ANNEXURES

Annexure 1: Seismic Hazard Study

General

The proposed Project site is located on the foothill of Himalayan range. It lies close to the Riasi thrust which is a branch of Main Boundary Thrust (MBT). Numerous large earthquakes with magnitude greater than VIII are believed to be associated with MBT in Himalayan range East of the Project site. As the Project site is located in active seismic region, evaluation of realistic seismic design parameters is therefore necessary to design the Project structures so that these can withstand the expected ground motions due to earthquakes.

Methodology

The methodology adopted for the seismic hazard evaluation of Gulpur Hydropower Project is as follows:

- Collection and review of the regional geology and tectonic setting in an area of 150 km radius from the site. For this, the data available with WAPDA, Geological Survey of Pakistan, Oil and Gas Development Corporation and various universities were collected and analyzed.
- Study of all available historical and instrumental earthquake data including data from regional network as well as Mangla local network and development of comprehensive earthquake catalogue.
- Study of existing faults of the area through satellite images and available geologic literature and maps.
- On the basis of synthesis of tectonic and siesmological data obtained from the above mentioned studies, development of a siesmotectonic map and evaluation of the active faults for their capability to generate earthquakes.
- Carry on seismic hazard analysis by using probabilistic and deterministic approaches. EZ-FRISK software was used for the probabilistic hazard analysis. For the deterministic analysis, several faults and attenuation relationship were used to calculate the maximum horizontal ground acceleration.
- Evaluation of OBE and MCE accelerations and selection of appropriate seismic design parameters for the design of the Project structures.

Tectonic Setting

Regional Tectonic Setting

The geodynamic of Pakistan is characterized by the collision and coalescence of Eurasian and Indian Continental Plates (**Figure 1**), which were once separated by oceanic domains. This process started in the late Eocene to early Oligocene with formation of the Himalayan ranges[18]. It is however, also

[18] Farah, A., De Jong, K.A; Geodynamics of Pakistan: An introduction; Geodynamics of Pakistan, Geological Survey of Pakistan (1979).

understood that the recent collision of Indo-Pakistan subcontinent has succeeded a similar collision immediately north of Pakistan[19] or throughout southern Asia[20] that took place in Paleozoic era.

The Himalayas are believed to form a sharp frontal thrust belt as the southern edge of a wide collision zone extending north to include Hindukush, Pamir, Tien Shan, Tibetan Plateau, and other collisional features of Central Asia.

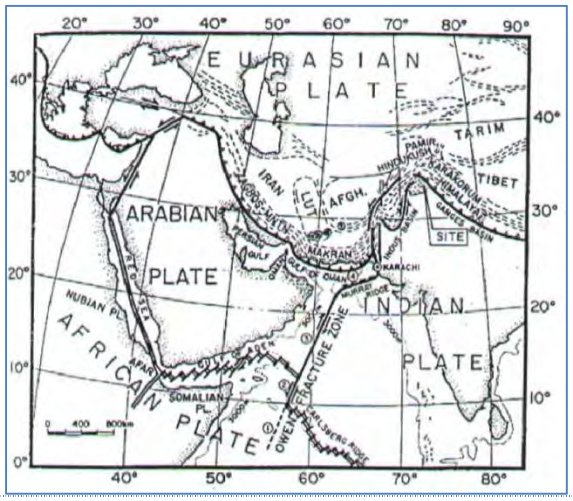

Figure 1: Regional Plate Tectonic Setting

Relative to Eurasia, the Indian Plate is still moving northwards at a rate of about 3.7 cm/yr near 73 degree longitude east[21]. Indus suture line that coincides with upper Tsengpo river valley represents the original site of the continental collision along which linear and well-developed ophiolite suites are found. These ophiolites are interpreted as the remnants of the oceanic crust of the Tethys ocean trapped during the collision between Indian and Eurasian continental blocks. The major portion of this convergence was taken up by deformation along the northern collision boundary involving folding and thrusting of the upper crustal layers[22] in the shape of MKT (Main Karakorum Thrust), MMT (Main Mantle Thrust), MBT (Main Boundary Thrust) and SRT (Salt Range Thrust), as shown in **Figure 2.**

[19] Kravchenko, K.N.; Tectonic evolution of the Tien Shan, Pamia and Karakorum; Geodynamics of Pakistan, Geological Survey of Pakistan (1979)
[20] Talent, J.A.; Mawson, R.; Paleozoic – Mesozoic biostratigraphy of Pakistan in relation to biogeography and the coalescence of Asia; Geodynamics of Pakistan, Geological Survey of Pakistan (1979)
[21] Minster, J.B., et el..; Numerical modeling of instantaneous plate tectonics, Royal Astron. Soc. Geophys. Jour. Vol.36 (1974).
[22] Seeber, L., Jacob K.H.; Micro earthquake survey of northern Pakistan, Preliminary results and tectonic implications; Proc. Symp. on Himalayan Geology, CNRS, Paris (1976).

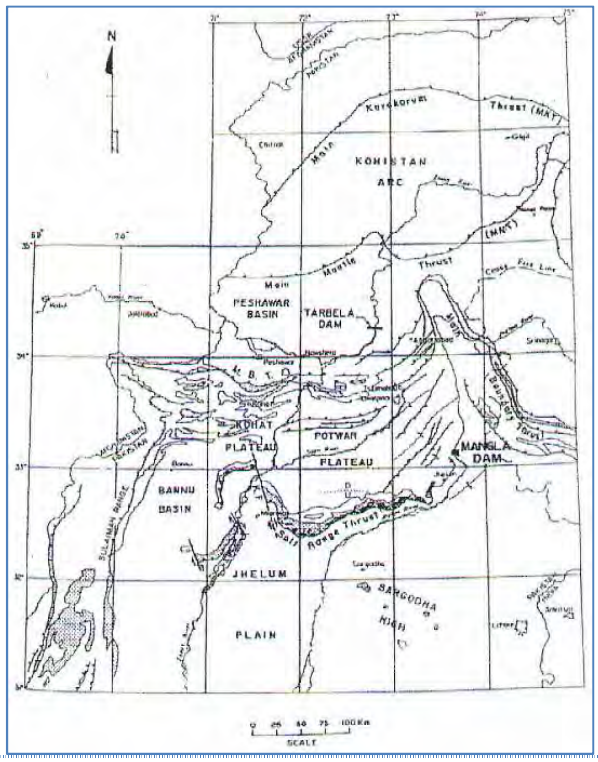

Figure 2: Generalized Tectonic Map Northern Pakistan

The MKT separates rocks of Asian landmass from Kohistan island arc complex. The Kohistan island arc is separated from the Indian plate by MMT. The MBT separates pre-collisional Paleozoic and Mesozoic sedimentary rocks of the Indian plate from the younger post-collisional Himalayan molasse sediments. A single detachment surface is believed to exist beneath the entire rocks south of MMT. This surface extends southwards till it emerges out in the shape of Salt Range Thrust[23].

Local Tectonic Setting

Project site is located close to Riasi thrust, which runs more than 200 km along the Himalayan range and is considered as a main branch of the MBT. Towards East it joins MBT and towards West it merges again into MBT at the axis of Hazara-Kashmir Syntaxial Bend, which is quite sharp near Muzaffarabad towards North and becomes less sharp towards South. On the East of the Hazara-Kashmir Syntaxial Axis, the geological features show predominantly northwest trend while their trend change to northeast towards the West of the axis. The main tectonic features West of Syntaxial Axis are Salt Range Thrust, Dil Jabba Thrust, Kahuta Fault and Riwat Fault (Fig-4.8). The Syntaxial Axis itself is believed to run along a north-south running strike-slip fault called Jhelum Fault. As many active tectonic features are present close to the Project site, therefore it is located within highly active geotectonic environment.

