

# ELUCIDATION OF PALAEOCHANNELS IN PARTS OF PUNJAB (INDIA) USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

RAJIV CHOPRA\*, C.M. BHATT AND P.K. SHARMA  
Punjab Remote Sensing Centre, Ludhiana 141004, (Punjab) India

Commission VI, WG-IV/10

**KEY WORDS:** Palaeochannels, Satellite Data, GIS, Indo-Gangetic, Punjab Plains & Groundwater.

## ABSTRACT

Climatic changes and neotectonic movements in the north-western plains of India have led to the migration and abandonment of drainage systems to form a large number of palaeochannels. Palaeochannels present in the study area were extracted from final geomorphological map. These were delineated from satellite image by considering combination of various factors. These channels show a discontinuous drainage pattern, trending in NE-SW and NNE-SSW directions. Their width ranges between 100-300 metres. Channels close to present day river course have comparatively high moisture as compared to others. These palaeochannels were occupied by reworked sand heaped in the form of dunal ridges. Presently signatures of these palaeochannels have been obliterated from the ground due to leveling/ sand removal for cultivation. Inference of the drilling data suggests that the column thickness of palaeochannels ranges between 17 and 85 metres. They are constituted by alternating layers of fine to medium sand including kankar and gravel beds at certain depths. Water level in most of the tube wells drilled ranges between 4 and 20 metres. Groundwater quality of the tube wells drilled along them is much better than those located away from the palaeochannels. Palaeochannels in this area are important because of their hydrological potential and can help in augmenting groundwater resources in the region through recharging.

## INTRODUCTION

Late quaternary climatic changes and neotectonic movements in the north-western plains of India have led to the migration and abandonment of drainage systems to form a large number of palaeochannels. Palaeochannels are the remnant scars of rivers/streams which were flowing either ephemeral or perennial during the geological past but presently these are lost due to internal (tectonic activity) and external (climatic, geomorphic and anthropogenic) activities. There are many mythological, archeological, geomorphological, geophysical and remote sensing evidences which point towards, the presence of well integrated drainage network in the alluvial plains of Punjab, Haryana and Thar Desert in Rajasthan (Ghose et. al., 1979). The present day geomorphic features in the Indo Gangetic plains are the result of climatic fluctuations and fluvial adjustments during late Pleistocene – Holocene period, with a subdued role of tectonics of Himalayas.

The palaeochannels considered as lost drainage are still having under flow of ground water evidenced by abnormally high pumpage discharge, fresh to low saline quality in comparison to water occurring in adjoining non riverine environment and are also comparatively older in character (Nair et. al., 1997). Such palaeo channels are being looked upon as possible reservoirs of ground water (Qinghai et.al., 1996). Various worldwide studies have established the fact that palaeochannels are not only source of good potable ground water, but their favourable conditions make them good rechargeable aquifers (Singh and Singh, 1988 and Singh et.al., 1990).

Satellite remote sensing due to synoptic, multi-spectral and multi-temporal coverage helps in systematic identification, delineation and reconstruction of the palaeo drainage system. It helps in understanding the palaeochannels in the regional context and narrowing down the area of investigation for

ground water targeting, thus reducing the cost and time involved in ground water exploration. Using Landsat satellite data, Yashpal et.al., (1980) provided detailed location of palaeochannels of Sutlej, Yamuna, Ghaggar and other river systems originating in Himalayas or foothills and flowing through the alluvial plains of Punjab, Haryana and Thar desert in Rajasthan.

The hydrophilic nature of alluvial and colluvial deposits constituting palaeochannels, their location contiguous to the river and retention of flood water, make them an excellent and rich source of ground water (Gautam 1990; Narsimhan, 1990, Sinha et.al.,1990; Singh 1996). For the ground water development and its rational utilization, it is essential to identify, delineate palaeochannels and estimate the aquifer thickness beneath them. In the present study an attempt has been made to delineate the palaeo channels, infer their ground water status through remote sensing and generation of permanent digital data base using GIS.

