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CARNALLITE HARVESTING & SALT BOTTOM REPORT

DECEMBER, 1980

CARNALLITE HARVESTING & SALT BOTTOM REPORT FORMAT

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ATTACHMENTS

1) IIRS Report on Salt Bottom Pan C-1
2) Report-Carnallite Harvester Alternatives
3) Carnallite Harvester Dwg. No. SK-144
4) Meeting Minutes - 25 November 1980
5) Meeting Minutes - 26 November 1980
6) Plan Drawing of Pans
7) Overall Schedule

SECTION 1.0
SUMMARY

The 40 year record rains during the 1979/1980 winter season have caused extensive dilution of the Dead Sea. This dilution has resulted in a significant reduction in the quantity and uniformity of the salt bottom formed in C 1 carnallite harvest pan.

Tests performed on the salt bottom in C 1 by outside consultants (IIRS) now show conclusively the current RAHCO prototype harvester cannot be supported by any economic thickness of salt. This is contrary to earlier projections from Lison test pan results that indicated on a unit weight basis there were no problems. The conflict is due to difference in sub base soil between C 1 and the Lison test pan and it is compounded by an increase in weight of the RAHCO prototype from 135 short tons at time of purchase to an actual 245 tons after design development.

After a detailed study of alternative harvesters, we recommend an independent floating harvester to be operated on 40 cm of salt thickness. IIRS has confirmed this thickness and incorporated safety factor for the proposed harvester. The prototype independent floating harvester would be supplied by RAHCO from an existing barge and equipment relocated from the existing prototype machine.

Additional Dead Sea brine pumping facilities will be required to accommodate the weaker brine and thicker salt bottom requirements. After a study of alternative methods to increase brine flow, we have recommended a second pipeline as the quickest and most reliable system.

Section 1.0
Summary

A summary of preliminary cost estimates covering the necessary expenditures follows:

Item	U. S. Dollars
Added cost of harvesters	(2,000)
Second brine pipeline system	9,500,000
Dike crossings for harvesters	1,000,000
Temporary Dikes, etc.	500,000
Raising carnallite pan dikes	330,000
Total	11,328,000

If we do not install the additional brine pumping system, it will take approximately twice as long to lay salt bottoms of 40 cm resulting in a loss of 1,110,000 mt of potash over that planned in the feasibility study. If we proceed as proposed here, and project production on the same basis, 340,000 mt will be lost. This loss can possibly be reduced and every effort will be made in that direction.

In order to be prepared with sufficient brine to meet the 1981 summer season, it is imperative that approval be obtained for the second pipeline by mid January. The construction program is extremely tight and with any set-backs, we could miss the deadline. If we miss the 1981 season with the new brine, but make the 1982 season, additional product losses of 221,000 mt are possible.

RAHCO will propose a study and tests of other alternative harvesting concepts to be completed by June 1981. If their proposal appears worthwhile, the results of their study can be considered for inclusion in the design of the 2nd and 3rd harvesters, which must be ordered by June 1981.

Section 1.0
Summary

The order for the fourth harvester can be placed in the fall of 1982 and its design will incorporate early operating experience gained from use of the first three machines.

SECTION 2.0
INTRODUCTION

2.1 BACKGROUND

The thickness of harvest pan salt bottom for operation of crawler motivated harvesting machines in the feasibility study was set at about 15 - 20 cm. This thickness was based on experience of USA operations in similar salt pans. The study requested field tests to confirm thickness required under actual conditions.

Initial salt bottom test were run in Lisan Peninsula test pans in late 1978. Preliminary projection of test salt thickness showed we could expect about 26 - 27 cm of salt bottom in the production pans based on existing schedules. The plate bearing tests indicated this thickness would be acceptable for the weight of the harvester as then conceived.

Subsequently the prototype harvester underwent a design evolution which resulted in an increase in weight at the time of purchase placement with Rahco to 135 short tons and by late 1979 to 220 short tons. While plate bearing tests at Lisan still indicated this weight would be acceptable on a unit weight basis, concern began to develop that the difference between the firmer mud base at Lisan and the soft mud base in most of the production carnallite pan area could result in failure of salt through bending moment caused by the gross weight of the harvester.

In the spring of 1980, an outside consultant - the Institute for Industrial Research and Standards (IIRS) from Ireland - was retained. After a preliminary review and additional Lisan tests, IIRS concluded an accurate mathematical model was not possible and further tests should be conducted in harvest pan C1 in October when 14 - 15 cm of salt thickness would be available.

2.1 BACKGROUND - continued

Meanwhile, JIL prepared a report covering carnallite harvesting alternatives. This report examined a number of alternative harvester concepts and made specific recommendations depending on the capabilities of the salt finally determined by the IIRS after completion of C1 tests. The IIRS tests were completed in November 1980 and are discussed in more detail in Section 3.1.

A further complication developed in the winter of 1979/1980 when 40 year record rains diluted the Dead Sea brine. This caused a significant reduction in salt thickness over a large area of C1 pan during the 1980 evaporation season.

2.2 PURPOSE OF THIS REPORT

The purpose of this report is to provide answers or recommendations for the following items:

(a) Based on the IIRS salt bottom test report and JIL alternative harvester report, recommend final minimum salt bottom thickness and prototype harvester design.

(b) Recommend procedure for design and procurement of prototype and additionally required harvesters.

(c) Recommend necessary alterations and requirements for pre-concentration of Dead Sea brine prior to feeding to carnallite pans for salt bottom laying. Also, recommend additional requirements for increasing salt thickness as indicated by the IIRS report.

(d) Review impact of above items on project capital cost and schedules.

SECTION 3.0

SALT BOTTOM TEST RESULTS AND HARVESTER RECOMMENDATIONS

3.1 IIRS TEST REPORT (JIL SUMMARY)

A copy of the final IIRS test report is appended as Attachment No. 1. This report concludes the RAHCO prototype harvester cannot be supported by any economic thickness of salt bottom. The report analyses an alternative independent floating harvester on 40 cm of salt bottom.

3.1.1 From the test results it was established that the salt layer, acting with the subgrade, has characteristic load/deflection curves with clearly defined "elastic" and "plastic" zones. The interface between the two zones indicates the onset of cracking in the salt layer. To allow for repeated trafficing this interface is considered to be the "failure" point in the calculations which follow.

3.1.2 The report identifies the theory which gives good agreement with the test results, and, using this theory, the above mentioned curves and a 40 cm thickness of salt extrapolates to calculate the ultimate static loads for given sets of parameters. These results show that the subgrade conditions, as well as the salt quality, have a significant effect on the load carrying capacity. An ultimate static load for the proposed independant floating harvester track and typical salt and subgrade parameters is given as 246 KN.

3.1.3 A factor of safety of two on this ultimate static load is suggested to cover unforeseen factors in the governing equation as well as local variations in the salt and subgrade properties. It also reflects the less than critical consequences of a failure.

3.1 IIRS TEST REPORT (JIL SUMMARY) - continued

3.1.4 Two main conditional qualifications of the above mentioned results are given, firstly, that the subgrade and final salt properties at least match those in the area tested, and secondly, that the stresses resulting from traction do not significantly effect the salt layer carrying capacity, although this is thought to be unlikely. Further testing to confirm the former and quantify the latter is recommended.

3.2 RAHCO PROTOTYPE HARVESTER

3.2.1 The RAHCO Prototype Carnallite Harvester is now being assembled at the job site for testing in the Lisan carnallite test pan. This harvester is entirely supported on the salt bottom by tracks.

From conceptual design of 135 short tons this harvester increased in weight to 245 short tons.

The original concept of the harvester was for machine to be able to float in 2m of brine. This required ballast to provide traction in the deep end of the pans and bouyancy in the shallow end of the pans to minimize salt bottom pressure.

The increase in weight means that the RAHCO harvester cannot now float in any area of the pans. The bearing pressure on the bottom of the pans still remains within the 4.5 - 6.5 psi, but the size of the track has had to increase considerably to achieve this.

3.2.2 Because of the harvester weight and the geometry of the tracks, it was determined by the IIRS report that the RAHCO harvester could not be supported on any economic thickness of salt bottom.

3.2 RAHCO PROTOTYPE HARVESTER - continued

The problem was discussed in depth between APC, JIL & RAHCO to determine if the loading on the salt base could be reduced by cutting the weight of the harvester or adding permanent outrigger pontoons.

A decision was reached that there was no practical method at reducing the weight to an operating level. Increasing the salt thickness to accommodate present harvester would require six seasons and was therefore ruled out. Because of the consequences of a salt break-through, the IIRS recommended a safety factor of 6 to 1 for RAHCO unit. Recovery of the unit with pontoons is extremely difficult.

3.2.3 The testing of the RAHCO prototype harvester will still be carried out in the test pan as planned. We will be able to test crowding force requirements, performance of the cutterhead, slurry concentrations possible from the dredge pump and hydro-cyclone system, pumping rates, pipeline friction factors, general operating characteristics and specific harvester operation parameters. This information and data will provide significant input towards the final harvester design as all major equipment and operating parameters will remain the same.

3.3 OTHER ALTERNATE HARVESTERS

A special report "Carnallite Harvesting Alternatives" prepared by JIL in September, 1980 is shown in Attachment No. 2. Our basic conclusions in that report recommended the independant floating harvester if IIRS tests indicated the salt would not support the RAHCO prototype harvester. A final review of alternatives and recommendations follows.

3.3 OTHER ALTERNATIVE HARVESTERS - continued

3.3.1 Dual Unit Harvesters

In an effort to reduce the weight on the salt bottom we proposed a smaller track driven harvester which would consist of a cutterhead, primary slurry pump steering controls with all of the balance of the equipment installed on a floating barge. With this method it would be possible to reduce the weight of the harvester to approximately 80 tons. This harvester again would be a scaled down model of the present harvester. Because of the geometry of the tracks on the bottom the 80 tons would act as a unit load on the bottom.

Analyzing this against the IIRS test results, it was determined that the unit could not operate on the salt bottom with any reasonable safety factor.

3.3.2 Independent Floating Harvester

This concept consists of a barge on which all of the equipment from the present harvester would be installed.

The barge plus equipment is capable of floating on any section of the carnallite pan and thus the only weight required on the salt base is that required to propel the harvester and overcome the resistance of the cutterhead. This has been calculated to be a maximum of 50 tons. A proposed arrangement of four retractable standard D-5L catterpillar tracks with a loading of 12,5 tons each was analyzed by the IIRS and the conclusion was drawn that this unit could be operated in any area of the pan with a safety factor of 2. This safety factor was deemed adequate as stated in attached report. Attachment No. 3 is a layout drawing of the proposed harvester.

3.3 OTHER ALTERNATIVE HARVESTERS - continued

3.3.2 Independent Floating Harvester

At a meeting in Dublin between APC, RAHCO, JIL & IIRS, it was agreed that the concept of this independent floating harvester was a viable solution. Present estimate of operating harvester weight is 280 metric tons.

3.3.3 Cable Operated Floating Harvester

In this concept the harvester is a completely contained, single floating unit. Propulsion would be by four automatic computer controlled winches, one on each corner of the barge connected by cable to permanent anchors, two on each dike.

This was investigated earlier in project and was discarded because of high cost as compared to bottom driven harvesters Also, because of the great width of our harvest pans, path control would be very difficult to achieve with such long cables.

Consideration to this type of harvester would only be given if the salt bottom had proved to have no load bearing capacity.

3.4 RECOMMENDED HARVESTER

As agreed between APC, JIL & RAHCO, (see Attachments No's. 4 & 5) the most feasible solution would be the independent floating harvester.

The principle advantages are:

3.4.1 This is the only track driven harvester analyzed which can be operated with an acceptable safety factor in accordance with the IIRS Report.

3.4 RECOMMENDED HARVESTER - continued

3.4.2 The total weight of the harvester unit can be floated anywhere in the pans and the only weight imposed on the bottom is that required for propulsion and cutterhead crowd. This would amount to a total weight on the salt base of 50 tons during normal operation.

This weight is distributed over four (4) small tracks. The tracks are separated such that they can be analyzed as unit loads of 12.5 tons on the salt bottom.

3.4.3 For turn around the tracks can be retracted and the harvester can be turned by using the workboat. Physical damage to the salt bottom by the tracks from slewing on tight turns can thus be virtually eliminated. The only steering required on the tracks are then limited to minor course corrections.

3.4.4 For routine inspection and repair, the tracks can be retracted completely out of the brine using the operating hydraulic system.

3.4.5 If a replacement track is required, a whole unit can be replaced without taking harvester out of the pan. A new track (approx. 8 tons including support steel) can be installed from the dyke using a mobile crane.

3.4.6 Equipment is located on the barge so that there is plenty of room for inplace repair of equipment. If any equipment has to be replaced, this can be done with minor dismantling of adjacent equipment or services.

3.4.7 In the case of a track breaking through the salt bottom because of localized soft spots, the harvester can be recovered by retracting the tracks and floating from the area.

3.4 RECOMMENDED HARVESTER - continued

3.4.8 If the new barges which are available in Ireland at a reduced cost, are modified (in accordance with the attached minutes of meeting) and RAHCO complete the balance of the fabrication as agreed between APC, JIL & RAHCO, the harvesters can be delivered in time to meet our present program.

3.4.9 Because of the ease of maintenance, repair and recovery of the harvester considerable down time can be saved. Thus, the operating costs would be reduced significantly.

3.5 PROPOSED RAHCO TEST PROGRAM

RAHCO feel other possibilities for practical harvesters exist, but a study and test program would be required to explore and prove them out. However, the period available for the development of a new concept is very limited. We therefore requested RAHCO to provide a complete proposal for a study and test program to be undertaken concurrently with the procurement of a prototype independent floating harvester. A final report and recommendations would be submitted by June, 1981.

3.6 SALT THICKNESS & SAFETY FACTOR

3.6.1 With the proposed tracks operating at a maximum of 50 tons, we are within the limits of the 2 to 1 safety proposed by the IIRS on a salt thickness of 40 cm. This salt thickness requires two summer evaporation seasons instead of the single season proposed to date. The effects of the two season requirements are examined in Sections 4.0 and 5.0.

3.6.2 Dykes around the carnallite pans should be raised a minimum of 15 cm to accommodate the added salt thickness. Gibbs estimate that the cost of this would be approximately J.D. 100,000 if work is carried out in the near future.

3.7 SALT BOTTOM TREATMENT

We have investigated the possibility of emptying the carnallite pans at the completion of the salt deposition and air drying the salt. The improvement by air drying cannot be quantified at this time. Without further tests to establish that air drying would significantly improve the bearing capacity of the salt we could not recommend doing this at this time.

3.8 SUBSEQUENT SALT BOTTOM TESTING

At a point just prior to salt laying brine attaining the carnallite point, the salt bottom in each carnallite pan will be extensively tested as recommended by IIRS.

3.9 USE OF DYES

From practical experience at the site and from looking through the available literature we feel that adding dye can increase the evaporation rate in the range 15 percent for brine of specific gravity 1,23 to 1,26. In order to maintain the desired specific gravity, flowrates in Section 4.2 would have to be increased by up to 20 percent. The maximum figure in this case would be 4,3 m^3/sec. which would only be possible only with the installation of the canal alternative. The dye recommended for this application is Napthol Green which would be added at approximately 3 ppm. We would expect yearly dye consumption to be in the range 175 to 200 tonnes. Dye storage and handling facilities would have to be provided. Based on estimates obtained from U.K. manufacturers, the yearly tonnage cost of dye is in the two million dollar range.

Due to increased brine flow rate requirements and projections of 40 cm of salt without dye, we see no reason to recommend the use of dye.

SECTION 4.0

SALT LAYING BRINE FLOW SYSTEMS

4.1 PRECONCENTRATION OF DEAD SEA BRINE

Following the heavy winter rains of the 1979/1980 season, the specific gravity (S. G.) of the Dead Sea brine dropped from about 1.236 at 30°C to 1.216 at 30°C. During the summer of 1980, the S. G. gradually rose by September to 1.225, but the former brine S. G. was never regained. As a result of feeding dilute brine, an estimated 20% to 25% of the salt bottom in C1 is of lesser thickness than the 15 - 16 cm found in the remaining areas. The poorest area is immediately adjacent to the brine feed point and the thickness increases with distance from the feed point.

While the Dead Sea solids concentration may continue to increase to its former strength if the 1980/1981 winter rains are light, we obviously have no guarantee. Even at a S. G. of 1.236 we would expect some bad salt adjacent to the brine inlet. The best brine feed should be just at or a little above the salt point (about S. G. 1.240 at 30°C). Therefore, we believe it is essential to provide solar pan area which can be used to concentrate Dead Sea brine to a S. G. close to the salt point before feeding to the carnallite pans. To achieve this result, we propose that PC-2 be used for preconcentration of Dead Sea brine. Temporary brine flow from the canal outfall will be fed directly into PC-2, and after preconcentration, into the carnallite pans for salt laying using the permanent transfer pumps.

During the final year of salt laying (1983) in C3, it will be necessary to dike off a small portion of the southern end of PC-2 to act as a preconcentration pan for C3. This pan will be fed Dead Sea brine from the temporary brine pipeline.

4.2 SALT-LAYING BRINE FLOW REQUIREMENTS

The necessity to preconcentrate Dead Sea brine along with simultaneous salt laying in two pans causes a large increase in the required flowrates. The following flowrates of temporary brine for salt-bottom laying have been developed. These flowrates are the maximum rates which will be required during the peak of the evaporation season.

Pans	Evaporation Season	Flow - m^3/sec
C1/C2	1981	2.9
C2/C3	1982	3.6
C3	1983	1.8

4.3 ANALYSIS OF SALT-LAYING BRINE TRANSFER ALTERNATIVES

4.2.1 General

Four possibilities with regard to the additional salt-laying brine flow problems are listed below:

Case A - Continue with only the existing system at 1.3 m^3/s.

Case B - Increase capacity of existing 1200 mm diameter brine pipeline.

Case C - Install a second 1200 mm diameter pipeline system.

Case D - Install a canal system along Lisan Peninsula from outfall across the SP to point B (see plans drawing - attachment No. 6).

To meet the 1981 schedule for laying salt would require whichever of the cases B, C or D is selected to be operable by 30th June 1981. This allows an extremely short period of time for installation. The effect on scheduled potash production of missing this date, or of not providing any additional brine transfer facilities is assessed in section 6.0.

4.3.2 Description of Alternative Cases for Additional Brine Facilities

Case B - Increase Capacity of Existing Pipeline

We have located three pumps along with diesel engine drives and gear boxes which could be installed in the existing temporary brine pipeline to provide an increase in flow from 1.3 m^3/s to 3.1 m^3/s. These pumps would be installed in series. Each booster pump will draw suction from an open tank in which the level will be manually controlled by the setting on a pump discharge valve.

The pumps and drives can be shipped from U.K. in April, which, by the time they arrive on site (even if on schedule), leaves very little time for installation. As well, the flow of brine through the existing system will necessarily have to be stopped for whatever period is required to connect up the new pumps. Any such downtime would reduce the time available before the S.G. reaches the carnallite point, making the schedule even less possible.

Pipeline operation would be difficult because of the multiple, remote pump locations and the coordination requirements.

Suction tanks could be provided with overflows, but air entrainment by low tank level operation could be a serious problem.

Furthermore, with the single pipeline dependcy operating near the pipe design pressure limits, we will have no redundancy in the event of any mechanical breakdown.

Case C - A Second Pipeline System

This case would involve a second 1200 mm diameter pipeline approximately parallel to the existing pipeline and discharging into PC-2 at Point B. The floating intake with a new impellor and diesel drive would provide about 1.8 m^3/s through this 16 km length of pipeline. The impellor and diesel drive are available for delivery to meet our schedule.

The advantage of this system is that the existing 1.3 m^3/s pipeline can operate uninterrupted throughout the construction period. After completion, the two pipelines would provide 3.1 m^3/s. This should be adequate for the summer of 1981. If experience shows 3.6 is actually needed for 1982, a 1.8 m^3/s electric driven pump could be installed on the existing pipeline in the winter of 1981/1982.

With two separate systems, chances of complete shutdown due to material problems would be remote.

Again, the big problem is construction time. We have checked pipe delivery from Arabian Pipelines. They feel enough pipe can be delivered in time, which would allow this system to meet the schedule requirements. We are proposing a purchase contract with bonus for delivery by 15th April 1981.

Case D - Brine Canal

We originally proposed a gravity canal from the outfall along the south shore of Lisan to the construction road across the SP (see attachment A). The portion across the salt pan would consist of two dikes about 30 m apart, using the haul road as one side of one of the dikes. At point B, brine would be ducted under dike 2 to the suction of the PC-1 to PC-2 transfer pumps. A temporary dike would be placed around the transfer pumps. This would allow pump transfer to PC-2 which would then be used as a brine preconcentration pan prior to feeding harvest pans in the salt laying phase.

This alternate has the advantage of more than adequate flow rates. Any leakage from the canal would merely end up in the salt pan where it will be fed in any event. There would be no problem of outside equipment delivery; all work would be controllable civil work.

The time schedule is again a problem; however, it is theoretically possible if the "go ahead" is received early enough.

An additional problem has occurred due to early exploration of the canal route which indicates good soil for excavation is above the controus required for gravity flow. We are still looking at the possibility of a canal at the higher elevation fed by lift pumps from the outfall. A series of test pits are currently being excavated along the canal route to ascertain soil conditions. However, present indications are that the canal may not be feasible.

4.3.3 Other Alternatives

Other alternates have been investigated and have been disregarded. One involved modifying the present temporary brine intake and canal outfall pumps. The maximum capacity that could be achieved using this solution would be 1.8 m^3/sec, which is too low. We also looked at installing two pump stations instead of three, but then there was a possibility that the present pipeline design pressure could be exceeded and so this idea was abandoned. Another idea was to pump into the Salt Pan and use a pump located on Dike 2 adjacent to the PC-1 feed station to pump to PC-2. However, because of the huge area involved, evaporation would occur in the Salt Pan with resultant salt precipitation. Much salt would be lost in the Salt Pan and supersaturated brine would have to be pumped up to PC-2 which would cause considerable salt precipitation in the pipeline.

SECTION 5.0

PROPOSED SALT LAYING & PRODUCTION SCHEDULE

5.1 GENERAL

Our calculations indicate the existing temporary brine pumping system is adequate to supply simultaneously both harvest pans C1 and C2 from 1st January to 30th June 1981. At this point, additional brine will be required to prevent the pans from reaching the carnallite point. We base our program on release from APC by 15 January 1981 to proceed with procurement and construction of facilities to increase salt bottom laying brine flow rates. We will plan to complete these facilities by 30th June 1981, but will make provisions and forecast the effect of missing this extremely tight deadline date.

