PINSTECH-165

HYDRO-GEOLOGICAL STUDIES AT THE PINSTECH QUADRANGLE

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Abstract

In order to save the huge amount of water bill and to overcome the shortage of water supply during summer, a resistivity survey was carried out to locate some suitable water bearing horizon/s within the PINSTECH Quadrangle. Eight shallow bore holes yielding limited amount of water supply were also drilled on trial basis. The work so far done indicates the existence of two water-bearing horizons in this area.

a. *A shallow water bearing horizon present at the contact of recent alluvium with bedrock at a depth between 7-20 meters.*
b. *A deep water bearing horizon present erratically in the sandstone of Kamlial Formation at a depth between 85-180 meters.*

On the basis of resistivity measurements, thirteen sites have been earmarked which may contain water bearing zones in the deep horizon. Out of these, nine sites have been classified as the favourable and four as semi-favourable sites. A geological survey of the area was also carried out. The Kamlial sandstone, indicated by the resistivity survey to contain water bearing zones, is less porous with low permeability. Therefore it is not a favourable lithology to contain an aquifer to produce a good water discharge. However, the hole/s penetrating through a faulted/fractured zone being charged through a stream in the vicinity may yield water.

INTRODUCTION

Pakistan Institute of Nuclear Science & Technology (PINSTECH) does not have its own water supply system and depends on Capital Development Authority (CDA), Islamabad for this purpose. To save the huge amount of water charges of about Rs. 3.5 million/year and to overcome the shortage of water supply during summers, a resistivity survey was carried out to explore the existence of water bearing horizon/s in the PINSTECH Quadrangle. Resistivity investigations for the delineation of subsurface water bearing zone/s were carried out by a team of experts from Atomic Energy Minerals Centre (AEMC) Lahore. Eight test holes were also drilled to tap the water present at the shallow depth (see table 2).

Geological studies like, preparation of geological map and cross sections, stratigraphic and structural studies, were carried out during October 1999 to March 2000, to understand the nature of the rocks present in the PINSTECH area and to interpret the water bearing horizons indicated by the resistivity survey.

On the basis of resistivity surveys and bore hole data, it has been concluded that the area contains two subsurface water bearing horizons as described below;

- A shallow water bearing horizon present in the recent alluvium at the contact with bedrock at a depth between 7-20 meters.
- A deep water bearing horizon present in sandstone of the Kamlial Formation between 85-180 meters, at places where the sandstone is faulted and fractured.

On the basis of resistivity measurements, thirteen sites have been earmarked which may contain water bearing zones in the deep horizon. Out of these, nine sites have been classified as the favourable and four as semi-

favourable sites. The favourable sites are promising zones in terms of porosity and permeability and have good chances to contain subsurface water. The semi-favourable sites are those which have relatively fewer chances to contain the subsurface water bearing zones.

When water penetrates the earth's surface, it is retained near the surface as soil moisture. When the soil moisture increases beyond a certain limit, the soil can not hold the water and flow begins under the gravity. If this flow strikes an impervious layer it will move laterally and possibly exit the subsurface by seepage and became part of surface flow. On the other hand, the groundwater flows down the gradient and forms an aquifer in the rock or in an unconsolidated gravel bed. The basic physical configuration of the hydrological cycle nature is illustrated in figure 1.

