A CRITICAL OVERVIEW OF A COMPLETED SHAFT PROJECT AND THE DISPOSAL OF EXCESSIVE WATER INFLOWS INTO THE UPCAST VENTILATION COMPARTMENT

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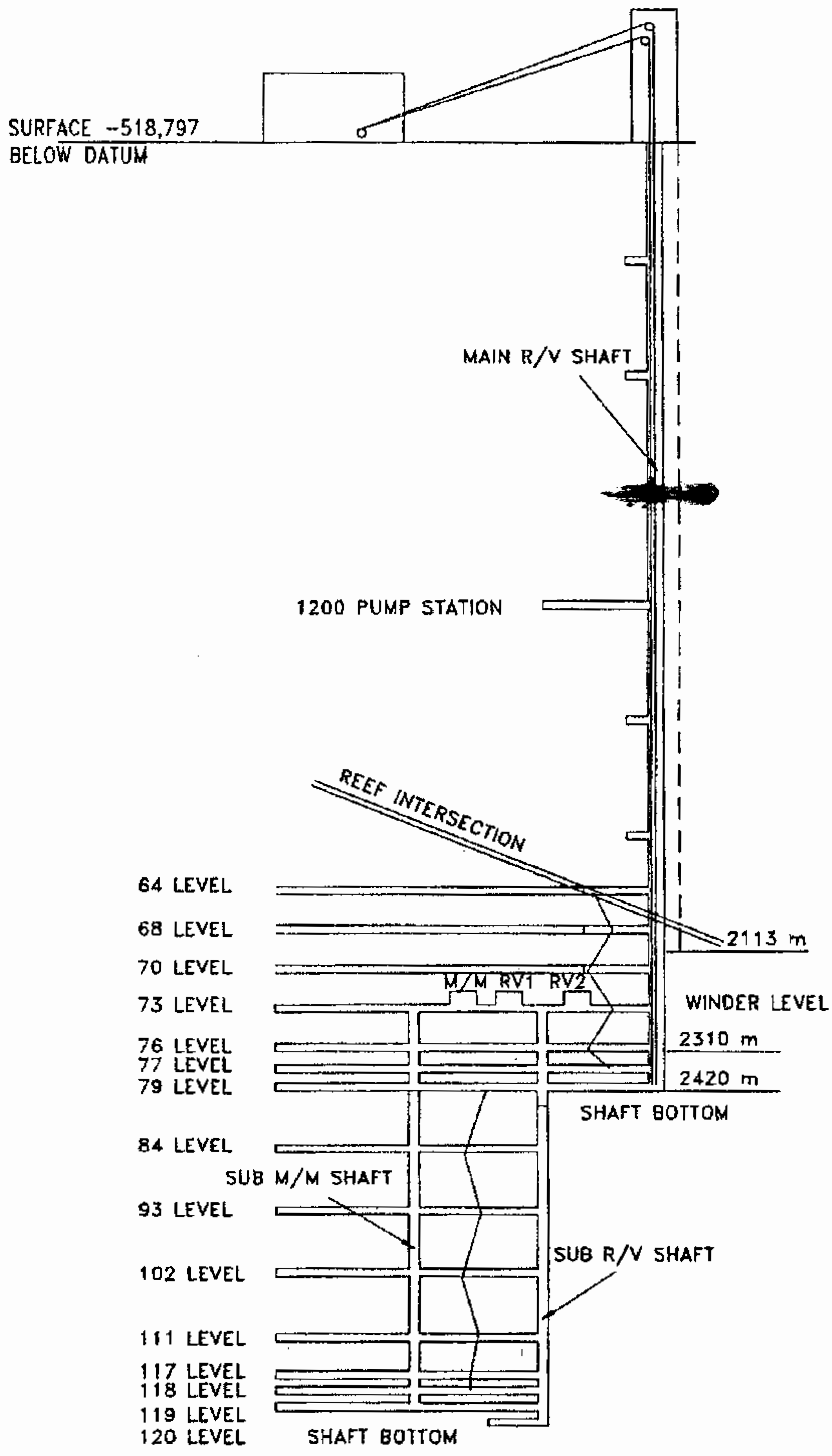
ABSTRACT

During the sinking of a 10,75 metre diameter shaft, 2500 metres deep through high water bearing strata large quantities of water was intersected. Cover drilling and limited cementation was carried out during the course of sinking but did not prove very successful. The design of the shaft required a brattice wall for utilising the shaft as a upcast ventilation shaft handling approximately 1400m^3 per second of upcast air. In addition to being a fresh air intake the shaft will hoist ± 200 000 tons per month of gold bearing ore and service the mining thereof with men and material.