5.2 CHRONOLOGICAL PROGRAM

The proposed chronological program follows:

5.2.1 Install valves intended for C2 and C3 waste pipelines on C1 and C2 temporary brine feed pipelines.

5.2.2 Start temporary brine into C2 on 1st January 1981. Fill by 28th February 1981.

5.2.3 Install fabricated elbow in temporary pipeline midway between points F and H to allow feeding brine into PC-2.

5.2.4 Install temporary dike across PC-2 in line with dike 7 to provide a preconcentration pan in the south end of PC-2. PC-2 to C1 and C2 transfer pumps will be included in the limits of the preconcentration pan.

5.2.5 When C2 is filled (about 28th February) connect remaining temporary pipeline feeding PC-2 at junction of C2 feed point. Start brine to preconcentration pan in south end of

PC-2 and into C1 and C2 as required through the permanent transfer pumps.

5.2.6 If by 1st May 1981 we can project completion of additional brine supply facilities by 30th June, continue pumping as in 5.2.5 until that time.

5.2.7 If completion by 30th June appears impossible, prepare to drain C2 by cutting dike 4 into preconcentration pan. Pump into C1 and out C1 waste drain (estimated time to drain, 30 - 40 days). After draining C2, repair cut in dike 4 and continue temporary brine into PC-2 preconcentration pan and then into C1 as required to maintain gravity.

5.2.8 If 5.2.6 above prevails, on 30th June or earlier, start additional brine feed into PC-2 at point B (also switch existing brine line to feed PC-2 at point B). Cut temporary dike across PC-2 near dike 4 such that all of PC-2 now becomes the preconcentration brine pan. Feed C1 and C2 from the revised preconcentration pan with the permanent transfer pumps as required to maintain gravity.

5.2.9 Allow gravity of C1 to rise during the late summer gradually so the carnallite point is just reached by 30th September 1981. Carnallite point feed brine from PC-1 will be pumped through the existing pipeline using the PC-1 to PC-2 transfer pumps or over the dike with the floating intake brine pumps.

5.2.10 About 1st January 1982 start temporary brine into C3. Continue feeding salt laying brine into C2 and C3 until 30th September 1982 at which time C2 will be at the carnallite point.

5.2.11 Extend temporary dike across PC-2 to dike 4, such that the south end of PC-2 becomes the salt laying brine preconcentration pan (excluding C1/C2 transfer pumps) for C3. The north end will revert to preparation of carnallite point brine to allow normal flow pattern from SP to PC-1 to PC-2 to C1 and C2. Reconnect the temporary brine line into the southern end of PC-2 and pump into C3 as required to maintain gravity through 30th September 1983. At this point all pans will be in the carnallite range. Open temporary dike in PC-2 near dike 3. All pans should now be in the normal operation phase.

5.3 PRODUCTION BRINE FLOW IN PANS

The salt pan will be filled on schedule as soon as the intake pumps are completed in early 1981. Actually, the current level of brine (from rainfall and drainage from other pans) is near the zero year level. This brine is high gravity because of dissolution of old salt deposits. We plan to flush this brine by pumping out of the salt pan to the waste channel for about two months. PC-1 will then be filled and allowed to concentrate by September 1981 to near the carnallite point. By this time C1 will also be at the carnallite point and forward flow from PC-1 to C1 can be started through the temporary brine pipeline using the regular PC-1 to PC-2 transfer pumps.

By September of 1982 the north end of PC-2 will be filled with near carnallite point brine from PC-1. The south end of PC-2 will have already been diked off for use as a preconcentration pan for salt laying brine to C3 for the 1983 season. Flow of carnallite point brine from the northern part of PC-2 can then be established to C1 and C2 through the permanent transfer pumps.

During the last period of salt laying in the summer of 1983, the S.G. in C3 will gradually be allowed to increase to the carnallite point by the end of September. At this point the temporary dike in PC-2 will be breached and normal production flows will be in effect throughout the pan area.

5.4 INSPECTION OF C1 SALT BOTTOM

Our proposal to allow the change in harvest pans from the salt laying phase to carnallite production without draining brine saves a considerable period of time. This action reduces the potash production losses compared to the goals cited in the feasibility study in spite of the added time consumed for salt bottom laying.

An important point is that carnallite will be available for plant feed by about 1st August 1982 (assuming that carnallite harvesting can commence in C1 when about 18 cm of depth is available). This will allow early plant trial runs to confirm process and equipment capability.

It would be desirable to drain C1 pan after completion of salt bottom laying to examine the surface visually and assure that no obvious defects are present. Some additional testing could also be accomplished when the pan is dry.

Since the IIRS salt thickness recommendations were based on tests conducted without draining the pan, we feel their projections should be adequate on the same basis. That is, an adequate margin of safety will be provided without draining the pan and providing any type of treatment. However, there are good and valid reasons to actually see the salt bottom in at least one of the three pans.

5.5 COMPLETE DRAINING OF C1

If we were to completely drain C1 for salt bottom inspection, the following changes to the chronological program listed in 5.2 and in the pan operating schedule would be required:

5.5.1 Arrange to reach carnallite point in C1 on 1st October 1981. Drain brine into PC-1 by cutting dike at low point. (Estimate 7 days)

5.5.2 Meanwhile the entire salt pan would be allowed to concentrate to near the carnallite point by 15th November 1981. Then, PC-1 would be filled with brine from SP after which the SP would be diluted to the normal operating gravity. (Estimated 40 days).

5.5.3 After examination and tests on C1 salt bottom, it would be filled from PC-1 and normal operation would continue.

5.5.4 The penalty to do the above would be approximately a 16% reduction in the carnallite inventory from the first year's crop in C1. The carnallite initiation point for C1 would move from 1-10-81 to 1-2-82. This would also delay harvesting start up for at least one month (to 1st September 1982.

5.6 PARTIAL DRAINING OF C1

As an alternate to 5.5 above, we could very simply partially drain C1 through the existing waste channel drain line. This would drain off about one meter of brine depth and expose about 25% of the salt surface at the west end of the pan. Remaining pan areas would be covered with brine of much less depth allowing improved observation through the brine.

The penalty for this alternate would be about an 8% reduction in carnallite inventory. The carnallite initiation point for C1 would move from 1-10-81 to about 15-11-81. Carnallite harvesting start-up would be delayed about 2 - 3 weeks.

We would recommend at least partial draining of C1 for inspection of salt bottoms.

5.7 SCHEDULE

Attachment No. 7 shows the overall program schedule.

SECTION 6.0
EFFECT ON PRODUCTION RATES

6.1 GENERAL

The requirement of brine preconcentration and two seasons for salt laying will have an impact on potash production. We have estimated this impact based on flow sheet conversions of carnallite to potash from the dryer.

6.2 ESTIMATED PRODUCTION LOSS

We have estimated the losses based on our flow sheet assumption of permanent carnallite inventory in the pans (about 10 months at full production rate).

We have allowed lower efficiency of carnallite conversion in early production years as follows:

1st year	65%
2nd year	85%
3rd year	95%
remaining years	100%

Production changes are examined for the following conditions:

Case I - Per feasibility study

Case II - No major change to existing salt laying brine system*

Case III - Additional facilities by 30 June 1981 to provide increased brine flow.

Case IIIa - Same as III, except allow for partial draining and inspection of C1 salt bottom in October 1981.

Case IV - Additional facilities installed, but too late for 1981 season for C2.

Section 6.0
Effect on Production Rates

Case	Annual Potash Production x 1000 mt/yr I	II	III	IIIa	IV
1982	100	45	45	33	34
1983	500	263	438	410	253
1984	900	424	815	815	696
1985	1150	808	1052	1052	1150
1986	1200	1200	1200	1200	1200
Total with 10 months carnallite inventory in pans	3850	2740	3550	3510	3333
Difference from I (loss)	-	1110	300	340	517

By reducing the carnallite inventory and by compression of schedule "float" time, it may be possible to gain up to 300,000 mt potash under Columns II, III or IV. Every effort would be made to do so. However, there are uncertainties in operating the pan system at a lower inventory of carnallite. A certain quantity of carnallite will be unavailable for plant operations because it will be below the reach of the harvester cutter head or the layer of carnallite could be too thin for effective harvesting.

*A small increase in capacity may be required in 1982 to account for brine dilution. This would require a larger pump and motor.

SECTION 7.0

DESIGN DEVELOPMENT OF INDEPENDENT FLOATING HARVESTER

Most of the basic operating parameters established for the RAHCO prototype harvester will be incorporated in the new floating harvester.

All of the equipment with the exception of the track system will remain the same. The track system hydraulics and controls will remain the same. The ballast tanks/bouyancy tanks and hull will basically be replaced by the barge.

7.1 PROTOTYPE UNIT AND TESTING

7.1.1 SHOP FABRICATION

We propose modifying RAHCO'S existing purchase order for the manufacture of the new harvesters. We recommend that RAHCO use Ross Engineering Co. in Ireland as a sub-contractor for the supply of the barges. We recommend this because of savings in cost and time. Modified barge could be ready to ship in four months.

Four barges are presently available at the Ross Engineering Co. in Ireland which we propose using as the hull for the new harvester. The barges could be modified in the shop to accept the new tracks and all the equipment from the present harvester. Barge would then be shot blasted, plasma arc galvanized and painted prior to shipment.

All of the slurry and major pipework could be shop fabricated for field installation. Electrical cable trays could be prefabricated in the shop for field installation.

7.1 PROTOTYPE UNIT AND TESTING

7.1.1 SHOP FABRICATION - continued

RAHCO would manufacture the track support assembly - slide plates, oscillating track support and hydraulic system for field installation.

All of the existing equipment on the RAHCO prototype could be transferred to the barge as skid packages.

7.1.2 HARVESTER ASSEMBLY

Modified barge could be shipped to the field in one piece. (Total weight 136 M.T.) unloaded on the dyke and launched into the pans by means of oiled planking. Equipment would then be installed and balance of fit-up completed with the harvester in the carnallite pan adjacent to the dyke. Fit-up of the units would be completed under the supervision of RAHCO personnel using No. 10 contract day rate labor in an estimated three months. The completed harvestor could be ready before the end of 1981.

7.1.3 PROTOTYPE TESTING

Since all of the slurry components on the existing prototype harvester, with the exception of the tracked system, will have been tested in the carnallite pans no further operational tests need to be carried out in the test pan. Salt bottom laying will have been completed in pan C-1 by the end of summer 1981. After this time the harvester can be operated on dry runs to test manuverability, etc. in pan C-1. APC personnel could be trained on the operation of the harvester pumping brine through the system.

7.2 ADDITIONAL UNITS

Unless RAHCO'S test program comes up with a radical improvement, we propose using Ross Engineering, as a RAHCO Subcontractor for supplying of the modified barges for conversion to harvesters. RAHCO would purchase all of the equipment and pre-assemble to the extent possible at the shop in Spkane for shipment to site.

Pre-assembled packages would consist of the following major items:

(1) Transformers, M.C.C. and control system completely wired.
(2) Operators cab and control system.
(3) Four complete track assemblies.
(4) Slurry pumps complete with gear reducer motor and hydraulic piping.
(5) Cutter-head assembly.
(6) Hydraulic package complete with electric motors hydraulic pumps and tank.
(7) All slurry piping prefabricated.

Final assembly would be at the site. Minor runs of piping and electrical connections to equipment would be field run.

7.3 NUMBERS OF HARVESTERS REQUIRED

For the purpose of this report we are still considering purchasing five harvesters. However, because of the ease of maintenance and recovery of the new harvester system we should re-analyse the expected down time for repair and replacement work. It may be possible to justify purchase of four harvesters. In any event, the fifth harvester should not be purchased until extended operating experience with the prototype and subsequent modifications are obtained.

7.4 HARVESTER PURCHASE SCHEDULE

The following purchase schedule is proposed:

Harvester No.	P/O Date	Completed at Site Date
1	15-1-81	1-12-81
2	1-6-81	1-6-82
3	1-6-81	1-8-82
4	1-9-82	1-9-83
5 *	1-9-82	1-11-83

7.5 REQUIREMENTS FOR PAN TO PAN HARVESTER TRANSFER

For transferring harvesters between the pans we investigated the use of a lock system, dry dock and ramps. After consulation with Sir Alexander Gibb & Partners, we concluded that ramps over the dykes in the shallow end of the pans at point C-2 and C-3 would afford the best means of transferring harvesters between C-1, C-2, and C-3.

Harvester track system would be used for propulsion with additional wheeled dollies under the fore and aft section of the barge to distribute the load in the dykes. If additional assistance is required to move harvester up the ramp a bulldozer could provide this traveling along dyke D-5.

* If required

SECTION 8.0

CAPITAL COST CONSIDERATIONS

8.1 HARVESTERS	U.S. DOLLARS
Prototype (Independent floating)	$ 1,000,000
4 Production units @ $2,200,000	8,800,000
Contingency @ 15%	1,470,000
Subtotal	$11,270,000
Loss on prototype	1,500,000
TOTAL New Harvesters	$12,770,000
Original Budget (per P.O. 39-1)	$12,472,000
V/A Provisional sum for assembly	300,000
Total Old Harvesters	$12,772,000
Differential Cost	$ (2,000)

*All of the track components can be used as spares for the new machines. This has not been taken into consideration in this report. The main scrap items will be the existing harvester steelwork.

Above budget prices were based on Voest Alpine unit rates for pipework, electrical and equipment setting.

Section 8.0
Capital Cost Considerations

8.2 Salt Laying Brine Systems

Approximate order of magnitude capital cost estimates have been prepared for each of the alternatives required for increased salt laying brine flow. These costs could vary depending on the final scope of work, but they are now in the range of:

	U.S. Dollars
Case A - Existing System *	$ 825,000
Case B - Increase Flow in Existing Pipeline	3,500,000
Case C - Install Second Pipeline	9,500,000
Case D - Install Canal from Outfall	8,250,000

We are in the process of obtaining additional data to firm up the above prices.

8.3 Dike Crossings

We will allow $1,000,000 for the two required dike crossings per section 7.5.

8.4 Temporary Dikes and Pipelines Connections

The temporary dike access PC-2 including cutting and relocations along with charges to connect and disconnect the temporary brine line is estimated at $500,000.

Section 8.0

Capital Cost Considerations

8.5 Raising Carnallite Fan Dikes

Per AGP estimate in section 3.6.2, this cost amounts to $330,000.

*If an increase in flow is required due to dilute Dead Sea brine.

8.6 Total Estimated Capital Cost Addition

Harvesters	$ (2,000)
2nd Pipeline	9,500,000
Dike Crossings	1,000,000
Temporary Dikes	500,000
Raising Dikes	330,000
TOTAL	$ 11,328,000

SECTION 9.0

RECOMMENDATIONS

9.1 RECOMMENDATIONS FOR ITEMS REQUIRING IMMEDIATE DECISIONS

Based on the investigations in these reports, we make the following immediate recommendations:

9.1.1 Purchase from RAHCO prototype independent floating harvester using equipment stripped from the present RAHCO machine and barge from Ross Engineering Company.

9.1.2 Review RAHCO proposal for concurrent study and tests of other harvester alternatives and make recommendations.

9.1.3 Confirm preliminary commitment to install second temporary brine pipe-line system for salt laying in harvest pans.

9.2 RECOMMENDATIONS FOR ITEMS NOT REQUIRING IMMEDIATE DECISIONS

The following recommendations are based on current knowledge. As an immediate decision is not essential for these items, additional study or data may influence a change in our recommendations.

9.2.1 Proceed with purchase from RAHCO of two additional independent floating harvesters using Ross Engineering Company barges. P/O deadline date about June, 1980. The fourth harvester can be ordered in October, 1982, and will reflect design development at that time.

9.2.2 Investigate dike crossing arrangement for independent floating harvesters in more detail and make final recommendation.

9.2.3 Plan on partial drainage of C1 to examine salt layer before feeding carnallite point brine.

9.2 RECOMMENDATIONS FOR ITEMS NOT REQUIRING IMMEDIATE DECISIONS - continued -

9.2.4 We do not feel the use of dye is economically justified to improve evaporation during salt laying periods.

9.2.5 Install temporary dikes and pipeline in PC-2 as required to provide preconcentration of salt laying brine.

9.3 OTHER ALTERNATIVES

We do not feel there are any other immediately viable alternatives to the items recommended in 8.1 above. As pointed out in Section 6.2, if we do not spend the capital to increase our salt laying brine flow, we estimate a production loss of 1,110,000 tonnes of potash. At a sales price of $100 per tonne, this represents a huge loss in revenues of about $111,000,000.

Our recommendation for the independent floating harvester is based on our certainty that the machine will work. There will undoubtedly be some design development necessary to obtain reliability and design production rates, but we feel strongly that only minor changes will be necessary.

Recommendations on RAHCO's proposal for additional concurrent study and tests on alternate harvesters will be made after a detailed study of their proposal.

ATTACHMENT NO. 1

Group Manufacturing Technology

Division Construction Industry

Sheet no. 1 of 14 sheets

An Instituúid Taighde Tionscail agus Caighdeán

Institute for Industrial Research and Standards

Ballymun Road,
Dublin 9, Ireland
Telephone (01) 370101
Telegrams "Research, Dublin"
Telex 25449

Confidential Report

Client: Jacobs International Ltd. Inc.,
Merrion House,
Merrion Road,
Dublin 4.

Title: A.P.C. Dead Sea Project.
Tests on Salt Layer - Pan C 1 - and evaluation of proposed harvester performance.

Report ref.	1404/4/3159.80	Order no./ref.	
File no.	R6/5101	Report by	F. K. Motherway (signature)
Date received		Approved by	
Copies to		Date	12th December, 1980.

Conditions

1.0 INTRODUCTION:

1.1 Following the completion of a series of plate bearing tests on site, on the salt botton in Pan C 1, during early November 1980, a preliminary report was issued, at a meeting held on-site, on 11th November 1980. This report indicated that the originally proposed harvester would have an ultimate contact pressure in the region of 3 - 4 p.s.i. (21 - 28 KN/m^2) on a present salt thickness of 21 cms. The opinion was put forward, therefore, that the original harvester arrangement would not work. A suggested alternative harvester arrangement was then put forward by the clients and this was subsequently examined. This consists of a floating barge with retractable tracks to provide propulsion.

1.2 In the preliminary report it was stated that the mode of failure was "punching shear". This was subsequently confirmed by further analyses and the analysis method by "VESIC (1970)" agreed well with the test results. The further analyses show that the underlying mud strength significantly affects the punching shear strength, so that this strength is not directly proportioned to the salt thickness, as was indicated earlier.

1.3 The purpose of the initial test programme was to identify the failure mode of the salt layer, with the results used to predict the behaviour of the full scale harvester by extrapolation. The further analyses on the alternative harvester are again based on extrapolation of the theory which fitted the failure of the plate tests.

2.0 STATIC BEARING CAPACITY:

2.1 The results of the plate bearing tests on-site indicate that the failure mode is by punching shear and this is consistant with the observation of others, in the situation where a soft soil is overlain by a material having both cohesion and friction.

The general case has been analysed by (VESIC 1970) as follows, for rectangular loading:-

$$q_o = \left[q_o'' + {}^{1}/_{K}\, C_1 \operatorname{Cot} \phi_1 \right] \exp \{2\, [1 + ({}^{B}/_{L})]\, K \operatorname{Tan} \phi_1\, ({}^{H}/_{B})\}$$

$$- {}^{1}/_{K}\, C_1 \operatorname{Cot} \phi_1$$

q_o = ultimate bearing stress

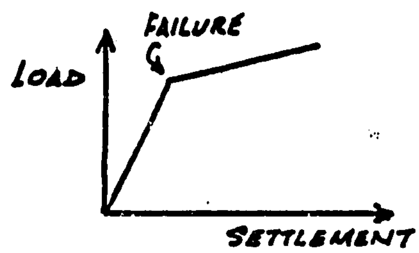
q_o'' = ultimate bearing stress of same footing on lower soft material = 6.2 C_2 for circular loading = 5.14 C_2 for rectangles

$$K = \frac{1 - \operatorname{Sin}^2 \phi_1}{1 + \operatorname{Sin}^2 \phi_1}$$

C_1, ϕ_1 = strength parameters of upper layer

C_2 = strength parameter of lower layer

The plate tests carried out on-site were back analysed and the failure loads obtained were in good agreement with those occurring in practice. The failure occurs at the end of the initial straight part of the curve.



This point is designated the failure point and suitable factors of safety are applied to the corresponding load to obtain the safe working load.

2.2 Using this approach, the Failure Loads for the proposed track arrangement under varying salt and mud properties are set out in Table 1 below. The failure load for the original harvester track is also included.

Case	Track Size m	Salt Properties		Mud Properties		Salt Thickness	Failure Load per Track
-		C_1 KN/m^2	ϕ^o	C_2 KN/m^2	ϕ^o	m	KN
1	4.88 x 0.76	25	45	3.6	0	0.2	150
2		0	45	3.6	0	0.15	80
3		25	45	3.6	0	0.40	246
3a		25	45	3.6	0	0.45	273
4		25	45	2.0	0	0.40	194
5		12.5	45	3.6	0	0.40	174
6		12.5	45	2.0	0	0.40	126
7		0	45	3.6	0	0.40	103
7a		0	45	3.6	0	0.45	112
8		0	45	2.0	0	0.40	57
9	12 x 2.1	25	45	3.6	0	0.20	662 5.8 psi
10		25	45	3.6	0	0.40	857 4.9

TABLE 1.

NOTES: i. The "average" properties of the salt layer, $C_1 = 25\ KN/m^2$ and $\phi_1 = 45^o$ were chosen from the results of tests carried out by R.S.S. Jordan on the poorer quality salt at the Lisan Test Pan and from back analysis of the plate tests in Pan C 1.

ii. Case 2 is where the salt forms a cohesionless mass as at Location D 0, Pan C 1.

iii. The total thickness of salt at the end of the coming season is assumed to be 40 cms. The analysis was also carried out for a thickness of 45 cms. Under "average" conditions it is assumed that the salt quality will be at least as good as the existing material i.e. that some thickness of hard cemented salt will be deposited. Cases 5 and 6 are to simulate the situation where future salt growth would be cohesionless.

iv. Cases 7 and 8 are those pertaining where the entire salt thickness is cohesionless.

v. The mud strengths were chosen from results of vane tests carried out by IIRS and by Sir Alex Gibb & Partners.
$C_2 = 2.0\ KN/m^2$ is the minimum value obtained in the general area in question to a depth of 1.0 m below the surface. The maximum value is $C_2 = 9.8\ KN/m^2$ and the resultant weighted average is $C_2 = 4.5\ KN/m^2$. For design purposes the significantly higher strength values were ignored and the resultant weighted average $C_2 = 3.6\ KN/m^2$ was chosen. This value was equalled or exceeded at 71% of the locations tested.

