factories. As pollution ebbed, the waterfront turned from toxic to gold, giving rise to luxury condominiums, marinas, hotels and ferry terminals among the shipping ports. But lurking below the water is a new threat - the shipworm. Known as "termites of the sea," the tiny, wood-eating creatures have become a growing nightmare for waterfront property owners, devouring millions of dollars worth of underwater timber.

As pollution has waned on the Hudson and New Jersey's coastal waters, shipworms and another type of marine borer known as the gribble are on an alarming comeback, officials say, transforming the wood in wharves, bulkheads, piers and boats into brittle honeycomb. "If you go back 25 years ago, marine borers weren't a problem," said Casimir J. Bognacki, who heads a marine borer-monitoring program for the Port Authority of New York and New Jersey. "There was too much pollution." Now, they're more widespread, Bognacki said. "They started showing up 15 years ago. In the past two years, they've been showing up in areas they didn't before."

Using the shell, the shipworm bores into

The shipworms are forcing agencies and private owners to spend millions to repair or

replace timber structures. Solutions can be pricey. In some cases, concrete is used to reinforce pilings, the long wood poles that are driven into a riverbed to support piers and wharves. In other cases, different types of plastic sheaths are wrapped around the underwater pilings to block the voracious marine mites.

wood like this piece of bulkhead at Launer's Forked River property.

Shipworms, also called Teredos, are actually not worms. They are mollusks similar to clams, with worm-like bodies that live in saltwater or brackish water. They invade wood when they are at a larval stage and then start devouring the cellulose interior, growing up to a foot long, until the wood disintegrates. "Wherever you have untreated timber, you're going to have problems with shipworms," said David M. Cacoilo, a partner and design engineer at Mueser Rutledge Consulting Engineers in New York, which has worked on a dozen marine borer projects. "Once they're there, the potential for the population to explode is tremendous."

Shipworms are not new. They've been a scourge for sailors and pier builders for centuries until pollution drove them away. During Columbus' fourth voyage to the Caribbean, he was forced to abandon two ships because of shipworm infestation. Another wood muncher giving marina owners grief is the gribble, also called Limnoria. This tiny saltwater isopod attacks the wood surface, reducing a piling to an hourglass shape.

The gribbles and shipworms concern the Port Authority, which is currently overseeing three multimillion-dollar maintenance projects that include marine borer damage control. One project entails wrapping pilings with plastic at two Brooklyn piers. Another involves concrete reinforcement of pilings at a pier near the Holland Tunnel. At the Port Newark Marine Terminal, the authority is spending about $8 million on repairs, some specifically targeted to reduce borer damage to berths where ships load.

While the berths are not in danger of collapsing at the terminal, the Port Authority wants to protect them from further damage. "No one can predict the rate of loss," said Robert C. Gill, an environmental analyst for the Port Authority. Variables that affect the rate of infestation include the type of wood, he said. Some piers and berths, often built with Douglas Fir or Southern Yellow Pine in the 1950s or'60s, are untreated. Others were treated with creosote, a

Attack of the Marine Borers

Shipworms
Teredo navalis, also known as the seaworm or sea termite.

Shipworms look like worms, but are really bivalve mollusks related to clams. They invade wood when they are tiny larvae. Once inside the wood, this animal grows quickly and ranges in size from 6 inches to 6 feet in length. Shipworms create a honeycomb of holes in wood. The wood may look fine, except for a few small holes, but be entirely eaten away inside. It only takes two or three months for severe damage to occur.

distillate of coal tar that prevents borer attacks until the chemicals leach into the water.

In New York, the city's Department of Transportation spent $6.1 million for underwater surveys of borer damage to thousands of pilings supporting the Franklin D. Roosevelt and Harlem River Drives and two small bridges, and is preparing to bid a multimillion-dollar contract for repairs. "The whole idea of this is to do it before it becomes unsafe and, quite frankly, to do it before it becomes expensive," said Henry D. Perahia , deputy Transportation Commissioner for engineering in New York City.

NJ Transit has also been monitoring the marine borer problem since the mid-1990s and will replace infested pilings at the Hoboken Ferry Terminal with concrete-filled steel pipe pilings as part of a $79 million restoration project, according to Ken Hitchner, a spokesman for the agency. "The steel pipes will totally mitigate any kind of shipworm issue," Hitchner said. "Steel isn't part of their diet."

Gribbles
Limnoria lignprum,
also known as a sea mite.

Gribbles are tiny, almost microscopic crustaceans that resemble a wood louse with seven pairs of legs and four pairs of mouthparts. They make up for their small size by attacking in huge numbers. They damage wood more slowly than the shipworm, but the damage is just as devastating.

Laurie Triefeldt, Star Ledger

Donald Launer, a lifelong sailor in Forked River, spent $18,000 to replace a shipworm-infested bulkhead with treated wood and vinyl parts. According to the U.S. Nuclear Regulatory Commission, various studies agree that heated effluent from the Oyster Creek Nuclear Generating Station have increased the abundance of a tropical wood-boring species in the Barnegat Bay area. "It was obvious that the bulkhead was failing and when I went under to look, I found all these holes in it," said Launer, an author who lectures on shipworms and other nautical issues. "The shipworms have attacked nearly every bulkhead in my lagoon."

In Edgewater, the shipworms have taken the spotlight in a multimillion-dollar civil suit. Owners of the 514-unit Independence Harbor Condominiums claim the developer is responsible for $18 million worth of repairs to the shipworm-damaged pier on which the homes were built. Dale Ludwig, president of the condo association, said when he bought his luxury home on the 1,500-foot pier in Edgewater, where a Ford Motor plant once shipped cars, trucks and tanks in the 1920s, he was attracted to the Manhattan skyline and scenic river view. He didn't know about shipworms. "I had no clue," said Ludwig. "We're homeowners, not experts in everything." Lawyers for the developer, Hartz Mountain Industries, claim the marine borer infestation is not at a level that threatens the structural integrity of the pier. They claim the salinity of the water is lower there than in the lower Hudson River, where most of the serious borer damage is occurring.

Andy Willner, the NY-NJ Baykeeper, said despite the cost of the shipworm problem, environmentalists are cheering the return of the marine borers because they indicate the river is cleaning up. "I guess it's called hubris when people build something they think can't be attacked by wind or water," Willner said. "Nature wins in the end. I guess you could say this is a very late lunch bill coming in."