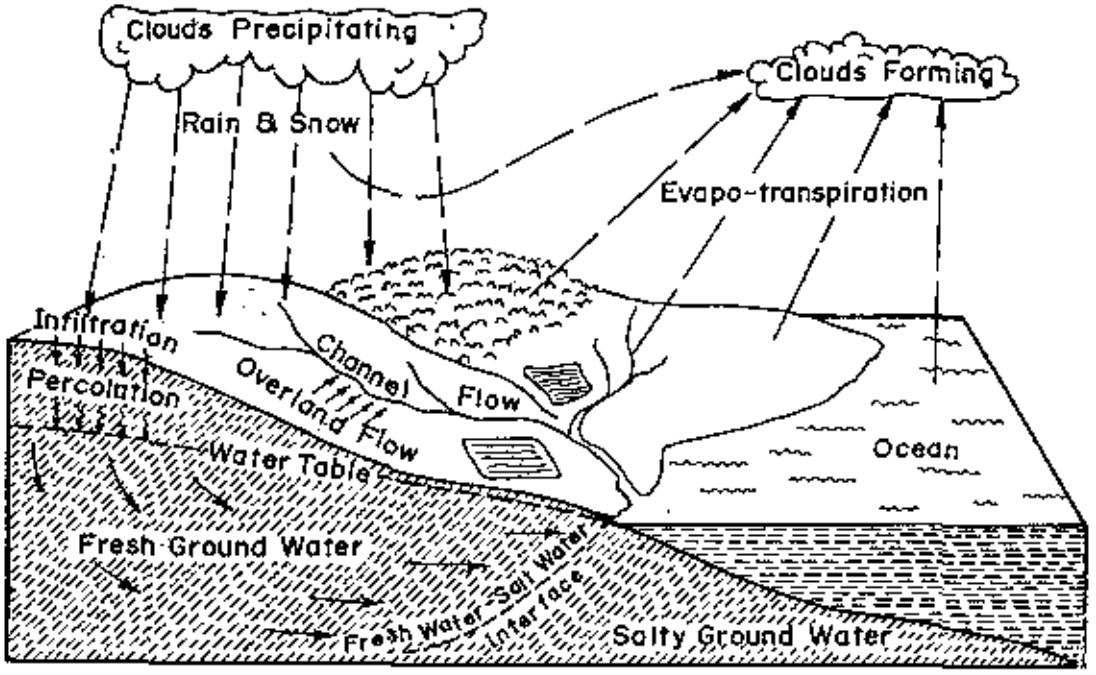

FIG. 1. The hydrologic cycle

There are two basic requirements for an aquifer to exist: porosity and permeability in the rock. Porosity of a rock is the ratio of aggregate volume of interstices in a rock or soil to its total volume. In general, porosity greater than

20% is considered as large, 5-20% as medium and less than 5% as small. It ranges from 0% in hard crystalline rocks to a maximum of 80% in loose, unlithified shales or mudstone. The search for water is confined to the suitable zones in terms of porosity and permeability. The porosity determines the amount of water that can be held in storage and permeability determines the ease of withdrawing the water for use. To be a good deep aquifer; sediments or rocks should not only be porous but pore spaces should also be interconnected. The large pore space in many fine-grained sedimentary rocks provides storage for vast quantities of water [2]. The Kamlial sandstone in PINSTECH has less porosity and low permeability. This is an indicative of low possibility of existence of an extensive aquifer except at places where the holes to be drilled would penetrate through a faulted/fractured zone being charged by stream in the vicinity.

GEOLOGY OF THE AREA

The PINSTECH area is located between longitudes 29° 15' to 35° 19' E and latitudes 52° 38' to 55° 40' N. The area is mostly hilly and is located at a height of about 600 m above sea level. Soan river flows in the East of PINSTECH at a distance of about 4 km. Halfway between the river and the PINSTECH site, is a small water divide that separates the drainage of Soan and Kurang rivers. Numerous seasonal streams like, Gumrah, Khad and Ling, flow in a generally south-westerly direction. A seasonal stream known as Milal Kas flows at a distance of about 1.5 km in the West of PINSTECH.

Locally the area is covered with 4-10 m soil cover. The soil cover is composed of Kaolinite, Mica, Quartz, Montmorillonite and some illite. The oldest rocks (rocks at the base) exposed in the streams and escarpments belong to Murree series.

Murree Formation

From top to bottom, in general, four lithological units can be distinguished in Murree Formation.

- **Light brown hard silt.**
- **Brown hard silty clay.**
- **Dark brown hard clay or claystone.**
- **Dirty grey hard sandstone.**

Light brown hard silt is hard but porous and loses strength when wet. Its thickness varies from 1.5-2.0 meters. This brown hard silty clay is found almost at every place. The clay content also increases with depth. The thickness of this unit varies from 1.0 – 4.5 m. The dark brown hard clay bed has chocolate colour and has grey interbedding of clay at places. Occasionally gravels and pebbles are also seen as interbeds. Its thickness varies from 1-2 m. The dirty grey hard sandstone is well-compacted, massive and hard rock unit. This sandstone consists of quartz, feldspar, mica and zircon.