3.0 ALLOWABLE LOAD AND FACTOR OF SAFETY:

3.1 Under "average" conditions where salt of similar quality to that existing at present, is deposited over the coming season, the Failure Load per track would be 246 KN and the expected settlement at failure would be 3 to 4 cms. If the final salt thickness is increased to 45 cm the Failure Load would be 273 KN.

3.1.1 From the results of the testing programme, the "average" conditions at the present time apply from D 4 to D 1 inclusive. The salt is significantly weaker at D 0. At locations D 5 and D 6 the salt is significantly stronger apparently due to layers of older strong salt being present beneath the new surface salt. In these latter areas the Failure Load would be increased by a factor approaching 2.

3.2 A suitable factor of safety is applied to the failure load to obtain the safe working load. In selecting this factor of safety the following aspects must be considered.

a. Consequence of Failure.

With the revised harvesting method, the consequences of failure are not as severe as those for the original arrangement, where failure would have been very serious, amounting to, perhaps, loss of the harvester. Under the proposed system, isolated failures would not be significant, as long as the pan area as a whole can be trafficked over the life of the project. Again such localised failure areas could possibly be repaired, using an inert mesh reinforcement, such as manufactured by Netlon.

b. Variations in Material Properties.

As Table 1 shows the salt quality and thickness will greatly effect the load carrying capacity. In dealing with, say, a concrete pavement it is common to apply a F.O.S. of 1.5, where the material properties can be controlled. In this instance this is not so. During the test programme, the only area with salt weaker than "average" was at D 0. The testing was also carried out along a line of expected weak mud. Therefore if we can assume that the picture is similar over the entire pan area, the main concern would

The present very weak area near D 0 could be isolated from harvester movement if the situation does not improve. If it is reasonable to make the above assumptions regarding salt strength over the major part of the pan area, a Factor of Safety = 2 would also appear reasonable. It would be very desirable to obtain a better picture of the salt quality and thickness throughout the pan and this will be discussed later. Variations in mud strength also come under this heading. From the original site investigation, the mud strength was found to be very variable over short distances. The lower bound was 1.7 to 1.8 KN/m^2. The lowest value obtained by IIRS was 1.8 KN/m^2 but the weighted average over 1 m depth is higher. The evidence to hand indicates that 3.6 KN/m^2 is a reasonable design figure. It is of interest to note that if we apply the concept of "Partial Factors of Safety" to the design properties, we arrive at a working load = 125 KN which is equivalent to an overall F.O.S. = 2.

c. <u>Load Transfer Characteristics of Tracks.</u>

Ideally load transfer should be uniform under the tracks but this is rarely achievable. It is assumed in this instance will be as rigid as possible and that the roller layout will achieve close to uniformity of loading. The stresses will be most severe in the transverse direction and the track should also be relatively stiff in this direction.

d. <u>Rate and Nature of Load Application and Expected Life of Pavement.</u>

The loading will be transient with probably no more than 2 track applications per season. The loading rate will also be relatively quick so that the ultimate strength will probably be somewhat higher than that for long term slowly applied load. The plate test results indicate that the expected loading frequency should not damage the salt if the loading intensity is kept well down the "elastic" range

As the loading is increased up the "elastic" range, progressive failure occurs in a layered material. This does not mean that premature failure will result but that the layer may be somewhat weaker for subsequent reloading.

e. Traction.

The effects of traction on the salt must also be considered. Unfortunately there is little previous experience or experimental evidence to draw on so that these effects cannot be calculated. The commonly used mobility theories for soft ground trafficking cannot be directly applied as the sinkage (or settlement) is very small in this instance, compared with that met with in soft ground mobility. For weak partially cemented materials approaching the cohesionless state, the tractive effort should be kept as low as possible. As slippage approaches the salt surface could be severely affected especially if grousers are used. Conversely, grousers in fact may perform better under working conditions, as they would allow higher effort to be applied without approaching the slippage situation. Further testing should be carried out to study this effect.

f. Vibration.

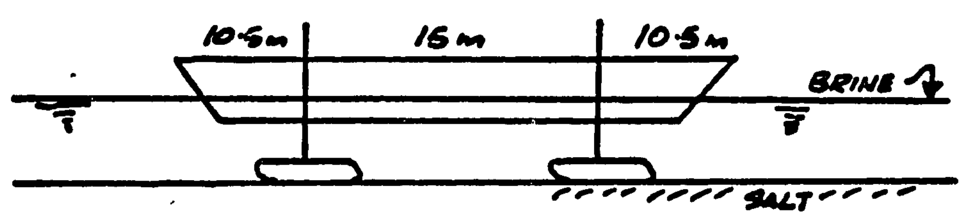
Vibration applied to certain soils of low plasticity tends to liquefy the soil, with the most serious effects in loose saturated silty sands and "quick" sensitive clays. The worst effects are found where the number of cycles, the frequency or the amplitude of vibration is large. It is difficult to assess the effect in this instance but as electric motors will be used it is considered that the vibrations will not be significant for transient loading. The effect of seismic disturbance was not considered in the evaluation.

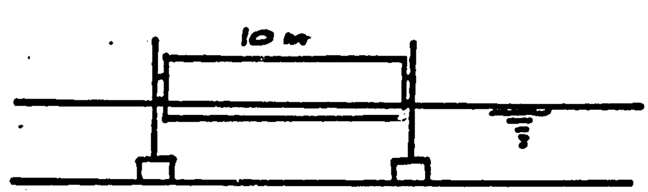
3.3 Conclusions.

A factor of safety of 2 is suggested as the minimum to be applied to the Failure Load under average conditions. This would suggest a maximum working load of 120 Kn. Where the salt is stronger than average, as apparently is the case at the shallow end of the pan, this load could be increased significantly. Such increase in load might not be possible for the other pans. The salt quality should however be evaluated more exhaustively over the entire pan area.

4.0 LOADING CONDITIONS:

4.1 Proposed Harvester.





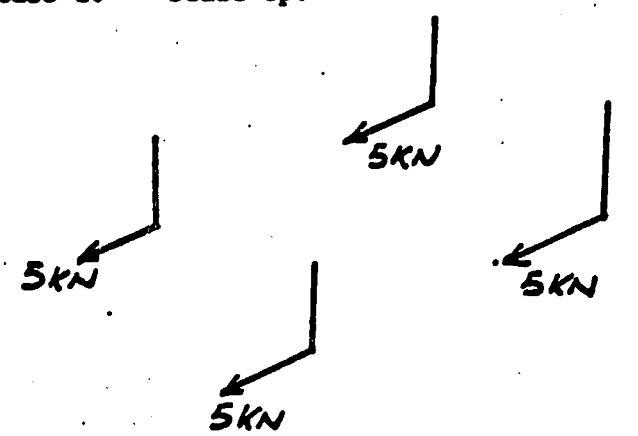
Tracks 4.88 m x 0.76 m.

4.2 Friction Coefficients.

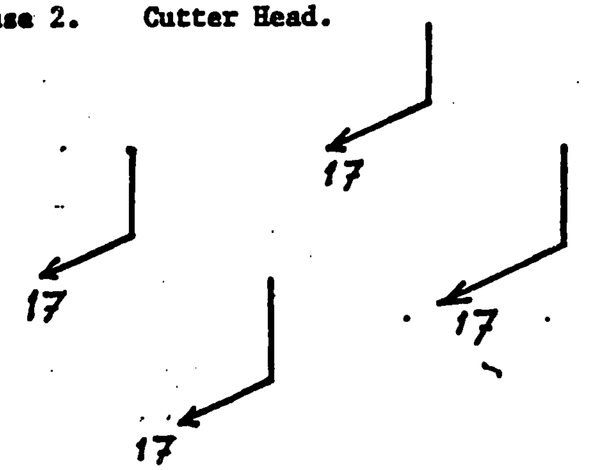
Smooth Plate	-	Breakaway	0.57 - 0.6
		Moving	0.355 - 0.368
Simulated Grousers	-	Breakaway	0.92 - 0.942

4.3 **Loading Situations.**

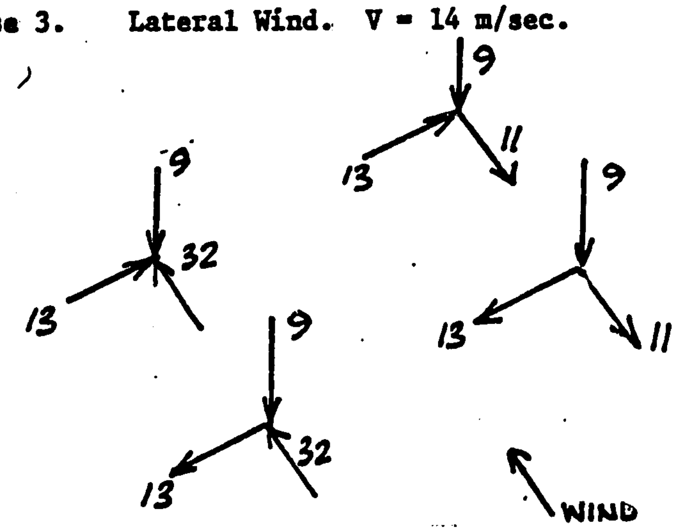
Case 1. Start Up.



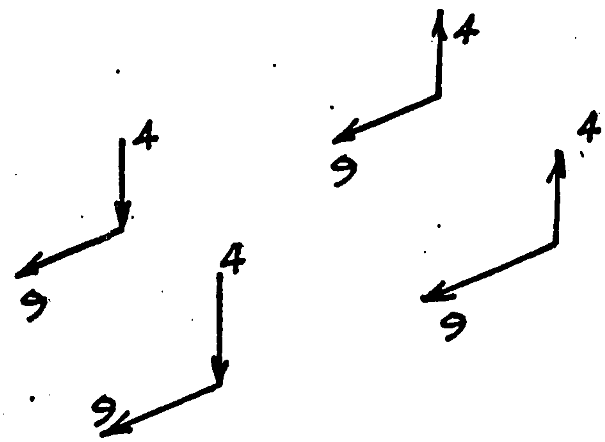
Case 2. Cutter Head.



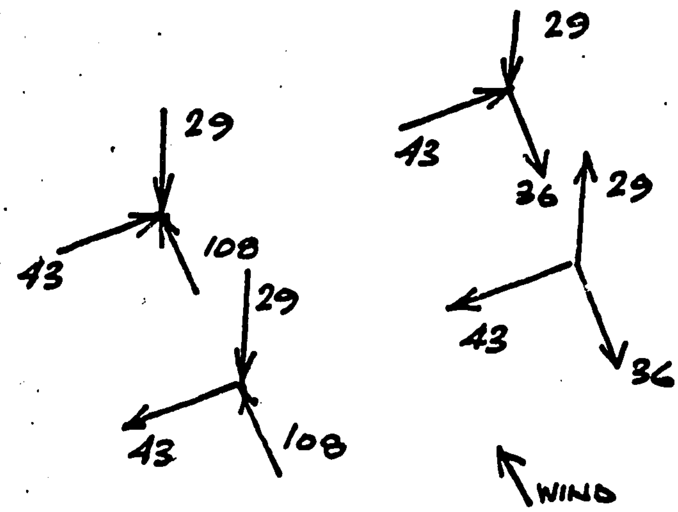
Case 3. Lateral Wind. V = 14 m/sec.



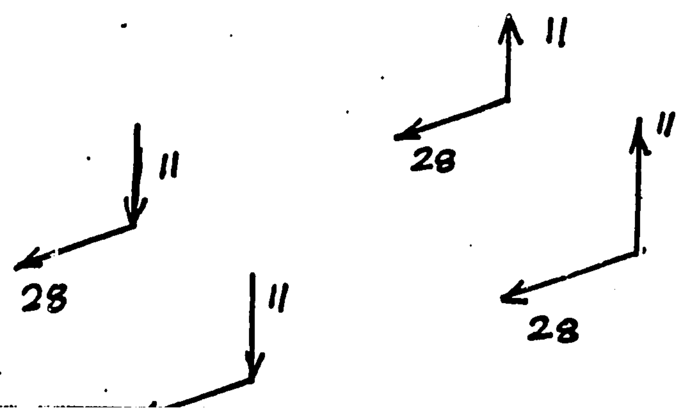
Case 4. Wind on Front of Harvester. V = 14 m/sec.



Case 5. Lateral Wind. V = 27 m/sec.



Case 6. Wind on Front of Harvester. V = 27 m/sec.



4.4 Traction.

Maximum Vertical Load with F.O.S. = 2.5 = 100 KN.
F.O.S. = 2.0 = 120 KN

Case 1. Start Up.

V = 100 KN
H = 5 KN
V = 120 KN

$H/V = 0.05$

$H/V = 0.04$

Case 2. Cutter Head.

V = 100 KN
H = 17 KN

$H/V = 0.17$

Case 3. Lateral Wind (14 m/sec) + Cutter Head.

V = 100
H = 30
V = 120

$H/V = \frac{30}{100} = 0.30$

$H/V = 0.25$

Case 5. Lateral Wind. V = 27 m/sec.

V = 100
H = 43
V = 120

$H/V = 0.43$

$H/V = 0.358$

4.5 Conclusions.

The harvester cannot operate above wind speed V = 14 m/sec. Above this speed, harvester must be turned into the wind to remain stable. 51

However, lengthy static loading should not be applied to the salt as creep and consolidation of the underlying mud will occur. The proposed anchoring method for the harvester must therefore be carefully considered.

4.6 Tractive Effort.

As discussed earlier the tractive effort should be kept as low as possible to avoid salt damage. Therefore the friction mobilised should also be kept low. It is advantageous to keep the vertical load as high as possible within the limits of the allowable bearing capacity.

5.0 SUMMARY OF CONCLUSIONS:

5.1 While it is obviously desirable to operate at the highest factor of safety possible, a minimum factor of safety of 2.0 on the ultimate static load under "test" conditions is suggested. This assumes that the "test" conditions pertain over the major part of the pan. The effect of track flexibility and possible uneven loading should be considered by the vehicle manufacturers.

5.2 The effect of traction on the salt should be considered further. Further tests should be carried out, and the matter should be referred to the vehicle designers for consideration.

5.3 The ultimate load on the proposed track was calculated by extrapolating the theory found to agree with the results of the in-situ plate tests. It is recommended that a further in-situ test be carried out using a plate approaching the size of a full scale track. This test would not be taken to failure but would verify that the working load on the initial elastic portion of the load/settlement curve. The test would fulfil Phase III of our original suggested test programme.

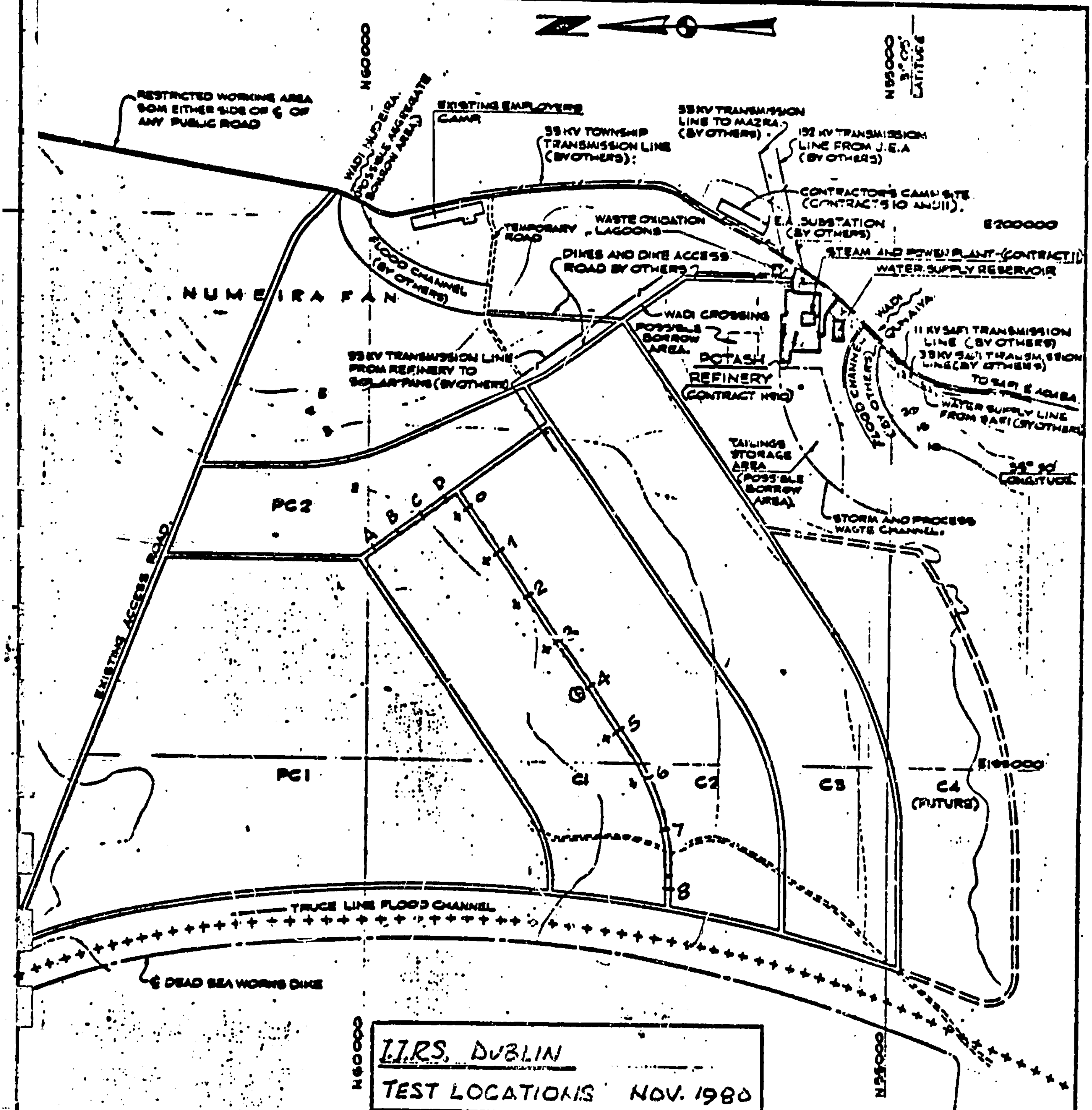
5.4 Further evaluation of the salt quality and thickness must be carried out. Improved coring and testing methods will be suggested in an Appendix to this report.

5.5 The quality of the salt deposited during the coming season will have an important bearing on the ultimate load carrying capacity. If any possible means of improving salt quality exist, these should be further investigated.

5.6 Methods of repairing isolated failed areas or weak salt areas should be investigated. The use of inert reinforcement meshes might be feasible.

5.7 The question of "parking" the harvester with the tracks imposing a load on the salt bottom must be considered. Ideally no long term static loading should be applied because of the tendency of the salt to "creep" under load and the underlying mud to consolidate.

CM/MB.



I.I.R.S. DUBLIN

TEST LOCATIONS NOV. 1980

LOCATION SHOWN +

LEGEND:

	HIGHWAY.
	DIKE OR LOCAL ROAD (EXISTING OR BY OTHERS)
	LOCAL ROAD (TO BE CONTRUCTED)
	CONTOURS (1977 SURVEY)
	CONTOURS (1966 SURVEY)
	POWER TRANSMISSION LINES.
	WATER SUPPLY LINE.
	FUTURE
+ + + + +	TRUCE LINE.