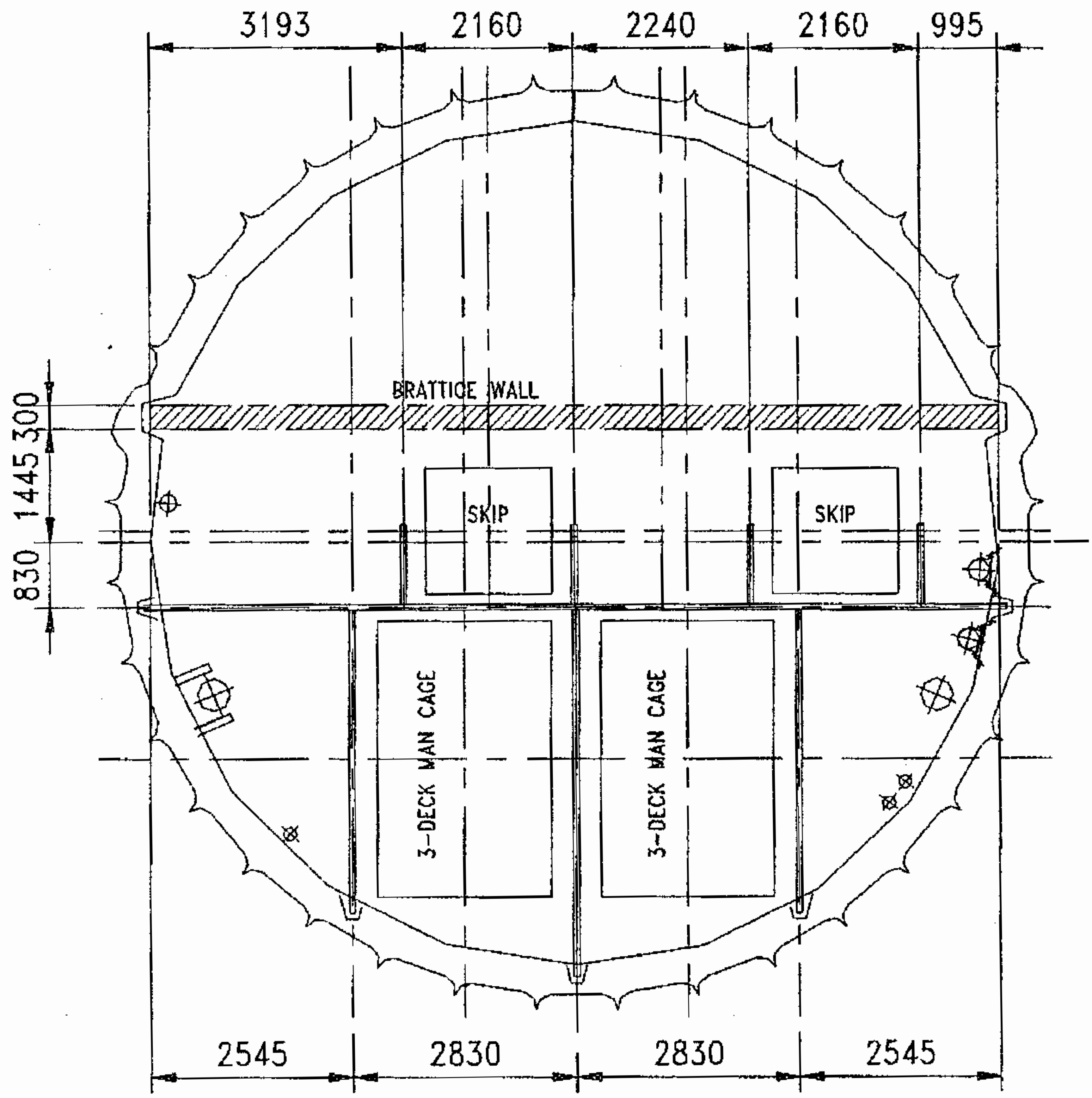
The excessive water inflow in both the intake and upcast section posed serious problems, this and the final method selected for handling and disposing of such water will be discussed in the paper.

INTRODUCTION

The contract was awarded to Shaft Sinkers (Pty) Limited during 1991 to sink, line and equip a shaft comprising of a single brattice 10.75 metres finished diameter from surface to 2500 metres below surface, which will result in the deepest single wind shaft in the world with a cross sectional area of 90.76m^2. A sub vertical shaft system is in process of being established from 73 level to 120 level, approximately 1460 metres to a final depth of 3960 metres below surface.



SHAFT SYSTEM



MAIN R.V. SHAFT CONFIGURATION

SHAFT DIA. 10.75m

Geology

The area is underlined by rocks of the Karoo, Transvaal, Ventersdorp and Witwatersrand super groups. The principal gold bearing reef underlying the area is the Vaal Reef, lying at depth from 2500 metres to 4700 metres below surface.

THICKNESS	FORMATION	SUBGROUP	GROUP	SUPERGROUP
			PRETORIA	
315-483	ECCLES	MALMANI	CHUNIESPOORT	TRANSVAAL
136-180	LYTTLETON			
540-760	MONTE-CHRISTO			
130	OAKTREE			
10-64	BLACKREEF		BLACKREEF	
290	ALLANRIDGE		PNIEL SEQUENCE	VENTERSDORP
530	PIETGAT KAMEELDOORN		PLATBERG	
330-1100	EDENVALE LORAINE		KLIPRIVIERSBERG	
254	ORKNEY			
180-289	ALBERTON-VENTERSPOST	V O R		
300	MONDEOR	TURFFONTEIN	CENTRAL RAND	WITWATERSRAND
300	KLERKSDORP			
200	GOLD ESTATES			
0-16	CRYSTAL KOP	C REEF		
250-300	STRATHMORE	VAAL REEF		
320	STILFONTEIN	JOHANNESBURG		
560	COMMONAGE COMMONAGE REEF ADA MAY			
585	ROODEPOORT	JEPPESTOWN	WEST RAND	
30-60	CROWN LAVAS			
100-200	BABROSCO			
250	RIETKUIL			
130	ELANDSLAAGTE	GOVERNMENT		
390	PALMIETFONTEIN			

FIGURE NO. 1

Stratosphere

The strata that was intersected during the sinking and development of the shaft system are shown in Figures 1 & 2, and approximate thicknesses are shown.

During sinking the shaft traversed from surface, the Malmani dolomites and the Black Reef of the Transvaal Super group which in turn overlaid the lavas and sedimentary deposits of the Ventersdorp group. The above in turn overlaid the sediments of the Witwatersrand Super group.

The Malmani dolomites contained aquifers and these water bearing strata extended to the Black Reef formation at approximately 1400 metres below surface.