[23] Seeber L. et al; Seismicity and continental subduction in the Himalayan arc, in Zagros – Hindukush Himalayas; Geodynamics Evolution, A.G.U. Geodynamics Services, Vol.3 (1981).

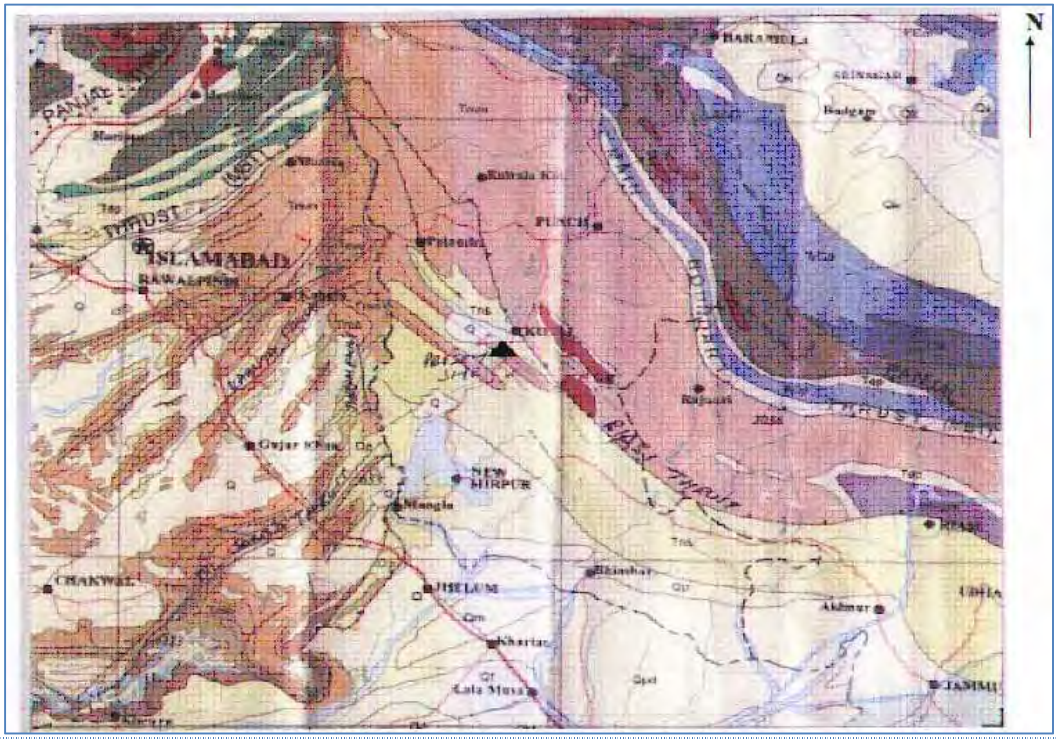

Figure 3: Regional Geological Map

Quittmeyer et al.[24] have classified whole of the area of Pakistan into fifteen seismotectonic provinces (**Figure 4**). Gulpur Hydropower project is located near the following four distinct provinces being discussed below:

a. Himalayas Province
b. Hazara Region Province
c. Salt Range Province and
d. Indus Basin Province

a) Himalayas Province

The Himalayas represent one of the primary compressional features that have resulted from the collision of the Indo-Pakistan Continental Plate with Eurasian Plate. This zone of deformation is the result of folding and thrusting associated with the development of large nappe structures and deep crustal shortening[25]. The Himalayas trends in a southeasterly direction just east of the Hazara-Kashmir syntaxis (Fig-4.7) where the project site is located.

Seismicity within this seismotectonic province is characterized as moderate to high level. Most events are associated with the frontal zone of deformation. They are located parallel to and northeast of the surface trace of the Main Frontal Thrust. One great earthquake, the 1905 Kangra event with Ms=8.0 occurred within this zone, probably rupturing a 300 km portion along the Main

[24] Quittmeyer, R.C., et al; Seismicity of Pakistan and its relation to surface faults; Geodynamics of Pakistan (1979).
[25] Ganser, A.; Geology of the Himalayas: New York, Inter Science Publications (1964).

Frontal Thrust[26]. Riasi thrust is a branch of MBT and runs almost parallel to MBT upto the syntaxial bend.

In the vicinity of the Hazara-Kashmir syntaxis, the mapped surface trace of the frontal thrust bends around from a southeast trend to a southwest orientation. The seismically defined fault zone, however, does not follow the mapped surface faults; it continues for an additional 100 km to the northwest of the Hazara-Kashmir syntaxis[27].

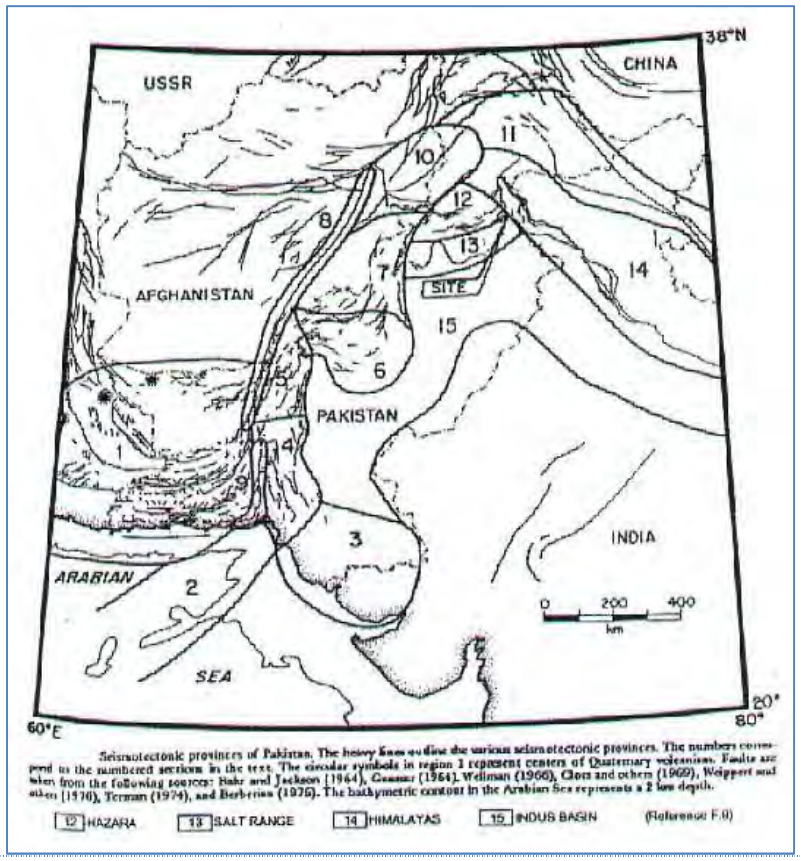

Figure 4: Seismotectonic Provinces of P[Pakistan

b) Hazara Region Province

The Hazara seismotectonic province encompasses mostly eastward trending folds and faults of the Hazara region in Northern Pakistan. The deformation within this zone is primarily the result of thrusting and a deep crustal decollement process associated with the collision between the Indian and Eurasian plates[28].