SCALE

500 0 500 1000 1500 2000 METRES

REV.	DATE	DESCRIPTION	APP'D.
B	20 APR 79	ISSUED FOR CONTRACT 10 TENDER	
A	9-2-79	ISSUED FOR CONTRACT 11 TENDER	

ISSUED FOR CONSTRUCTION

DESIGNED	DRAWN	REVIEWED	APPROVED
JIL	JH	VCS	

HASHEMITE KINGDOM OF JORDAN

ARAB POTASH COMPANY LTD

POTASH PROJECT BASED ON DEAD SEA BRINE

JACOBS INTERNATIONAL LIMITED

GENERAL PLAN OF PLANT AREA

SCALE	PROJECT NUMBER	DRAWING NUMBER
1:125,000	08-1875	FIG. 1

54

IIRS

11. XI. 1950

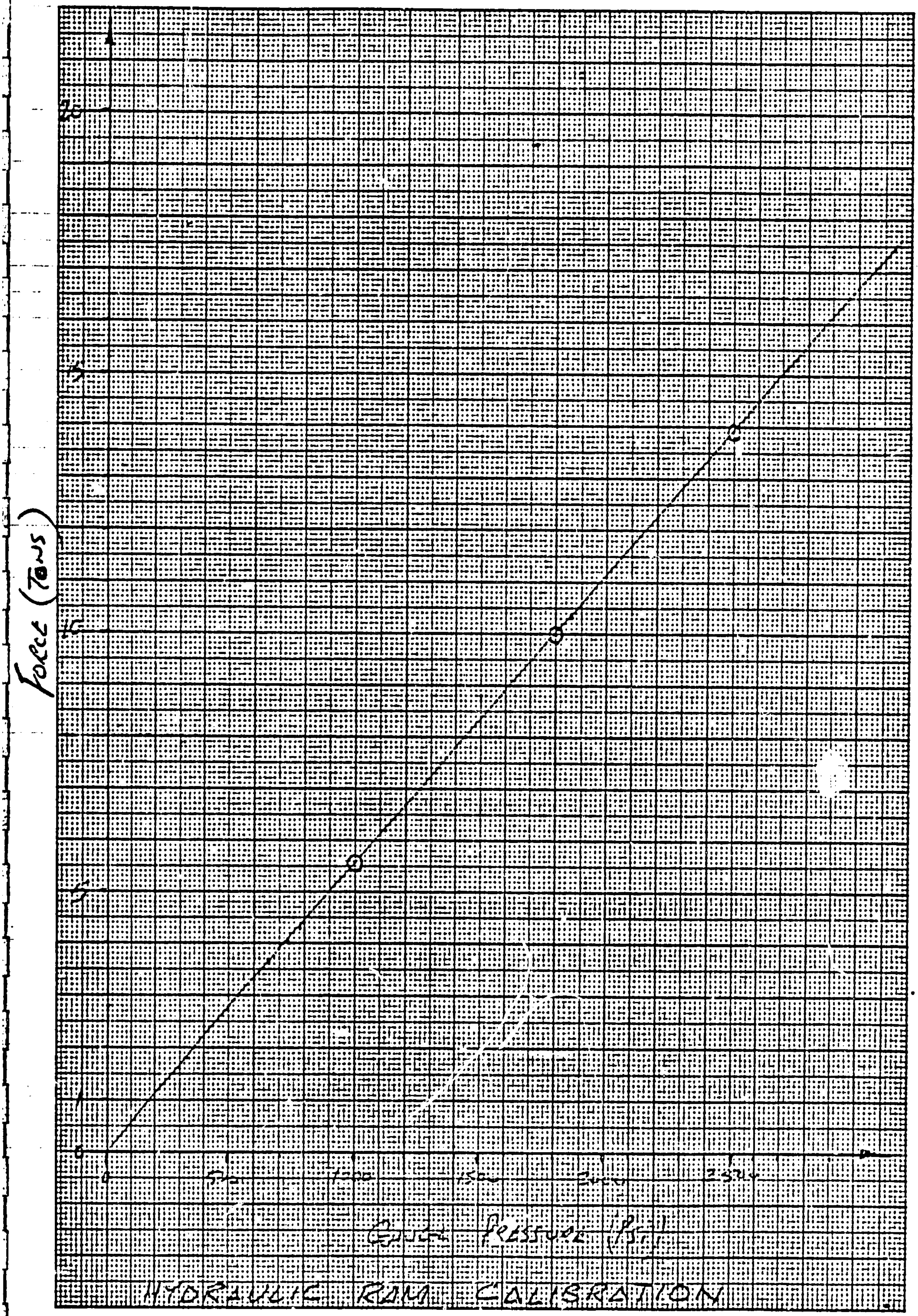
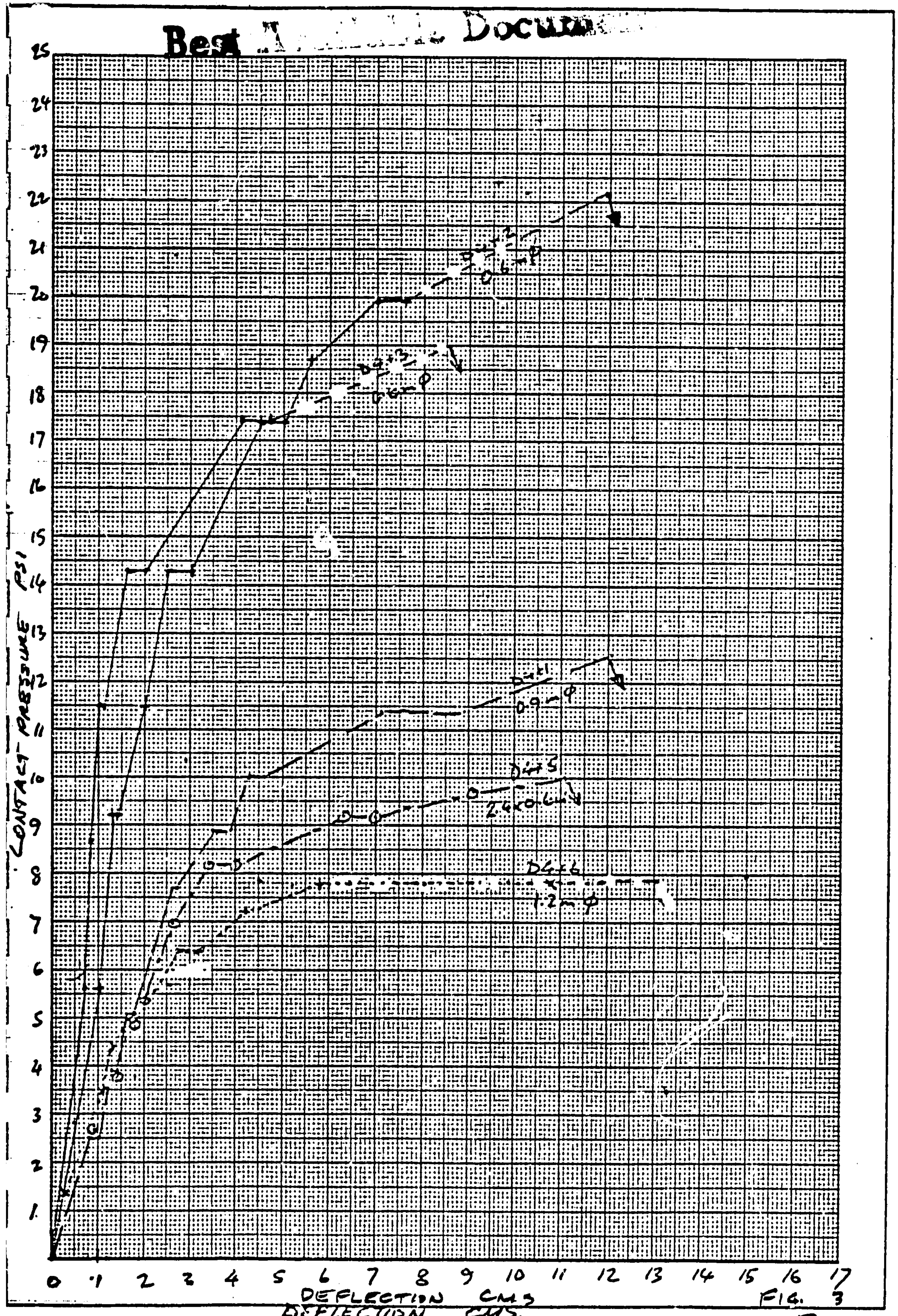


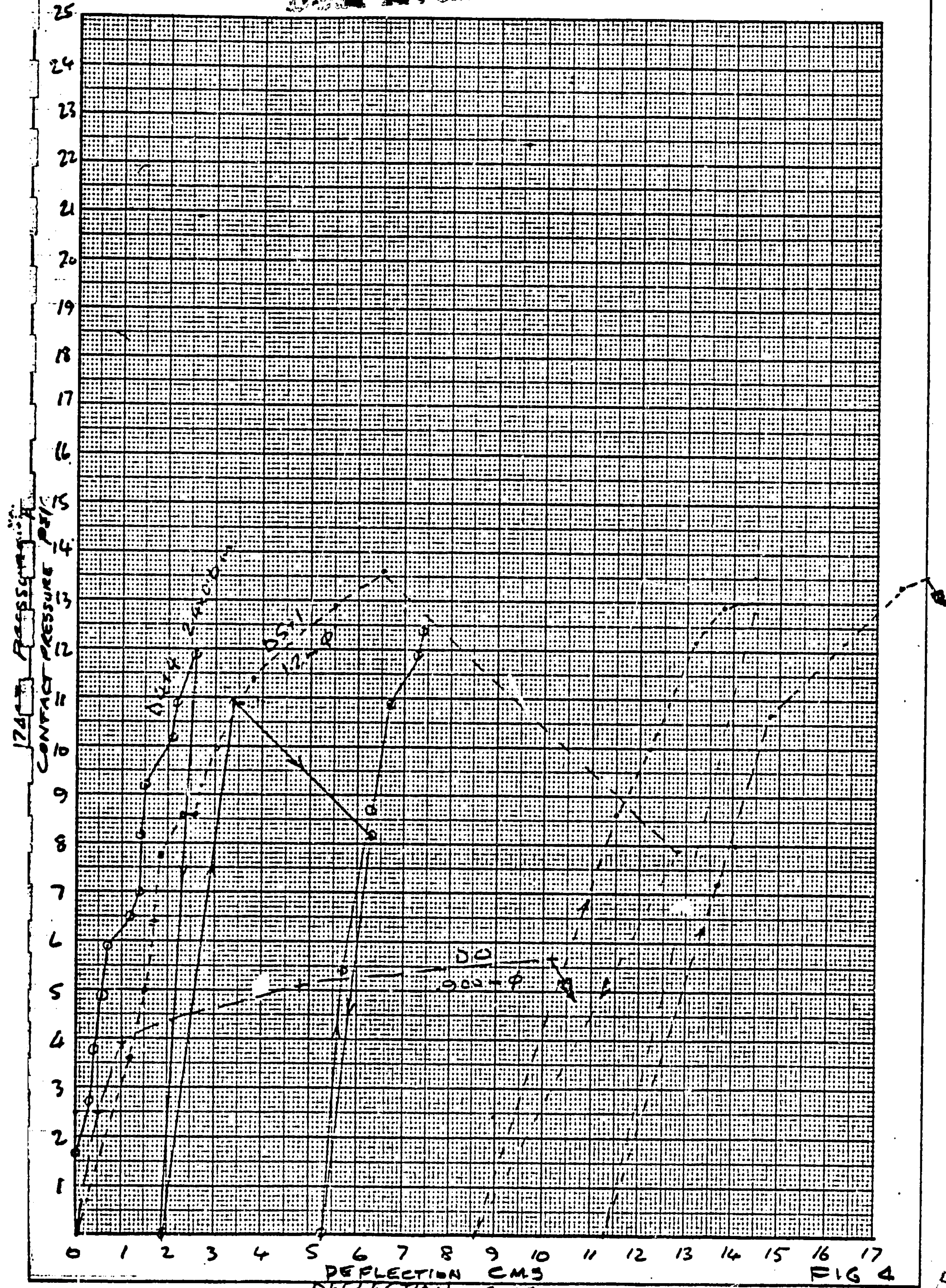
FIG. 2



Best ... Document
CONTACT PRESSURE PSI
DEFLECTION CMS
D4+2
0.6m Φ
D4+3
0.6m Φ
D4+1
0.9m Φ
D4+5
2.4x0.6m
D4+6
1.2m Φ
FIG. 3

E1/2 56

Best Available Document



DEFLECTION CMS.

FIG 4

57

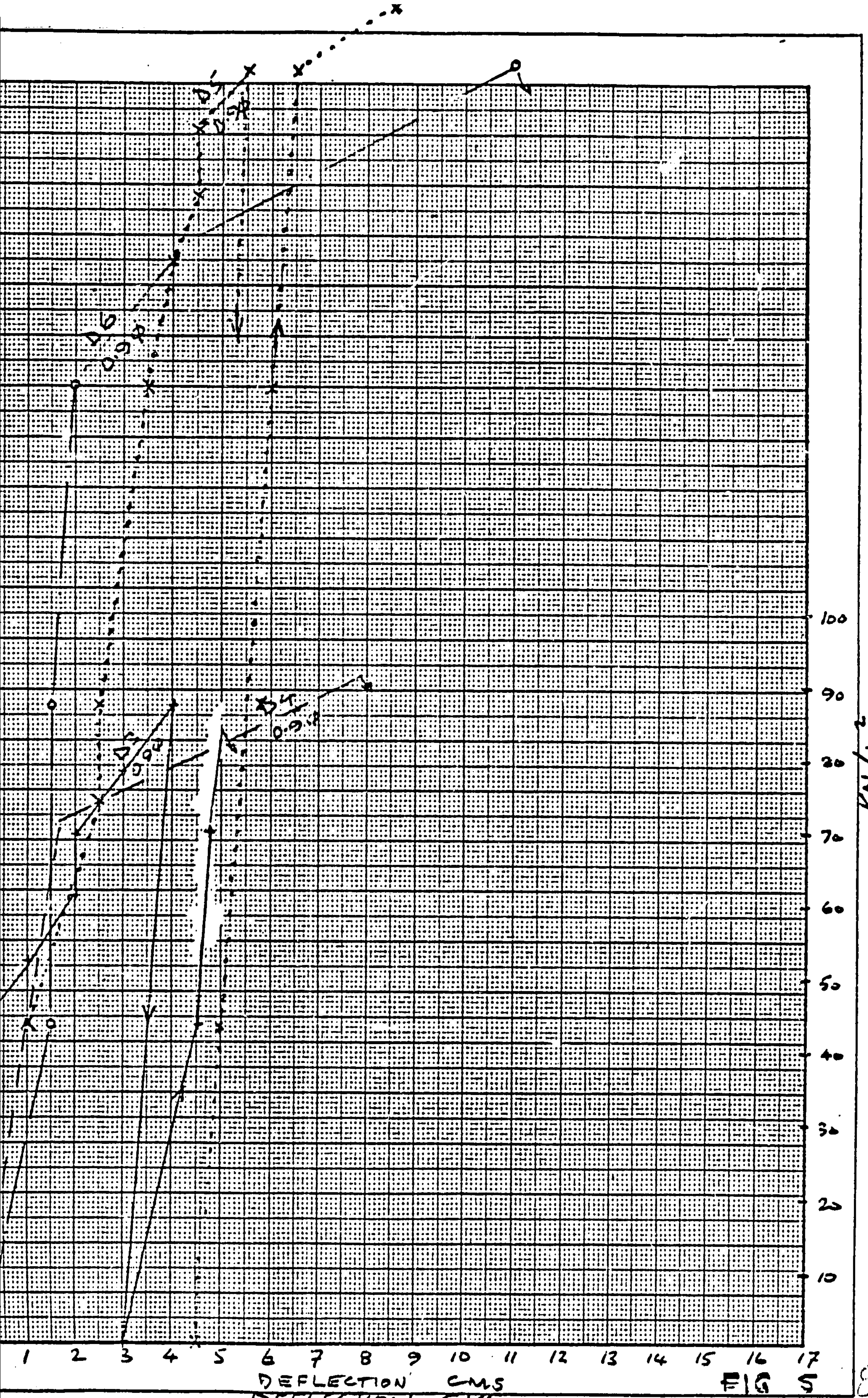


FIG 5

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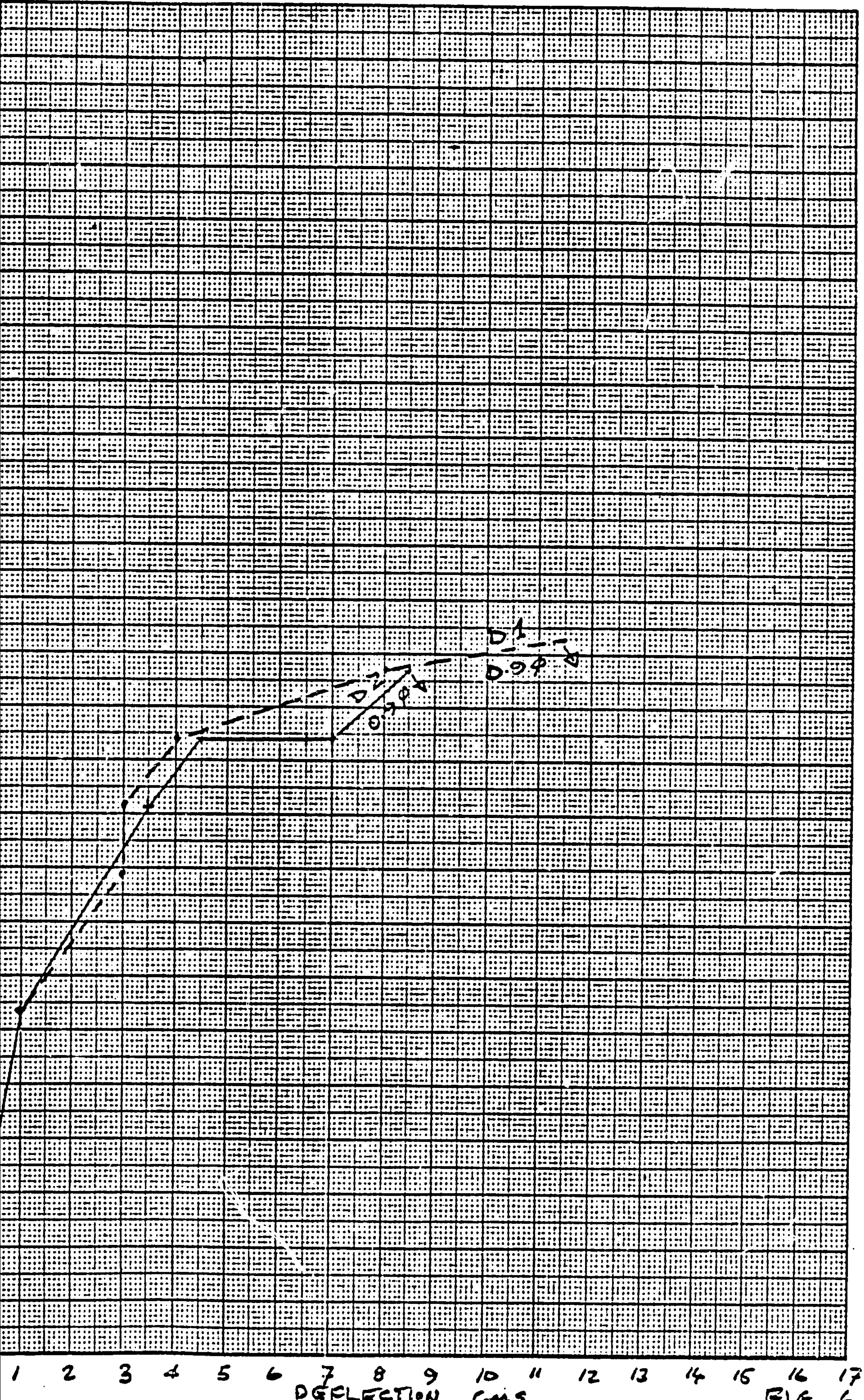
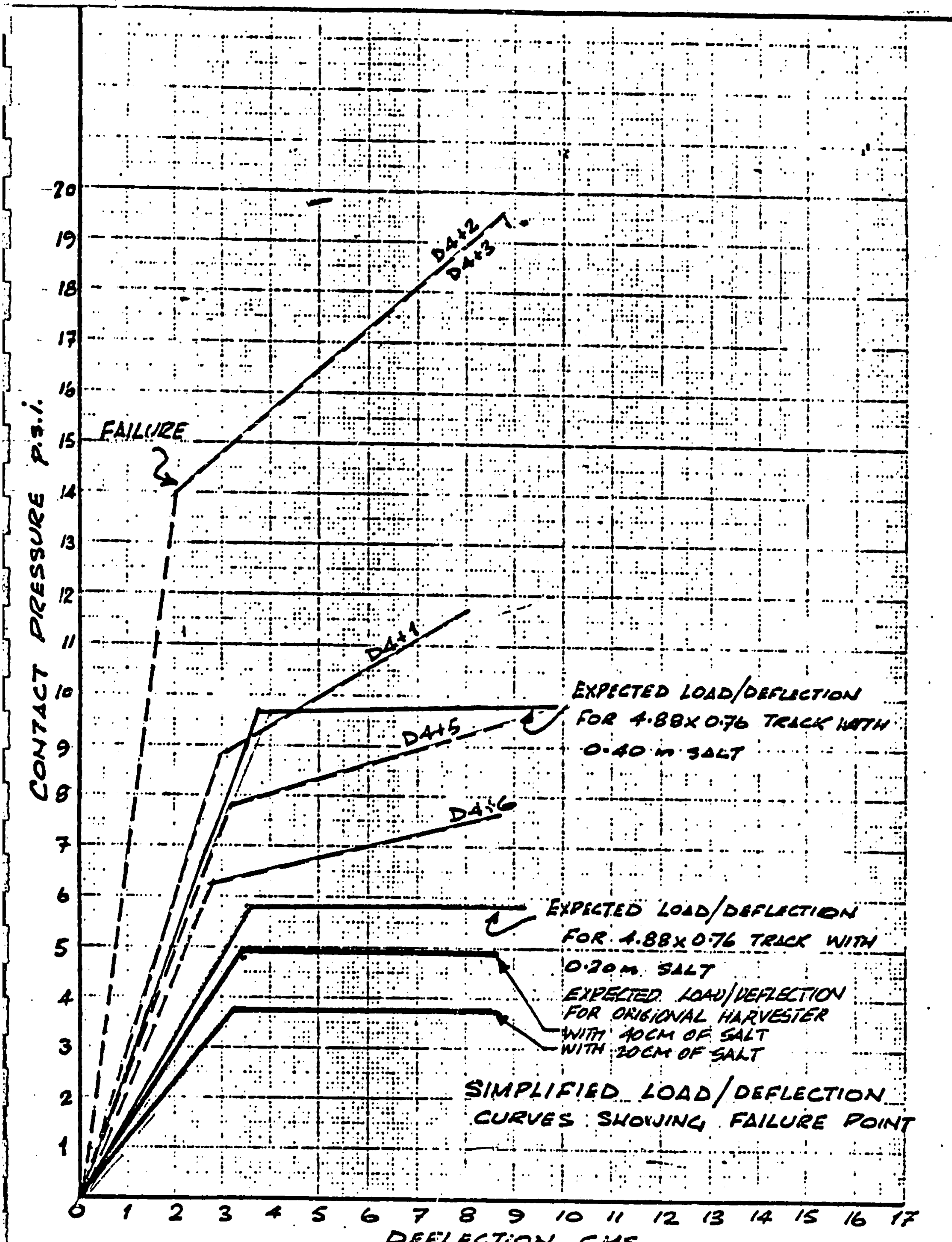


FIG. 6

DEFLECTION CMS

FIG. 6

84



TITLE

JACOBS INTER LTD INC.

