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Developing an effective groundwater monitoring plan for the Kathmandu Valley

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ABSTRACT

The rise in urbanization and the increase in the surface sealing has constantly reduced infiltration from the surface in the Kathmandu Valley. On the other hand groundwater exploitation has been thoughtlessly amplified in excess of its replenishment capacity. The result has been a decrease in ground-water level over the years. Though this has been reported in the past from the observation of the piezometric layer data, the actual scenario is not known as most wells have multi-screens tapping possibly different aquifers or same aquifer of different hydrogeological characteristics. Also in the absence of regular monitoring works, very little data exists on variation in piezometric layers over the years.

Though there are estimated 700 deep wells in the valley, from the data available so far only 29 wells have single screen thus tapping possibly a single aquifer or a single aquifer unit. Similarly 65 wells have two or multiple aquifers spaced closely together tapping possibly single aquifer units. A new monitoring plan is proposed whereby the wells to be monitored will be selected based on number of screens and screen spacing as well as geographical distribution. Areas which are not covered through the existing wells are to be monitored through new wells especially constructed for monitoring purpose.

Keywords: Multi- screens, interference, monitorin, single-screen wells

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INTRODUCTION

Groundwater abstraction from deep wells in Kathmandu Valley started in the early 1980s and has become a principal source of water supply. At present the extraction rate exceeds four times the recommended rate of 15Million Liters per day (MLD) (JICA 1990). Alarmed at the fast rate of head decline, reportedly around 2.5 m/yr (MPPW_2002), concerned agencies have voiced the need for effective monitoring of groundwater in Kathmandu Valley. However, past practices of multi screening along with concentration of wells in a limited area and the very design of wells makes most existing wells unsuitable for monitoring. Many experts believe that large scale groundwater mining makes the area vulnerable to land subsidence in the future (JICA 1990). Some monitoring work is being carried out at present, but it is indeed a difficult task to predict the consequences of groundwater mining that is taking place at the moment (Adhikari 2006). This study analyses the existing wells and proposes an ideal scheme for monitoring that would help in analyzing the true situation of groundwater at present.

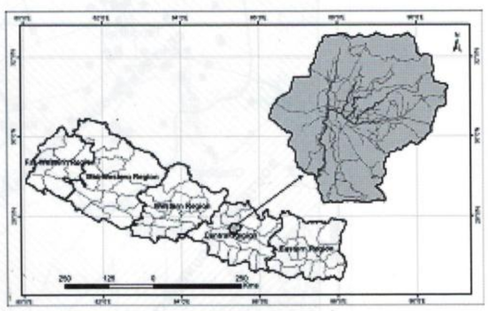

Fig. 1: Location of Kathmandu Valley in the map of Nepal

OBJECTIVES

The major objective of the study was to propose and develop a sound and effective monitoring plan for groundwater in Kathmandu Valley.

STUDY AREA

Kathmandu Valley is an oval-shaped intermountain valley basin situated in the Lesser Himalaya of Central Nepal (Fig.1), stretching 30 km. in the east-west and 25 km. in the north-south direction and covering an area of about 600 km^2. Out of 600 km^2, about 400 km^2 is the central valley floor, while the remaining 200 km^2 is the surrounding hills (JICA 1990). The valley floor is gently sloping toward the center and is dissected in a radial pattern by river networks giving rise to number of terraces.

AQUIFER SYSTEM

The fluvio-lacustrine deposits on the valley floor constitute the major screen system. The groundwater system consists of shallow unconfined aquifer (0-40 m) distributed on surface in most parts of the valley. It is thicker in the northern part of the valley while it is absent in some central parts. Thick basal gravel deposits, at the depth of about 200 m from the surface, form the deep confined aquifer and the principal aquifer system in the central and southern parts of the valley. The basal gravel deposits appear to be inhomogeneous and highly stratified as evident from number of screens in the wells drilled to the depth of about 200 m. In the absence of lithologs, whether the screen taps different aquifer systems (different aquifer material of variable hydrogeologic parameters and quality) or merely simple stratified units is not known. Thick (about 200 m) black clay bed (Kalimati clay) separates the deep confined aquifer of basal gravel deposits, from the shallow system. The black clay bed thins out in the north and totally absent in some places. In addition wells in the valley periphery have screens