## STUDY AREA

The study area forms a part of Indo Gangetic alluvial plain. It lies south of river Sutlej and has an expanse of 3,068 sq.kms. The area under study covers 12 districts namely Mohali, Fatehgarh Sahib, Patiala, Ludhiana, Sangrur, Mansa, Bathinda, Moga, Faridkot, Muktsar, Firozpur and part of Rupnagar district of Punjab state (Figure 1). It is bounded by geo-graphical co-ordinates 73° 52' 26" & 76° 56' 36" E longitudes and 29° 32' 40" & 31° 09' 14" N latitudes. It is composed of quaternary alluvial deposits brought down and spread out by rivers of Indus system (perennial Sutlej River and non perennial Ghaggar River). The area is characterized by distinctive geomorphic features like alluvial plain, active/old flood plains, palaeochannels, terraces, sand dunes etc. It is an extensively cultivated area with nearly 53% of it being irrigated by tube wells. During the period from 1981 to 2004 the number of tube wells has increased from 1.38 lakhs

to 4.84 lakhs (Economic Advisor, Punjab, 2004) resulting in over exploitation of groundwater and decline in water table. The climate of the area is mainly influenced by

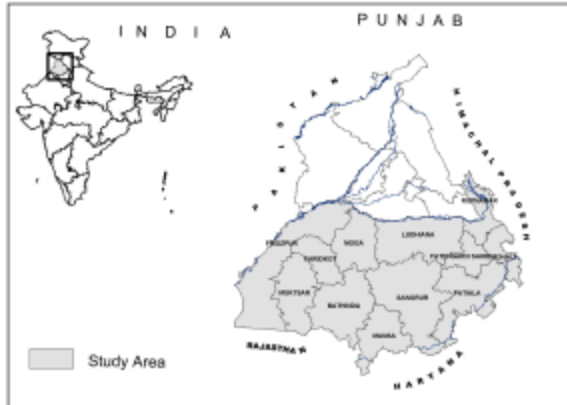


Figure1. Location map of the study area.

Thar desert in the South. Rainfall is quite erratic both in time and space. During 2003 average annual rainfall was 353.17mm. The major portion of annual rainfall is received during monsoon season. Rainfall gradually decreases towards south-west. The monthly average annual rainfall ranges between 474 mm to 29.8 mm from Ludhiana to Ferozpur. The monthly minimum temperature in the region is as low as 2.8°C (February) and the monthly maximum temperature is as high as 44.4°C (May).

## MATERIALS AND METHOD

Palaeochannels and other landforms were delineated through visual interpretation of multi-date satellite data for the years 1987 and 2004 in the form of false colour composites generated on band 2, 3 & 4 on 1:250,000 scale. The relevant path and row numbers and year of pass are given in Table 1.

Satellite & Sensor	Path	Row	Year of Pass
Landsat TM	148	039	1987
IRS-1D LISS III	93	50	1997
IRS-P6 AWIFS	95	50	2004

Table 1: Satellite data used for geomorphological mapping.

Detailed geomorphological maps for the year 1987 and 2004 were prepared using variation in photo elements like tone, texture, shape, size, pattern and association. The geomorphological units were delineated on the base map prepared from SOI topographical maps on same scale. The palaeochannels were delineated on the basis of their linear/curvilinear/meandering courses, channel like shape, high moisture, linear depressions, vegetated regions and association with fluvial landforms (Figure 2). Nearly 20 percent of the study area was checked in the field for confirmation. During field work few palaeochannels were also traversed using GPS to collect georeferenced lithological data from twenty-three sites where tube wells were being drilled by different agencies. Lithological data available in CGWB reports has also been used to confirm the existence of palaeochannels on ground. The georeferenced ground water samples collected from different tube wells,

located in palaeochannels have been assessed for different water quality parameters.