[26] Quittmeyer, R.C., et al; Seismicity of Pakistan and its relation to surface faults; Geodynamics of Pakistan (1979).
[27] Armbruster, J., et al.; Tectonics of the lower Himalayas in north Pakistan based on micro earthquake observations, Jour. Geophys. Res., Vol.83 (1978).
[28] Ganser, A.; Geology of the Himalayas: New York, Inter Science Publications (1964).

Seismic activity within this province has occurred at a low level[29]. Historical data however do indicate moderate events causing significant damage in this region.

Shallow seismicity within the Hazara region occurs on perpendicular, steeply dipping faults characterized by reverse and strike-slip faulting. The microseismicity data suggest that the Hazara Thrust Fault may be related to a decollement surface identified at depth[30]. However, as the mapped faults are dominantly of thrust nature, a narrow alignment of epicenters along these faults is not to be expected. Furthermore, some activity is also associated with faults that are located below the decollement surface, which do not have any surface expression. The broad band of activity following the dominant structural trend, however, suggests that at least some of these earthquakes may be related to the major mapped structures[31].

c) Salt Range Province

The Salt Range is situated south of the Hazara seismotectonic province and extends from the Sulaiman Range on the West to the Himalayas in the East (Fig-4.9). General orientation of this range is east northeast, but prominent southeast trending transverse features offset parts of it (Fig-4.7). It is composed of folded and faulted thrust sheets and represents thin-skinned internal deformation within the Indian Plate resulting from its collision with Eurasia.

Although it is the frontal zone of deformation in this region, the Salt Range is characterized by a low level seismic activity, in contrast to other parts of the frontal zone in Pakistan. It has limited known history of moderate or large magnitude earthquake. Micro-earthquake studies, however, indicate that at low magnitude levels (m<4), the entire Salt Range is active, especially along transverse faults at points where it is offset. Cambrian salt deposits may provide an explanation for this aseismic character of the Salt range. Deformation may result from aseismic slip along a decollement surface mechanically detached by the salt[32]. The micro seismic activity may represent small readjustments within the decollement sheets.

d) Indus Basin Province

The Indus Basin is located within the Indo-Pakistan Plate South and Southwest of the Himalayas and Salt Range, and East of the predominantly northward trending mountain ranges of Pakistan (Fig-4.8). This feature is a foredeep basin. The seismicity occurring within this zone is generally of low level. Although infrequent, some events have caused considerable damage. Southwest of the Himalayas, the events occur along a discontinuous, but nevertheless, linear trend about 200 km from the Main Frontal Thrust[33]. This same trend parallels the Salt Range, but not at as great a distance. This activity

[29] Seeber, L., Jacob K.H.; Micro earthquake survey of northern Pakistan, Preliminary results and tectonic implications; Proc. Symp. on Himalayan Geology, CNRS, Paris (1976).
[30] Seeber L. et al; Seismicity and continental subduction in the Himalayan arc, in Zagros – Hindukush Himalayas; Geodynamics Evolution, A.G.U. Geodynamics Services, Vol.3 (1981).
[31] Quittmeyer, R.C., et al; Seismicity of Pakistan and its relation to surface faults; Geodynamics of Pakistan (1979).
[32] Seeber, L., et al; Seismicity of the Hazara arc in northern Pakistan; Decollement vs. basement faulting; Geodynamics of Pakistan (1979).
[33] Menke, W., and Jacob, K.H.; Seismicity Patterns in Pakistan and north western India associated with continental Collision: Seismol. Soc. America Bull; Vol.66 (1976).

within the Indus Basin may be related to bending of the lithosphere[34], active basement faults transverse to the fold and thrust belts[35], and/or development of a new frontal thrust[36]. A focal mechanism for one event near New Delhi showed normal faulting on one of two nodal planes parallel to the Himalayas[37].

Surface faults have not been mapped in the Indus Basin; the extensive alluvial cover has buried any structural evidence of faulting on the surface. Inferences based on gravity data, however, indicate basement faults may exist in some portions of the Indus Basin[38].

Seismicity

General

Earthquakes pose a multitude of hazard to dams, either by direct loading of the structures or by initiating a sequence of events that may lead to dam failure. For example, strong ground shaking or fault offset at the dam foundation is a direct load on the structure while an upstream failure, seiche or landslide into the reservoir are earthquake generated events that can lead to overtopping and failure. Effects of ground shaking by earthquakes are also documented in terms of loss of free board due to differential tectonic ground movements, slope failure, piping failure through cracks induced by ground shaking, failure of spillway and outlet works[39].

Earthquakes are generated by tectonic process in the upper part of the earth called lithosphere that is divided into several rigid parts called as “Plates”. Due to movements along these plates, stress build up takes place and results in the deformation of the crystal mass. This energy accumulation gives birth to seismic events. The contact zones between adjacent plates are, therefore, considered as most vulnerable parts from the seismic hazard point of view.

The project site is located near one of these contacts between Indian plate and Eurasian plate. This contact represented by the Himalayas has always been generating moderate to large earthquakes including Kangra (1905), Bihar-Nepal (1934) and Assam (1897) earthquakes that caused widespread destruction and huge loss of life.

[34] Molnar, P., et al; Fault plane solutions of shallow earthquakes and contemporary tectonics in Asia, Earth and Planetary Science Letters, Vol.19 (1973).
[35] Valdiya, K.S.; Himalayan Transverse faults and folds and their parallelism with subsurface structures of north Indian plains, Tectonophysics, Vol.32 (1976).
[36] Le Fort, P., Himalayas: The collided range. Present knowledge of the continental Arc: A.M. Jour Sci., Vol.275-A (1975).
[37] Molnar, P., et al; Fault plane solutions of shallow earthquakes and contemporary tectonics in Asia, Earth and Planetary Science Letters, Vol.19 (1973).
[38] Farah, A., et .el; Gravity field of the buried shield in the Punjab plain, Pakistan: Geol. Soc. America Bull., Vol.88 (1977).
[39] Seed, H.B. “Earthquake resistant design of earth dams:, International Conference on Recent Advances in Geotechnical Earthquake, Engineering and Soil Dynamics, Missouri, (1981).

Historical Seismicity

The earthquakes originated before the advent of seismic recording instruments that have been mentioned in the literature and were located within the Project region give mainly information about the level of damage that this region has undergone historically. Though this information does not give a conclusive account of their epicentral location, these do give an understanding about the extent of structural damages and probable life loss in return. This non-instrumental data is solely dependent upon human observation. In order to perform a quantitative analysis of the effects of an earthquake, it is convenient to reduce the raw data to a more manageable form. For this purpose intensity scales have been established which categorize the effects experienced by human being into well defined level ranging from minimum sensations to catastrophic extremes. The historical / pre-instrumental earthquake data was collected from Oldham[40], Heuckroth et al.[41], Ambraseys et al.[42] and Quittmeyer et al.[43] catalogues as the same source of information has been used in the seismotectonic studies of other large projects in Pakistan (Tarbela dam, Mangla dam, etc.).

A brief description of the main historic events in the region under study is given below:

a) 4th Century B.C

The first known historical account of seismicity in this region was described in 4th Century B.C by Aristobulus of Cassanderia. He accompanied Alexander on his expedition to India and pointed out that the country above river Jhelum was subjected to earthquakes which caused the ground to open up so much that even the river bed was changed.

b) Year 25 A.D

Another historical record of a destructive earthquake is available of Taxila event. This event was located in the Hazara area and occurred in 25 A.D. Seismic intensity at Taxila was about X and felt throughout the country. The damage effects are still witnessed in the remains of Jandial, Sirkap and Dharmarajika around Taxila. After the earthquake, building methods had to be changed and height of the buildings was reduced. It was also started to ensure that foundations of the new buildings are more secure.

c) June 23, 1669

An earthquake with as much intensity as IX was felt at the city of Attock.

d) September 24, 1827

A destructive earthquake was felt in Lahore Region. The Fort Kolitaran near the city was destroyed. About 1000 lives were lost. A hill was shaken down which fell into the River Ravi. Its maximum intensity was estimated as VIII-IX.