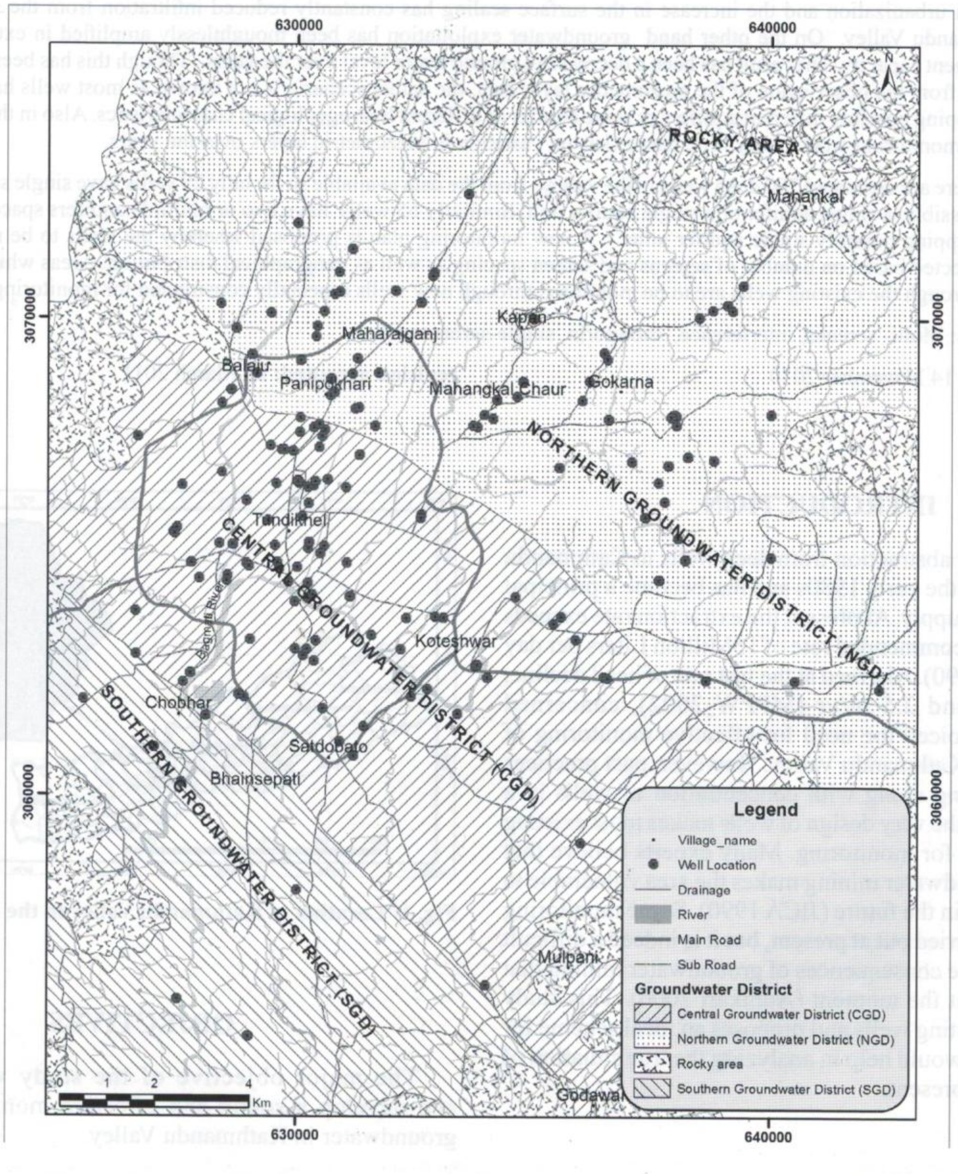

Fig. 2: Ground water district and the distribution of deep wells in Kathmandu Valley

placed on basement rocks in addition to the valley floor sediments. Based on the nature of sediments, the shallow aquifers in the northern, northeastern, and deeper aquifers (> 90 m) of the central and southern districts fall can be regarded as good aquifer zones (DMG/BGR/DOI 1998).

Based on aquifer parameters and water quality, JICA in 1990, divided Kathmandu Valley into three divisions called Northern Groundwater District (NGD), Central Groundwater District (CGD) and Southern Groundwater District (SGD) as shown in Fig.2.