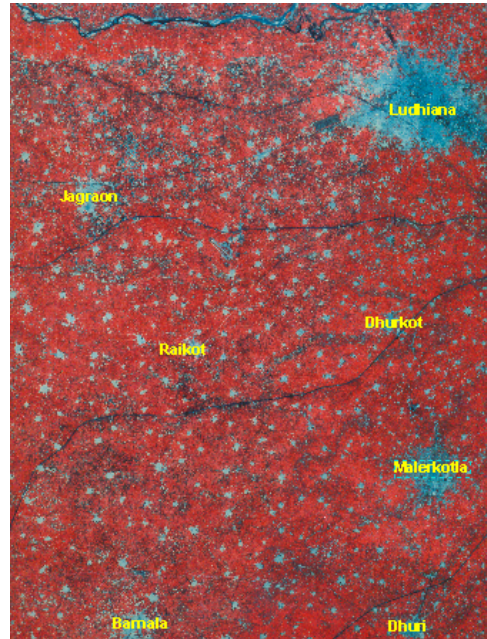


Figure2: IRS 1D LISS III image showing palaeochannels in part of study area

The geomorphological maps for the years 1987 and 2004 were digitized using ARC/INFO and attributes assigned. Palaeochannels present in the study area were extracted from final geomorphological map.

## RESULTS AND DISCUSSIONS

Superimposition of basin boundaries over the palaeochannels map shows the existence of eight prominent discontinued channels out of which five channels lie in Ghaggar basin and remaining three in Satluj Basin (Figure 3). Existence of these channels has been confirmed on the basis of geomorphological, lithological and archeological evidences.

### Geomorphological Evidences

The linear/curvilinear/meandering courses, channel like shape, high moisture, linear depressions, vegetated regions and their association with fluvial landforms helped in delineating palaeo channels in the area. These channels show a discontinuous pattern, trending in NE-SW and NNE-SSW directions. Their width ranges between 100-300 metres. Channels close to present day river course have comparatively high moisture as compared to others. A closer look of the palaeochannels in the region suggests a gradual shift in their courses from south to south-western direction. Similar conclusion was made by Yash Pal et al., 1980 and Sahai 1999. Presence of natural levees/ palaeo banks near Chamkaur Sahib, Sanghol, Sunet and Janer villages unequivocally confirm the presence of palaeochannels. These channels were occupied by reworked sand heaped in the form of dunal ridges. In the last two decades there has been a large scale land transformation in the area resulting in total modification/alteration of the country side. The reclamation of land by leveling of sand dunes for bringing them under agricultural use has completely obliterated their signatures on the latest satellite images.