Kamlial Formation

The Murree Formation is overlain by Kamlial Formations of Miocene/Pliocene age. The Kamlial Formation consists of grey sandstones and brick red shales with intraformational conglomerates. The sandstones are medium to coarse grained and are up to 90 m thick in this area. At places they are faulted and fractured. These faulted and fractured zones are possibly the water bearing zones indicated by resistivity survey in this area. However, this is to be pointed out that, to be a permanent water source, these zones should be connected to some stream for recharging.

Siwalik Group

The Kamlial Formation in this area is overlain by rocks of Siwalik Group. Only Lower Siwaliks, represented by Chinji Formation, are exposed in PINSTECH area. The Chingi Formation consists of red clay with subordinate ash and greyish sandstone. The sandstones are fine to medium grained and soft. The Chingi formation is the last lithological unit in this area and is overlain by alluvial cover [3].

GEOLOGICAL CROSS SECTIONS

For correlation studies, sections were studied at Soan river and Milal Kas. The cross sections prepared on the basis of the geological studies in these two streams have been presented in figure 2. Following is the geological section along Soan river:

Sr. No	Rock Type	Thickness (meters)	Description
1.	Shale	5	Shale with argillaceous material
2.	Silty Sandstone	14	Fine grained, hard and fractured. Fractures are parallel and perpendicular to strike and sheared type. Fractures are calcite filled.
3.	Hard Sandstone	33	Sandstone is hard and well compacted.
4.	Soft Sandstone	50	Sandstone is soft less fractured and cross-bedded. Local patches of compact silty sandstone are also present.
5.	Shale	24	Consist of small lenses of sandy and silty shale at various places. Brown to reddish brown in colour.