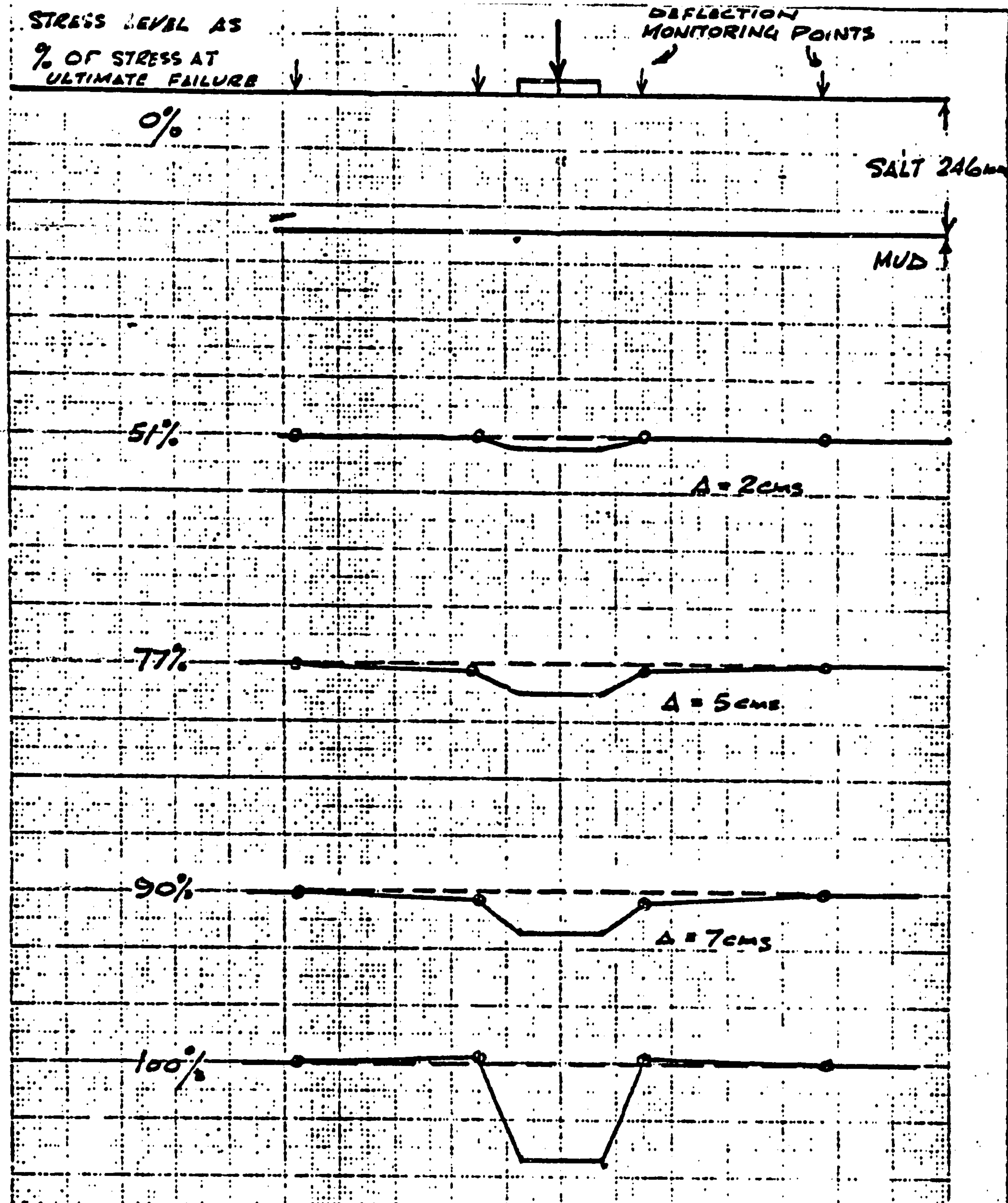
PROJECT A.P.C. DEAD SEA JORDAN

INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS
BALLYMUN ROAD : DUBLIN 9

DRAWING NUMBER FIG. 7

DEC. 1990

60



NOTE: CALCULATED PUNCHING SHEAR FAILURE STRESS OCCURS AT 62% OF ULTIMATE (APPROX.)

SCALE: HOR. 1:40
VER. 1:10

TEST D4+2 600mm ϕ PLATE

TITLE –

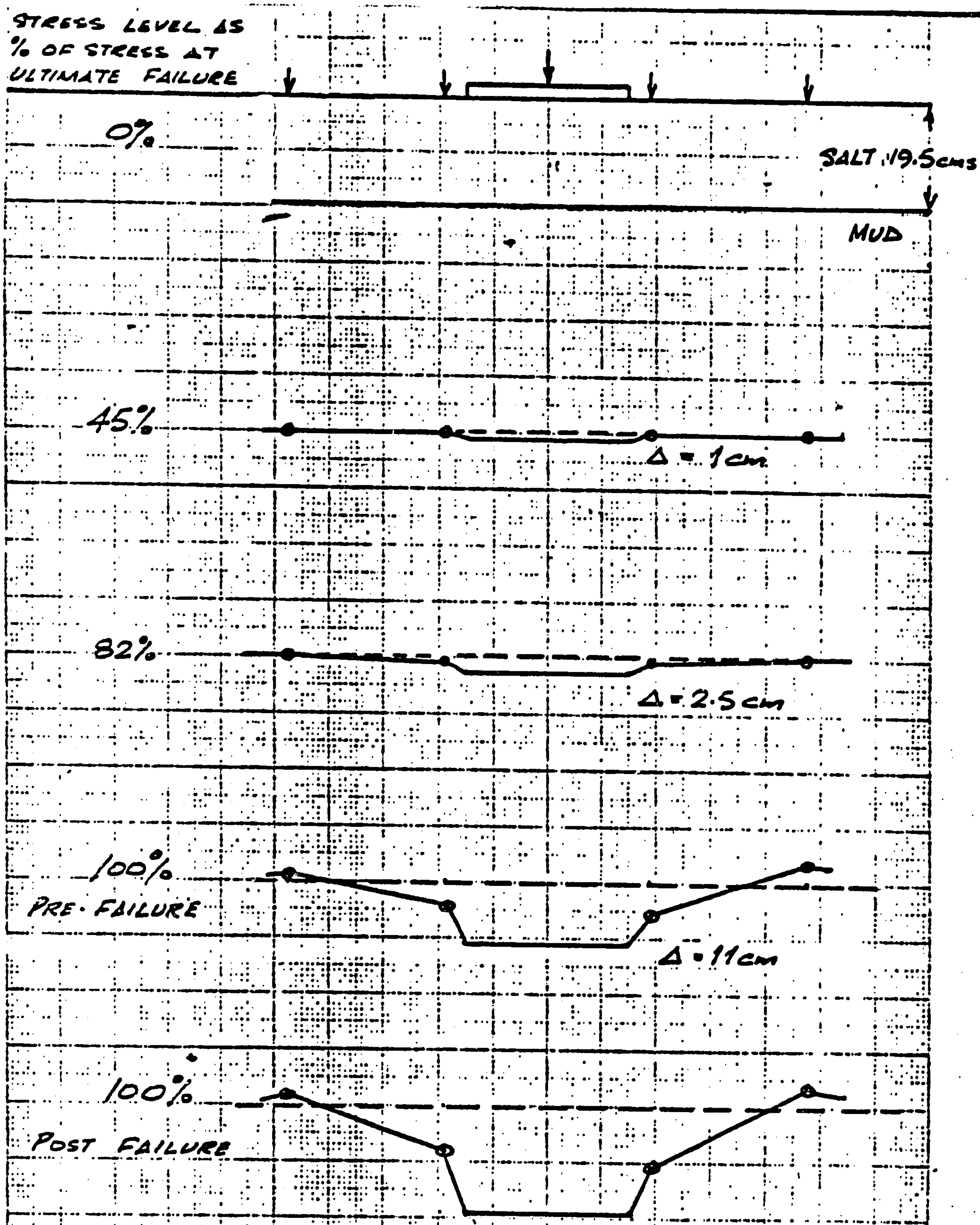
JACOBS INTER. LTD/INC.

PROJECT A.P.C DEAD SEA JORDAN

DEC 1980

INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS
BALLYMUN ROAD : DUBLIN 9

DRAWING NUMBER FIG 8.



NOTE: CALCULATED PUNCHING SHEAR FAILURE STRESS OCCURS AT 52 % OF ULTIMATE (APPROX).

SCALE: HOR 1:40
VER. 1:10

TEST D4+6 1.2 m Φ PLATE

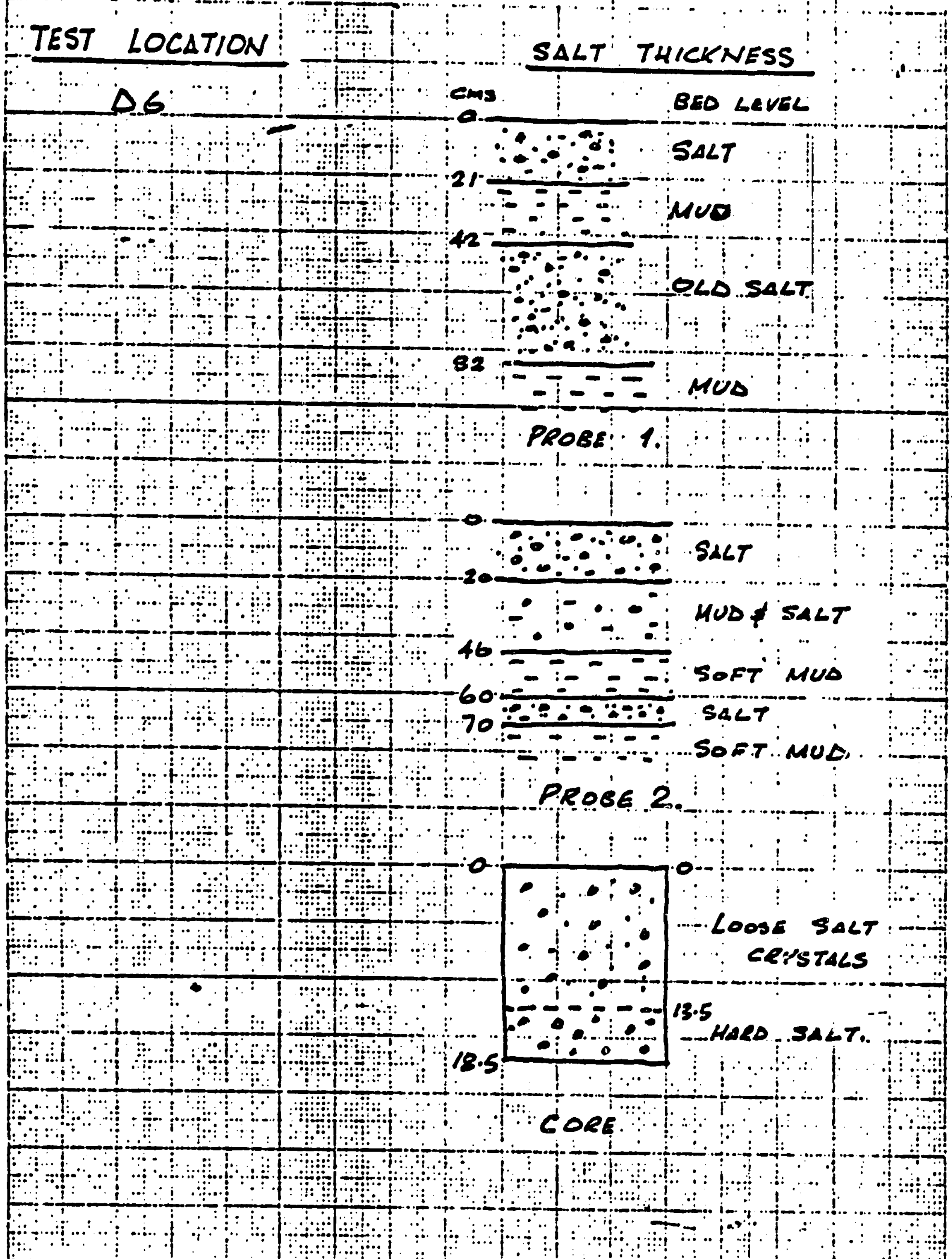
TITLE

JACOBS INTER. LTD/INC.

PROJECT A.P.C. DEAD SEA
JORDAN

INSTITUTE FOR
INDUSTRIAL RESEARCH
AND STANDARDS
BALLYMUN ROAD : DUBLIN 9

DRAWING NUMBER FIG. 9



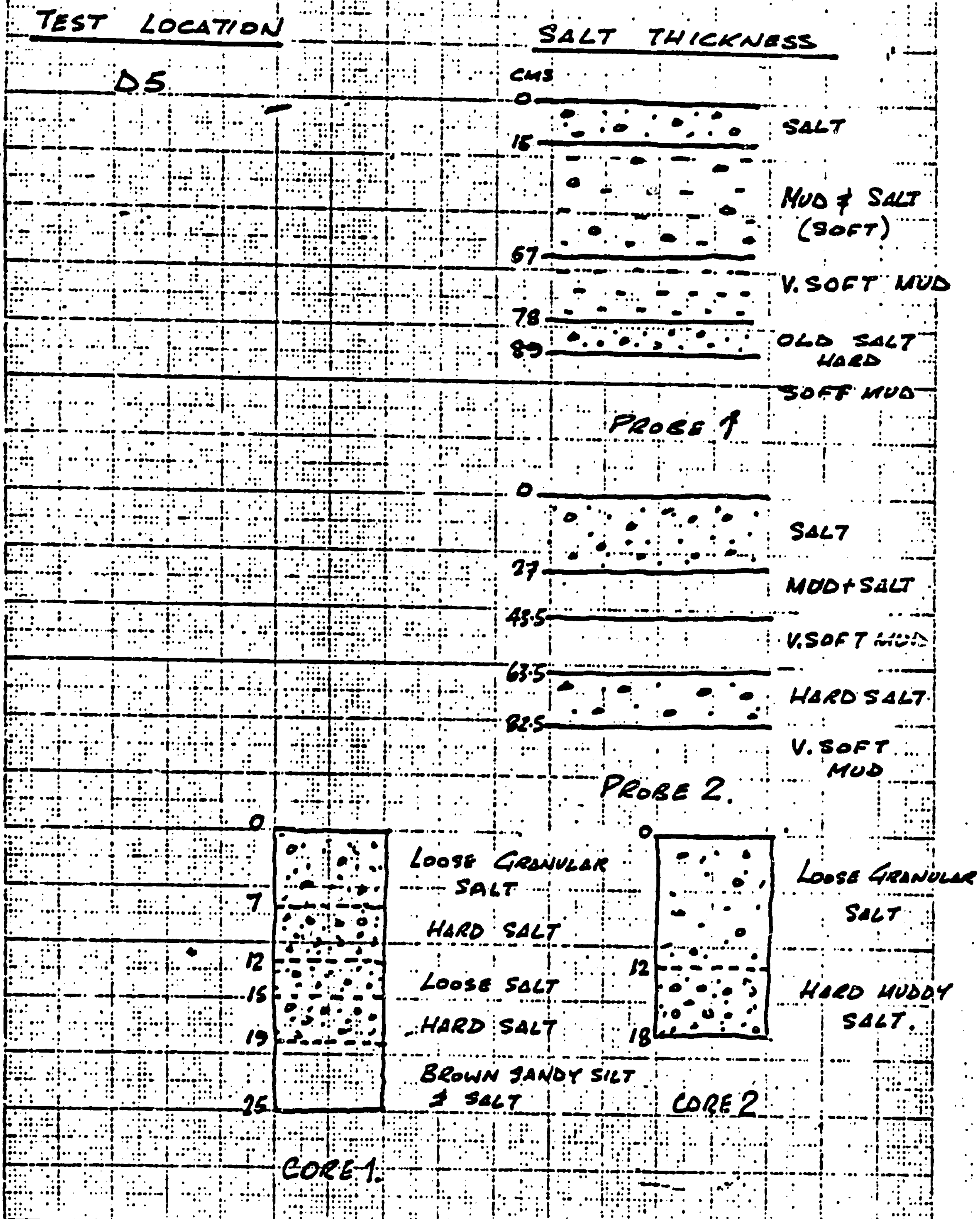
TITLE: SALT THICKNESS & QUALITY

JACOBS INTER LTD/INC. PROJECT A.P.C. DEAD SEA JORDAN

DEC. 1980

INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS
BALLYMUN ROAD : DUBLIN 9

DRAWING NUMBER FIG. 10



TITLE
SALT THICKNESS & QUALITY

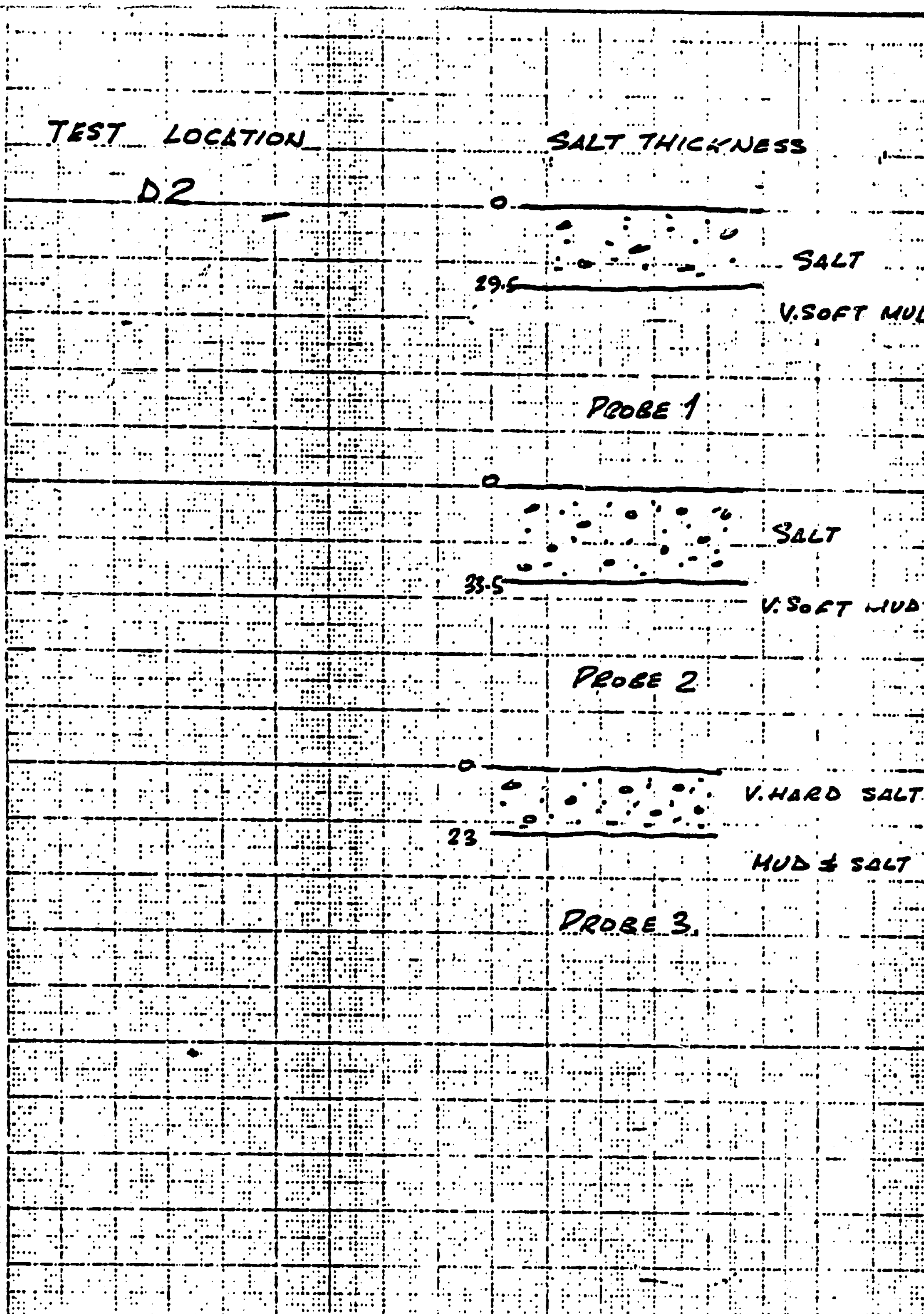
JACOBS INTER LTD INC

PROJECT A.P.C. DEAD SEA JORDAN

DEC 1980

INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS
BALLYMUN ROAD : DUBLIN 9

DRAWING NUMBER FIG 11



TITLE SALT THICKNESS & QUALITY

JACOB INTER LTD INC. PROJECT APC DEAD SEA

JORDAN

DEC. 1980

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BALLYMUN ROAD : DUBLIN 9

DRAWING NUMBER FIG 12.

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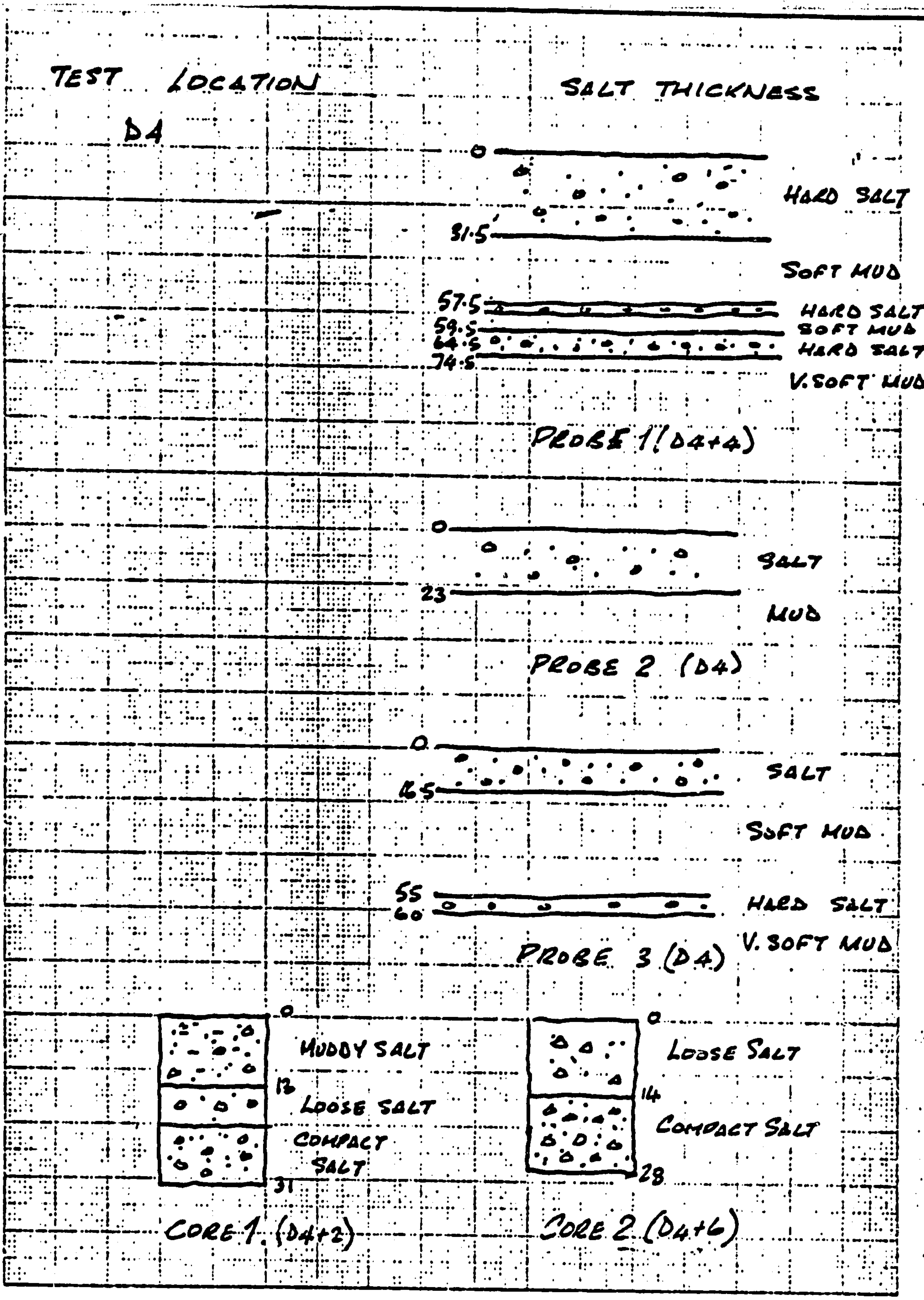

TITLE SALT THICKNESS & QUALITY	INSTITUTE FOR INDUSTRIAL RESEARCH AND STANDARDS BALLYMUN ROAD : DUBLIN 9
JACOBS INTER. LTD INC PROJECT A.P.C. DEAD SEA JORDAN	
DEC 19[illegible]	DRAWING NUMBER FIG 13

ATTACHMENT NO. 2

CARNALLITE HARVESTING ALTERNATIVES

ARAB POTASH PROJECT

PROJECT NO. 08-1875

25th September, 1980

TABLE OF CONTENTS

1.0 SUMMARY

Due to concern as to the capability of the harvest pan salt bottoms to support the harvesting machinery, APC has requested a preliminary review of possible alternatives.