[40] Oldham, T.; A catalogue of Indian earthquakes, Mem. Geol. Survey India, Vol. 19 (1893)
[41] Heuckroth, L. and Karim, R.: Earthquake history, seismicity and tectonics of the regions of Afghanistan, Seism. Centre, Kabul University (1970).
[42] Ambraseys A. Lensen G., and Monifer A.; The Pattan earthquake of 28 December 1974, UNESCO Publication (1975)
[43] Quittmeyer R.C and Jacob K.H; Historical and modern seismicity of Pakistan, Afghanistan, northwestern India and southeastern Iran ; Bull. Siesm. Soc. Am. Vol. 69, No.3 (1979)

e) May 30, 1885

A destructive earthquake in Kashmir, which inflicted heavy destruction in Sopor, Gulmarg and Srinagar area, 3,000 people were killed. Radius of perceptibility was about 650 km. Many aftershocks were recorded. The maximum intensity in the epicentral region was VIII.

The intensities of the felt earthquakes recorded in this region are shown in **Figure 5**.

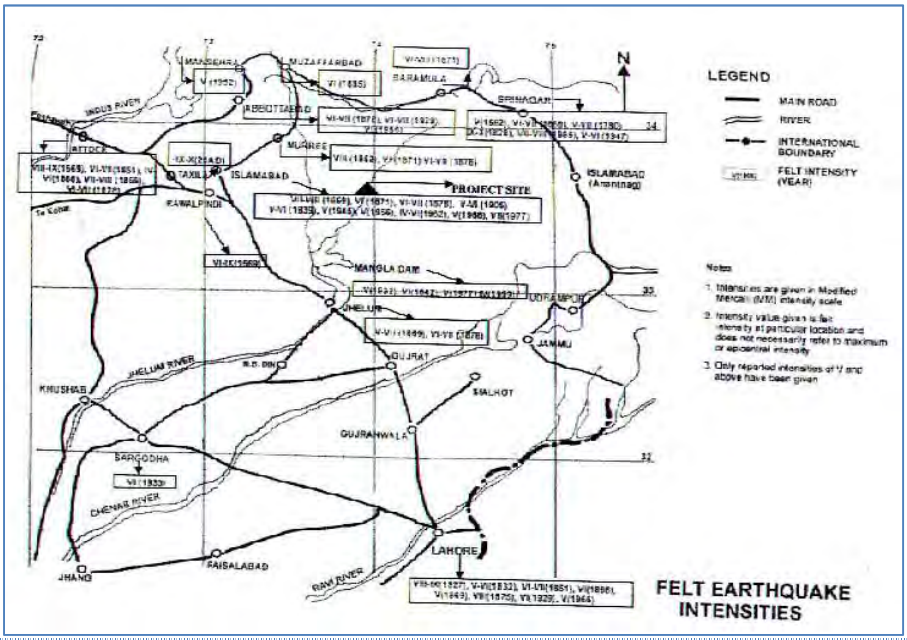

Figure 5: Felt Earthquake Intensities

A chronological list of available intensity data of the earthquakes occurred in the Project region before the present instrumental recordings started in 1904 is given in **Table 1**.

Table 1: Historical Earthquakes in the Project Region

Sr. No.	*Year*	*Date*	*Description*	*Estimated Intensity MM*	*Source*
1	4th Century BC		Aristobulus of Cassandreia, who accompanied Alexander on his expedition to India, points out that the country above the river Hydaspes (Jhelum) is subjected to earthquakes which cause the ground to open up so that even the beds of river are changed.	IX-X	Ambraseys
2	25 AD		A destructive earthquake in north-western Pakistan laid Taxila in ruins and caused wide spread havoc throughout the country side. The effects of this earthquake can still be seen among the excavated remains at Jandial, Sirkap and Dharmarajika. As result of the earthquake new methods of buildings were introduced and the height of buildings was reduced from four to two storeys with special precautions to make the	IX-X	Q&J

Sr. No.	Year	Date	Description	Estimated Intensity MM	Source
			foundation secure.		
3	1669	4-Jun	Strongly felt in Mandra	VI-X	Q&J
4	1669	23-Jun	An earthquake at Attock, a fissure 50 yards long was formed in the ground.	VIII-IX	Q&J
5	1827	24-Sep	Destructive in Lahore region. Fort Kolitaran near city destroyed, about 1000 perished in ruins. A hill shaken down, which fell into river Rowee (Ravi) produced an inundation of 100 coss of land.	VIII-IX	Q&J
6	1831		Peshawar & valley of Indus – Severe, extended from Peshawar to Dera Ghazi Khan, felt most at Dera bank (Darban); men and camels unable to stand, rocks fell in many places, water forced from crevices in the plains.	Daraban VIII-IX Peshawar & D.G. Khan IV-VI	Q&J
7	1832	22-Jan	Near Lahore-violent, people all rushed out of houses.	V-VI	
8	1832	21-Feb	Lahore, valley of Badakhshan, N.W. India huge masses of rock was thrown from the cliffs at many places chocking up valleys. Great part of population destroyed.	Lahore V-VI Mangla V	
9	1842	19-Feb	Kabul, Peshawar. At Kabul said to have lasted for 3 minutes, several shocks, rocked the fouth in a frightful manner. At Peshawar very destructive, "earth-trembled like aspen leaf" several killed. At Ferozpur severe. At Ludhiyana north south, the hot springs of South (temp. 140 deg-110 deg) become as cold as the ordinary wells, water diminished greatly and at times the springs were completely dry. These appearances continued for 25 days.	Kabul	Q&J
				VI-VII Peshawar VI Ferozpur VI	
10	1851	4-Feb	Lahore, appears to have extended all over Punjab.	Lahore V-VI	
11	1851	6-Feb	Lahore, appears to have extended all over Punjab.	Lahore V-VI	
12	1851	17-Feb	Strongly felt in Lahore, Multan	Lahore V-VI	
13	1853	Nov.	Strongly felt in Attock	VI	Q&J
14	1858	29-Aug	Lahore-sharp shocks	Lahore IV-V	
15	1865	22-Jan	Slight damage and great panic in Peshawar, long duration.	V-VII	
16	1865	4-Dec	Lahore – tow smart shocks	III-V	
17	1867	10-Nov	Damaging in Bannu	VII-VIII	Q&J
18	1868	11-Aug	Damaging in Peshawar, a portion of the fort was shaken down (official record).	VII-VIII	Q&J
19	1868	12-Nov	Violent shock felt in Lahore, Dera Ismail Khan and Attock, followed by many aftershocks which were felt throughout the Punjab.	Attock IV-VI & D.I. Khan IV-VI	Q&J
20	1869	24-	Severe shock in the upper reaches of Jhelum	V-VII	Q&J