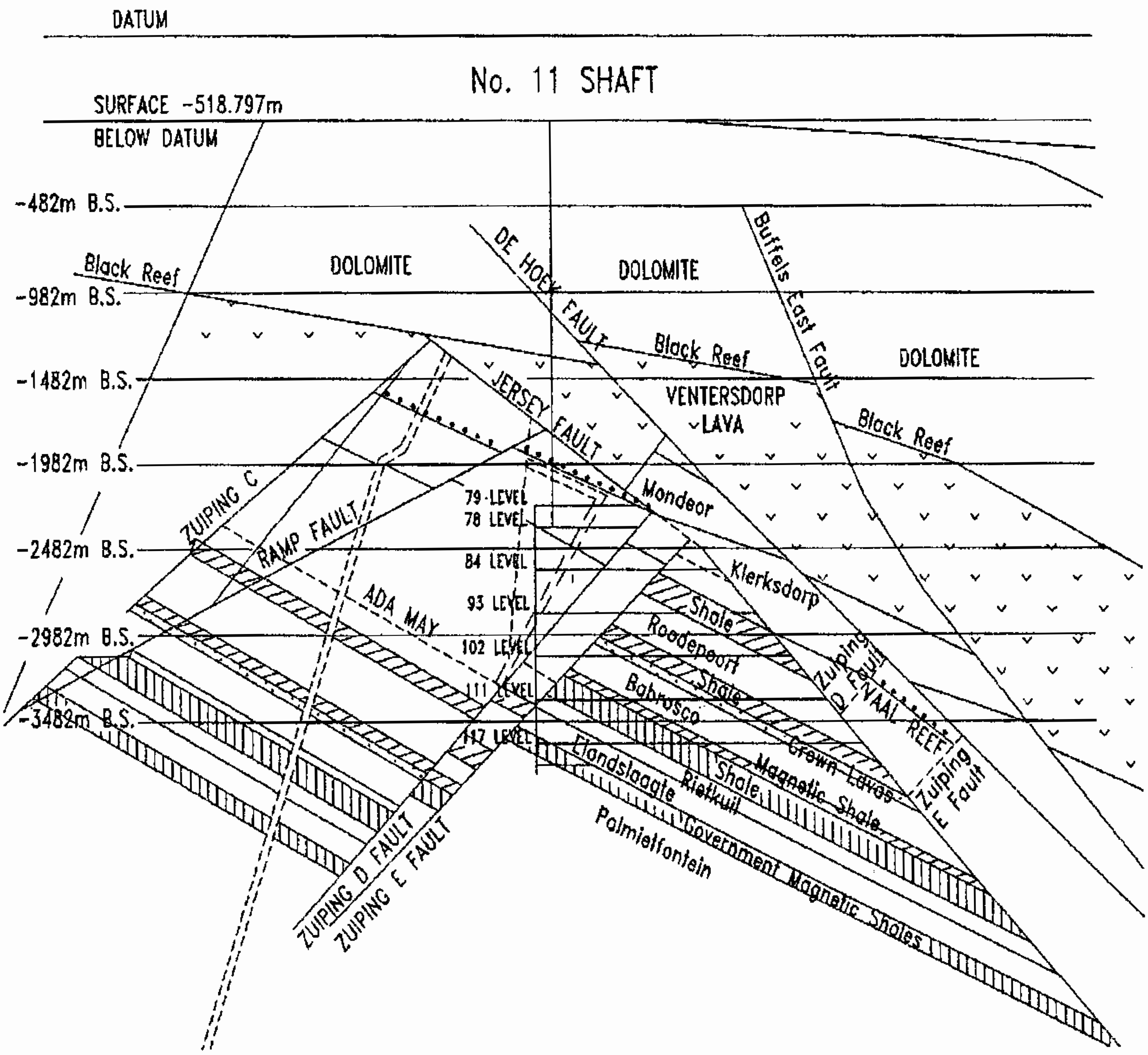


FIGURE NO. 2

SHAFT SINKING

Pre-sink to a depth of 72 metres commenced in October 1991 and was completed by February 1992. Collar and headgear construction commenced and was completed by October 1992 at which time the main sinking commenced.

During the first year of sinking the shaft reached a depth of 1000 metres below surface. Progress during this period was seriously affected by several large water intersections.

Traditional South African shaft sinking methods were employed during the sinking of this shaft.

Cycle Times

The sinking cycle was designed so that each working shift of 8 hours would be able to clean, drill and blast a shaft round of 2 metres.

The design provided for an average advance of 130 metres per month and making provision for cover drilling and cementation at 36 metre intervals, cover drilling 42 metres. The designed cycles is shown in table 1.

Table 1 : Cycle times for each shift.

Operation	Standard Time per hour	Shortest time per hour
Re-entry and make safe	0,1	0,20
Cleaning	4,0	2,27
Blowing over shaft bottom / examination for misfires	1,0	0,92
Drilling	1,25	1,53
Charging up the round	1,0	0,45
Blasting and changing shift	0,15	0,25
TOTAL	7,5	5,56

Drilling

Seco 24 handheld pneumatic rockdrills were used for drilling the blast holes. The sinking round consisted of 315 holes 2.3 metres in length.

Cleaning

A 0.87 m^3 cactus grab loading into 12 ton kibbles was used for cleaning the 610 tons broken during each blast.

Ventilation

The shaft bottom was ventilated by using 2 x 170Kw fans which were located on surface, delivering approximately 50 m^3 per second of air to the shaft bottom.

