WATER SUPPLY AND DEWATERING AT WMC RESOURCES LTD WESTERN AUSTRALIAN MINES

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ABSTRACT

Most of WMC Resources Ltd's nickel and gold and a proportion of copper is mined in Western Australia. The majority of the state is semi-arid, with evaporation far in excess of rainfall and negligible surface water resources. Groundwater is used for industrial and domestic purposes, and mine dewatering requirements are relatively modest by worldwide standards. The mines span a broad geographic and geologic range, climatic variations combine to give a variety of hydrogeologic environments.

This paper gives a summary of WMC's Western Australian mining operations, aquifer types encountered and their response to pumping for water supply and water control.

Nifty Copper Project

The Nifty copper deposit is hosted by a carbonate unit in a tightly folded Proterozoic Sedimentary sequence. The orebody is located on the north limb of an east-west trending, east plunging syncline, very close to the outcropping axis of the fold (Figure 2).

The current ultimate open pit mine has a planned depth of 105m and strike length of 1000m. The hanging wall and footwall are excavated in shales. Rocks are highly weathered to a depth of 80m. Mineralisation extends to the axis of the syncline at about 400m depth, but there are currently no plans for the recovery of this ore. Mine production has been about 0.5MTpa for 10 000T of refined copper.

Dewatering has been achieved exclusively by pumping from the Carbonate unit which hosts the orebody. The Carbonate aquifer is bounded to the north, west and south by the limits of the syncline and to the east by a dolerite dyke. Water is pumped from bores located along strike from the pit, on the southern limb of the syncline opposite the pit and from bores and sumps within the pit.

Prior to the commencement of mining it was predicted that drawdown of 55m could be achieved over 3 years by a pumping rate starting at 2ML/d and declining thereafter. As the carbonate yield was expected to gradually decline, alternative groundwater supply sources were investigated for the mine.

Mining was commenced in April 1993. In September 1993 a total of 12m drawdown had been achieved, the current pumping rate was 3.2ML/d and the dewatering ratio 39ML/m. In March 1994 drawdown was 22m and the dewatering ratio had increased to 63Ml/m. The later ratio had included a cyclonic rain event which had been shown to produce a water level step up of about 1m. In January 1996 water level in the Carbonate aquifer was at RL 250m, or a drawdown of about 33m with very little ongoing drawdown at pumping rates of about 2.5ML/d.

Further in pit bores have since been installed. Water production is in excess of the plant and heap leach requirements and is discharged to a constructed lake.

Yilgarn Craton

The remaining mines discussed are within the Archean Yilgarn Craton. Background hydrogeology for mines in this district is described by Morgan (1993). A brief summary based mainly on this reference follows.

The Archean Yilgarn Craton comprises mostly granitoid rocks sandwiching remnant north trending volcanic/sedimentary (greenstone) belts. Mineralisation is hosted by the metamorphosed greenstone belt rocks, which are generally near vertical and highly sheared. Groundwater occurrence is influenced by bedrock lithology and structure plus Mesozoic to Recent weathering and sedimentation. A typical geologic cross section with groundwater occurrences is shown in Figure 3.

There has been very little sedimentation across the Craton since the Archean. The current land surface has been stable over much of the post Palaeozoic. These factors combine to form a relatively flat and deeply weathered surface (regolith profile). The surface was incised by narrow sinuous river systems during the Mesozoic, sands at the base of the Tertiary infill sequence are an important groundwater source.

Climatic zones are shown on Figure 1. The southwest zone has a Mediterranean type climate, annual rainfall of 500-1200mm occurs during cool winter months with a hot dry summer.

The Eucla region receives 250-500mm of rainfall annually which is spread throughout the year. Low permeability regolith, slight topographic relief and a widespread tree cover combined with sporadic and often low intensity rainfall means that direct rainfall recharge is negligible. Low salinity groundwater does not occur in significant quantities.

The inland region of the Yilgarn Craton receives average annual rainfall of 200-300mm, although annual totals are highly variable. Much of the rainfall is the result of occasional brief tropical rain bearing depressions during summer months. Permeable chemical deposits in the regolith especially ferricrete and calcrete in low lying areas can accept significant recharge during storms. Vegetation is limited to low woodland and scrub resulting in low rates of transpiration of stored groundwater.

Groundwater salinity varies enormously across the region, controlled mainly by climatic zonations and local topography.

Mt Keith Nickel Operation

Mineralisation occurs within a pod of ultramafic flow units with sheared contacts to felsic footwall volcanics and hanging wall ultramafics. The orebody has proven reserves of 129MT at 0.6% nickel. Mining commenced in 1993 and is currently at 8.5MTpa and is expected to rise through optimisation and expansion. The mine design for currently proven ore reserves is for an open pit to 300m depth

Aquifers identified at the mine site include shallow patchy Tertiary alluvium at up to 15m depth, a continuous zone of low-moderate transmissivity near the base of the regolith (base of oxidation) at 40-60m and a bedrock, fracture controlled aquifer at 120-200m. Dewatering and pit slope stability has been enhanced by slightly inclined drainholes drilled up to 200m into the pit walls. Total dewatering rate is believed to be about 2ML/d from drain holes, pit sumps and perimeter bores.