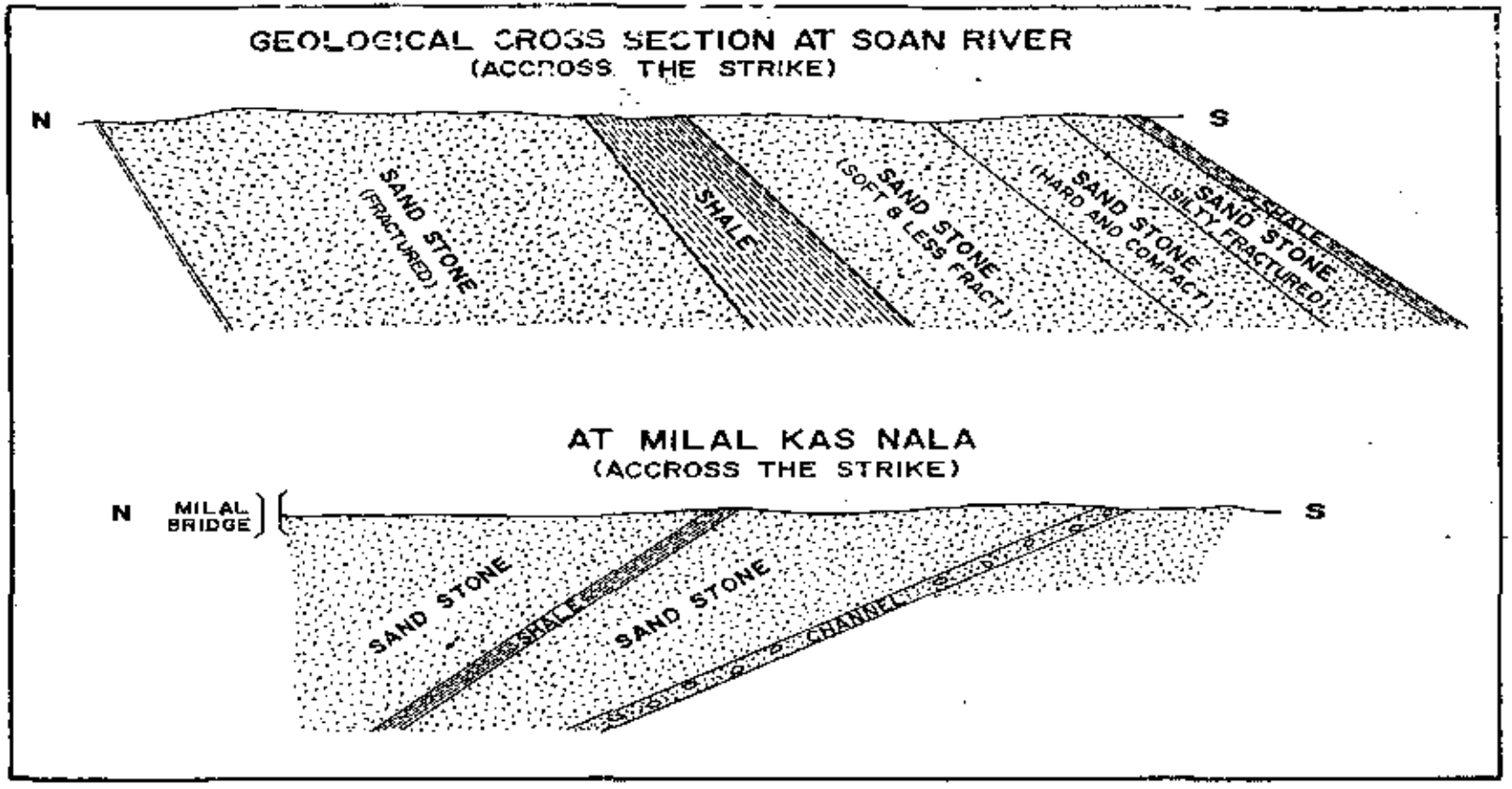

Fig 2. Geological Cross sections showing the various lithologies at Soan River and Milal Kas Nala accross the strike.

6.	Sandstone	110	Half a meter wide gritty bed is present at a distance of 12 meters from shale contact. Half a meter wide channel showing pinching and swelling behaviour is present at 27 meters from shale. At 33 meters from shale, the sandstone is fractured.

RESISTIVITY SURVEY

The resistivity investigations were carried out in PINSTECH area by a geophysical party of Atomic Energy Mineral Centre Lahore during July/August 1999. The objective of the survey was to assess the subsurface water potential of the area. The SAS 300 Terrameter was used to acquire the resistivity data using Schlumberger configuration at 26 sites. The minimum spread length was 140 m which investigated 70 m deep section. The maximum spread length was kept 700 m where ariel extent was possible with depth of investigation up to 350 m.

The resistivity investigations help in assessing the area containing potential rocks with depth of occurrence which bear water. These investigations are based on the measurement of electrical resistivities of various subsurface rocks which show different resistivities. The resistivity data combined with geohydrological data of the area are used to assess the depth of water table and its potential.

On the basis of preliminary qualitative analysis of the data of the resistivity survey conducted in the area, some sites have shown the presence of subsurface water bearing zones. The location of these sites, estimated depth of water table and thickness of the water bearing zones have been tabulated in table-1. However, the resistivity survey results are not helpful in predicting the yield/discharge of water from the aquifer. Therefore, it is recommended that

test well may be installed at the favourable sites/locations and aquifer yield/discharge tests be conducted accordingly.

Table 1. Detail Of Favourable And Semi-Favourable Sites At PINSTECH.

Site Location	Estimated thickness of water bearing zone (meters)	Favourable/ Semi-favourable
Near PINSTECH Model School (VES-8)*	85-180	Favourable
South of Milat Khas Bridge (VES-21)*	65-130	Favourable
Near Admin. Block (VES-16)*	10-45	Favourable
600 m south of PIEAS Auditorium (VES-13)	40-110	Favourable
On the VIP Entrance Road (VES-17)	90-150	Favourable
South of NLP Exhaust Stack (VES-10)*	50-120	Favourable
Near PINSTECH Mosque	25-50 85-160	Favourable
South west of INNUP Tower (VES-3)*	60-110	Favourable
Opposite NLP Service Station (VES-6)	55-90	Favourable
1 km South of PIEAS Auditorium (VES-24)*	26-50	Semi-Favourable
Near Power Station (VES-25)	60-110	Semi-Favourable
ACD Road Opposite NLP-Mess B (VES-7)	40-70	Semi-Favourable
Near Army Post West of Power Station (VES-19)	90-140	Semi-Favourable

* V.E.S. numbers marked by stars have also been considered important by AEMC team, after the resistivity investigation.