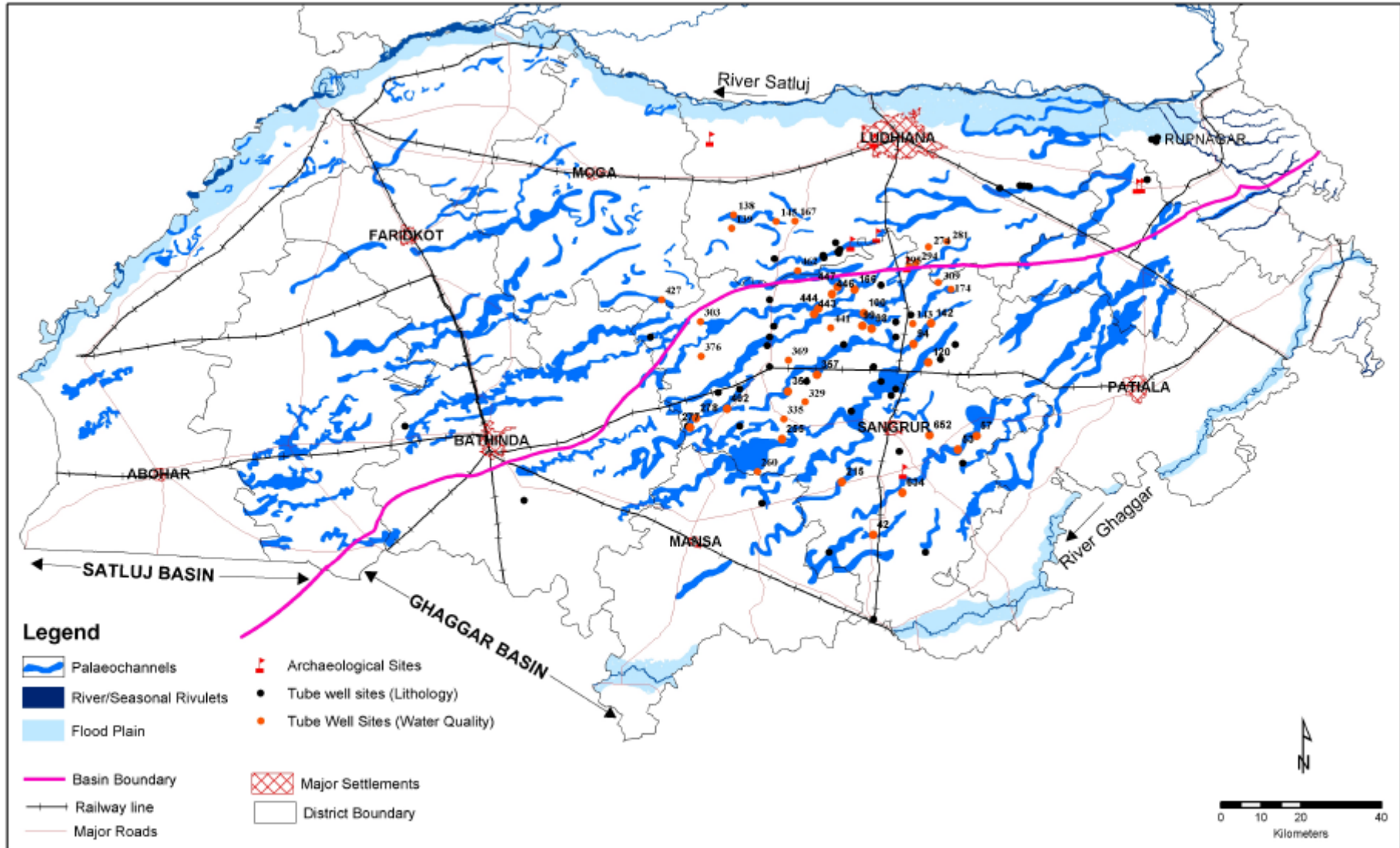


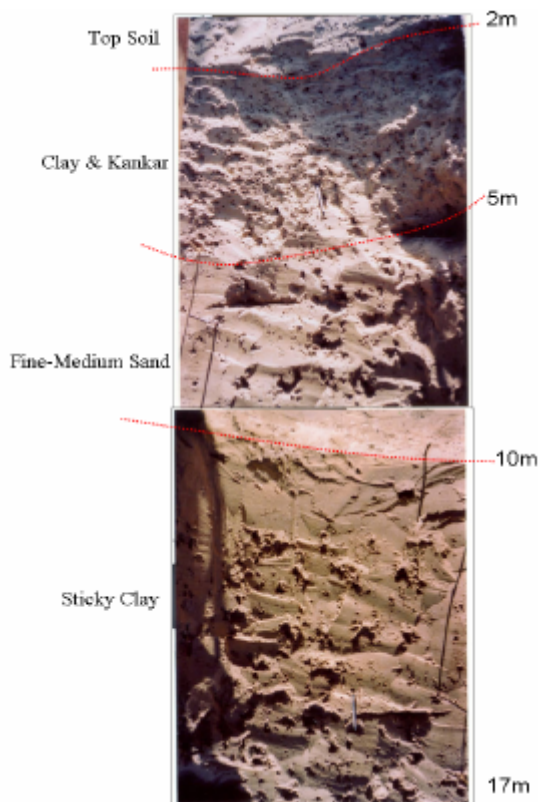
Figure2. Map showing basin wise palaeochannels in the study



## Lithological Evidences

Analysis of lithology as well as groundwater quality from the bore wells sunk in the area has confirmed the presence of palaeochannels. Inferences of the drilling data suggest that column thickness of palaeochannels ranges between 17 and 85 metres (Figure 4). They are constituted by alternating layers of fine to medium sand (micaceous in nature), sandy clay, sticky clay (*Pandoo*), calcareous concretions (*Kankar*) and pebbles intermixed in varying proportions at different depths (Field Photo 1). Static water level in most of the drilled wells range between 5 and 20 metres and the water quality is good both for drinking & irrigation purposes.