The following alternatives have been compared:

Case	Description	Max. Weight on Salt - MT	Added Capital Cost - $ x 1000
I	Rahco Prototype	218	-
II	Dual Unit	65	4,260
III	Floating-track guided	50	1,240
IV	Floating-cable guided	-	12,110

Larger scale tests will be conducted on C1 harvest pan salt bottom in October and November when 13-15 cm of thickness are anticipated. We expect to derive an empirical mathematical model from the test data with which we can extrapolate the maximum allowable harvester weight for various thickness of salt bottoms.

If we find the thickness of salt bottoms anticipated during the current program schedule is sufficient to safely support the Case I RAHCO harvester, then we would recommend releasing the additional four units for fabrication after incorporation of any changes suggested by the Lisan field tests.

If the tests indicate the RAHCO harvester is too heavy for even up to 40 cm of salt thickness, we would recommend reverting to Case III harvester (floating-track guided). This harvester should provide the safest alternative at the lowest increase in capital expense. We also project that this change could be incorporated within our current schedule.

1.0 SUMMARY - contd.

In the unlikely event the tests show salt bottoms have little or no structural support capability, Case IV would have to be seriously considered.

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2.0 INTRODUCTION

During the design development of the RAHCO prototype carnallite harvester, the dry weight of the machine increased from a conceptual weight of 135 short tons to 235 short tons. This fact created concern as to the ability of the harvest pan salt bottoms to structurally support the harvesters.

The salt bottom tests in the Lisan Penninsula test pan indicated an adequate safety factor on a unit weight basis, but only a single test was conducted over unstable mud similar to the base found in the production harvest pans. In May the Institute for Industrial Research and Standards, (IIRS) was retained to attempt to derive a mathematical model using laboratory test data from salt bottom samples to calculate a safe salt thickness over the mud bases in the production carnallite pans. The IIRS report completed in July concluded that no appropriate mathematical model was available to provide positive evidence as to a safe salt thickness. The report recommended conducting large scale tests in C1 harvest pan this fall when 13 to 15 centimeters of salt have formed on the mud bottom. From these tests, an empirical mathematical model will be derived from which a safe salt thickness can be calculated.

Meanwhile, APC has requested a preliminary study of methods of reducing the bearing pressure of the current RAHCO prototype harvester and other harvesting alternatives as indicated by the test results in C1. This report covers a preliminary examination of various harvesting alternatives and their cost impact.

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3.0 CARNALLITE PAN SALT BOTTOMS

A preliminary report (attachment A) reviewing the effects on project schedule of various salt bottom thickness requirements, indicates up to 40 cm of salt is possible without major alterations of our program. Additional temporary brine pumping capacity may be necessary to obtain 40 cm, but this goal probably represents the maximum salt bottom thickness obtainable without production delays.

The salt bottom tests to be conducted in C1 carnallite harvest pan in October and November should provide information on which maximum loading can be based. This maximum loading, including adequate safety factor, could be less than that required by the current RAHCO prototype carnallite harvester. If this occurs, assuming the 40 cm of salt bottom thickness, it will be necessary to consider other harvesting alternatives economically against the cost impact of even greater salt thickness.

A test is now underway in the carnallite test pan to determine the actual co-efficient of traction. Up until now we have used an estimated figure. This co-efficient will allow calculation of the unit track pressure required for steerability and cutterhead driving force. We can then more accurately calculate the minimum weight a harvester must exert on the salt bottom and still provide satisfactory operation.

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4.0 DISCUSSION OF ALTERNATIVE CASES

4.1 General

In this section we will discuss the following alternative carnallite harvesters:

Case I

RAHCO prototype - salt bottom supported with track drive.

Case II

Dual unit harvester - salt bottom supported, track driven dredge unit with separate floating carnallite concentration and service unit.

Case III

Independent floating harvester - floating single unit with retractable track drive.

Case IV

Cable operated floating harvester - driven by cable winch.

4.2 Case I - RAHCO Prototype Harvester

This Case covers the prototype harvester produced by RAHCO. The harvester is entirely supported by the salt bottom and is driven by tracks. The harvester is fitted with ballast tanks to add weight in deep areas as required to provide bottom traction.

The prototype machine has been tested in the factory and is currently being dis-assembled and packed for export to Aqaba. It is expected to arrive at Aqaba the third week of October. After shipment to the site and re-assembly, it will be ready for field tests in the Lisan test pan.

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4.0 DISCUSSION OF ALTERNATIVE CASES - contd.

4.2 Case I - RAHCO Prototype Harvester - contd.

The Lisan tests will provide the first data on how the prototype machine will perform in actual harvesting operation. We will be able to test manoeuverability, performance of the cutterhead, slurry concentrations possible from the dredge pump and hydro-cyclone system, pumping rates, pipeline friction factors, general operating characteristics and specific harvester operation parameters. This information and data will provide significant imput towards the final harvester design regardless of salt bottom considerations.

If it is determined that the current weight of the RAHCO harvester is too high for the thickest economic salt bottom, there is little that can practically be done to reduce the weight. We have considered operation with the two recovery pontoons attached, but Rahco feels the large volume of the pontoons would significantly reduce manoeuverability. If actual salt bottom conditions require a minor weight reduction in the current prototype, it may be possible to devise a smaller, less bulky set of pontoons for attachment to the same connections used by the recovery pontoons. Hydraulic rams could be arranged to force the smaller pontoons to a maximum of 0.5 meters submergence, thus providing a weight reduction equivalent to the brine displacement. The pressure to the hydraulic rams could be automatically adjusted depending on the brine depth.

If we find it consistant with manoeuverability, by leaving the ballast tanks empty, the RAHCO machine will be able to operate in the deeper portions of the pan with a reduced pressure on the bottom. In this manner the RAHCO machine will exert only an estimated

4.0 DISCUSSION OF ALTERNATIVE CASES - contd.

4.2 Case I - RAHCO Prototype Harvester - contd.

190 short tons on the salt bottom when operating in areas of 1.8 meters of brine depth and even less at greater depths. This weight could be further decreased by mounting lower ballast tanks. About 50% of the production harvest pan area is in the plus 1.8 meter depth range. This type of operation would provide a stop-gap means of starting harvesting operations. In the long run, it is probably impractical, because a completely different harvester would have to be designed for use in the shallow areas of the pan.

If it is ultimately determined that the RAHCO harvester will not be basis of final design, we will have still gained valuable test and design information. As well, many of the components and parts can be used in any of the other alternatives listed herein.

4.3 Case II - Dual Unit Harvesters

A large share of the weight of the RAHCO prototype harvester is contributed by electrical transformers and switchgear, slurry tank, hydrocyclones and booster pumps. If these items could be arranged on a separate platform, the harvester could consist mainly of a cutter head, track drive unit and dredge pumps weighing perhaps 80 tons. The dredge pump would be fitted with a 600 HP, 3,300 volt drive motor. The slurry from the cutter head would be pumped at 15-25% solids through a floating 16 inch pipeline approximately 850 meters long to a floating concentration unit anchored in a fixed position.

The concentration unit would basically be a barge fitted with ballast tanks and containing the 11/3.3 KV transformer and switchgear, the LV switchgear, slurry

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4.0 DISCUSSION OF ALTERNATIVE CASES - contd.

4.3 Case II - Dual Unit Harvesters - contd.

tank, hydrocyclones and booster pump. A 12 inch floating pipeline and 11 KV power cable about 1,250 meters long would be connected to the dike pipeline feeding the refinery and the 33/11 KV dike transformer. A 3,300 volt power cable would follow the 16 inch pipeline from the concentration barge to the harvester.

The ballast tanks on the concentration barge would be flooded to sink and anchor the barge on the bottom near the center of the harvester pan. The harvester would work the area adjacent to the barge for about 4-5 days, then the barge would be relocated midway between dikes in the direction of harvesting.

The overflow of fine carnallite solids from the hydrocyclones would remain in a stationary position for 4-5 days at a time. Some distribution could be expected from wind and wave action, but the coarser carnallite particles could create local piles reaching the surface of the brine. This could create a problem in subsequent harvesting. More frequent movement of the concentration barge would improve distribution of these cyclone overflow fines, but never to the level achieved by having the concentration done right on the harvester.

We have located four new barges in Ireland that were part of a cancellation by the original puchaser. They are near the size required and are available for about 50-60% of the original purchase price. We have used these barges as a basis for our conceptual design and cost estimates for this Case and for Case III.

Drawing number SK-100 in the Addendum shows the harvester concept involving only the dredging operation.

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4.0 DISCUSSION OF ALTERNATIVE CASES - contd.

4.3 Case II - Dual Unit Harvesters - contd.

Drawing number Sk-101 shows the concentration barge and drawing number SK-102 shows a plan view of a carnallite pan with Case II harvesting operation.

We believe the existing pipeline pontoons purchased for the 12 inch floating slurry pipeline can be adapted for use with 16 inch pipe. However, cancellation charges on the portion of 12 inch pipe already ordered by Voest-Alpine could be very heavy.

4.4 Case III - Independent Floating Harvesters

This concept offers the safety of a floating unit coupled with the independance of a bottom operated track drive. One of the barges mentioned in Case II would form an ample platform to support all of the components on the present prototype harvester. Four standard Caterpillar excavator D5L track units would be located, two on each side of the barge, on a vertical sliding support whose elevation would be controlled by a hydraulic cylinder. Drawing number SK-103 shows plan and elevation view of the harvester. Drawing number SK-104 shows an isometric arrangement of one of the track drive units.

During harvesting operations, the four tracks would be forced downward by the hydraulic cylinders at an automatically controlled pressure such that a maximum of approximately 50 short tons total weight is exerted against the salt bottom. This is the calculated weight required to overcome resistance of the cutter head to forward movement and the force attributable to

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4.0 DISCUSSION OF ALTERNATIVE CASES - contd.

4.4 Case III - Independent Floating Harvesters - contd.

the floating pipeline from the wind along with an appropriate safety factor.

The harvester would then cut a path directly across the pan. On reaching to opposite dike, all four tracks would be retracted off the salt bottom. The total displacement of the harvester is estimated to be 75 cm, which means it will float free of the bottom in the minimum pan depth of one meter. The work boat can then rotate the harvester 180 degrees for the return trip. By avoiding the necessity to reverse position with bottom drive tracks, no damage to salt bottoms from turning will occur. Only very minor track steering adjustments will be required to keep the harvester on the laser beam track across the pan.

The track units can be retracted completely out of the brine for routine maintenance anywhere in the pan. Any one of the track units could be lifted by crane completely away from the harvester and replaced by a spare unit in a very short period of time. Maximum unit bearing pressure of the tracks will be 4 to 5 psig.

4.5 Case IV - Cable Operated Floating Harvester

In this concept the harvester is a completely contained, single floating unit as in case II, except no track drive is provided. Instead, four automatic computer controlled winches, one on each corner of the barge, are connected by cable to permanent anchors, two on each dike. Drawing number SK-105 shows a plan view of the harvester in a carnallite pan.

This concept was investigated earlier in project and

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4.0 DISCUSSION OF ALTERNATIVE CASES - contd.

4.5 Case IV - Cable Operated Floating Harvester - contd.

was discarded because of high cost as compared to bottom driven harvesters. Also because of the great width of our harvest pans, path control would be very difficult to achieve with such long cables.

We would hold this concept in reserve if salt bottom operation of any type becomes impractical.

5.0 CAPITAL COST CONSIDERATIONS

5.1 General

The current definitive capital cost estimate for the project is based on five RAHCO type harvesters. Capital cost increases can be expected in the event that any of the alternative Cases other than Case I are subsequently adopted.

For early evaluation and comparisc
have prepared "order of magnitude" estimates of the capital cost for each Case.

5.2 Capital Cost of Alternative Harvesters

An order of magnitude capital cost is shown below for a harvester representing each Case along with the price of the Case I RAHCO machine.

Case	Capital Cost $ x 1,000
I	2,540
II	2,600
III	1,960
IV	3,250

5.3 Total Capital Cost for Each Alternative Case

Case	U.S. $ x 1,000 I	II	III	IV
Harvesters - delivered and assembled.	12,700	13,000	9,800	16,250(*)
Loss on Prototype harvester (1)	-	1,500	1,500	1,500
16 Inch slurry pipe - line (3400 m)	-	1,900	-	-
12 Inch slurry pipe - line (3400 m)	-	650	-	-
Additional Pipeline pontoons (160 ea.)	-	480	-	-

5.0 CAPITAL COST CONSIDERATIONS - contd.

5.3 Total Capital Cost for Each Alternative Case - contd.

	U.S. $ x 1,000			
Case	I	II	III	IV
Revised pontoon clamps and saddles (160 ea.)	-	80	-	-
Dike Anchors	-	-	-	6,900
Pan Anchors	150	-	150	150
Dike 7 Lock	-	-	300	300
Total	12,990	17,610	11,750	25,100

(*) Includes cables

6.0 EFFECT ON PROJECT SCHEDULE

If we follow our current schedule, we estimate a total of 26-28 cm of salt will be formed on the bottoms of the carnallite pans. On this basis, the earliest date on which carnallite harvesting could begin is April, 1982. Assuming a minimum of twelve months for harvester delivery to the site after release for fabrication we must give that release by March 1981 in order to maintain schedule.

If we find up to 40 cm of salt bottom thickness is required, about four months will have to be added to the above schedule. Our release for fabrication could also be delayed, if necessary. However, if any alternative harvester other than Case I is to be used, additional time for design development will be needed.

On the above basis, we do not feel we are in serious trouble schedule wise, regardless of the Harvester alternative adopted (except Case IV where dike anchors would be a problem). However, the schedules will be tight, requiring very close attention.

Imput from the results of the RAHCO harvester tests can be incorporated in whatever Case is agreed before fabrication release. Little other data can be gained until the time carnallite is ready to be harvested in C1. Delivery of subsequent harvesters is spaced such that 12 months elapses between delivery of the first and last units.

7.0 COMPARISON OF ALTERNATIVE HARVESTERS

7.1 General

Table 7-1 is a comparison of the major features of each alternative case. A more detailed review follows:

7.2 Bearing on Salt Bottoms

Case I, by far, will exert the greatest total loading on salt bottoms. Case II to a lesser degree, but with either Case, continued operation is completely contingent on the integrity of the salt bottom. Even an occasional salt break-through is a serious problem because of recovery difficulty and because there is no practical or economical method to repair the salt bottom.

Any destruction of salt bottoms created by turning a tracked type harvester 180 degrees after each pass is cummulative over the planned 20 years of plant operation. Cases I and II are in this category. Cases III and IV are turned with no salt bottom contact and would therefore cause no damage.

Case IV is entirely floating without salt bottom contact, so no problems can be contemplated in this regard. Case III has minimum salt bottom contact as required to maintain position on straight passes. An occasional salt break-through could create some minor difficulties on future passes, but not nearly to the extent as in Case I or II.

7.3 Operation and Maintenance

Maintenance of tracks will be most difficult for Case I and II. To accomplish routine greasing of track rollers and tightening track shoe bolts, the harvester must be removed from the pan. Accessibility can be

TABLE 7-1 COMPARISON OF ALTERNATIVE HARVESTERS

CASE	I	II	III	IV
Estimated Harvester dry weight - ST	235	80/180	250	270
Minimum bearing on salt bottom - psig	2.9(1)	?	0	0
Maximum bearing on salt bottom - psig	6.5(2)	5-6(2)	5	0
Maximum total operating weight on salt bottom - ST	218(2)	65(2)	50	0
Possible damage to salt by turning	High	Medium	Nil	Nil
Interruption caused by salt break through	Long	Long	Short	N/A
Ease of salt break-through recovery	Poor	Fair	Good	N/A
Accessibility for track maintenance	Fair	OK	Good	N/A
Ease of outside hull maintenance	OK	Good	Fair	Poor
Ease of inside hull maintenance	Tight	Tight	OK	OK
Laser tracking capability	Good	Good	Good	?
Number of Operators required per harvester	2	3	2	2
Ease of pan to pan harvester movement	OK	OK	Fair	Fair
Distribution of hydrocyclone fines	Good	Poor	Good	Good
Cost Difference - order of magnitude - US $ x 1,000	-	4,620	- 1,240	12,110

(1) In 2.8 m brine depth w/o ballast

(2) In 1.0 m brine depth w/o ballast

7.0 COMPARISON OF ALTERNATIVE HARVESTERS - contd.

7.3 Operation and Maintenance - contd.

accomplished by driving the harvester up a special slope onto the dike. However, this is inconvenient and time consuming as the floating pipeline must first be disconnected. For Case III, most track maintenance can be accomplished by merely retracting each individual track wherever the harvester is located. In Case IV there are no tracks.

Accessibility for maintenance inside the hull is tight for Case I and II as space is very limited. Much more space is available on floating versions, Cases III and IV.

Repainting of hull bottoms is relatively easy in Cases I and II but difficult for Cases III and IV. A rental crane large enough to lift an entire floating harvester is probably uneconomical. In Case III, it is possible to design retractable tracks sufficiently strong to elevate the hull out of the brine. Undoubtedly some reasonable method can be worked out, as the Dead Sea Works must have done for their floating harvester.

In operation, Case IV has restricted freedom of movement in that its entire manoeuvering capability is provided by cables. Because of the extreme width of the APC pans, very long cables would be required. This will make path control by laser very difficult, particularly when intermittant winds are blowing.

In general the ease of operation of Cases I, III and IV should be about the same. All operating equipment is on one platform and one floating pipeline connects with the shore pipeline. However, with Case II, harvesting operations are carried out on two separate platforms, one track operated dredge unit connected by a 16 inch

7.0 COMPARISON OF ALTERNATIVE HARVESTERS - contd.

7.3 Operation and Maintenance - contd.

floating pipeline to a slurry concentration barge. At least one additional "around the clock" operator will be required. Also the requirement of frequent relocation of the concentration barge will interrupt operations. The larger floating pipeline will provide less mobility and ease of manoeuver.

7.4 Distribution of Carnallite Fines

Hydrocyclone overflow containing carnallite and salt fines is directed back into the pans. In Case I, III and IV these fines will be uniformly distributed over the area of the pan. In Case II, they will be dumped in piles along the long centerline of the pans. This could cause interference with harvesting and/or reduce the consistancy of carnallite feed.

7.5 Pan to Pan Transfer of Harvesters

With a total of four harvesters as originally conceived, one machine would be required to work, in any given year, in both harvest pans C2 and C3. As well, in the first year of operation before carnallite is ready in C2 or C3, two or possibly three harvesters will be required temporarly in C1 for 75% operation tests. Therefore, ease of pan to pan transfer to harvesters is a consideration.

For Case I and for the dredge harvester portion of Case II, the machine could easily crawl over an earthen ramp spanning the dike with power supplied by a temporary cable.

For the floating portion of Case II and for Cases III and IV, inter-pan transfer will be much more difficult. 86

7.0 COMPARISON OF ALTERNATIVE HARVESTERS - contd.

7.5 Pan to Pan Transfer to Harvesters - contd.

Again, a rental crane of the size required would probably not be economical. However, if five harvesters are available as provided in the final Rahco purchase order, two could be located in C2 and two in C3, removing the necessity for transfer between those two pans. We have remaining the problem of moving one or two harvesters from C1 to C2.

We have tentatively proposed to handle this transfer with a lock between C1 and C2. To keep the cost down, the lock would consist of a canal cut through dike 7 about 12 meters wide, lined on each side by sheet steel piling. A temporary clay dam would seal each end and the center would be filled with sand/gravel backfill. When ready to transfer, the dam on the C1 side and the backfill would be excavated by dragline or back hoe. A harvester can then be floated into the canal and the dam replaced behind it. The lock can then be filled with brine to the C2 level and after cutting out the downstream dam, the harvester can be floated into C2. Consideration can also be given towards the use of the lock as a dry dock for repainting harvester hulls.

7.6 Capital Cost Differences

The Order of Magnitude capital cost differentials have been brought forward from section 5.3 and are shown on table 7-1. It is obvious that use of the Case I RAHCO harvester represents the lowest cost. In the event, Case I cannot be used, Case III will provide the lowest increase in capital cost.

8.0 RECOMMENDATIONS

Our recommendations will depend largely on the results of the salt bottom tests to be conducted in Cl harvest pan. We may find the strength of the salt bottom is variable. If something approaching 95% of the area is acceptable and the unacceptable 5% is in many widely distributed areas, the whole may be unacceptable. The same may not be true if a few bad areas can be effectively isolated.

Obviously the least costly route is to remain with the current RAHCO harvesters (Case I) as modified by the results of field tests. We would make this recommendation only if the tests result in conclusive evidence that salt bottoms of 40 cm or less are safe for 20 years of operation. If 40 cm of salt proves to be marginal for Case I, we should calculate the time required to add a "safe" thickness and assess the loss of potash production due to late startup against the cost of other harvesting alternatives.

If there is no chance of accepting Case I, our next recommendation would be Case III. The maximum salt bottom loading requirement with this option is 50 short tons (only 25% of Case I). We feel this is conservative and that even lower loadings may be possible within the design criteria specified. The floating unit has the obvious and overriding advantage that whatever happens to the salt bottom, the harvester remains safe and operable. The retractable tracks are easily accessible for maintenance. The additional capital cost over Case I is the lowest and it is possible to maintain the overall schedule.

It may be desirable to consider using the RAHCO prototype harvester as the 5th unit for operation in deep areas only (assuming salt bottom will support it). This would eliminate the scrap loss estimated at $1,500,000.

