

Case study summary: HYDROGEOLOGICAL STUDIES OF RISHIKESH AND MOHAND AREAS IN DOON VALLEY USING ELECTRICAL AND SEISMIC REFRACTION METHODS. (Teshome Maru Adane, 1999)

Among various groundwater exploration techniques a combined use of electrical resistivity and seismic refraction methods is effective in mapping the groundwater in the earth subsurface. Moreover; the cost of the investigation is cheaper than other methods. These methods have been employed to study the hydrogeology of Reshikesh and Mohand areas of the Doon valley, Uttra pradesh, India to meet the water supply demand of the towns. Rishikesh and Mohand is situated in the Himalaya ranges of mountain in the doon valley where thick gravels overlain thick Siwalik meta-sedimentary rocks. Ten vertical electrical resistivity sounding and seven seismic refraction profiling were carried out.

The geological interpretation of geophysical parameters show that the average resistivity and velocity ranges of various formations respectively are:

- Dry loose clayey boulder-boulder gravel having 360-868 Ωm and 483-1127m/s;
- Water saturated boulder gravel-bajri-sandy gravel having 53302 Ωm and 970-3517 m/s;
- Semi consolidated clayey boulder - boulder clay having 289-566 Ωm and 970-2843m/s;
- Highly to slightly weathered friable sandstone having 20-98 Ωm and 569-1382 M/S;
- Compact hard sandstone having 410- Ωm and 2740 m/s;
- Clayey bed, mudstone having 20-25 Ωm and 5000m/s;

The study outcome confirms that there are, substantial groundwater resources both in Rishikesh and Mohand areas to meet the water supply of both Mohand and Rishikesh towns. Dhalwala followed by Munikireti and Mohand one followed by Mohand two are highly recommended sites for water well drilling.

GEOLOGY AND HYDROGEOLOGY

Rishikesh and Mohand is found in the Doon valley in Dehradun and Saharan pur districts Uttrapradesh, India within the Himalaya ranges of mountain in the outer (Sub) Himalayan division. The Southern most zone of the outer Himalaya consists of about 9500m thick piles of Tertiary sedimentary rocks (conglomerate, Sandstone, mudstone, phyllites, shale, limestone ranging in age from paleocene to lower pleistocene (Thakur, 1992). The breakdown of the rising central Himalaya has resulted in deposition of the Siwalik group in the form of Molasses deposits, overlain by Late pleistocene Doon gravels (parkashetal, 1980).

In the Siwalik range, a number of Longitudinal valleys occur, of which one of the largest is the Doon valley having 80km length and 20km width (Nossion. J.J. 1971). The Doonvalley and its environ were studied as one hydrogeologic system to understand the

ground water recharge, movement, storage and discharge on the regional hydrogeologic context. The valley having more than 1600km² area enjoys up to 2800mm rainfall during rainy season from June to September Meijerink (1974,1987). Knowledge of this regional geology and hydrogeology of the areas played a lot on selection of specific sites for Vertical electrical resistivity sounding and Seismic refraction profile as well as hydrogeological interpretation of the geophysical data.

GEOPHYSICAL STUDIES

Ten vertical electrical resistivity sounding and seven Seismic profiling were carried out on both on middle siwalik Sandstone in Mohand area and on Doon gravels terrain in Rishikesh area. Electrical resistivity data were collected using aquametre, India make and data quantitatively interpreted using computer automatic interpretation (zohdy,A.A.R. 1989)) and geolectric Section parameters have produced. Similarly Seismic profile were also carried out to generate seismic refraction data using Smarteis Model of Geometrics TM S12 Seismograph, USA make. Seismic refraction data were processed and interpreted quantitatively using Seismic interpretation programs (SIP) (Scott and others 1972) and Qualitative control programs for quick interpretation of Seismic refraction data (SIPQC) (Rim Rock Geophysics Inc. 1993).

GEOLOGICAL AND HYDROGEOLOGICAL INTERPRETATION OF GEOPHYSICAL PARAMETERS

Quantitative values of Seismic wave velocities and electrical resistivity of subsurface formations are further interpreted geologically and hydrogeologically by correlating the area geology and nearby borehole data and the result is presented on table 1 and 2.