Elongated to sub rounded pebbles of various sizes and colours and shells were observed between the depths of 60 and 110 metres confirming the riverine environment. A perusal of Table 2 shows that the groundwater quality inside or along the palaeochannels is much better for most of the drilled tube wells as compared to those located away from them. Electrical conductivity values ranges between 0.26 and 1.14  $\text{dSm}^{-1}$ , pH varies between 8.77 and 9.04 and  $\text{CO}_3/\text{HCO}_3$  ranges between 1-4/1-5.5  $\text{me}^{-1}$  respectively. Other parameters were also found to be lying within the permissible limits.



Field Photo 1. Lithological sections observed in field

## Archeological Evidences

Indo-Gangetic plain has been the cradle of many civilizations. The availability or lack of waters in the rivers flowing in this region determines the growth or decay of these civilizations (Yash Pal et al., 1980). Archeological evidences as broken pieces of pottery were observed during field visits from Kupp Rheda, Chhapaar and Mard Khera villages. Discovery of antiquities like coins, seals and

artifacts from Sanghol village (*Uncha Pind*) by ASI suggest the flourishing of social and cultural activities in the region during Harappan period to Mediaeval age. Three Buddhist Stupas of Kushana period excavated by the Archaeological department in Sanghol village suggest this region to be great centre of Buddhist learning (Field Photo 2). Remnants of ancient bridges in the village of Racchin also confirm the existence of ancient civilization in the region (Field Photo 3). Georeferenced archaeological sites observed during field survey were plotted on the palaeochannel map (Figure 2) to see if any correlation exists between ancient civilizations and palaeochannels. It was found that all the sites fall on or along these channels suggesting a close relationship between palaeochannels and ancient civilization.



Field Photo 2: Buddhist Stupas in village Sanghol



Field Photo 3: Remnants of ancient bridge in Racchin village

## CONCLUSIONS

Satellite remote sensing due to synoptic multi-spectral and multi-temporal coverage helps in systematic identification, delineation and reconstruction of palaeo drainage system. Existence of image identified palaeochannels on the ground has been confirmed through lithological and archaeological evidences. These palaeochannels due to the high volume of storativity are the excellent and rich source of groundwater. The chemical analysis supports the existence of good quality groundwater fit for both drinking as well as irrigation purposes. These palaeochannels can be the possible locales for artificial recharge and can be effectively used for groundwater exploration to cope with the water scarcity in the region.

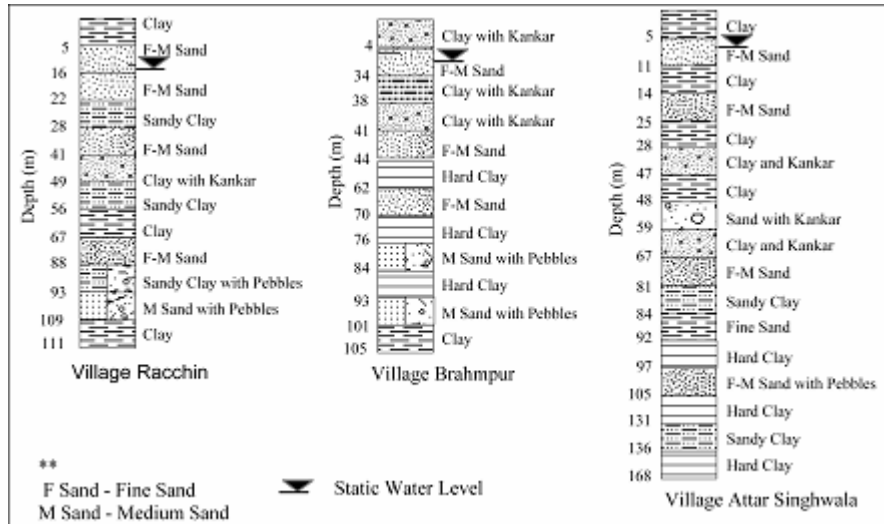


Figure 4. Lithological sections along palaeochannels.