BORE HOLE DATA

Geological information on the lithology encountered in the eight bore holes recently drilled at different locations in the PINSTECH have been presented in table 2. Juster pumps have been fitted on the five successful bore holes and continuous water pumping up to seven hours did not cause any decrease in the discharge.

CONCLUSIONS AND RECOMMENDATIONS

1. Shallow Water Bearing Horizon

The shallow water bearing horizon has been encountered in five, out of the eight holes, drilled in PINSTECH area. The diameter of these holes is 4 inches and limited supply of 3000 litres/hour from hole No. 2 drilled in VIP Guest house and 2350 litres/hour from hole No. 3 drilled in front of Admin Block has been estimated. Seven hours of continuous water yield was obtained from hole No. 2, 3, 4, 5 and 6.

This data shows that success rate of hitting water in shallow holes is about 65%. It is however, recommended that new holes with larger diameter may be drilled in VIP guest House and in front of Admin Block and their yield be checked with a more powerful pump. It is further recommended that a few additional shallow holes may be drilled in area between VIP Guest House and Administrative Block to establish the existence of the water bearing horizons in the area in-between.

H. No	Location	Total Depth (m)	Water level (m)	Water Discharge	Lithology
1	Near Water Tank in Market	30.5	7.6	Recommended for Hand Pump (very low)	Alluvium consisting of sand, grits and shale. Strata is loose with no underlying rock to retain water.
2	In VIP Guest House	24.4	7.5	3000 Lit/H	Alluvium consisting of alternating silty, sands and grit upto 12.2 m. Followed by sandstone upto 24.4 m with gritty layer. Below sandstone is a shale barrier.
3	In Admin. Block	36.6	13	2350 Lit/H	Alluvium consisting of alternating sands, grits and shales. At depth shale is present as a barrier.
4	Near old D-Type Houses	19.8	12.2	Juster Pump fitted for discharge of water	Alluvium with alternating layers of hard bands & channels material. Presence of underlying hard barrier is not confirmed.
5	Near new D-Type Houses	24.40	18.30	-do-	Alluvium with sandstone & channel material.
6	Near Technical Hostel	13.72	9.15	-do-	Alluvium with alternating layers of hard bands & channel material.
7	In PNISTECH Model School	12.8	10	very low	Alluvium with alternating layers of hard bands & channel material. Presence of underlying hard barrier is not confirmed.
8	Near Market Bus Stop	13.5	12.2	very low	Alluvium with sandstone & channel material.

2. Deep Water Bearing Horizon

To reach a water bearing horizon, thirteen sites have been recommended for deep drilling considering the resisitivity survey conducted by a team of experts from Atomic Energy Minerals Centre Lahore. The location and favourability of these sites have been presented in figure 3.

The lithological, stratigraphic and structural studies indicate that at thirteen sites, where the drilling has been recommended, the holes will penetrate the Kamlial Sandstone. The Kamlial sandstone is not a favourable lithology to contain a good water reservoir due to less porosity and low permeability. Secondary porosity and fractured/jointed zones have been noted at many places in the Kamlial sandstone in this area. The water bearing zone indicated by the resistivity survey may have similar structure at depth to host ground water reservoir. However, it is necessary that, the reservoir should be recharged from a nearby stream to yield continuos water supply.

If this is true, the Kamlial sandstone may act as possible potential water source at sites shown as favourable and semi favourable in figure 3. Estimated depth of water table and thickness of water bearing zones have been tabulated in table 1. It would however, be advisable to drill a few test holes in steps at a few sites shown as favourable, before going for a full fledged drilling operation. After drilling 10 meters in water bearing zone, a compressor test to check the water yield may be carried out.