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8.0 RECOMMENDATIONS - contd.

While it seems extremely unlikely, we may find salt bottoms are so structurally variable that no significant loading is practical. In this event, we may be forced to consider some version of Case IV. If a complete series of dike anchors is required, as now felt necessary, the startup schedule could be affected. A more thorough review of means of positioning and driving a floating unit should be undertaken if this alternative appears imminent.

ATTACHMENT A

gust 25, 1980

): J. D. Buehler

OM: Mark Frimodig

BJECT: APC Project - Effects of Thicker Salt Bottom in Harvest Pans

0 Background

By early 1980 we were advised by RAHCO that the final weight of the prototype carnallite harvester would approach 220 short tons. As this weight is about 85 tons higher than the estimated weight at time of purchase, concern was expressed as to whether the proposed carnallite pan salt bottom would be sufficiently thick to adequately support the harvesters. The current weight of the harvester is 235 ST.

The salt bottom tests in the Lisan Penninsula test pan indicated an adequate safety factor on a unit weight basis, but only one small area of salt bottom tested was over unstable mud similar to the base found in the production harvest pans. In May, the Institute for Industrial Research and Standards, (IIRS), was retained to attempt to derive a mathematical model using laboratory test data from salt bottom samples to calculate a safe salt thickness over the mud bases in the production carnallite pans. The IIRS report completed in July concluded that no appropriate mathematical model was available to provide positive evidence as to a safe salt thickness. The report recommended conducting large scale tests in C-1 pan this fall when 13 to 15 centimeters of salt have formed on the mud bottom. From these tests, an empirical mathematical model will be derived from which a safe salt thickness can be calculated.

0 Effect of Required Salt Thickness on Schedules

Alternative plans have been considered in the event that the required salt thickness is more than originally anticipated. We have compared the effects on our overall construction and operating schedule for each of the following cases:

Effect of Required Salt Thickness on Schedules - continued

Case I — Current schedule - estimated salt bottom thickness - 25 centimeters (10 inches).

Case II — Revised schedule - estimated salt bottom thickness - 36 centimeters (14 inches). Original annual potash production schedule and quantity possible, but there will be a reduction in construction schedule "float" and carnallite inventory. Carnallite brine will be fed to harvest pans about 4 months later than in Case I.

Case III — Revised schedule - estimated salt bottom thickness - 46 centimeters (18 inches). Carnallite brine will be fed to the pan about one year later than in Case I. Under this revised schedule, we could reasonably expect to produce 3,040,000 metric tons of potash by the end of 1985. This quantity is about 810,000 metric tons less than in Case I, or a schedule loss of about two-thirds of a full year's production.

Revised construction schedules are provided for Cases II and III, along with a basic schedule for Case I in the addendum. The schedules for all of the above cases reflect the best current estimate of the effect of the weaker Dead Sea brine resulting from last winters rain. The basic cases do not consider the use of dye in the pans to increase solar evaporation. If dye is used throughout the salt formation period, we would expect an increase in the deposit thickness of about 10%.

We have considered using brine from the salt pan for dual use as feed to PC-2 for production of carnallite brine and for pumping directly to C-2 and C-3 for salt bottom preparation. However, the higher specific gravity brine (1.280) required for carnallite production will not provide much more salt than the weaker Dead Sea brine. Furthermore, severe problems with deposition of salt in the transfer pipeline between the salt pan and the harvest pans could be anticipated.

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2.0 Effect of Required Salt Thickness on Schedules - continued

We believe it is worthwhile considering moving brine forward through the normal path, that is: SP, PC-1, PC-2, to C1 and C2, such that brine reaches the salt point just as it is transferred to harvest pans. This would only be practical in Case III for the period when the transfer pumps are commissioned (Feb.-March, 1981), until it is necessary to start increasing gravities for preparation of carnallite point brine (about February, 1981). This would add about 5 centimeters to the total salt thickness.

The following table summarizes the salt bottom thickness for each of the three cases, along with scheduled dates and estimated effect on potash production. The "A" subscript for each case indicates dye used. The "B" subscript indicates the use of the normal plan flow pattern to evaporate harvest pan feed to the salt point as mentioned above along with dye.

Case	Salt Bottom Thickness - CM	Carnallite[1] Feed Available - Date -	75% Test Complete - Date -	100% Test Complete - Date -	Total Potash Reduction MT x 1000
I	25	April 1982	Jan 1983	Oct 1983	None
I A	26-28	April 1982	Jan 1983	Oct 1983	None
II	36	July 1982	May 1983	Jan 1984	None
II A	40	July 1982	May 1983	Jan 1984	None
III	46	Dec 1982	Dec 1983	Oct 1984	810
III A	51	Dec 1982	Dec 1983	Oct 1984	810
III B	56	Dec 1982	Dec 1983	Oct 1984	810

The above conclusions are based on preliminary data.[2] Adjustments will be made, if required, when additional data is obtained.

When calculating maximum brine flow rates for salt deposition, we have assumed equilibrium conditions. On this basis, our flow rates are considerably higher than those actually experienced for C-1 to date. Based on C-1 experience, our present temporary brine pumping system would probably be adequate to handle two pans simultaneously during the peak evaporation system. Additional data will be required before this can be confirmed.

3.0 Prototype Carnallite Harvester Alterations

We are in the process of evaluating methods of reducing the operating weight the RAHCO prototype harvester exerts on the salt bottom.

Field tests will be conducted at the Lisan test pan to determine the coefficient of traction provided by a tracked vehicle operating on the salt bottom. From this data we can calculate the minimum weight on the harvester tracks that will allow steer-ability and resistance to drag from the floating pipeline.

When the coefficient of traction is available, we will work with RAHCO to come up with the most practical and economic methods of harvester weight reduction.

An overall evaluation of the salt thickness projected from tests in C-1 this fall, along with possible harvester alterations, shall be the basis of final recommendations.

Note

(1) Based on an estimated 18 cm depth of carnallite deposited in C1.

(2) A single salt sample taken from C1 on 18 August 1980 after 50% of a normal evaporation year was 10 cm thick.

JACOBS INTERNATIONAL LIMITED

ARAB POTASH COMPANY LTD.
PROJECT SCHEDULE
JACOBS INTERNATIONAL LIMITED

CASE I

ARAB POTASH COMPANY LTD.
POTASH PLANT
03-1075
SHEET No. 25 OF 26
DATE 12-1-79

YEAR: 1979, 1980, 1981, 1982, 1983

DESCRIPTION	REMARKS
SHAKEDOWN & COMMISSIONING	
REFINERY	
UTILITY SHAKEDOWN	
UTILITY START UP	
PROCESS SHAKEDOWN	
PROCESS STARTUP	
SOLAR PANS	
FILL SALT PAN WITH BRINE	
FILL PC1 WITH BRINE	
FILL PC2 WITH BRINE	
PAN C1	
FILL C1 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C1 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C1	
PANS C2	
FILL C2 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C2 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C2	
PAN 3	
FILL C3 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C3 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C3	TO 01. OCT'86 (LENGTHS)
HARVESTER STARTUP	
PROTOTYPE HARVESTER (No. 1)	
No. 2	STARTUP 1 APRIL 1982
No. 3	STARTUP 1 JULY 1982
No. 4	STARTUP 1 OCT. 1982
No. 5	STARTUP 1 APRIL 1983
POWER & FRESH WATER	
TEMPORARY POWER FROM HOUSING STN	
POWER SUPPLY TO TEST POND	
PLANT SUPPLY ENERGISED	
WATER SUPPLY TO PC1	
" " TO TEST POND	
PERFORMANCE TESTS	
75 % TEST FOR 48 HOURS	
100 % TEST FOR 48 HOURS	

JACOBS INTERNATIONAL LIMITED

ARAB POTASH COMPANY LTD.
PROJECT SCHEDULE
JACOBS INTERNATIONAL LIMITED

CASE III

[illegible] 25 [illegible] 25
[illegible] SEE NOTE

[illegible] COMPANY LTD.
POTASH PLANT
G9-1875
12-[illegible]-79 [illegible] KJB/132
[illegible] 22-5-80 [illegible]

DESCRIPTION	REMARKS
[illegible] & [illegible]	
[illegible]	
UTILITY SHAKEDOWN	NOTE CASE III ALTERNATIVE PROGRAMS FOR INCREASING SALT BOTTOM THICKNESS IN [illegible]
UTILITY START UP	
PROCESS SHAKEDOWN	
[illegible] STARTUP	
SOLAR PANS	
FILL SALT PAN WITH BRINE	
FILL PC1 WITH BRINE	
FILL PC2 WITH BRINE	
[illegible] C1	
FILL C1 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C1 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C1	
PANS C2	
FILL C2 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C2 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C2	TO 15-FEB-'86
[illegible]	
FILL C3 WITH BRINE	
LAY SALT BOTTOM & FINISH	TO 15-JUN-'84
FILL C3 WITH CARN-POINT BRINE	15-JUN-84 TO 15-AUG-84
CARNALLITE DEPOSITION - C3	15-OCT-85 (14 MONTHS)
[illegible] STARTUP	
[illegible] HARVESTER (No.1)	
No 2	STARTUP 1 APRIL 1982
No 3	[illegible]
No 4	STARTUP 1 [illegible] 1982
No 5	STARTUP 1 [illegible] 1983
[illegible] & FRESH WATER	
[illegible] CLOSING STA	
POWER SUPPLY TO TEST POND	
POWER SUPPLY ENERGISED	
WATER SUPPLY TO PC1	
TO TEST POND	
[illegible] TESTS	
[illegible] % TEST FOR 48 HOURS	
100 % TEST FOR 48 HOURS	OCT. 84

Time scale: 1979 – 1983 (months)

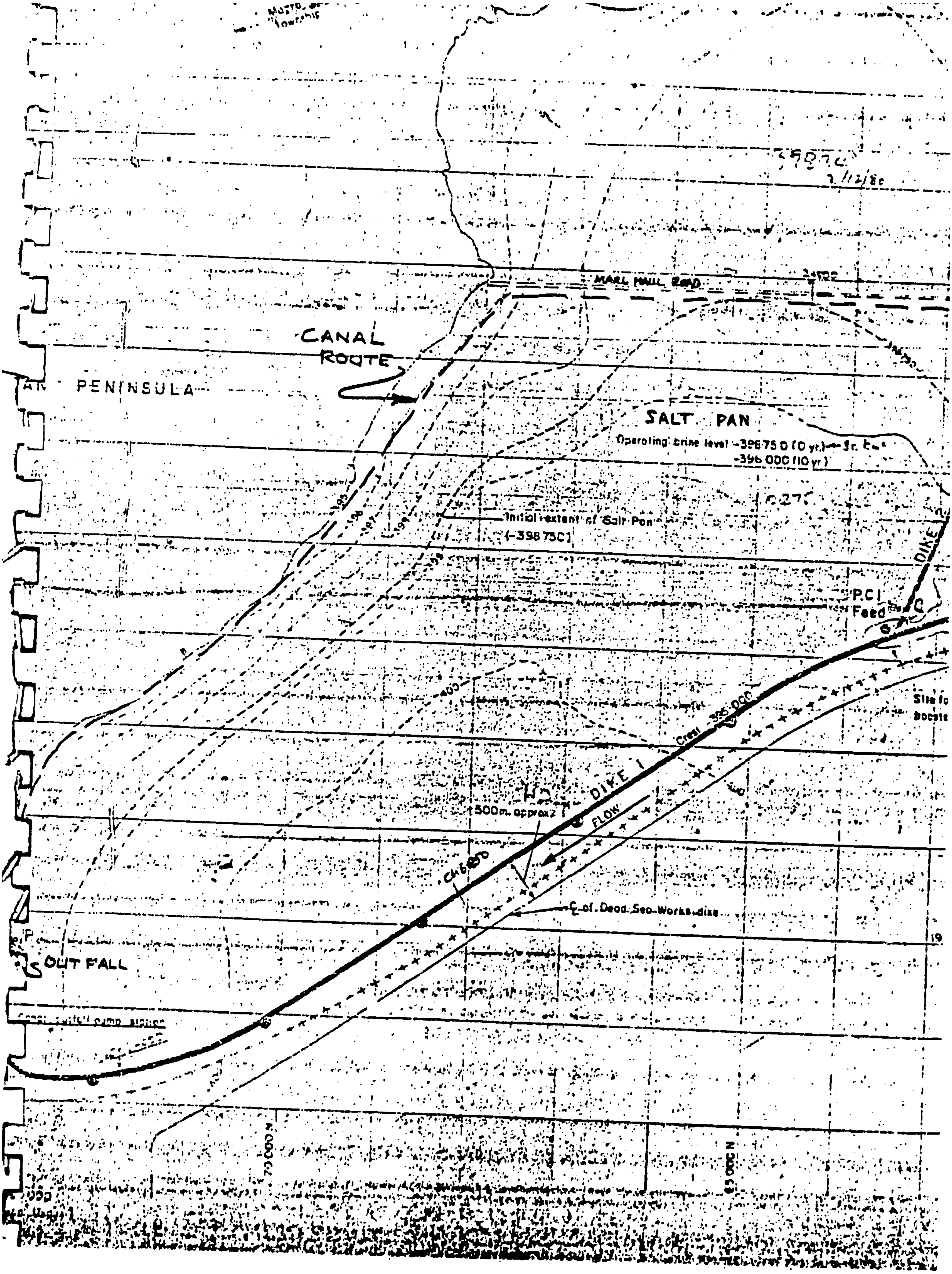
JACOBS INTERNATIONAL LIMITED

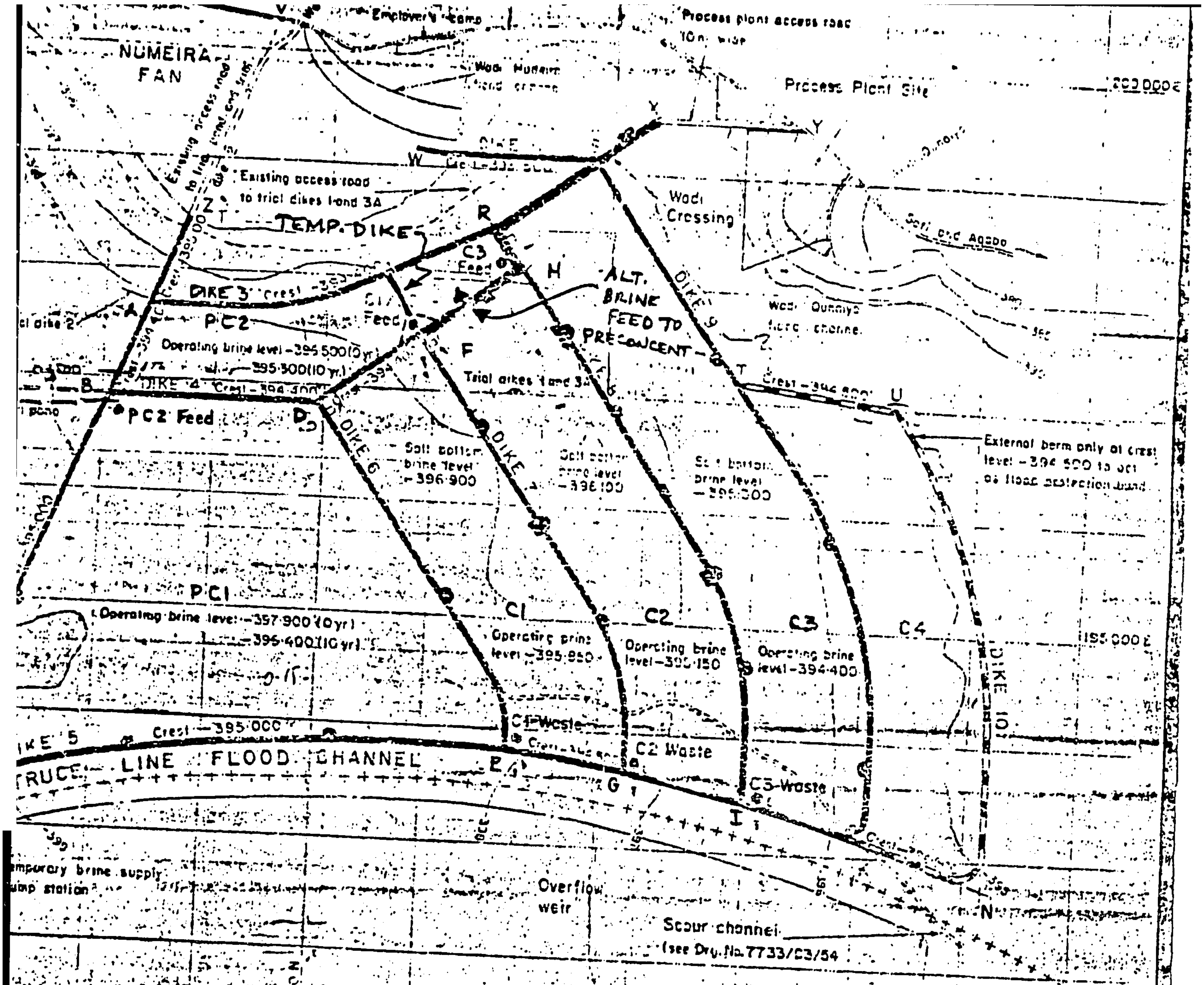
ARAB POTASH COMPANY LTD.
PROJECT SCHEDULE
JACOBS INTERNATIONAL LIMITED

CASE II

ARAB POTASH COMPANY LTD.
POTASH PLANT
03-1575
12-1-79

DESCRIPTION	REMARKS
SHAKEDOWN & COMMISSIONING	
UTILITY	NOTE IN CASE II ALTERNATIVE PROGRAMME FOR INCREASING THICKNESS OF SALT BOTTOM IN PANS
UTILITY SHAKEDOWN	
UTILITY START UP	
PROCESS SHAKEDOWN	
PROCESS STARTUP	
SOLAR PANS	
FILL SALT PAN WITH BRINE	
FILL PC1 WITH BRINE	
FILL PC2 WITH BRINE	
PAN C1	
FILL C1 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C1 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C1	
PANS C2	
FILL C2 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C2 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C2	
PAN 3	
FILL C3 WITH BRINE	
LAY SALT BOTTOM & FINISH	
FILL C3 WITH CARN-POINT BRINE	
CARNALLITE DEPOSITION - C3	30-JAN-86 (16 MONTHS)
HARVESTER START UP	
PROTOTYPE HARVESTER (No. 1)	STARTUP 1 APRIL 1982
No 2	STARTUP 1 OCT 1982
No. 4	STARTUP 1 OCT 1982
No. 5	STARTUP 1 APRIL 1983
POWER & FRESH WATER	
TEMPORARY POWER PLANT BOOSTING STA.	
POWER SUPPLY TO TEST POND	
POWER SUPPLY ENERGISED	
WATER SUPPLY TO PC1	
" " TO TEST POND	
PERFORMANCE TESTS	
75% TEST FOR 48 HOURS	
100% TEST FOR 48 HOURS	


MARL HAUL ROAD
CANAL ROUTE
PENINSULA
SALT PAN
Operating brine level -396750 (0 yr.)
-396 000 (10 yr.)
Initial extent of Salt Pan
(-398750)
DIKE 2
P.C.1 Feed
Crest -395 000
DIKE 1
500m. approx
FLOW
CH6800
℄ of Dead Sea Works dike
OUT FALL
70 000 N
85 000 N



ATTACHMENT "6"

NOTES

1. Operating Brine Levels during Potash production
Oyr indicates the brine level at the start of operations
10 yr indicates the brine level after 10 years of operation
2. The Salt Bottom Brine Levels are the levels of brine maintained in the Carnallite Pans during the salt bottom laying operation when brine is delivered via the Temporary Brine Supply Pipeline
3. Key Plan for Dike Construction is shown on Drg. No 7733/C3/4
4. Harvester Pump Station Areas, Passing Bays, and Boat Jetties are shown on Drg. No. 7733/C3/24
5. Brine Transfer Stations are shown on Drg. Nos 7733/C3/32 to 7733/C3/44 inclusive
6. Longitudinal Sections are shown on Drg Nos 7733/C3/5 to 7733/C3/12 inclusive.
7. Dike Sections are shown on Drg. Nos. 7733/C3/13 to 7733/C3/15 inclusive
8. Crest levels are the finished road levels on the dikes. The top of Zone I where it exists is 0.400 below the defined crest level. Rip rap levels are shown on Drg. No. 7733/C3/17

LEGEND

Dike (8.000 crest)	
Dike (10.000 crest) FHRSX	
Dike access road	
Flood protection bund	
Contours 1977 survey	
Contours 1966 survey (partially interpolated)	
Brine transfer station	
Boat jetty	
Harvester pump station area	
Passing bay	

HASHEMITE KINGDOM OF JORDAN
ARAB POTASH COMPANY LTD
ARAB POTASH PROJECT
SOLAR EVAPORATION SYSTE...

The Arab Potash Company Ltd.
Arab Potash Project
Amman, Jordan

Project No.08-1875

ATTACHMENT NO. 4

MINUTES OF MEETING WITH
ROSS ENGINEERING LTD.
HELD 25TH. NOVEMBER 1980.

THOSE PRESENT:

A.P.C.	J.I.L.I.	Rahco	Ross Eng. Ltd.
Mr. N. Samawi NS	Mr. K. Byrne	Mr. R. Hodges	Mr.J.McCallum
Mr. I. Duke			Mr. Tideman

The problem with the existing harvester were discussed. We will put components on a barge at Safi site from the existing prototype harvester.

Rahco would do track procurement, slide arrangement hydraulic etc. which would bolt onto the Ross Company mounting on the barge assembly.

Ross would modify steel work, recess i... ..... for track installation, installation of slurry tank structure for cyclone, handrail around perimeter of barge, 2-12" pipes to a fitting, feeding a 16" suction to pump, mechanical mount support for the cutter head (half ton of steel) checker plate on floor, to drain two (2) sump areas in each bilge.

Ross to put heavy plate down for bases of pumps, motors and drives, with checker plate around it. One (1) meter x four (4) meters for each pump and then Rahco will put in base as a unit. Put cross members to support twenty two (22) tonnes of electrical gear. Operators cabin can fit flush to the deck and leave flush to front. Rahco would fabricate the hydraulic box and drive unit and Ross would prepare the hull cutaway with flange section. Box in on top as a beam support of track units. Have 12" dia. x12" long connection on the back to the floating pipeline.

The Arab Potash Company Ltd.
Arab Potash Project
Amman, Jordan

Project No.08-1875

Minues of Meeting

Ross will give a unit price for loose steelwork, i.e. beams, base plates, angle iron etc.