CURRENT STATUS

Approximately 700 deep wells (> 50 m but mostly > 200 m) and an unknown number of shallow wells extract over 60 MLD of groundwater (GWRDB 2010), which is approximately four times the estimated recharge of 15 MLD (JICA_1990).

Most deep wells have multiple screens and are clustered together especially in the central groundwater district, which probably has an interfering effect among the wells.

Table 1: List of monitoring wells with single screen

S.N.	No.	Location	Client	Depth (m)	Screen	Screen Section (m)	Screen Section (AMSL)	Water Level (m)	Water Level (m)	Rate (l/s)	(m)	(µS/cm)
				Northern Groundwater District (NGD)								
				Eastern								
1	YG	Kapan	Yani Gumba	126		48-120	1372-1300					
2	KV203	Kapan, Ktm	Shyalpa Mon	60	6"	12~60		30.85	39.15	0.33		485
3	KP	Kapan(Moni	MWSP	104		81-101	1239-1219					
4		gokarna	Hotel l.m.suv	100	200mm	55-91	1158.7-1221.7					
5	DK4b	Dhobikhola, (	NWSC	163	250mm	113~159	1218.5-1172.5	5.8	12.05	44.55	6.25	
6	DK7	Mahankalcha	NWSC	55	300mm	35~46	1299.8-1288.8	30.09	30.42	9.73	0.33	
7	dk5	Mahankalcha	NWSC office (	65	300mm	43-59	1292.1-1276.1					
8	OM	Chabahil	Om Hospital	204		156-198	1161-1119					
9	KV180	Gaushala, Kt	Pashupati	225	6"	189~225		35.8	48.8	8		632
10	B19	Gaushala near Pashupatin		115		84-104	1231-1211					
				Central								
11	KV183	Naxal, Ktm	Police Head (	250	100mm	195-244	1110-1061	24		7	17	
12		Lainchour, Kt	Dairy Develo	260	100mm	200-242	1106-1064	19.25				
				Western								
13		Balaju, Ktm	Baisdhara Uc	118		68-116	1250.2-1202.2			25	25	
14		Balaju bypas	Kathmandu K	140		90-137	1207-1160	0.55	31.13	20.33		300
				Central Groundwater District (NGD)								
				Eastern								
15		Katunje, Bha	Water Supply	148	6"	111~147	1224-1188	0	18.56	13.33		313
16		Manbhawan,	British Gurkh	242	4"	170~236		59.65	91.95	1.82		
17		Sunakothi	civil Homes	233		173-188						
18		Katunje, Bha	Water Supply	148	6"	111~147	1224-1188	0	18.56	13.33		313
				Central								
19		thamel	Hotel Center	230	100mm	202-230	1100-1072					
20	KV133	Baneswar, Kt	Mr. Nunkarar	77	6"	20~50		12	13.7	10		267
21	p29	kupondoll	Hotel Himala	218	150mm	175~218	1120.2-1077.2	5.1				980
22	km1	Kalimati, Soa	NWSC	260	250mm	233-253						
23		Nursing campus ,Lalitpur		74.65		49.30-73.69						
				Western								
24	KV211	Swoyambhu,	Taini Interna	89	6"	50~86	1305.4-1269.4	12.9	35.75	2.32		196.1
25	KV123	Tahachal, Ktr	Mahalaxmi G	300	4"	210~294	1088.3-1004.3	6	33.81	2.75		822
26		Tahachal, Ktr	hotel grand	260	100mm	209-254	1078.7-1033.7					
27		swoyambhu	hotel madari	89	150mm	50-86	1305.4-1269.4					
28	KV67	Sitapaila, Ktr	Hem Trading	225	4"	214~244		9	14.7	11.12		