Tube wells located on or along the palaeochannels												
Well Code	Village Name	EC dSm <sup>-1</sup>	Na mel <sup>-1</sup>	CO <sub>3</sub> mel <sup>-1</sup>	HCO <sub>3</sub> mel <sup>-1</sup>	RSC mel <sup>-1</sup>	SAR	pH	Ca+Mg mel <sup>-1</sup>	K mel <sup>-1</sup>	Cl mel <sup>-1</sup>	SO <sub>4</sub> mel <sup>-1</sup>
SNQ053	Batriana	0.26	0.76	2.00	2.00	2.00	0.76	8.77	2.00	0.07	3.00	0.73
SNQ057	Ratgarh	0.65	6.30	2.00	3.00	1.30	4.63	9.02	3.70	0.18	4.00	1.87
SNQ094	Bhasani	0.65	6.74	2.00	2.00	0.50	5.09	8.93	3.50	0.45	3.00	0.68
SNQ098	Farbhai	0.50	4.02	2.00	3.00	2.10	3.34	8.85	2.90	0.17	3.00	0.78
SNQ099	Purgarh	0.55	4.98	4.00	3.00	0.90	2.85	8.91	6.10	0.16	3.00	1.87
SNQ100	Alipur Khalsa	0.50	3.69	2.00	3.00	1.50	2.79	8.82	3.50	0.16	3.00	1.25
SNQ120	Dhandra	0.56	4.24	2.00	3.00	1.10	3.04	8.84	3.90	0.15	4.00	0.99
SNQ142	Manak Majra	0.50	2.71	2.00	2.00	-0.60	1.79	8.70	4.60	0.18	4.00	0.88
SNQ166	Khurd	0.62	3.58	4.00	1.00	0.50	2.39	8.72	4.50	0.15	5.00	4.01
SNQ215	Sheron	0.62	4.35	2.00	3.00	1.40	3.24	9.91	3.60	0.19	5.00	1.30
SNQ446	Bapla	1.01	8.26	2.00	1.00	-5.00	4.13	9.04	8.00	0.21	5.00	1.40
LDQ138	Akhara	1.11	5.22	2.00	4.00	0.60	3.18	8.78	5.40	0.35	5.50	0.00
LDQ139	Bhami pura	0.98	2.83	3.00	2.50	-1.00	1.57	8.72	6.50	0.29	6.00	0.00
LDQ145	Talwandi Rai	1.14	5.22	2.00	5.00	0.60	2.92	8.92	6.40	0.32	6.25	0.00
LDQ167	Rajoana Khurd	0.97	2.17	1.00	5.50	0.70	1.27	8.77	5.80	0.32	5.50	0.00
Tube wells located away from the palaeochannels												
SNQ143	Shakopur	0.79	7.72	4.00	4.00	4.40	5.75	8.97	3.60	0.17	4.00	0.88
SNQ174	Mandian	0.65	5.33	2.00	4.00	2.60	4.09	9.02	3.40	0.15	7.00	2.13
SNQ260	Pandher	1.68	21.08	6.00	7.00	10.10	17.51	9.00	2.90	0.15	9.00	4.95
SNQ369	Sanghera	0.98	8.70	2.00	5.00	2.90	6.08	8.88	4.10	0.16	4.00	3.07
SNQ376	Sehna	0.91	6.74	4.00	5.00	2.60	3.77	9.13	6.40	0.29	3.00	2.50
LDQ274	Kheri	1.00	10.00	9.00	4.00	7.20	6.45	7.91	4.80	0.20	4.00	0.00
LDQ281	Ber Khurd	0.65	1.96	6.00	3.00	3.00	1.13	7.77	6.00	0.23	2.75	0.00
LDQ294	Sohian	0.72	4.57	4.00	5.00	4.80	3.15	7.78	4.20	0.14	3.75	0.00
LDQ309	SihanDaud	0.58	3.96	2.00	6.00	2.60	2.41	7.71	5.40	0.15	3.75	0.00