Total water use at the mines ore processing plant has been of the order of 20ML/d. Much of the process water supply is obtained from the Albion Downs Borefield, a Tertiary palaeochannel aquifer located about 30km east of the mine (Figure 4). The aquifer has been developed by a 50km long borefield. There are 32 production bores at an average spacing of 1.5km tapping a continuous stringer sand/gravel unit. The river deposits thicken (5 to 20m), widen (100 to 500m) and deepen (70 to 120m depth and RL 415 to RL 380m) to the southeast in the flow direction of the ancient river. The sand unit is covered by thick lacustrine clays and blanketed by Quaternary alluvium. The meandering channel axis and production bore sites were identified by geophysical methods, mainly gravity surveys, airborne and ground EM surveys. Water salinity in the channel sands ranges from 2 000 to 150 000mg/L, being lower in segments where the ground level is higher, and highest where the channel approaches or underlies playa lakes.

Ore processing has a sub-potable water requirement (<5 000mg/L) which is obtained from a tributary palaeochannel which flowed east away from the low strike ranges which host the orebody. The South Lake Way Borefield has been established at a more topographically elevated level. The distance from surface water discharge zones (playa lakes) means salinity levels are low. Sub-potable supplies are also obtained from a borefield spread along the greenstone belt strike ridge. This Caprock aquifer develops pods of dunite within the greenstone belt, weathering of this rock type tending to form vuggy siliceous replacement products.

Leinster Nickel Operations

Economic grade nickel sulphide mineralisation occurs in a lens of ultramafics, within near vertical metasediments and metavolcanics. Weathering oxidation is to a depth of 50m. There was intermittent development between 1973 and 1989 when the mine was purchased by WMC. The orebody has since been developed by a shaft and decline to a depth of more than 1 100 m. Production is 1.8Mtpa for 28 000T nickel in concentrate

Groundwater inflows to the mine were greatest during early shaft development, averaging about 1 900KL/d over the first year. Detailed water level monitoring was undertaken during dewatering of the abandoned shaft in 1978. Water table decline from RL 1 480m (40m below ground level) to RL 1 440m saw the effective porosity of the induced cone of drawdown decline from 8% to 2.5%. Monitoring of the phases of flooding and pumping showed that the area affected by dewatering was only 2.3sqkm in extent and that recharge to the area averaged 200KL/d. Later developments have encountered flows of up to 1 000KL/d which diminish rapidly over several days. Average daily groundwater inflow is about 300KL/d (Whincup and Domahidy, 1982).

Total groundwater abstraction for mining, processing and domestic use is about 6.5ML/d. This is obtained from borefields tapping palaeochannel, weathered silicified ultramafic and bedrock fracture zone aquifers. Brackish to saline water used in ore processing, obtained from major palaeochannels is relatively abundant. Potable quality water for domestic and industrial use is mostly obtained from the upper reaches of the palaeochannel system with small amounts from the other aquifer types. These aquifers show a trend of continued drawdown even during years of exceptionally high rainfall. Water in storage is expected to allow continued supply at current rates for several decades.

Agnew Gold Operations

Historical mining at Agnew was near the axis of the Lawlers Anticline. Since 1986 WMC have operated a number of open pit and underground mines extending 10km south from the early mining centre, along the western limb of this large scale structure. Gold mineralisation occurs in a variety of host rocks and structural settings throughout the district. WMC production is about 1.0MTpa for 135 000oz of gold.

Much of the current production is from the Redeemer underground mine. During construction of the Redeemer decline an exploration drillhole was encountered producing a flow of about 1ML/d, under 100m head at a depth of 225m. Inspection of core down dip showed the water was from two brittle fractures either side of a major shear zone. The decline was then advanced under cover of depressurisation holes drilled onto the structure. Yields from these holes diminished rapidly due limited extent of the aquifer. Ongoing groundwater inflow to the workings is very low.

Water supplies for the gold processing plant are mostly provided by the Emu Borefield. The borefield taps a pod of weathered dunite at the nose of the north plunging Lawlers Anticline. Production has been at a rates of 1 500-3 500KL/d, depending on the availability of other sources. In early years relatively high abstraction rates resulted in a linear drawdown trend. In recent years the mill operators have gained access to water discharged to waste from mine dewatering by other operators in the district (Figure 5). Under reduced abstraction and deeper pumping water levels the borefield water levels have tended to stabilise.