Sr. No.	Year	Date	Description	Estimated Intensity MM	Source
		Mar			
21	1869	25-Mar	A large earthquake in the Hindukush, strongly felt at Kohat, Lahore, Peshawar and at Khojend and Tashkent; shocking lasting 20 seconds.	Kohat, Lahore & Peshawar V	NESPAK
22	1869	April	Peshawar – Part of fort shaken down (official record).	VII-VIII	Q&J
23	1869	20-Dec	Rawalpindi – Shock said to have lasted for 1/2 a minute; cracked walls and caused all people to run out of houses. Attock – A series of shocks at intervals of about 20 sec. Lawrencepur – Ist shocks 15 sec others at 5 sec. interval. Campbellpur – For half an hour; building much damaged. Talagang – Not felt	VII-VIII	Q&J
24	1871	April	Severe at Rawalpindi and Murree; originating from Kashmir	Rawalpindi & Murree VI	Q&J
25	1875	12-Dec	Damaging in villages between Lahore and Peshawar where a number of people were killed.	VII-VIII	Q&J
26	1878	2-Mar	Damaging earthquake in the Punjab. At Kohat several houses, public buildings and portion of the wall of the fort fell. At Peshawar, it caused damage to houses and city walls. Damaging at Attock, Abbottabad, Rawalpindi, Jhelum, Murree. Strongly felt at Bannu, Nowshera, Mardan, Lahore and Simla. Many aftershocks.	Peshawar & Kohat VII-VIII, Attock VI-VII, Lahore VI	
27	1883	April	Damaging shock at Peshawar.	VI-VIII	Q&J
28	1885	30-May	Destructive shock in Kashmir, Sopor, Gulmarg and Srinagar about totally ruined and 3,000 people killed. Heavy damage at Gurias and Punch: Muzaffarabad heavily damaged. Felt in Peshawar, Lahore, Simla, Leh, Kanpalu, and Gilgit. Radius of perceptibility about 650 km. Many aftershocks.	Kashmir VIII, Muzaffarabad VI-VII, Peshawar IV	Q&J
29	1893	3-Nov	Slight damage at Peshawar, Nowshera, felt throughout the Punjab	VI-VII	Q&J
30	1905	4-Apr	Kangra earthquake, in Rawalpindi few lofty buildings cracked, some damage in Lahore.	Kangra VIII Rawalpindi V-VI	Q&J
31	1929	1-Feb	Destructive earthquake, perhaps shallower than calculated, ruin Skorzor and Drosh. Damage was equally heavy in the USSR at Kulyab. It caused substantial damage in Abbottabad, Peshawar, Cherat, Gurez, Chitral and Dushambe. It was felt within a radius area of 1,000 km.	Abbottabad & Peshawar VI-VII	NESPAK
32	1939	21-Nov	Destructive in the Badakhshan area, the damage extending to Srinagar, Rawalpindi and Kargil. Drosh was seriously damaged. Felt within a radius of 600 km.	Rawalpindi V-VI	NESPAK
33	1945	27-Jun	Felt in Peshawar	IV	NESPAK
34	1945	22-Jun	Destructive at Chamba and parts of Kahsmir. Strongly felt at Rawalpindi, Peshawar, Lahore and Simla.	Rawalpindi V	NESPAK
35	1953	1-Mar	Slight damage in Cambellpur	VI-VII	Q&J
36	1956	16-	Destructive in the Ghazi district in Afghanistan	Rawalpindi V	NESPAK

Sr. No.	Year	Date	Description	Estimated Intensity MM	Source
		Sep	where many villages were destroyed and animals lost. The damage was equally serious at Said Karem. Cause panic at Kohat. Strongly felt at Parachinar, Parwan, Loger, Ghaiz, Nazerajat, Beshud, Makur, Rawalpindi and Rawalpindi Srinagar. Radius of perceptibility about 450 km.		
37	1962	2-Aug	Felt at Rawalpindi	IV-VI	Q&J
38	1966	11-Jan	Felt at Risalpur	IV	NESPAK
39	1966	2-Feb	Strongly felt around Abbottabad where it caused minor damage at Havelian. Felt at Rawalpindi, Islamabad, Abbottabad, Taxila. The shock was felt at Muzaffarabad and Gujar Khan.	Abbottabad VI Islamabad V Taxila VI	Q&J
40	1977	14-Feb	About 7 km northeast of Rawalpindi caused damage in 20 villages. In villages Kuri, Malot and Pindi Begwal around Nilour most of the "Katcha" houses either collapsed or damaged. A few houses built with dressed blocks of sandstone and sand-cement mortar also developed extensive cracks.	VII	NESPAK
41	1978	7-May	Felt widely at Punjab and NWFP Provinces. Some damage at Peshawar and Chitral.	Mangla IV Tarbela VI	WAPDA
42	1980	12-Feb	Felt widely in the areas of Punjab and NWFP.	Mangla IV Tarbela V	WAPDA
43	1983	31-Dec	Felt widely in the areas of Punjab and NWFP. Damages at Peshawar, Chitral and many northern areas. Some damage near Tarbela also. Felt in parts of Afghanistan also.	Chitral VII Peshawar VI Rawalpindi V Tarbela V Mangla III	WAPDA
44	1996	4-Apr	Felt widely in the areas of Punjab and NWFP. Some damages at Peshawar, Chitral and Northern Areas. Some damage near Tarbela also. Felt also in parts of Afghanistan.	Chitral VI Peshawar V Rawalpindi IV Mangla III Lahore & Jhelum III	WAPDA
45	1999	17-Feb	Epicenter near Mangla. Felt also in the adjoining areas.	Mangla IV	WAPDA

Instrumental Seismicity

The instrumental recording of earthquakes started in 1904 but the number of seismic stations remained small in South Asian Region until 1960 when the installation of high quality seismographs under World Wide Standard Seismograph Network (WWSSN) increased the quality of earthquake recording. In addition, local microseismic networks were also established at important dams and other projects in Pakistan. In the present seismic studies, two classes of instrumental earthquake data have been used. The first one is based upon earthquakes recorded by local seismic networks and the other is compiled from regional data catalogues.

Seismicity Recorded by Local Networks

Near the Project site, an independent telemetry microseismic network belonging to Mangla Dam Project is functioning. Initially, it comprised of three stand-alone stations since 1966. However, in 1993, it was replaced with a more modern microseismic network having thirteen field seismic stations out of which seven have been put to operation. The Central Recording Station (CRS) is installed near the left abutment of the main embankment of Mangla dam. The microseismicity recorded by Mangla Dam network is shown in **Figure 6**.

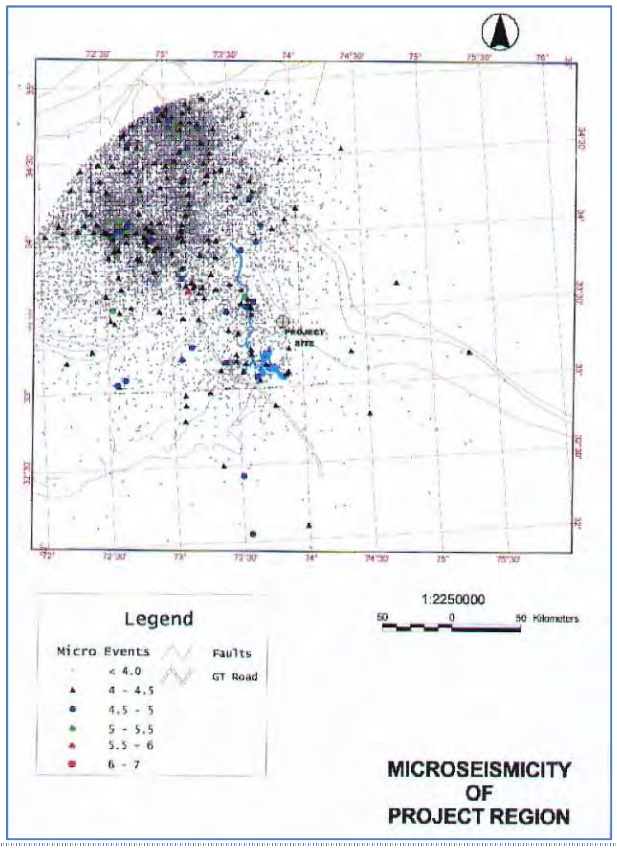

Figure 6: Microseismicity of the Project Region

Seismicity Recorded by Regional Networks

The regional seismic data catalogue being used in the study is compiled on the basis of seismic events listed since 1904 by various agencies like British Association for the Advancement of Science (BAAS), International Seismological Centre (ISC), International seismological summary (ISS), United States Geological Survey (USGS) and others. It consists of a list of 594 earthquakes among which 331 earthquakes have magnitude more than or equal to 4 within a radius of about 200 km from project site.