Lining & Support

The main support of the shaft was a monolithic concrete lining 300mm thick, comprising mass concrete at a compressive strength of 28 Mpa after 28 days. The concrete was batched on surface and gravitated down the shaft in 2 x 150mm pipe columns. The concrete lining was carried approximately 20 metres from the shaft bottom. Concrete lining is a concurrent activity which takes place during the cleaning and drilling activity.

Rockbolts are installed prior to lining when conditions dictate.

Cover drilling

Cover drilling and cementation ahead of the advancing shaft bottom is a standard practice. The main purpose being to give advance warning and preventing blasting into large fissures containing large volumes of gas or water.

Design

In consultation with the client a 10 hole cover round was designed and elected for this particular application.

The standard primary round was such that all the holes drilled will intersect a point approximately 11 metres outside the excavated shaft diameter at the projected drilling depth and radially in line with the collar of the adjacent clockwise hole (Refer Figure 3). The design ensured that one or more of the holes would intersect the plane of any randomly orientated water bearing fissure or fault in the ground ahead of the shaft being sunk. The 11 metre projected point is of extreme importance as any distance closer than 6 metres to the shaft excavation line might suffer blast damage and might result in leakage from fissures sealed previously. The design length of the cover round is extremely important in that the longer the round the bigger the possibility of deflections and inaccuracies resulting there from. The cover round in question was designed to match a six day sinking rate and to facilitate cover drilling and any possible cementation / grouting on the seventh shift. An overlap of 6 metres between successive rounds ensured that sinking took place in tested ground only.

As mentioned previously major water bearing fissures were intersected at the following depths below surface 300, 450, 700, 780 and 1200 metres, refer figure 3a..

Apart from these intersection several minor intersection occurred up to the 1200 metre elevation.

Due to the time and finance involved and insistence from the client the standard procedure of cementation and cover drilling was not always adhered to, viz., drilling of secondary, tertiary or quaternary cover rounds. In addition the client very often refused the sealing of minor intersections.

The combination of these decisions resulted in the progressive water make-up during the sinking process becoming excessive and serious delays became the order of the day, the excessive water above the shaft bottom working area made quality concrete lining virtually impossible.