Kambalda Nickel Operations

Underground mining of nickel ore was commenced at Kambalda by WMC in the 1960's. A large proportion of production is still from deep mines in the Kambalda Dome area although ore is trucked up to 50km from some mines. Production is about 1.2MTpa for 37 000T of nickel in concentrate.

Groundwater inflow rates into most mines are low. Recent figures for 13 mines being dewatered were an average pumping rate of 400KL/d, and a maximum of 1 700KL/d. Groundwater is hypersaline (in excess of 100 000mg/L) and is discharged to playa lakes.

Relatively low rates of groundwater inflow have caused problems at upcast ventilation shafts. The hypersaline water expelled can affect vegetation near the shaft. At Victor shaft this problem was tackled by a programme of chemical grouting using the proprietary SCEM 66 system. The inflows were from widely spaced fractures in fresh, competent rock between 16 and 95m depth. Total discharge was reduced from 2.1 to 1.1L/s. At Foster a similar problem was solved by reversing air flow through the mine.

Water supplies are obtained from the government operated goldfields water pipeline which has its source at dams near the west coast at Perth. The Kambalda district is unusual for the Yilgarn in that there is just sufficient surface topographic relief to allow local surface water collection in dams. This is used to supplement process water supplies after infrequent heavy rains.

St Ives Gold Mines

A number of open cut and underground mines spread over a strike length of 30km supply ore to the St Ives gold mill. Gold mineralisation occurs in a number of host rock types mostly associated with splay faults from the Boulder-Lefroy shear zone which is the major structural feature of the belt. Most of the area is covered by up to 60m of Cenozoic alluvium, several more recent discoveries are under complete cover in the bed of Lake Lefroy playa lake. The St Ives Mill processes 3.0MTpa for about 380 000oz.

Prior to 1993 mining was concentrated at three separate complexes, Junction, Victory and Revenge. Each included a deep underground mine with several pits up to 80m deep nearby and total groundwater pumpage from all workings was about 6 000KL/d. Piezometers near the workings have shown very little drawdown. It is believed that the bedrock fracture systems discharging water in the workings are feed from overlying saturated alluvium, forming a constant head to the aquifers.

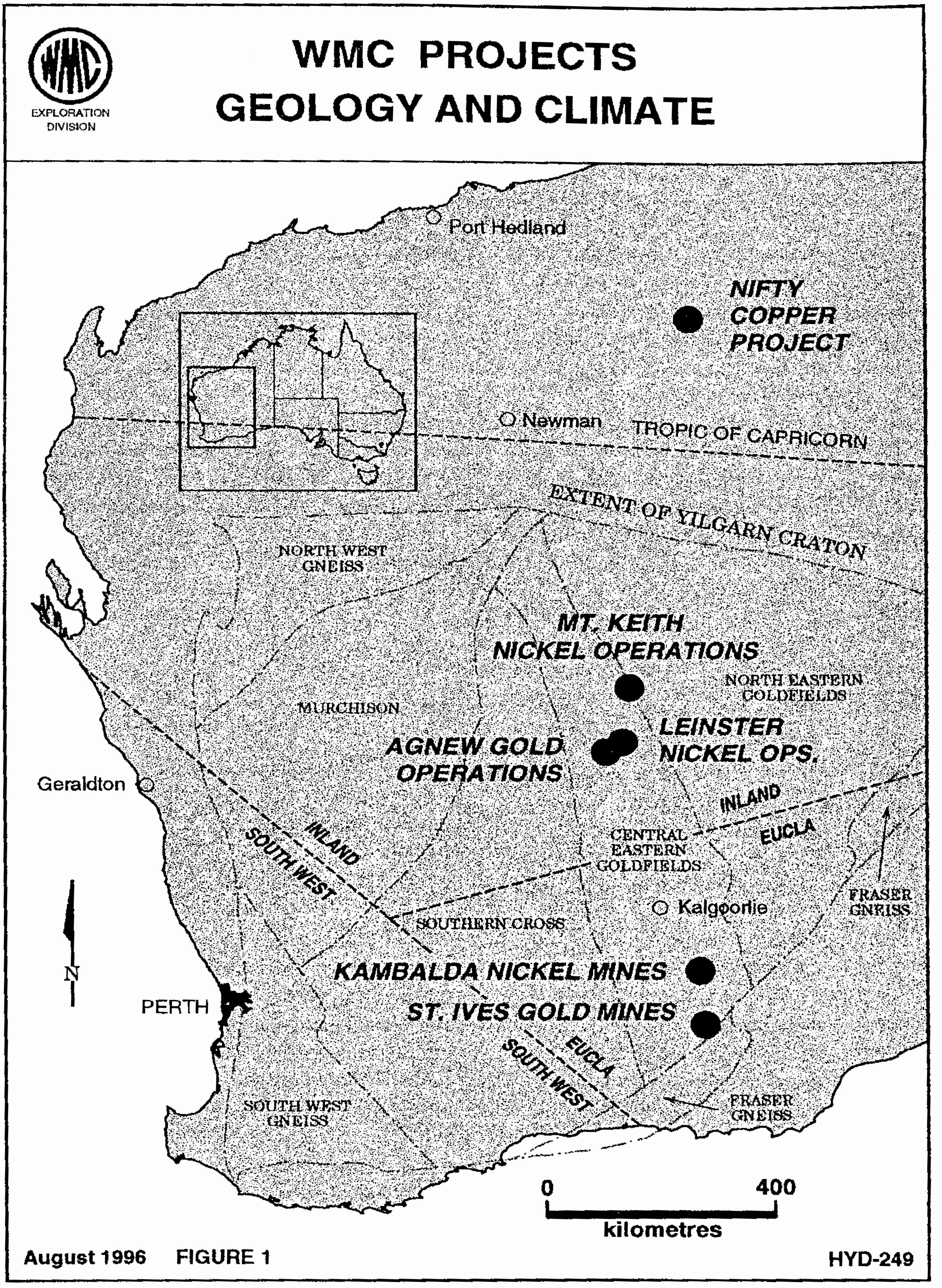
Recent open cut pits have encountered permeable Cenozoic sediments producing larger groundwater inflows and pit slope stability problems. A full sequence of palaeochannel sediments is intersected at the southern end of the Argo pit including (alluvial gold bearing) basal sands up to 15m thick and overlying saturated silts and clays (Figure 6). Groundwater inflows to the pit at a depth of 60m (50m drawdown) were about 7 000KL/d. Measures for water control and pit wall slope stability include horizontal drainholes drilled from the pit benches, dewatering bores pumping from the palaeochannel sand aquifer, and vertical drain holes where the basal sands are present.