Composite Earthquake Catalogue

A composite list of earthquakes recorded within about 200 km of the Project site was prepared from the data collected from regional as well as microseismic networks mentioned above. This list contains all the earthquakes recorded in area between latitude 32.0o-35.0oN and longitude 72.0o-76.0oE. This list is presented in **Table 2**. The epicenters of these earthquakes are plotted in **Figure 7**.

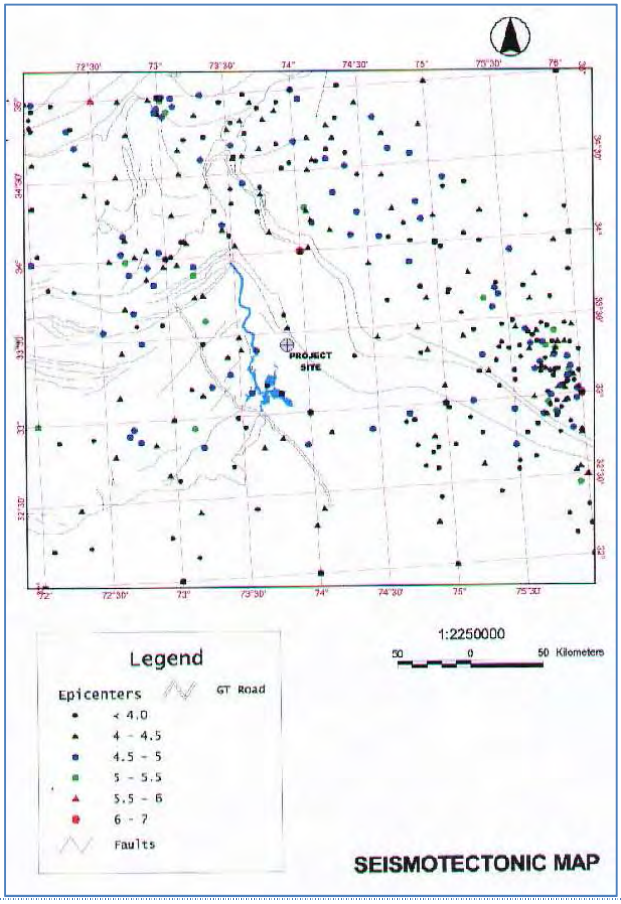

Figure 7: Seismotectonic Map of the Project Region

Table 2: Composite List of Recorded Earthquake Data

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
1	1905	4	4	00:50:00.00	33.0000	76.0000	35	6.8	8.0		PAS
2	1928	11	14	04:33:09.00	35.0000	72.5000	110	5.6	6.0		PAS
3	1937	11	7	19:07:40.00	35.0000	73.0000	100	5.5	5.8		PAS
4	1945	6	22	18:00:57.00	32.5000	76.0000	60	5.9	6.5		PAS
5	1964	2	13	05:10:47.20	34.9900	72.7000	68	4.5			ISC
6	1964	7	3	14:10:27.80	34.1500	74.9100	33	4.9			ISC
7	1964	12	31	08:21:11.00	34.9000	73.0000	131	4.4			ISC
8	1965	10	9	04:34:22.00	32.3000	74.0000	79	4.5			USCGS
9	1965	11	8	21:23:09.40	34.6000	73.3000	65	4.6			USCGS
10	1966	2	2	09:20:09.30	33.8900	73.2000	37	5.1			ISC
11	1966	3	16	00:08:17.30	33.2300	75.9100	33	4.7			ISC
12	1966	4	6	01:51:53.20	34.9100	73.0600	54	5.1			ISC
13	1967	2	10	05:46:29.00	33.2800	75.2900	21	4.8			ISC
14	1967	2	20	14:23:48.70	33.6900	75.4200	38	4.8			ISC
15	1967	2	20	15:18:39.00	33.6300	75.3300	20	5.5			ISC
16	1967	2	20	15:39:54.40	33.4800	74.8300	96	4.0			ISC
17	1967	2	21	12:37:43.00	33.6500	75.4400	20	4.9			ISC
18	1967	2	24	00:17:38.80	33.5700	75.3900	32	4.6			ISC
19	1967	7	2	08:32:39.70	33.2100	75.7100	42	4.8			ISC
20	1968	3	3	09:31:21.60	34.7100	72.3600	43	5.0			ISC
21	1968	7	3	19:46:55.00	34.8000	74.6000	88	4.6			ISC
22	1969	1	23	20:01:21.00	32.1900	76.0000	64	3.9			ISC
23	1970	1	2	20:01:02.00	32.5000	76.0000	96	4.1			ISC