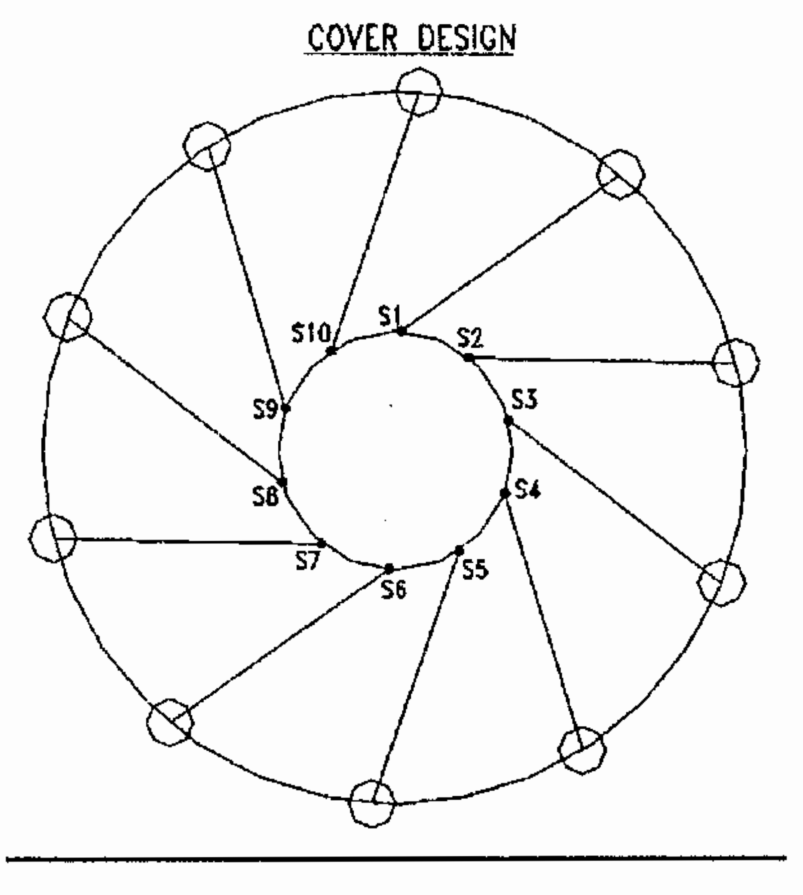


FIGURE No. 3

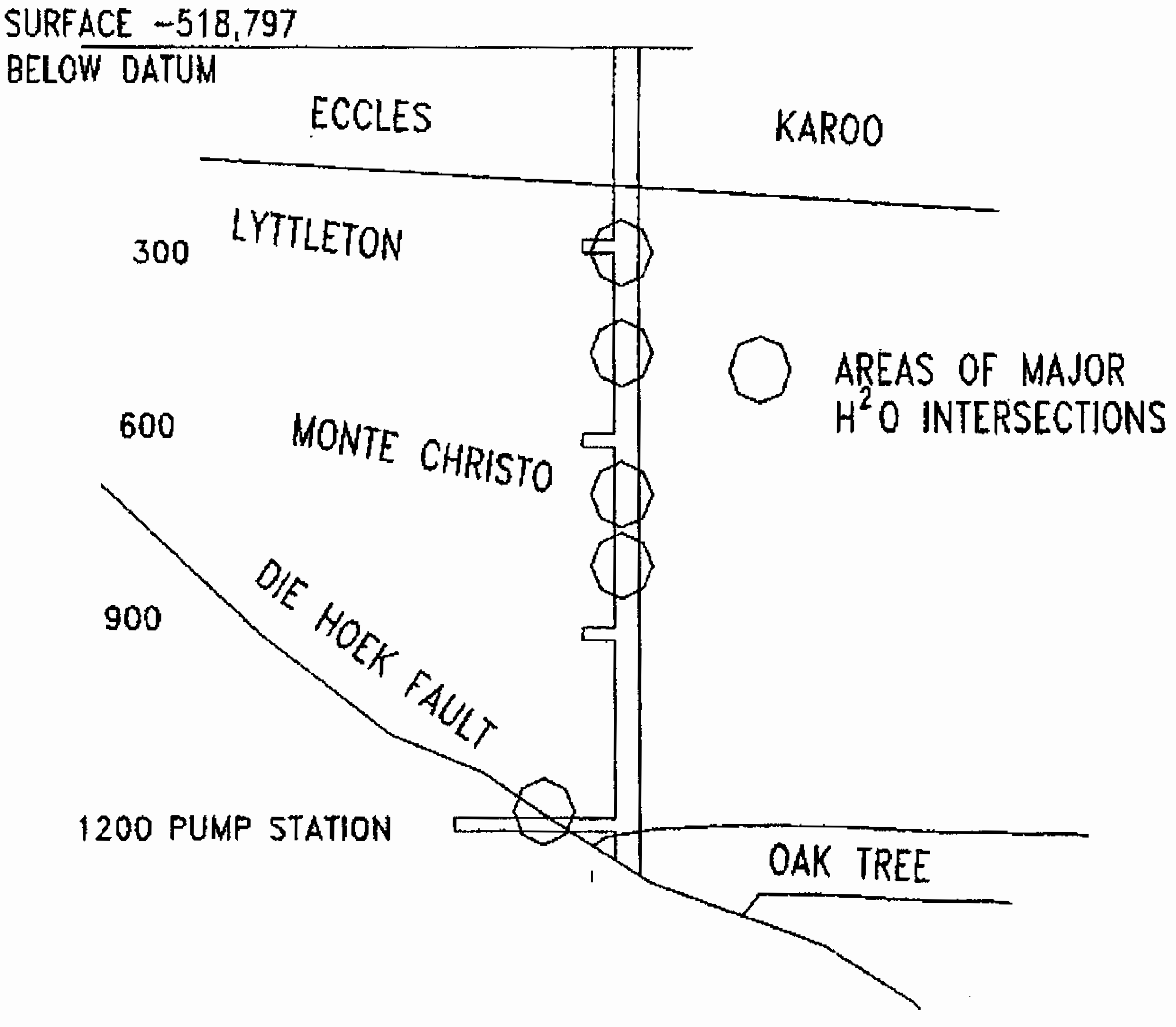
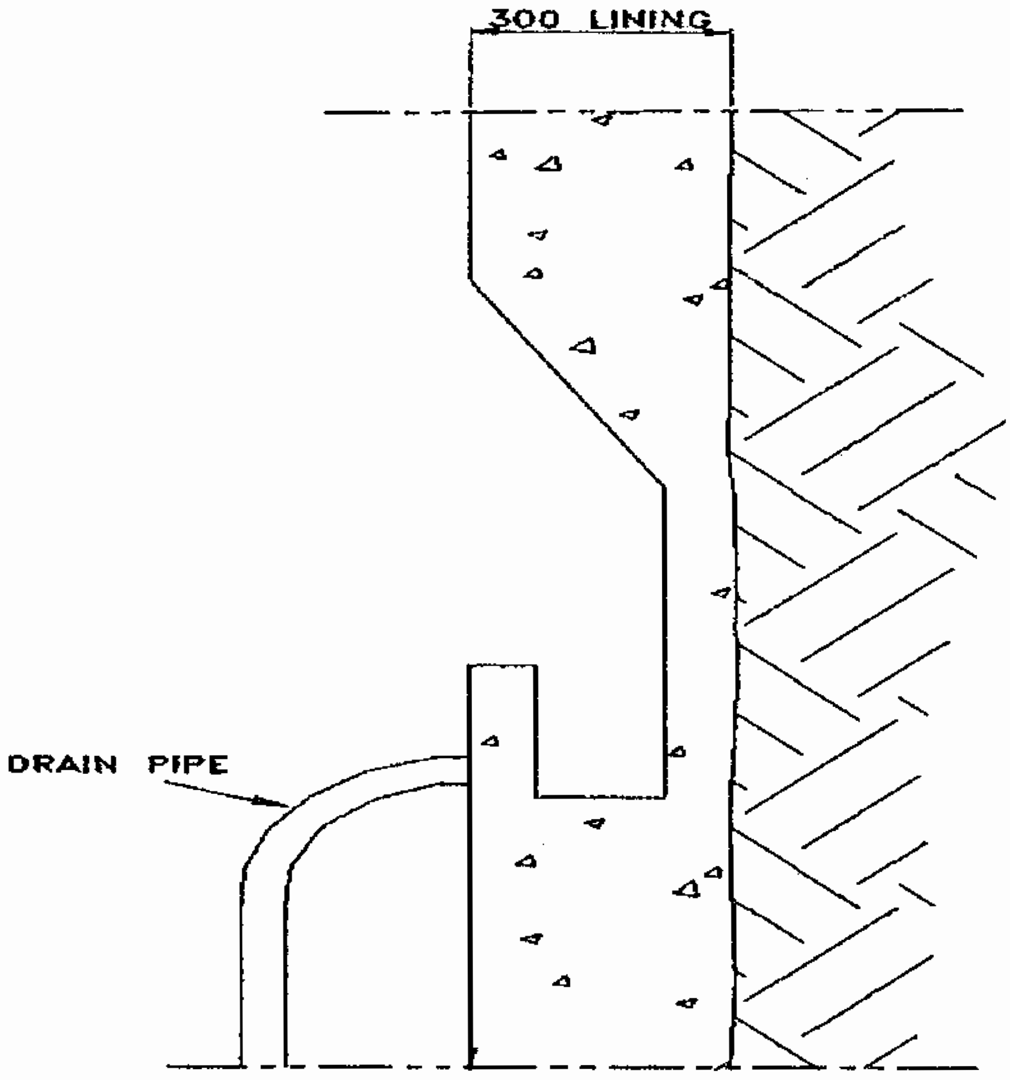


FIGURE NO. 3A

Main Sinking

The client decided to call in a sub-contractor and embarked on a sealing programme using a latex based chemical grout.