All groundwater pumped from The St Ives gold mines is hypersaline at 150 000 - 250 000mg/L. To minimize water treatment costs for ore treatment at the mill a lower salinity groundwater source has been developed from palaeochannel sediments located 30km from the mill. The upstream part of the channel has been developed for a supply of 6ML/d with salinity of 30 000mg/L. Production over 5 years has induced relatively small drawdown. Usefulness of the aquifer over the long term at higher abstraction rates may be threatened by the intrusion of hypersaline water from downstream in the channel. Salinity profiles of observation bores have shown a wedge interface between the two water types which conforms to the Gyben-Herzberg relation for static water levels. Lowering of upstream water levels by pumping has not yet induced any movement of the wedge.

References

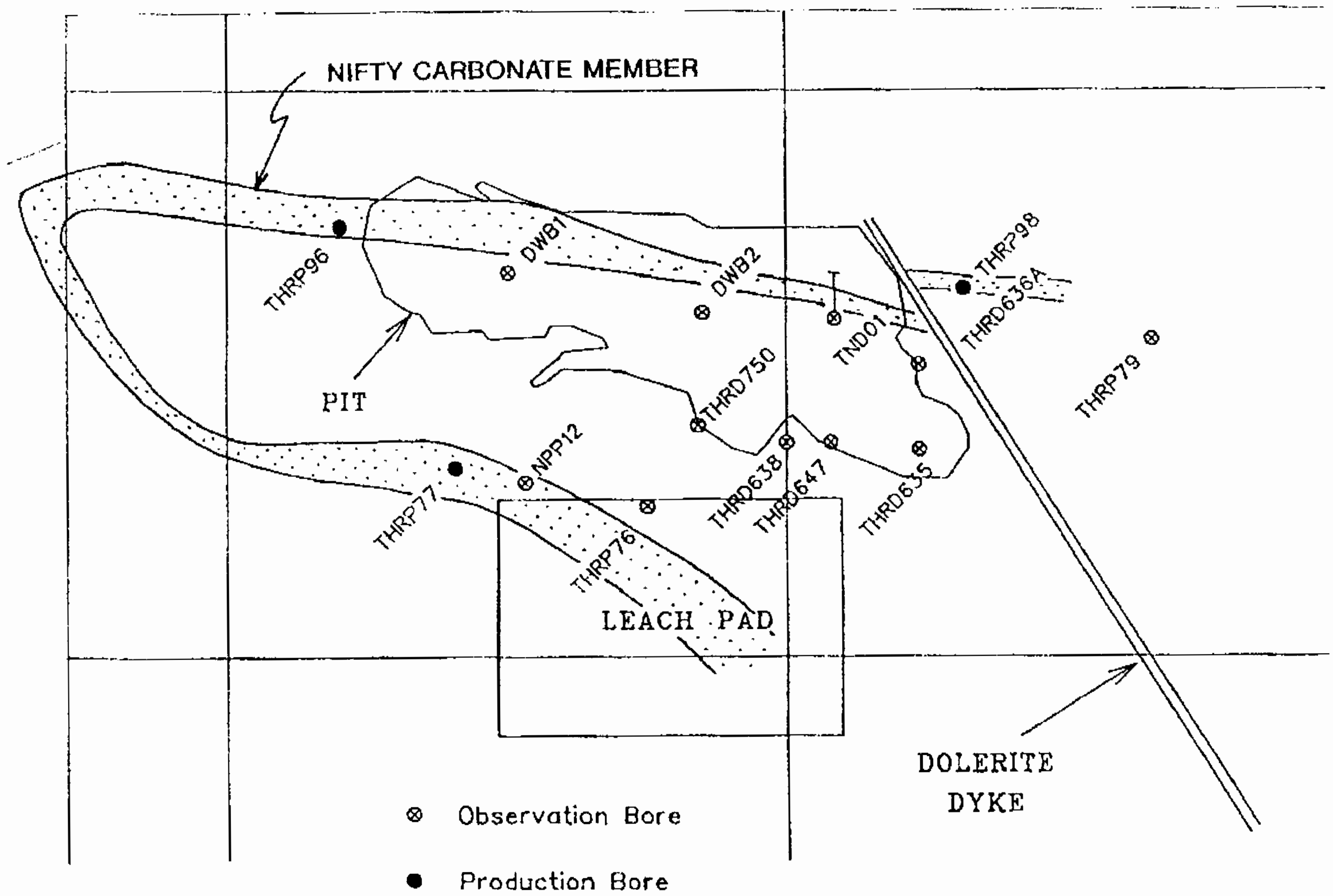
1. Morgan K. H. 1983. Dewatering Open Pit Mines, Yilgarn Craton, Western Australia. International Mining Geology Conference. Kalgoorlie Western Australia.