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
24	1970	4	28	14:12:32.00	32.8000	74.9000	116	4.5			ISC
25	1970	4	28	15:11:47.70	32.9000	74.7000	126	3.5			ISC
26	1970	4	30	03:24:54.30	33.2600	73.4300	33	4.8			ISC
27	1970	6	11	10:30:39.90	33.1100	75.0000	72	4.5			ISC
28	1970	9	7	21:19:09.00	33.0000	75.2000	54	4.6			ISC
29	1970	12	5	17:51:54.00	33.9000	74.5000	75	4.3			ISC
30	1971	4	28	15:12:42.62	34.4449	73.5973	43	4.8			ISC
31	1971	12	27	20:59:39.26	34.9776	73.0234	55	5.2			ISC
32	1972	1	8	01:30:35.00	34.7000	74.1000	96	4.0			ISC
33	1972	3	10	14:36:16.95	33.9073	72.7158	40	4.9			ISC
34	1972	4	17	02:24:50.14	33.9487	72.8622	52	4.8			ISC
35	1972	9	27	02:03:39.00	33.9910	72.6996	41	5.1			ISC
36	1973	1	16	21:31:25.86	33.2922	75.8320	39	5.1			ISC
37	1973	4	10	00:10:02.88	33.1703	75.7460	61	4.4			ISC
38	1973	7	13	22:03:38.06	33.1732	75.6747	48	4.8			ISC
39	1973	7	13	22:54:27.85	33.1819	75.7057	55	4.4			ISC
40	1973	10	24	05:23:51.34	33.1479	75.9166	37	5.3			ISC
41	1973	10	24	19:57:17.09	33.1167	75.9269	48	4.9			ISC
42	1973	12	16	19:09:46.94	34.2686	74.0466	40	5.1			ISC
43	1974	3	25	13:44:05.79	33.7003	72.6774	39	4.4			ISC
44	1974	3	26	04:45:54.73	33.8805	72.8457	72	4.1			ISC
45	1974	4	12	10:32:48.23	33.5311	73.8677	50	4.4			ISC
46	1974	5	20	17:39:19.59	34.5632	74.2327	49	4.8			ISC
47	1974	8	1	19:54:11.76	33.4410	74.5294	0	4.5			ISC
48	1974	8	11	17:21:00.02	34.8828	73.2713	33	4.1			ISC
49	1974	12	28	22:38:53.24	34.9946	73.1013	68	4.8			ISC
50	1975	1	20	09:28:00.68	34.9363	73.1054	63	4.6			ISC
51	1975	4	7	06:41:02.95	34.9085	72.9663	53	5.0			ISC
52	1975	10	17	10:46:09.30	34.2535	74.0640	77	4.1			ISC
53	1975	10	30	14:20:54.36	32.8923	75.7092	75	4.7			ISC
54	1975	10	30	14:36:44.40	32.9700	75.9583	45	4.8			ISC
55	1975	12	10	05:03:47.30	32.7871	75.9180	76	4.7			ISC
56	1976	1	9	23:50:16.49	32.7799	75.9813	96	4.5			ISC
57	1976	2	25	07:45:23.79	33.3444	74.8921	51	4.5			ISC
58	1976	5	22	18:32:53.58	33.0491	75.8290	71	4.4			ISC
59	1977	1	21	14:57:46.38	32.7601	75.9826	51	4.5			ISC
60	1977	2	14	00:22:37.80	33.5967	73.2669	27	5.2			ISC
61	1978	4	12	02:10:16.20	33.7184	75.4263	33	3.8			ISC
62	1978	4	27	18:12:24.79	35.0022	73.0280	58	4.9			ISC
63	1978	5	7	10:32:25.57	33.3964	73.6306	25	5.0	4.4		ISC
64	1978	5	16	06:31:57.14	33.1817	75.3309	96	4.1			ISC
65	1978	5	17	08:39:15.29	32.8934	75.7301	96	4.0			ISC
66	1978	11	18	01:35:00.00	32.8740	72.7513	39	4.6			ISC
67	1979	3	4	02:51:47.95	33.9436	73.1959	42	4.7			ISC
68	1979	7	2	16:27:04.29	34.7364	74.9361	74	4.4			ISC
69	1979	7	2	16:30:47.22	34.5062	74.3684	89	4.6			ISC
70	1979	12	4	04:05:42.07	34.1725	74.0963	33	4.7			ISC
71	1979	12	22	22:28:44.99	33.1078	75.8963	18	4.8	4.1		ISC
72	1980	2	5	20:17:56.85	33.2496	75.8083	33	4.2			ISC
73	1980	2	9	18:23:01.17	32.7900	72.5576	27	4.1			ISC
74	1980	3	29	02:02:53.68	32.7961	73.9736	18	4.7			ISC
75	1980	3	29	07:12:56.39	33.1427	73.2231	30	4.5			ISC
76	1980	5	1	05:43:10.65	33.0264	75.9745	18	4.9	3.8		ISC
77	1980	7	27	11:24:00.24	34.6240	72.0444	53	4.0			ISC
78	1980	8	23	21:36:49.04	32.9637	75.7509	3	5.2	4.9		ISC
79	1980	8	23	21:50:01.20	32.9023	75.7974	13	5.2	4.9		ISC
80	1980	10	5	10:47:18.67	34.6882	74.2892	33	4.1			ISC

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
81	1981	2	6	09:54:01.40	34.3459	72.0258	263	3.8			ISC
82	1981	6	23	19:54:02.10	34.2608	74.8815	33	4.8			ISC
83	1981	7	4	03:49:25.77	34.3555	75.2542	209	3.7			ISC
84	1981	8	17	09:11:15.75	33.4165	75.6202	6	4.9	3.8		ISC
85	1981	9	27	11:10:42.48	33.2954	75.6352	33	4.5			ISC
86	1981	11	9	19:31:02.47	33.3267	75.8524	33	4.5			ISC
87	1981	12	14	18:25:39.23	33.1881	75.7226	21	4.5			ISC
88	1982	1	17	12:17:37.86	34.5236	73.9030	33	3.9			ISC
89	1982	4	3	22:39:21.98	33.3664	73.4204	3	4.1			ISC
90	1982	9	8	17:53:18.54	32.9277	75.4959	33	4.8			ISC
91	1982	10	25	08:16:27.39	34.0589	73.5200	83	4.3			ISC
92	1983	1	18	13:45:30.03	34.3461	74.2660	33	4.8			ISC
93	1983	5	30	08:39:49.37	32.7136	75.4850	41	4.6			ISC
94	1983	10	12	02:44:42.23	33.7596	75.7209	33	4.5			ISC
95	1984	2	18	07:08:56.67	34.3491	72.0208	33	4.1			ISC
96	1984	4	21	20:34:20.58	34.9902	73.6360	10	3.8			ISC
97	1984	5	23	03:14:17.66	33.1703	75.9302	14	4.8			ISC
98	1984	6	4	05:03:50.16	34.8752	73.0254	52	4.6			ISC
99	1984	8	15	05:31:04.62	34.9020	74.4680	53	4.5			ISC
100	1984	12	20	07:32:07.23	32.9495	72.6961	37	4.6			ISC
101	1984	12	27	20:22:05.91	32.9062	72.6691	22	4.6			ISC
102	1984	12	28	16:28:01.63	34.6108	73.6090	47	4.5			ISC
103	1985	2	25	18:56:07.72	34.2191	74.4430	44	4.6			ISC
104	1985	4	23	12:23:56.07	32.8225	73.2092	64	4.6			ISC
105	1985	8	10	12:56:13.90	33.8905	74.8008	41	4.6			ISC
106	1986	4	25	06:30:50.46	34.8207	73.5379	33	3.9			ISC
107	1986	5	16	05:16:13.70	34.0000	72.5800	15	4.3		4.0	ISC
108	1986	7	10	07:56:12.00	34.1500	72.6900	2	4.7		4.5	ISC
109	1986	7	30	04:03:27.18	33.0499	75.8544	61	4.6			ISC
110	1986	9	19	11:15:38.56	34.2749	73.0635	64	4.4			ISC
111	1987	3	16	06:09:36.61	34.8302	72.3380	212	3.7			ISC
112	1987	7	12	12:19:18.59	33.4897	73.5054	22	4.4	3.3		ISC
113	1988	1	9	01:16:12.48	34.4401	73.3257	95	4.4			ISC
114	1988	1	20	11:48:33.40	34.6956	74.6575	33	4.3			ISC
115	1988	1	21	10:26:48.69	34.7349	73.1783	33	3.4			ISC
116	1988	11	25	00:07:07.45	32.8931	75.8088	80	4.8			ISC
117	1988	12	7	21:13:54.99	33.9486	72.9770	50	4.4			ISC
118	1989	4	7	05:43:24.49	33.7463	73.2029	43	4.3			ISC
119	1989	5	7	10:19:33.68	32.2303	72.3548	33	3.9			ISC
120	1989	5	10	20:05:28.01	33.3402	75.6956	33	3.9			ISC
121	1989	5	10	20:19:21.56	33.3270	75.6545	37	4.7	4.0		ISC
122	1989	9	7	07:42:36.94	34.7668	74.2484	147	4.4			ISC
123	1989	12	5	02:46:11.18	34.8303	73.7770	33	4.2			ISC
124	1990	3	3	05:53:37.96	32.8660	74.1490	10	4.3			ISC
125	1990	3	6	14:43:08.50	33.2381	75.3939	10	3.8			ISC
126	1990	3	15	17:33:27.92	34.5038	74.0883	33	4.5			ISC
127	1990	4	26	15:39:18.31	34.5983	73.5383	33	4.2			ISC
128	1990	9	7	01:57:55.58	34.1017	73.1395	33	4.0			ISC
129	1990	10	9	21:56:38.54	34.0921	73.1564	33	4.4			ISC
130	1990	11	12	15:45:19.76	33.2544	75.8220	67	4.8			ISC
131	1990	12	20	05:46:48.57	34.4392	74.6409	33	4.3			ISC
132	1990	12	25	03:56:46.06	33.3059	75.7558	51	5.3	4.5		ISC
133	1991	1	10	01:33:22.37	34.0152	74.8202	33	3.9			ISC
134	1991	3	16	03:57:42.41	34.5221	72.6623	33	4.5			ISC
135	1991	5	17	17:04:30.87	34.9251	73.8863	33	3.9			ISC
136	1991	5	24	15:38:03.11	34.9778	72.2006	210	3.4			ISC
137	1991	12	18	14:17:21.95	32.8030	73.6496	42	4.2			ISC