Table 2: List of monitoring wells with multiple screen

S.N	Well No.	Location	Client	Drilling Depth (m)	Diameter of Screen	Screen Section (m)							
Northern Groundwater District (NGD)													
Eastern													
1		Guheshwori	BASP	212		46-64	70-118						
2		Manahara		274		54-70	79-120	126-154					
3	pr17	Batisputali, K	Hotel Dwarik	268		202-214	219-231	234-241	244-256	259-265			
4	MH5	Mulpani-4, Kt	NWSC	202	300mm	53-75	75-114	114-125	129-141	146-164	174-196		
5	GK2a	Nayapati-6, K	NWSC	149	300mm	32-37	41-52	58-64	66-72	76-93	93-138		
6	GK2b	Nayapati-6, K	NWSC	199	250mm	51-54	57-65	69-87	96-105	110-134	137-140	154-176	186-192
7	DK1	Mahankalcha	NWSC office c	72	300mm	37~42	48~64						
8	DK-4	Ramhiti, Naya	NWSC	165		105-128	128-160						
9	KV106	Pepsicola, Kt	KUKL (Sagarm	300	6"	227~245	254~278	284~296					
10		Bouddha, Ktm	Taragoan Reg	264		194.25-199	205.25-224	227.25-244	253-263				
11	2	Gokarna		150		31.50-37	41.50-51.50	58.20-63.70	65.60-70.50	76-91.40	92.50-138.30		
12	W5	Gokarna		164.67	300mm	36~41.5	46~69	79.5~85	89~100				
13	KV107	Gokarna Golf	L. M. Suvir bro	101	8"	58~60	65~73	75~83	88~91	94~98			
Central													
14	BB9	Chapaligaon,	NWSC	146	250mm	Jun-93	102-123	132-142					
15		Bansbari, Ktm	JICA (JW-3)	284.3	4"	234-246	252-258	268-280					
16		Lazimpat, Ktm	hotel cross co	260	100mm	209-234	235-240	242-254					
17	KV52	Panipokhari,	Embassy Japa	200	4"	125~143	149~155	164~176					
18	KV31	Baluwatar, K	Chinese Emb	275	150mm	194-206	212-221	231-234	244-247	253-259	265-272		
19	KV86	Lainchaur, Kt	Indian Pensio	55	4"	209~227	233~257						
20	KV79	Lazimpat, Ktm	Hotel Radisso	270	6"	204~215	219~231	240~249	252~258	261~264			
21		Maharajgunj, Ktm		294		181-187	211-217	223-235	241-259	271-277			
22	po7	Maharajgunj	Hotel Kathma	250	6"	160~172	178~196						
23	KV196	Gorkha Army	Sainik Chatra	300		209-227	233-257						
24		Naxal, Ktm	Chitwan Co-e	232	4"	197~209	212~218	223~229					
Western													
25	P2	Balaju Indust	BID2	276	200mm	7.8~13.8	17~32.5						
26		Balaju		230		185-191	200-212	215-227					
Central Groundwater District (NGD)													
Eastern													
27	JW4	Jadibuti, Bkt	NWSC	230	100mm	200-212	215-227						
28	JW4	Jadibuti, Bkt	NWSC	260	250mm	202-230	233-253						
29	KV90	Koteswor, Kt	JICA (JW-4)	225	4"	200~212	215~227						
30		New Road, Kt	Bishal Bazar (	306	150mm	213.94-220	228.94-235	241.94-248	252.87-265	273.88-286	287.73-299.87		
31	BH4	Bhaktapur		170		54-70	79-120	126-154					
32	W4	Bhaktapur		164.67	300mm	36~41.5	46~69	79.5~85	89~100				
33	BH-LK1	Lokanthali, B	NWSC	251	200mm	172-178	188-194	200-212	215-245				
34	P25	Sinamangal,	Pepsicola	255	6"	192~210	215~243	249~252					
35	BH4	Bhaktapur		170		54-70	79-120	126-154					
36	W4	Bhaktapur		164.67	300mm	36~41.5	46~69	79.5~85	89~100				
Central													
37	KV36	Teku(DMG)	DMG Gas We	451	100mm	209-234	235-240	242-254					
38	DMG 05	Hyumat tole,	DMG Gas We	451		298-338	345-354	364-424	430-450				
39	DMG 03	Teku, Ktm	DMG Gas We	302		171-174	180-189	191-216	220-227	234-253	258-297		
40	DMG 01	Tripureswor,	DMG Gas We	260		209-227	233-257						
41	KV72	Kalimati, Ktm	HMTTC, Ravib	282.28	100mm	218-243	252-276						
42	KV102	Kanyamandir	KUKL	300	10"	232~238	242~251	257~266	272~278	281~287			
43		Hariharbhaw	Improvemen	250	4"	151-178	181-193	199-238					
44		Darbarmarg,	Hotel Aquam	245	100	186~192	197~209	212~215	224~230	236~239			
45	KV47	Pulchowk, La	DPTC (DWIP)	250	100mm	118~124	130~136	142~166	172~178	184~190	196~208	214-244	
46	H30	Laldurbar, Kt	Hotel Royal S	262	100mm	198-208	217-223	231-239	245-253				
47	KV127	Thapathali, K	Maternity Ho	300	4"	207~225	234~240	246~252	260~266	270~276			
48	KV132	Baneswar, Kt	Mr. Nunkaran	140	6"	35~53	59~65						
49	KV135	Putalisadak,	My Shop	265	150mm	203-228	234-259						
50	KV137	Naradevi, Ktm	Nardevi hosp	258	4"	213~219	225~255						
51	KV146	Pulchowk, La	Nepal Engine	250	150mm	186-198	208-244						
52	H30	Laldurbar, Kt	hotel Shanka	293	6"	203~215	221~236	245~251					
53	P14b	Darbarmarg,	Hotel Yak and	293	100mm	190-208	214-220	226-229	238-250	253-265	277-280		
54	KV50	Battisputali,	Dwarika Hote	270	150mm	202-211	219-231	234-240	243-255	258-265			
55	KV168	Kalimati, Soa	NWSC	250	200mm	172-178	188-194	200-212	215-245				
56	KV181	Lagankhel, La	Patan Hospit	250	100mm	178~214	220~244						
57	KV192	Thapathali, K	Royal Drug	280	4"	196~202	208~214	220~226	231~246	249~255	265~268		
58	KV197	Pulchowk, La	Sajha Bus	250	4"	151~178	181~193	199~238					
59	KV90	Jawalakhel, L	Jawalakhel D	270	8"	134~188	194~200						
60	KV224	Ravibhawan,	U.S. AID Miss	300	4"	223~241	250~259	265~298					
Western													
61		Sitapaila	Hem Electron	150	4"	54-72	84-120	126-144					
Southern Groundwater District (NGD)													
Eastern													
62	KV202	Harisiddhi, L	Shrestha Con	70	6"	40~46	56~62						
Central													
63	KV87	Chobhar, Ktm	Indian Schoo	130	4"	62~80	88~106	112~130					
64	KV103	Tyanglaphat,	KUKL	110	6"	27~33	33~69						
65	PH2	Bungmati-9,	NWSC	90	250mm	37-55	65-84						
66	JW3	Sundarighat,	NWSC	284	100mm	234-246	252-258	268-280					