2. Whincup P. and Domahidy, G. 1982. The Agnew Nickel Project - No. 1 Mine Dewatering. A.W.R.C. Conference. Groundwater in Fractured Rock.


WMC PROJECTS
GEOLOGY AND CLIMATE
EXPLORATION DIVISION
Port Hedland
NIFTY COPPER PROJECT
Newman
TROPIC OF CAPRICORN
EXTENT OF YILGARN CRATON
NORTH WEST GNEISS
MT. KEITH NICKEL OPERATIONS
NORTH EASTERN GOLDFIELDS
MURCHISON
LEINSTER NICKEL OPS.
AGNEW GOLD OPERATIONS
Geraldton
INLAND
EUCLA
INLAND
SOUTH WEST
CENTRAL EASTERN GOLDFIELDS
FRASER GNEISS
Kalgoorlie
SOUTHERN CROSS
N
KAMBALDA NICKEL MINES
PERTH
ST. IVES GOLD MINES
EUCLA
SOUTH WEST
FRASER GNEISS
SOUTH WEST GNEISS
0
400
kilometres
August 1996
HYD-249
FIGURE 1

WMC EXPLORATION DIVISION

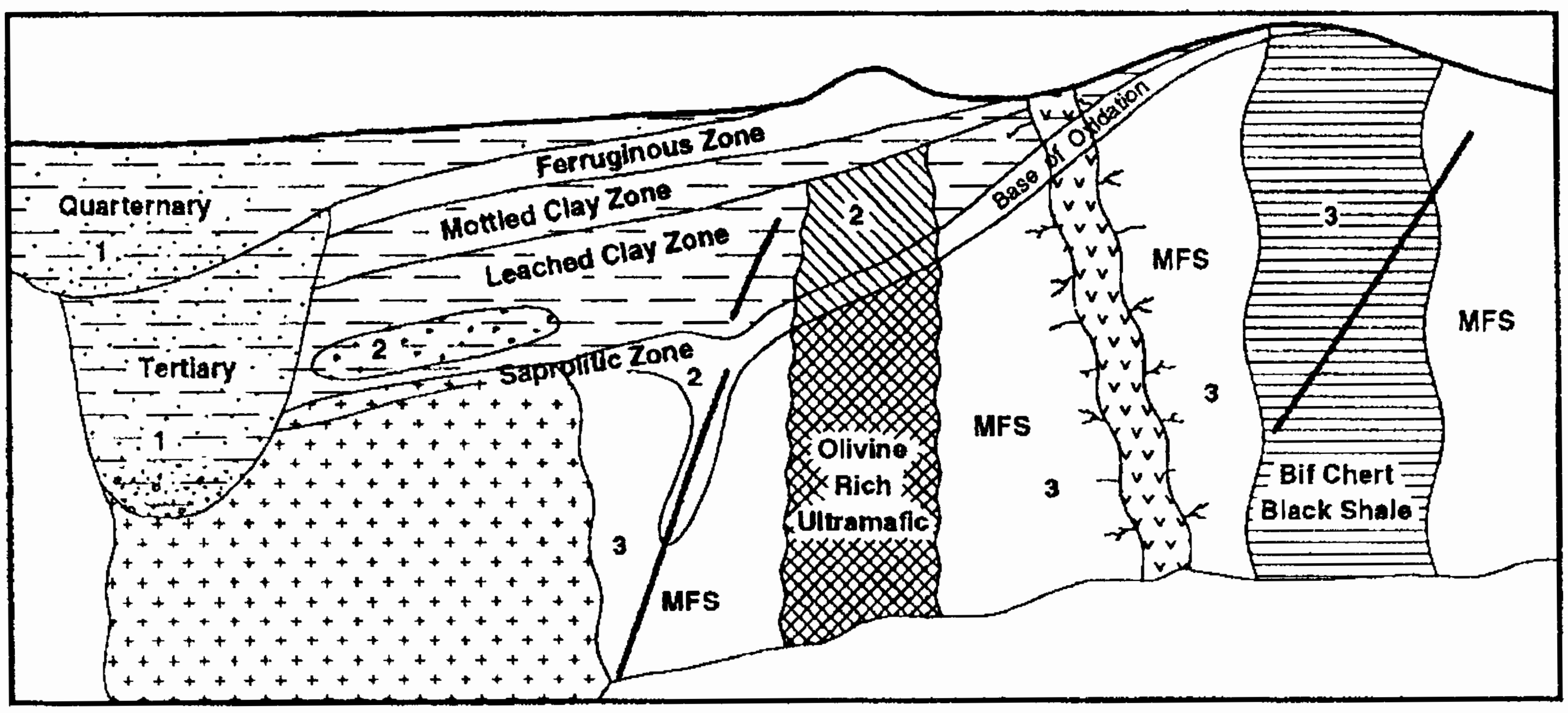
NIFTY COPPER PROJECT



June 1993 FIGURE 2 1166-1724

WMC EXPLORATION DIVISION

IDEALIZED SECTION
SHOWING GROUNDWATER OCCURENCES : YILGARN, W.A.



1 - Buried Alluvial Aquifer
2 - Weathered Zone Aquifer
3 - Fractured Rock Aquifer