At first it appeared that this decision was successful but approximately 3 months after sealing water ingress was the same as before. It appeared that the material used washed out and was thus rendered ineffective. In order to continue and complete the shaft to the designed depth a fully fledged pump station was established on 1200 metres below surface with a series of cast-in water rings gravitating to this pump station. (Refer to Figure 4).



SECTION THROUGH WATER RING

FIGURE NO. 4

The water collected on 1200 was pumped to 600 level pump station and from there to surface. These temporary measure proved reasonably successful and the shaft was completed to its final designed depth.

It is maybe opportune to mention and qualify the statement "reasonably successful" at this point. From previous experience it is a known fact that any water make-up in excess of a 4 l/s in a sinking shaft bottom causes delays, viz., returning after the blast will produce a flooded shaft bottom, any delay in the hoisting system will result in a flooded shaft bottom and will require dewatering prior to whatever activity was taking place can commence. Water quantities of up to 4 l/s is normally handled with up-going kibbles without any interference to the sinking activities, any quantity in excess of 4l/s seriously impede on the sinking progress..

The permanent design of the shaft required a single brattice wall utilising a section of the shaft as a upcast ventilation section handling approximately 1400 m^3/s of air, the other section would be utilised as a fresh air intake and hoisting ± 200 000 tons per month of gold bearing ore and servicing the mining thereof with men and material. The excessive inflow of water in both these compartments posed serious problems.

In the upcast section water will form a water cloud and cause stalling of the surface fans interrupting the total ventilation system.

On the intake side the problem was mainly two fold:-

Firstly, the excessive inflow would seriously effect the intake air by saturating it and virtually nillifying the cooling power thereof, keeping in mind that at the proposed mining depths virgin rock temperatures of Ç50°C is of the order of the day.

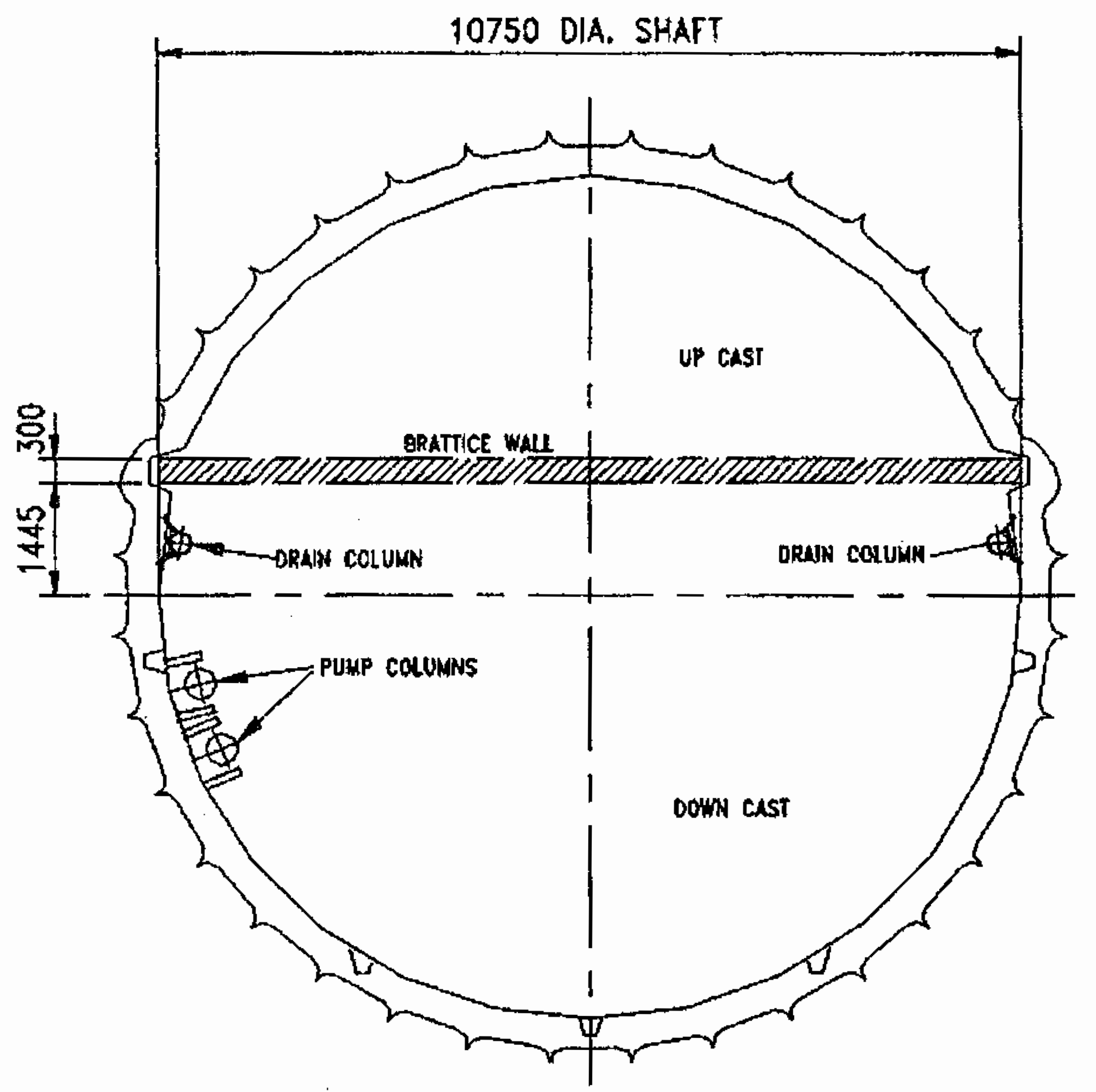
Secondly, the water having a P.H. of 6.5 would seriously affected the permanent steel and other services which would be required to service the mining systems for the designed 25 years.