The cumulative effect probably results in the more than natural lowering of potentiometric levels, thereby decreasing discharge in all the wells.

Similarly, tapping of multiple aquifers and aquifer units not only mixes water of various qualities, but also increases the probability of contamination from the surface as some wells tap both shallow and deep aquifers. Due to multiple screens tapped, the groundwater potential and quality of individual aquifers system and aquifer units are not known. Data collected on the wells shows that maximum number of aquifer units tapped is nine in wells MH3a at Mulpani and well GK1 at Nayapati. both of which are Nepal Water Supply Corporation NWSC wells.

As few monitoring works are being carried out, the overall effect of such massive groundwater abstraction on the groundwater system and water quality is unknown.

Due to coarser grained deposits and the absence of fine grained clay deposits, the northern part of the valley holds good groundwater potential as indicated by the discharge of wells, especially in the north-eastern part around Gokarna, Mahankalchaur, and Kapan. Here well discharges range from of 10 - 20 L/sec from aquifers in the depth range 35 - 100 m below ground level (mbgl) (ADB 1999).

The central part of the northern area around the Dhobi Khola area has relatively high yield from aquifers at the depths of 50 – 100 m at Bode (43 L/s)and 100 - 150 m at Dhobikhola (44 L/s) (ADB 1999).The western part, however, around Mahrajgunj and Panipokhari, has a lower yield of 4-7 L/s from aquifers at the depth of 100-200 mbgl. Similarly, wells in Gongabu and Balaju have yields of 5 L/s and 20-25 L/s, respectively, from aquifers at depths of 60-150 m (ADB 1999). In comparison though there are more number of deep wells in the central groundwater district, the discharge is not as high as in the northern groundwater district.