MFS - Mafic Felsic or Sedimentry
- Shear Zone

April 1997 FIGURE 3 HYD-275

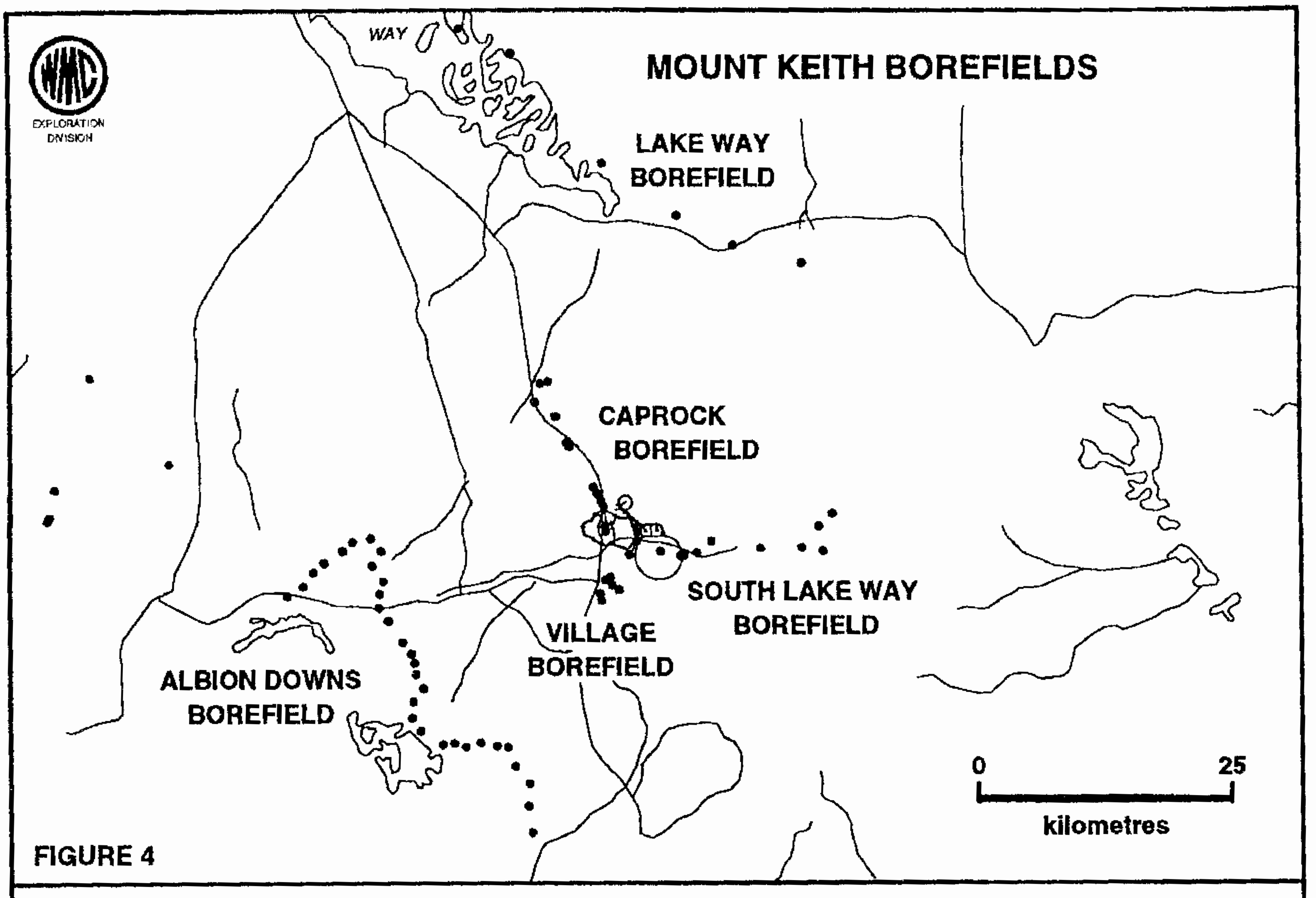


FIGURE 4

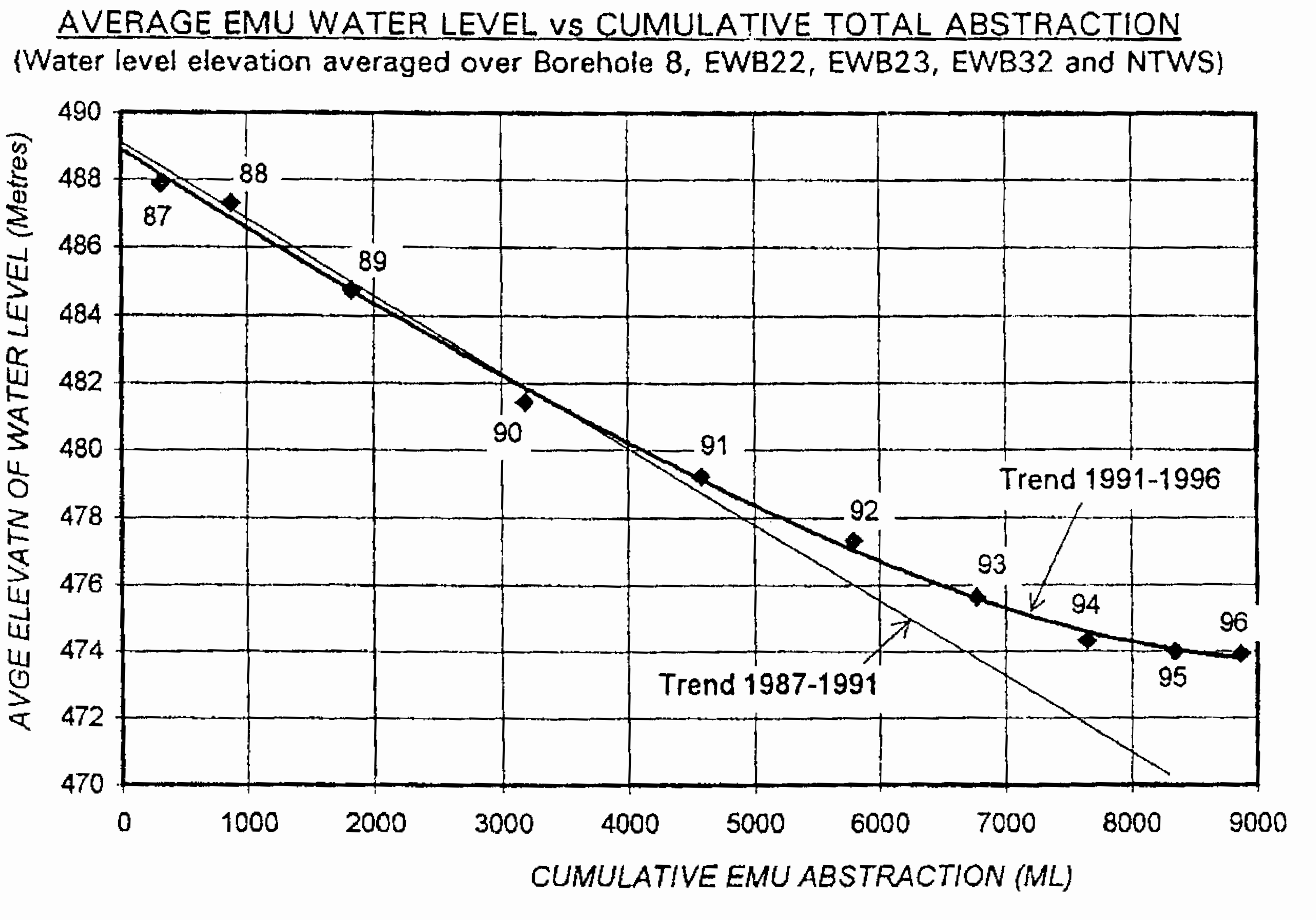


FIGURE 5