Disposal of excess water

__In view of the serious effect on the permanent design the client and contractor investigated several options of either eliminating or reducing the water effect on the overall design. The objective was not only to be cost effective but also guarantee effective / positive results.

A "no seal, no pay", philosophy was adopted and although many companies were initially interested, this scared them off.

On completion of sinking and concurrent with the stripping out of temporary sinking services, from the bottom to surface the permanent 200 mm pump columns and 2 x 150 mm drain columns, one on the north and one on the south side of the shaft. These columns were all located in the downcast section of the shaft. (Refer to Figure 5). The drain columns were fitted with 50mm sockets at 6m intervals.



MAIN R.V. SHAFT CONFIGURATION

FIGURE No. 5

Reaching surface slight modifications were made to the sinking platform to facilitate the drilling of holes into the shaft lining. On completion thereof the selected sealing method commenced.

The sinking platform was lowered to the position where the first water was leaking into the shaft, approximately 300 m below surface .Wherever leaks, in the lining, was detected or evident, 75mm hole was drilled approximately 500mm deep to ensure penetration into the rock sidewall.

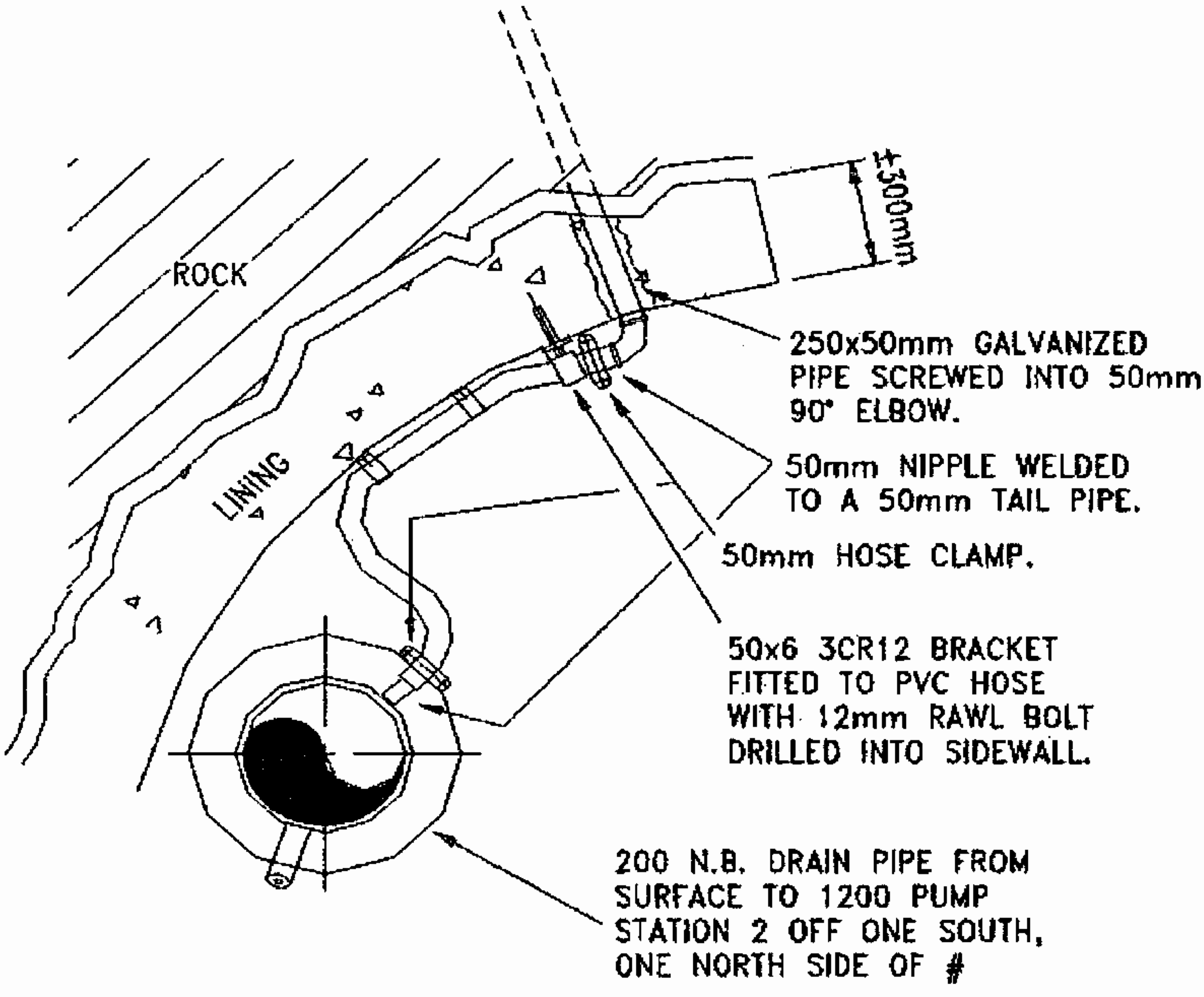


FIGURE NO. 6

50 mm x 250 mm galvanised casing pipe with threaded end was grouted in with special quick set resin. The hole was extended another 1 metre by using standard 38 mm drill steel to ensure proper intersections and drainage of the water source.