CONCLUSION

The hydrogeological investigation result shows that both Rishikesh and Mohand areas (the former is better than the latter) have adequate groundwater potential that can be used for domestic and Industrial uses. Dhalwalla followed by Munikireti and Mohand one followed by Mohand two are promising sites for water well drilling. In both localities the groundwater occurs in unconfined to Semiconfined aquifer conditions. In most cases two aquifer system one situated at shallow (1 to 22m) and other at deeper level to depth of 149m are existing. Moreover the combined use of electrical resistivity and seismic refraction methods have proved themselves that they can render valuable aid in reducing ambiguities regarding Electrical equivalence, Suppression and Seismic blind zone problems to delineate the potential water bearing zones in the subsurface of Rishikesh and Mohand areas.

Table 1 - Rishikesh and Mohand areas geological interpretation of geophysical data

No	Site and direction of Surveying	Vertical Electrical Resistivity Survey					Converging of evidences and geological interpretation	Seismic Refraction Profile (SRP)			
		Type curve	Ohm m (average)	Layer	Thickness (m)	Depth (m)		P wave velocity (m/s)	Layer	Thickness (mean) (m)	Mean Depth (m)
1	Lalpani VES: N4°W-S4°E SRP : N42°E-S42°W	HK	439.71	1	2.89	2.89	dry loose boulder gravel	545	1	9.77	9.77
			161.94	2	16.79	19.68	Sandy gravel	2114	2	9.24	19.01
			566.18	3	71.68	91.36	semi consolidated clay boulder	2843	3	∞	∞
			188.37	4	42.74	134.10	saturated sandy gravel				
2	Kali Kemali VES:N7°W- S7°E SRP:N30°E-S30°W	QQ	868.47	1	4.71	4.71	sparsely vegetation covered Loose clayey boulder dominated gravel	1127	1	6.99	6.99
			385.21	2	17.16	21.87	saturated boulder gravel	2029	2	46.74	53.73
			138.88	3	127.13	149.00	saturated clayey sandy gravel	2582	3	∞	∞
			50.16	4	∞	∞	"				
3	Dhalwalla VES:N60°W-S60°E SRP: N45°W-S45°E	HK	464.44	1	6.92	6.92	dry loose boulder and bajri	541	1	11.85	11.85
			100.98	2	25.18	32.10	saturated boulder and bajri	1829	2	26.48	38.33
			200.72	3	116.9	149.00	saturated boulder, pebble bajri	3517	3	∞	∞
			70.60	4	∞	∞	"				

Continuing Table

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No.	Site and direction of Surveying	Vertical Electrical Resistivity Survey					Converging of evidences and geological interpretation	Seismic Refraction Profile (SRP)			
		Type curve	Ohm m (average)	Layer	Thickness (m)	Depth (m)		P wave velocity (m/s)	Layer	Thickness (mean) (m)	Mean Depth (m)
4	Ranipokhri	HK	252.92	1	4.19	4.19	wet clayer boulder	710	1	21.69	21.69
	VES: N50°W-S50°E		154.15	2	37.69	41.88	boulder dominated gravel				
	SRP: N30°W-S30°E		288.84	3	90.56	132.44	wet clayey boulder	970	2	∞	∞
			109.13	4	∞	∞	saturated clayey boulder				
5	Muniki reti	HK	359.82	1	2.89	2.89	dry loose sand, bajri and boulder	483	1	6.51	6.51
	VES: N30°W -S30°E										
	SRP:S30°E - N30°W		301.73	2	10.52	13.41	boulder bajri	1166	2	30.01	36.52
			486.41	3	15.48	28.89	clayer boulder				
	156.72	4	105.21	>134.10	saturated sandy gravel	2144	3	∞	∞		
6	Local Bus station	HK	454.43	1	0.89	0.89	dry loose river gravel				
	VES: N40°W-S40°E										
			234.41	2	8.05	8.94	saturated boulder-brajri				
			489.09	3	19.33	28.27	clayey boulder				
			62.08	4	61.13	>89.41	Saturated sandy gravel				