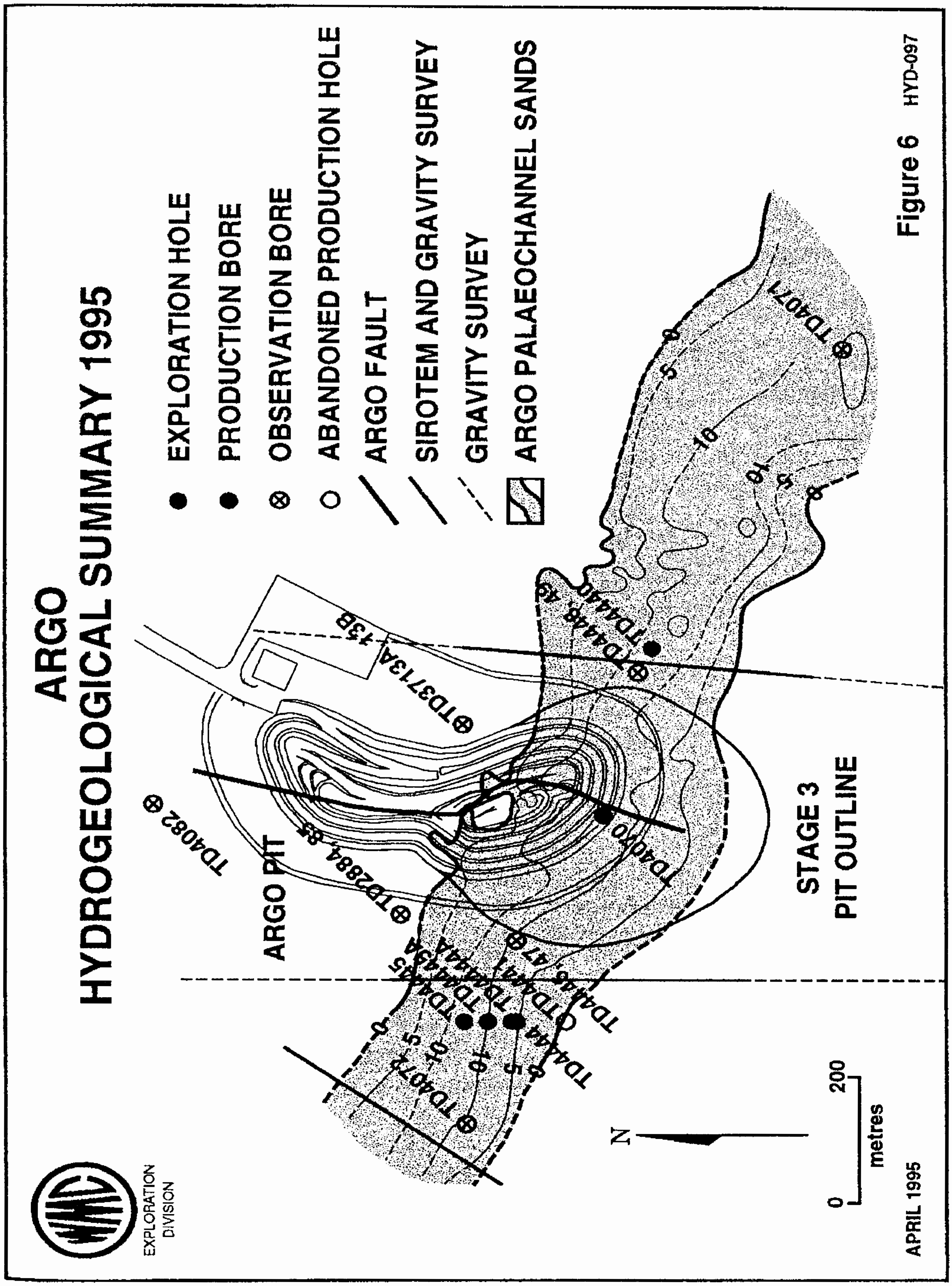

ARGO
HYDROGEOLOGICAL SUMMARY 1995
EXPLORATION HOLE
PRODUCTION BORE
OBSERVATION BORE
ABANDONED PRODUCTION HOLE
ARGO FAULT
SIROTEM AND GRAVITY SURVEY
GRAVITY SURVEY
ARGO PALAEOCHANNEL SANDS
EXPLORATION DIVISION
ARGO PIT
STAGE 3
PIT OUTLINE
TD4082
TD2884, 85
TD3713A, 13B
TD4070
TD4071
TD4072
N
0
200
metres
APRIL 1995
HYD-097

Figure 6