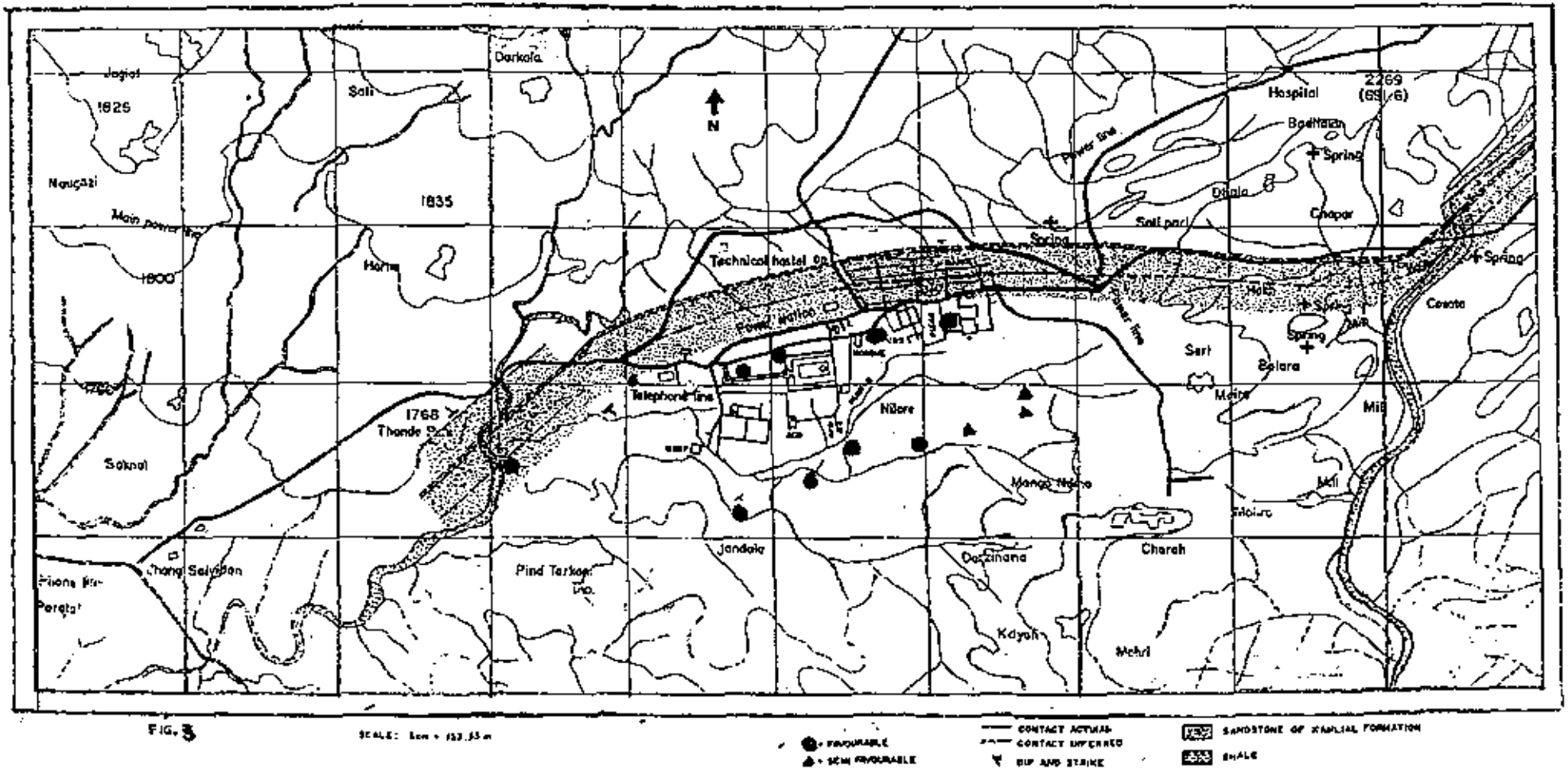

FIG. 3

SCALE: 1cm = 152.55 m

- FAVOURABLE
- SEMI FAVOURABLE
- CONTACT ACTUAL
- CONTACT INFERRED
- DIP AND STRIKE
- SANDSTONE OF KAMLIAL FORMATION
- SHALE

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