DISCUSSIONS ON PROPOSED MONITORING MECHANISM

The groundwater system in Kathmandu Valley is complex with two distinct groundwater systems recognized especially in the center and the southern parts of the valley, consisting of a shallow unconfined groundwater system and a deep confined groundwater system. The water table in the shallow unconfined groundwater system has seasonal water table fluctuations and is recharged from the surface. The deep groundwater system is rather complex with multiple aquifer units with widely ranging aquifer parameters and water quality. With regard to the diverse nature of aquifer parameters, the deep groundwater system in Kathmandu Valley is divided into three groundwater districts (JICA 1990).

Hence monitoring different groundwater districts, regions, aquifer systems and wherever possible each aquifer units, is essential for clear understanding the system. In the absence of information on the lateral extent and distribution of individual aquifer units, only wells with single aquifer units or closely spaced multiple units (max. separation 10m between individual aquifer units) are considered for monitoring. From the data collected on wells, only twenty nine wells have single screens tapping single aquifer units (Table 1). Out of the twenty nine deep wells, at least twenty two wells can be used for monitoring purpose as some wells are close to each other. The proposed wells are well distributed in the northern and central groundwater districts, however in the southern groundwater districts, only one well in the central part is available for monitoring.

Similarly seventeen deep wells have two sets of screens closely spaced to each other (less than 10m apart) and forty nine wells have multiple wells but closely spaced to each other (maximum 10 m apart) as given in Table 2. These wells are of the second priority monitoring wells. Though most of the valley is represented by the proposed wells, many wells are located in the central and eastern part of the valley.

The proposed monitoring wells have been selected based on the

- Wells having single screen set or sets closely spaced to each other (max 10 m gap between two sets of screens).
- Uniform geographical distribution in different groundwater districts, different aquifer systems tapped.

Limitations:

There are however certain limitations when monitoring the wells in Tables 1 and 2 which are as listed below:

- In the absence of well detail lithologs, the nature of aquifer is not known. Similarly as the lateral extent of the aquifers is not known, it is difficult to correlate the aquifers tapped with each other.
- In the absence of the data base, the knowledge of well distribution, the aquifers tapped and the pumping hours, it is difficult to say whether the data obtained is free from interference, or the water level data really represents the static water level data in the area.

The selection of the existing wells for monitoring shows some areas with no monitoring wells. Where existing wells are not available or are not suitable for monitoring purposes, new monitoring wells would be required.

Data base on the deep wells show few wells having a long single set of screens. Deep well KV 213 at Boudha shows screens placed from 180 to 294 (meter below ground level) mbgl. Another well P32 at Dhobigaht, Lalitpur shows screens placed at 132 mbgl to 205 mbgl. Similarly two deep wells in Pharping in the south western part of the valley show screens being placed at the depths of 71-173 mbgl and 74-157 mbgl. These could be single set of screens tapping multiple aquifer units.

CONCLUSIONS

For effective monitoring of groundwater in the Kathmandu Valley, wells with single screens are the most appropriate as they tap a single aquifer horizon. 29 deep wells, listed in Table 1, have single set off screens. These wells can be monitored provided they are accessible and have the necessary facilities (for monitoring purpose). Wells having multiple screens closely spaced to each other are on the second priority list. Sixty six deep wells having two or multiple screens closely spaced to each other are suitable for monitoring purpose under the second priority (Table 2). Total number required can be selected from the above depending on the locality, access and facilities available. Areas not covered by the existing wells are to be monitored by installation of new monitoring wells.

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REFERENCES

JICA, 1990, *Groundwater Management Project in the Kathmandu Valley*. Final Report, 6 -162 (Unpublished).

D.M.G/B.G.R./D.O.I, 1998. *Hydrogeological Conditions and Potential Barrier Sediments in the Kathmandu Valley*. Technical Co-operation Project-Environmental Geology. Final report pp. 17-59, Appendix 3.

MPPW, 2002, *Optimizing Water Use in Kathmandu Valley Project*. Inception Report, ADB TA 3700- NEP, 11 p.

ADB,1999, *Urban water supply reforms in KTM valley (interim report)*. Metcalf and Eddy in association with CEMAT consultant, pp. 10-23.

Adhikari,2006: *Deep Aquifer Recharge Study Through Water level monitoring in The Kathmandu Valley*. Master Dissertation, Unpublished

GWRDB, 2010, *Developing Effective Groundwater Monitoring for Kathmandu Valley*.Unpublished.