Table 2. Groundwater quality parameters of tube wells sunk inside or along and away from palaeochannels.

#### REFERENCES

Archeological Survey of India, Cultural affairs, Archaeology and Museum, Punjab, Chandigarh (Introduction Board at Village Sanghol).

CGWB (1990). Hydrogeomorphology of Sangrur district, Punjab State, CGWB, GOI. Ministry of Water Resources.

Economic Advisor (2004). Statistical Abstract of Punjab.

Gautam, A.M. (1990) Application of IRS-1A data for delineating buried channels in southern part of Allahabad district of Uttar Pradesh., *Photonirvachak* 18 (3), 52-55

Ghose, B; Kar. A and Hussun, K; (1979). The lost course of the Saraswati river in the Thar desert, western India, *Rec. Geol Sur: India* 116, 77-86.

Gupta, A.K., Sharma, J.R. Sreenivasan, G. and Srivastav K.S. (2004). New findings on the course of River Saraswati. *Photonirvachak* 32 (1), 1-24.

Narsimhan, T.N. (1990). Palaeochannels of the Polar river west of Madras city. Possible implications for vertical movement. *Jour. Geol. Soc* 36 (5), 471-474.

Nair A.R. Narvado S, Vand Rao S M (1997) Isotop study to investigate origin and age of Ground Water along Palaeo channel in Jaisalmer and Ganganagar districts of Rajasthan Geological Society of India, *Memoir* 42, 315-320.

Qunghai, X. Chen, W., Xuanqing, Z. and Xiaolian, Y. (1996). Palaeochannels on the north China plain: Stage, division and palaeoenvironment. *Geomorphology* 18, 15-25.

Sahai (1999). Unraveling the lost Vedic Sarasvati. In : *Vedic Sarasvati* (Eds. B.P. Radhakrishnan and S.S. Mer.). *Memoir Geol. Soc. of India* 42, 121-142.

Singh, I.B, (1987). Sedimentological history of Quaternary deposits in Gangetic plains. *Indian Joun. Earth Sci.*, 14, 272-282.

Singh, K.P. and Singh, B.D. (1988). Study of hydromorphology of Doon Valley and Ganga Jamuna Doab area using remotely sensed data. *Publ. Cent. Adv. Stud. Geol. Panjab Univ., Chandigarh* 3, 77-82.

Singh, I.B., Bajpai V.N. Kumar, A and Singh, M. (1990) Changes in the channel characteristics of Ganga river during late Pleistocene- Holocene *Jour. Geol Sci: Ind.* 36 pp 67-73.

Singh, K.P., (1996) Significance of Palaeochannels for hydrogeological studies – A case study from alluvial plains of Punjab & Haryana State India. *Sub surface – water Hydrology*. Kluwer Academic Publishers, Netherlands, 245-249.

Sinha A.K. Raghav K.S., and Sharma Anoop. (2005). Palaeochannels and their recharge as drought proofing measure: Study and experiences from Rajasthan, Western India. *Proc. Int. Conf. Drought mitigation and prevention of land desertification*, Bled, Slovenia. (<http://www.wg-crop.icidonline.org/63 doc.pdf>)

Yash Pal, Sahai, Baldev, Sood R.K. and Agarwal, D.P., (1980). Remote Sensing of the lost Sarasvati River. *Proc. Ind. Acad. Sci. (Earth Planet Sci)*, 89 (3) 317-331.