Galvanised couplings were screwed onto the casing pipe and using plastic hose the water was discharged into the 150 mm drain column. Special 3CR12 steel brackets was used to clamp the hose to the concrete sidewall, special attention was paid to all installations especially those on the return air side as access afterwards would be virtually impossible.

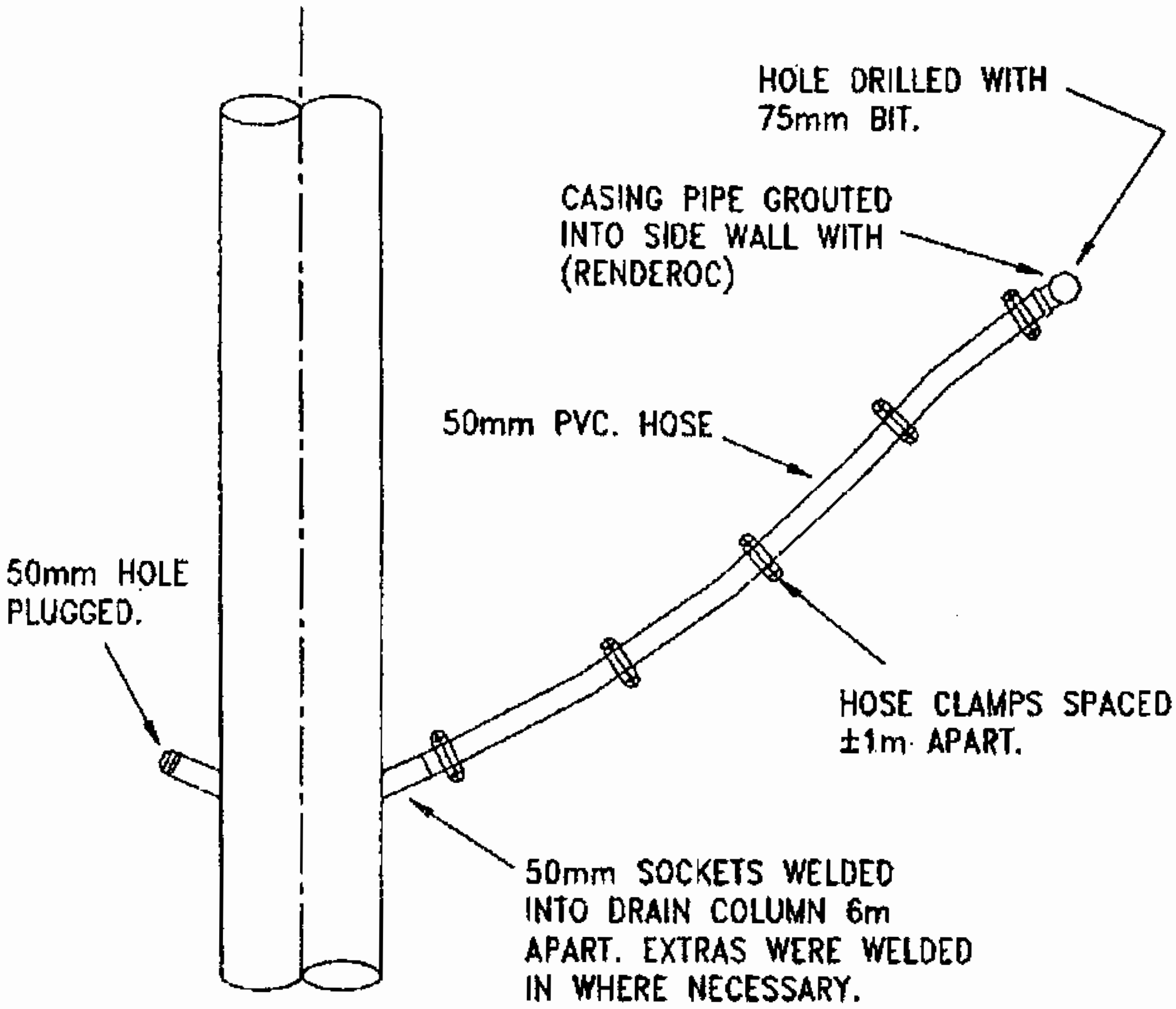


FIGURE NO. 6A

The process was continued up to 1200 metres below surface where both drain columns discharged into the permanent dams.

On reaching 1200 level approximately 30 000 l/hr were discharged by the two columns.

From 1200 level down the process was repeated to the shaft bottom where the water was discharged into a dam for pumping to surface

The water made in the shaft was reduced by approximately 95% and large sections of the shaft was completely dry. The method described took 72 days in total and was considered very successful by the client.

A very interesting fact was later discovered and observed whilst equipping of the shaft took place. It was found that the water flowing down the drain columns caused a very strong suction through the drain holes whereby previously surrounding small leaks especially on matching joints in concrete lining reversed its direction of flow.

Conclusion

During the construction of shafts and especially those in water bearing formations treatment and sealing of water bearing fissures will always remain problem for Mining Engineers.

The temptation will always be there to become impatient because of the time and finance involved in carrying out proper standard cover drill and cementation procedures. During sinking this should be avoided at all cost. Attempts to speed up this process or by taking short cuts and thereby plugging fissures rather than sealing them resulting in high pumping cost, bad environmental conditions and the disastrous consequences of expensive rescue operations or even the abandoning of a project.

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