Continuing Table

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No.	Site and direction of Surveying	Vertical Electrical Resistivity Survey					Converging of evidences and geological interpretation	Seismic Refraction Profile (SRP)			
		Type curve	Ohm m (average)	Layer	Thickness (m)	Depth (m)		P wave velocity (m/s)	Layer	Thickness (mean) (m)	Mean Depth (m)
7	Mohand 3 VES: N12°E-S12°W SRP: 40°E-S40°W	A	25.52	1	24.59	24.59	Wethered clayey friable sandstone	569	1	10.7	10.7
			97.64	2	28.39	52.89	Slightly weathered friable sandstone	1382	2	28.23	38.93
			410.48	3	∞	∞	fresh compact sandstone	2740	3	∞	∞
8	Mohand 2 VES: N25°E-S25°W	Q	165.42	1	6.62	6.62	wet river terrace gravel				
			71.68	2	14.32	20.94	saturated sandy gravel				
			49.77	3	>45.28	>66.22	moderately weathered sandstone				
9	Mohand 1 VES: N35°E-S35°W	H	52.82	1	9.72	9.72	saturated sandy gravel				
			25.52	2	56.5	66.22	saturated weathered sand stone with subordinate thin clay bed interclation				
			34.52	3	∞	∞	moderately to slightly weathered sand stone				
10	Mohand 4 VES: N35°E-S35°W SRP: N45°W-S45°E	QH	230.55	1	6.27	6.27	saturated sandy gravel	1515	1	14.21	14.21
			51.25	2	22.81	29.08	saturated weathered gravely sandstone	2509	2	23.66	37.87
			20.03	3	62.89	91.97	Mud stone	5000	3	∞	∞
			79.98	4	∞	∞	compact sandstone				

- Remark 1. In the upper layer in most of the cases, the first seismic refraction interface represents the water table.
 2. VES and SRP measurement at Kali Kemali were undertaken in different sites about 1km apart each other.

Continuing Table 1

Table 2 : Rishikesh and Mohand areas hydrogeology for groundwater development

Sl. No	Site	Aquifer					Recommended borehole depth (m) for groundwater development	Remarks
		Lithology	Min. average depth range (m)	Min. average thickness (m)	Type of aquifer	Anticipated Water quality		
1	Lalpani	sandy - gravel	9.77-19.01	9.24	Unconfined	Relatively fresh	19.01	
		sandy - gravel	>91.36-134.10	>42.74	semi-confined	Saline	130.00	
2	Kalikemali	boulder dominated gravel and sandy gravel	6.99-21.87	14.88	Unconfined	Fresh	21.87	Clay beds within sandy gravel
		sandy gravel	21.87-149.0	127.13	Semi-confined	Saline	130.00	
3	Dhalwalla	Pebble boulder barjri-gravel	11.85-149	>137.15	Unconfined	Fresh	100.00	
4	Ranipokhri	big boulder dominated gravel	21.69-41.88	20.19	Unconfined	Fresh	41.88	
5	Munikireti	loose boulder-bajri	6.51-13.41	6.9	Unconfined	Fresh	13.41	
		semi-consolidated sand gravel	28.89-134.10	>105.21	Semi-confined	Fresh to Saline	130.00	
6	Local bus station	loose boulder-bajri	0.89-8.94	8.05	Unconfined	Fresh	8.05	Clay beds within
		semi-consolidated sandy-gravel	28.27-89.40	>61.13	Semiconfined	Fresh	89.40	
7	Mohand 3	Moderately weathered sandstone	10.7-38.93	28.23	Unconfined	Fresh	38.93	Thin clay beds within weathered sandstone
8	Mohand 2	Sandy gravel passing to friable weathered sandstone	6.62-66.22	59.6	Unconfined	Fresh	66.22	
9	Mohnad 1	Gravel sand passing to friable weathered sandstone with very thin mudstone layers	0-66.22	>66.22	Unconfined	Relatively fresh	66.22	thin clay beds within sandstone
10	Mohand 4	River gravel passing to gravelly sand stone	0-29.08	>29.08	Unconfined	Fresh	29.08	