Put in monorail for maintenance of both pump systems.

Design responsibility would be with Rahco with sub-contract responsibility by Ross Ltd.

Painting should be all galvanized according to the original Specifications We could maybe epoxy paint below deck. However, use galvanized checker plate and galvanize one foot (1') up the side, then use a marine epoxy for remainder of inside. Outside is galvanized to brown line and epoxy above this on green area.

The turning and work boat sizing will be specified later by Jacobs to Ross to locate bollards.

Ross will check the lifting eyes and capability to handle the extra steel mentioned above.

Ross will telex a 'ballpark' figure on the cost of their proposal to Rahco, with timing for the Ross modifications.

Rahco will provide a price by 15th. December 1980 meeting in Amman.

Rahco would likely buy the barge from Ross Company. Final decision by 1st. January 1981. Best possibility for completion of barge modifications by Ross could be the end of March 1981. It will require thirty (30) days fro shipping to Aqaba, i.e. 30th. April 1981.

If an answer was given by 19th. December 1980, for steel purchase, the above could be possible according to Ross.

Minutes of Meeting

Equipment is all there, so Rahco could have design and fabrication complete by end of February 1981.

Therefore, hopefully everything would be shipped by end of March 1981, for delivery to Jordan by end of April 1981.

Four (4) barges are available now. However, Ross can not guarantee to hold them. Ross would like to know on all four (4) barges and ship together if possible as cheaper this way.

Shipping should be no problem on 500 ton ship, when the barges are combined. Ship tackle is needed to put barges on Aqaba docks. The road transport to Safi will be investigated by Jacobs to ensure that the size and weight can be accommodated.

The Arab Potash Company Ltd.
Arab Potash Project
Amman, Jordan

Project No.08-1875

ATTACHMENT NO. 5

MINUTES OF MEETINGS
JACOBS INTERNATIONAL LTD - DUBLIN
26TH NOVEMBER, 1980

PRESENT:

APC - N. Samawi. N. Samawi

KW - I. Duke. I. Duke

Rahco - R. Hodges. R. Hodges - Rahco reserves the right to submit alternate proposals and considers this to be only one of several solutions.

JIL - K. Byrne Ken Byrne

SUBJECT: Guidelines for Design and fabrication of Prototype Carnallite Harvester

The "Independent Floating Harvester" as proposed by Jacobs has been approved by both APC and Rahco. The following are the basic parameters.

Hull will consist of a barge which will be modified in the shop to accept the major equipment which is presently on the Prototype Carnallite Harvester.

Every effort will be made where practical to reuse components from existing Carnallite Harvester.

APC requests Rahco to submit proposal for the modification of the prototype harvester and the design and fabrication of four additional units.

Four barges are presently available at Ross Engineering in Ireland, one of which we propose to use for the Prototype Harvester and consideration should be given to their use if practical for the additional production harvesters.

The Arab Potash Company Ltd.
Arab Potash Project
Amman, Jordan

Project No.08-1875

Scope of Work

1. Tracks system based on 4 tracks at rating of 15 tons max. on bottom 16ft x 2,5ft wide flat pads. Considering a 2,5 safety factor. Pipe line loads are per JIL design loading.

2. Tracks will be oscillating and will be capable of being moved up and down by means of hydraulic cylinders. Design should be such that tracks can be totally maintained out of the brine when in a raised position.

3. Track frame shall be fabricated by Rahco. Components from existing Prototype Harvester Tracks shall be reused i.e. track drive, chains idler and rollers.

4. All existing Carnallite Harvester propulsion hydraulics to and controls to be reused.

5. Additional hydraulic equipment will be required to operate the raising and lowering of tracks and cutterhead.

6. Modification existing carnallite harvester cutterhead will be made to accommodate increased operating range of cutterhead.

7. Operators cab from existing prototype carnallite harvester relocated as a unit to the new harvester.

8. Electrical system comprising transformers MCC's and misc. control systems to be relocated from existing carnallite harvester as a unit.

9. All existing prototype harvester slurry handling equipment - pumps cyclones, valves, controls, delumpers etc., can be relocated according to the agreed general arrangement. JIL SK-103.

10. New harvester (barge) will be structurally modified to accommodate new slurry tank, the new track drive system and all associated harvester equipment.

11. Main hall of harvester to be shot blasted, galvanized and painted after modifications and prior to shipment.

12. Changed piping runs will be shop fabricated as for as practical for field installation. Smaller piping runs (2" and down) will be field fabricated.

13. Electrical - Main cable trays shall be shop fabricated - local conduit runs to equipment shall be field run.

REFER TO FICHE

3 OF 3

FOR

FIGURE(S):

Attachment # 3

Jacobs International

Limited

JACOBS INTERNATIONAL LIMITED

LEGEND

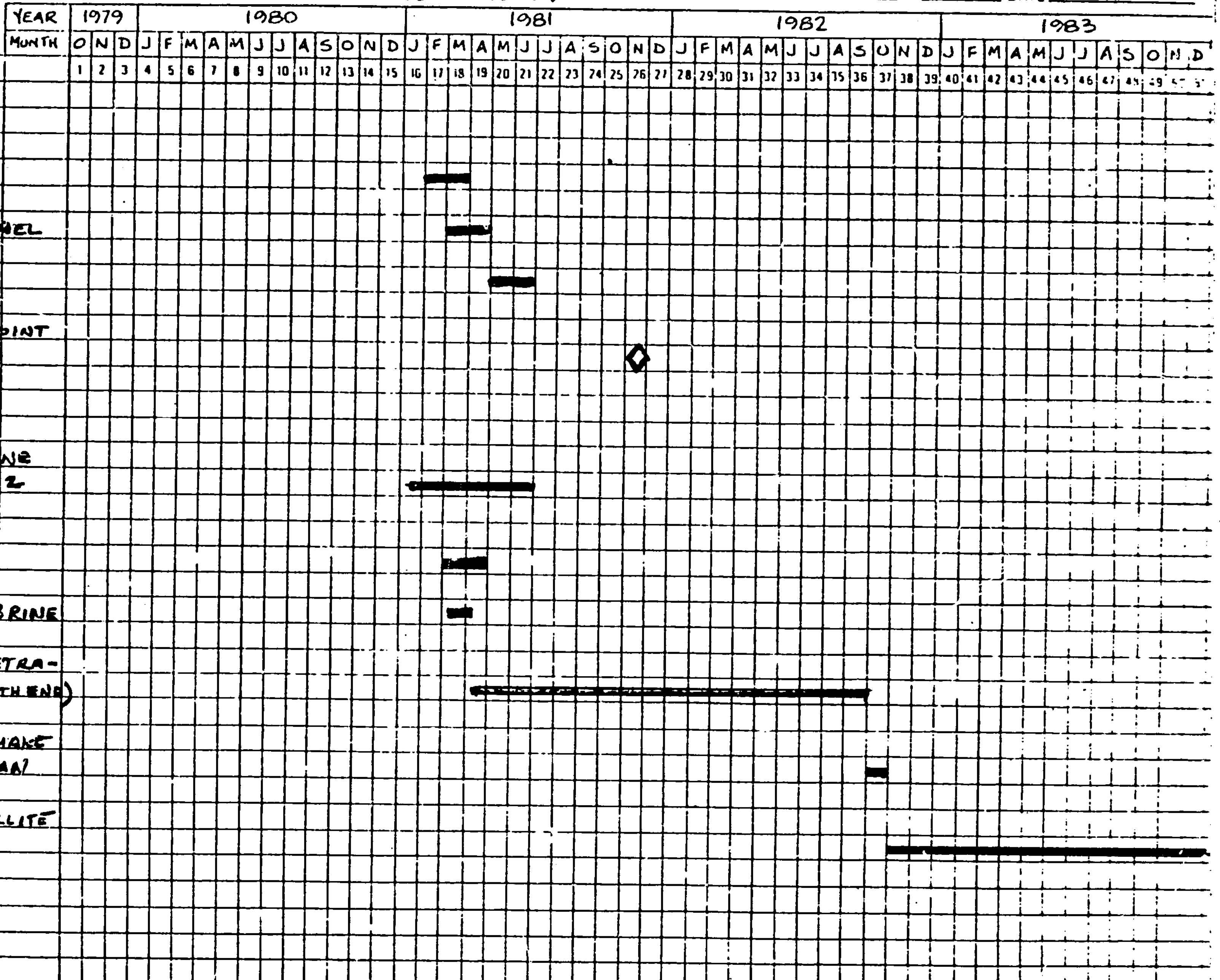
- I INQUIRY ISSUE
- ▲ APPROVAL ISSUE
- D DESIGN ISSUE
- ∇ CONSTR ISSUE
- BS BID SUMMARY
- S/C SUBCONTRACT
- ○ SCHEDULED DELIVERY
- ◎ RESCHEDULED DELIVERY
- △ SCHED PURCH EQUIP—MAT'L—S/C
- ▲ RESCHED PURCH EQUIP—MAT'L—S/C
- ◇ SCHED VENDOR DWG DUE DATE
- ◈ RESCHED VENDOR DWG DUE DATE
- ▨ SCHEDULED ACTIVITY
- ▬ ACTUAL ACTIVITY
- [ ] RESCHEDULED ACTIVITIES
- ● ▲ ◆ COMPLETED EVENTS
- ACTUAL ACTIVITY / ORIGINAL DURATION / RESCHED DURATION / RESCHED ACTIVITY

REVISED PAN & HARVESTER SCHEDULE.

ATTACHMENT NO. 7

CUSTOMER: ARAB POTASH COMPANY LTD.
TYPE OF UNIT: POTASH PLANT
JOB NUMBER: 08-1875
ORIGINAL ISSUE: 31 DEC. 1980 BY: MMF/JOB
REVISION: ______ BY: ______ DATE: ______

LINE REF	DESCRIPTION
1	
2	SALT PAN & PC-1
3	
4	FILL SALT PAN WITH BRINE
5	
6	FLUSH S.P. TO WASTE CHANNEL
7	
8	FILL PC-1 WITH BRINE
9	
10	START PC-1 CARNALLITE POINT
11	BRINE TO C1
12	
13	PAN PC-2
14	
15	INSTALL 2ND BRINE PIPELINE
16	FROM OUTFALL TO PC-2
17	
18	INSTALL TEMP DIKE IN
19	SOUTH END OF PC-2
20	
21	FILL PC-2 WITH D.S. BRINE
22	
23	PC-2 IN BRINE PRECONCETRA-
24	TION SERVICE (NORTH END)
25	
26	REVISE TEMP. DIKE TO MAKE
27	SOUTH END PRE-CONC PAN
28	
29	NORTH END IN PRECARNALLITE
30	SERVICE
31	
32	
33	
34	
35	



JACOBS INTERNATIONAL LIMITED

LEGEND

- I INQUIRY ISSUE
- A APPROVAL ISSUE
- D DESIGN ISSUE
- ∇ CONSTR ISSUE
- BS BID SUMMARY
- S/C SUBCONTRACT
- ○ SCHEDULED DELIVERY
- ⊙ RESCHEDULED DELIVERY
- △ SCHED PURCH EQUIP—MAT'L—S/C
- ▲ RESCHED PURCH EQUIP—MAT'L—S/C
- ◇ SCHED VENDOR DWG DUE DATE
- ◈ RESCHED VENDOR DWG DUE DATE
- SCHEDULED ACTIVITY
- ACTUAL ACTIVITY
- [ ] RESCHEDULED ACTIVITIES
- ●▲◆ COMPLETED EVENTS

REVISED
PAN & HARVESTER
SCHEDULE.

CUSTOMER ARAB POTASH COMPANY LTD.
TYPE OF UNIT POTASH PLANT
JOB NUMBER 08-1875
ORIGINAL ISSUE 31 DEC.1980 BY MMF/JOB
REVISION ____ BY ____ DATE ____

ACTUAL ACTIVITY — ORIGINAL DURATION — RESCHED DURATION — RESCHED ACTIVITY

YEAR: 1979 | 1980 | 1981 | 1982 | 1983

MONTH: O N D | J F M A M J J A S O N D | J F M A M J J A S O N D | J F M A M J J A S O N D | J F M A M J J A S O N D

REF	DESCRIPTION	
1	PAN C1	
2		
3	FILL C1 WITH BRINE	
4		
5	LAY SALT BOTTOM & INSPECT	
6		
7	C1 AT CARNALLITE POINT	
8		
9	CARNALLITE DEPOSITION - C1	
10		
11	START HARVESTING	
12		
13	PAN C2	
14		
15	FILL C2 WITH BRINE	
16		
17	LAY SALT BOTTOM	
18		
19	C2 AT CARNALLITE POINT	
20		([illegible] MONTHS)
21	CARNALLITE DEPOSITION-C2	
22		
23	START HARVESTING	
24		
25	PAN C3	
26		
27	FILL C3 WITH BRINE	
28		
29	LAY SALT BOTTOM	
30		
31	C3 AT CARNALLITE POINT	
32		([illegible])
33	CARNALLITE DEPOSITION-C3	
34		
35	START HARVESTING	AUG 83

JACOBS INTERNATIONAL LIMITED

REVISED PAN & HARVESTER SCHEDULE.

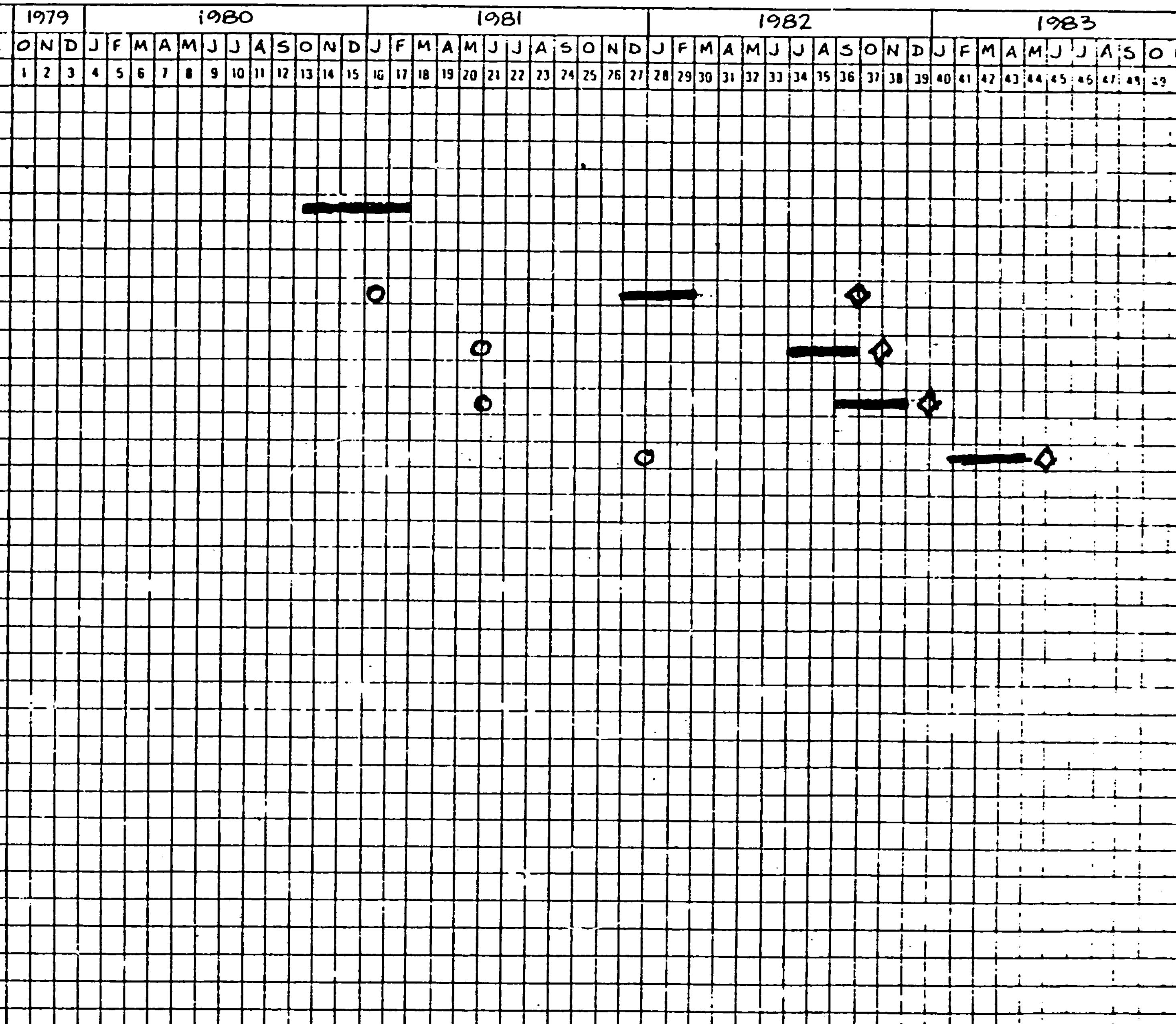
LEGEND

- I INQUIRY ISSUE
- A APPROVAL ISSUE
- D DESIGN ISSUE
- ▽ CONSTR ISSUE
- BS BID SUMMARY
- S/C SUBCONTRACT
- ○ SCHEDULED DELIVERY
- ⊙ RESCHEDULED DELIVERY
- △ SCHED PURCH EQUIP—MAT'L—S/C
- ▲ RESCHED PURCH EQUIP—MAT'L—S/C
- ◇ SCHED VENDOR DWG DUE DATE
- ◈ RESCHED VENDOR DWG DUE DATE
- ▨ SCHEDULED ACTIVITY
- ▬ ACTUAL ACTIVITY
- [ ] RESCHEDULED ACTIVITY
- ●▲◆ COMPLETED EVENTS
- ◇ START HARVESTING
- ACTUAL ACTIVITY / ORIGINAL DURATION / RESCHED DURATION / RESCHED ACTIVITY

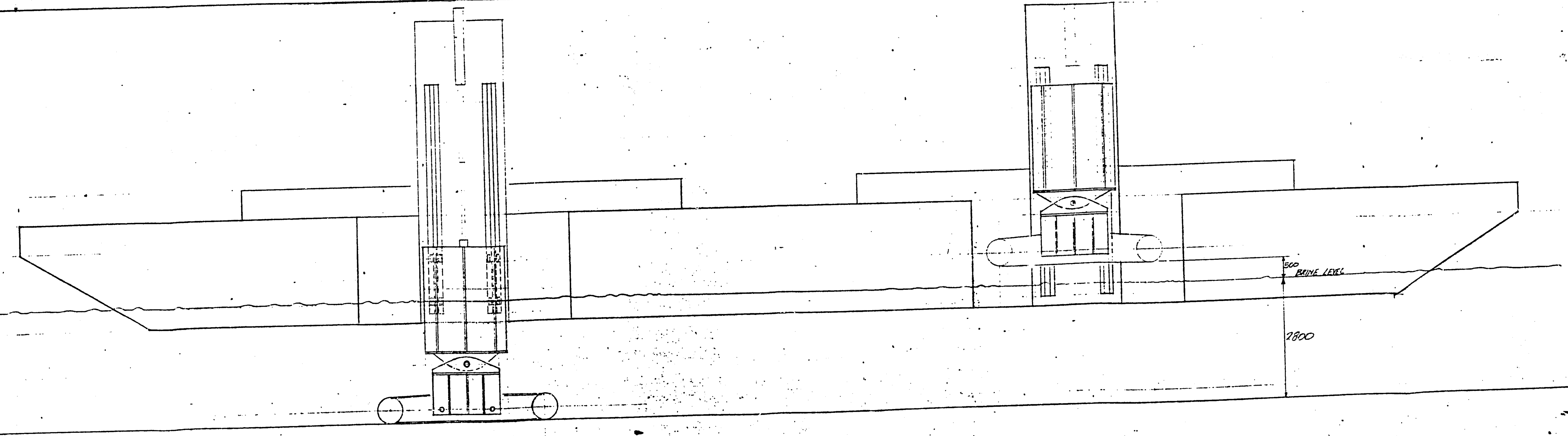
CUSTOMER: ARAB POTASH COMPANY LTD.
TYPE OF UNIT: POTASH PLANT
JOB NUMBER: 08-1875
ORIGINAL ISSUE: 31 DEC. 1980 BY: MMF/JOB
REVISION ____ BY ____ DATE ____

LINE REF	DESCRIPTION
1	
2	HARVESTER - SITE ASSEMBLY
3	AND TEST
4	
5	1st PROTOTYPE - RAHCO
6	
7	2nd. PROTOTYPE - INDEPEND-
8	ANT FLOATING TYPE
9	
10	NO. 2
11	
12	NO. 3
13	
14	NO. 4
15–35	

YEAR: 1979 (O N D), 1980, 1981, 1982, 1983 (J F M A M J J A S O N); MONTH columns 1–49



36000
7000 APPROX
℄ AUGER
16"-CS-107-A
16"-CS-108-A
PONTOON
FLOATING LINE
TRANSFORMER
ELEC. CABIN
BILGE PUMP No 1
2"-CS-112-A
12"-CS-106-A
MOTOR
GEAR
LUBE OIL CONSOLE
BOOSTER PUMP 11-01-211
HYDROCYCLONE 11-23-011
HYD. OIL TANK
HYDRAULIC DRIVE UNIT
HYDROCYCLONE 11-23-021
SLURRY TANK
DELUMPER 11-26-011
DELUMPER 11-26-021
12"-CS-104-A
16"-CS-103-A
18"-CS-102-A
PRIMARY PUMP 11-01-201
16"-CS-100-A
CONTROL CABIN
12" DREDGE HOSE
BILGE PUMP
2"-CS-113-A
WATER BOOSTER PUMP 11-01-281
3"-PW-200-H
3"-PW-201-H
3"-PW-202-H
3"-PW-203-H
HANDRAIL
℄ OIL COOLERS 1,2,3,4
8"-CS-111-A
16"-CS-109-A
16"-CS-110-A
9000



PNAAV 677

3 of 3

REV	DATE	DESCRIPTION	APPROVED
ISSUED FOR CONSTRUCTION		CUSTOMER APPROVAL	
DESIGNED	DRAWN L CURRAN	REVIEWED	APPROVED

ARAB POTASH COMPANY LTD.

JACOBS INTERNATIONAL LIMITED
ENGINEERS • CONSTRUCTORS
CALIFORNIA – ILLINOIS – NEWJERSEY – FLORIDA – WASHINGTON
PUERTO RICO – LONDON – DUBLIN

ATTACHMENT NO. 3

CARNALLITE HARVESTER

SCALE 1:50	PROJECT NUMBER	DRAWING NUMBER	REVISION
DATE 1C DEC 80	08-1875	1875-SK-144	