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
138	1992	1	6	19:07:13.99	34.0237	74.0587	34	4.3			ISC
139	1992	2	6	18:47:03.05	34.7764	72.7539	33	4.0			ISC
140	1992	3	24	21:01:47.77	33.8365	72.9023	14	4.9	4.4		ISC
141	1992	4	17	12:42:58.71	34.1295	72.7016	13	4.2			ISC
142	1992	6	19	23:02:35.62	32.2247	72.0831	33	3.8			ISC
143	1993	2	17	16:06:07.62	33.5623	72.5114	26	4.9	4.3		ISC
144	1993	5	15	07:27:12.14	34.8269	72.0362	33	3.8			ISC
145	1993	5	15	08:14:04.96	34.9046	72.0295	33	3.8			ISC
146	1993	6	8	14:30:37.83	33.6669	72.7367	32	4.8			ISC
147	1993	7	2	21:03:59.63	34.1576	73.4272	19	4.3			ISC
148	1993	7	12	01:27:51.90	33.3303	75.9049	33	4.0			ISC
149	1993	9	15	15:08:14.79	33.3314	75.7436	44	5.0	4.3		ISC
150	1993	11	13	00:01:40.54	34.3166	73.5060	33	3.9			ISC
151	1994	4	15	09:44:21.37	34.5578	74.1278	58	4.5			ISC
152	1994	5	13	09:19:52.17	32.5496	75.9544	33	4.3			ISC
153	1994	8	4	22:43:10.32	33.8449	72.1197	28	3.8			ISC
154	1994	12	19	03:22:18.05	34.0508	72.0483	33	3.9			ISC
155	1995	9	26	20:31:54.64	32.2679	74.8940	0	4.2			ISC
156	1995	12	8	21:00:25.17	33.4263	72.6422	10	4.1			ISC
157	1995	12	30	23:40:16.95	34.8482	72.0314	33	3.8			ISC
158	1996	2	14	01:52:22.94	34.9863	73.0220	30	3.9			ISC
159	1996	2	20	02:55:52.66	34.0396	72.6740	46	4.7	4.2		ISC
160	1996	3	25	06:31:20.76	33.1437	73.5821	16	4.6	3.5		ISC
161	1996	4	21	01:09:48.70	34.7841	73.5142	34	4.0			ISC
162	1996	5	5	10:21:23.30	33.5900	72.7600	0	3.7			EIDC
163	1996	5	15	15:02:06.43	33.1462	75.8056	58	3.5			ISC
164	1996	5	24	16:23:44.70	34.4198	72.4188	55	4.1			ISC
165	1996	8	8	14:58:19.85	34.0425	72.9533	21	4.8	4.2		ISC
166	1996	8	17	15:48:02.76	33.4550	75.4542	78	3.2			ISC
167	1996	8	25	05:13:25.20	34.1200	75.6900	0	3.8			EIDC
168	1996	9	8	10:47:15.70	33.8220	72.3103	33	3.6			ISC
169	1996	9	23	11:13:11.52	33.3954	75.6388	33	3.5			ISC
170	1996	11	28	22:56:33.30	32.2700	72.9400	85	3.6			EIDC
171	1996	12	14	09:48:39.36	34.2335	74.7044	33	4.0			ISC
172	1996	12	16	17:59:35.16	33.1416	75.9892	46	3.4			ISC
173	1997	1	19	13:59:24.10	33.6811	75.0662	33	3.6			ISC
174	1997	4	12	05:35:24.18	33.4529	75.7405	33	3.4			ISC
175	1997	5	19	22:21:49.17	34.6110	72.4376	16	3.8			ISC
176	1997	5	31	19:20:21.03	34.8346	73.6131	57	4.4	3.9		ISC
177	1997	7	2	12:01:58.75	34.4141	73.7255	33	3.8			ISC
178	1997	7	21	17:24:49.30	32.9030	72.3950	0	3.8			EIDC
179	1997	7	29	09:43:35.67	32.8482	73.7897	7	4.0	3.1		ISC
180	1997	8	28	01:15:41.20	33.7600	73.2600	15	4.5		4.3	BJI
181	1997	9	5	15:41:52.39	33.9647	73.0764	24	4.0			ISC
182	1997	10	25	12:20:34.30	34.2825	73.3834	0	3.6			EIDC
183	1997	12	7	18:59:50.80	32.9700	75.0200	33	3.2		2.7	NDI
184	1997	12	23	04:15:04.96	33.8045	75.2336	33	4.0			ISC
185	1997	12	27	12:38:20.70	33.9600	75.8800	26	4.1		3.8	BJI
186	1998	3	18	13:35:22.56	35.0082	74.3500	102	3.7			ISC
187	1998	3	24	04:25:43.89	32.3976	74.0587	54	4.0	3.6		ISC
188	1998	5	10	09:42:23.20	34.3737	72.5867	0	3.8			EIDC
189	1998	5	18	12:29:31.78	33.1574	75.8387	65	3.5			ISC
190	1998	5	24	13:22:28.84	34.5864	74.3820	33	3.6			ISC
191	1998	5	29	19:11:05.14	34.1016	73.1230	33	3.9			ISC
192	1998	6	7	08:20:35.68	34.0109	73.0408	33	3.5			ISC
193	1998	6	8	12:22:07.70	34.5535	74.1551	0	3.6	3.3		EIDC
194	1998	7	6	22:50:49.32	33.0806	75.9018	23	3.7			ISC

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
195	1998	7	6	10:24:06.24	32.9384	75.7640	59	3.8			ISC
196	1998	7	12	05:45:02.41	34.0217	72.7723	66	4.5			ISC
197	1998	8	17	17:55:01.86	33.1524	75.7102	33	3.5			ISC
198	1998	8	21	01:58:36.26	34.3694	73.7272	64	4.0			ISC
199	1998	9	28	15:28:01.46	34.1280	74.7807	33	3.7			ISC
200	1998	9	28	18:10:55.53	34.0470	74.6599	33	3.5			ISC
201	1998	11	9	17:52:55.24	34.9465	72.0533	122	3.6			NDI
202	1999	1	5	03:06:05.90	33.1180	75.7970	10	2.7			NDI
203	1999	1	11	00:35:08.90	32.3080	75.9890	5	1.7			NDI
204	1999	1	13	15:01:36.90	34.6720	73.8730	272	3.4			NDI
205	1999	2	12	16:30:49.90	32.9333	73.5163	0	3.6			NDI
206	1999	2	17	03:02:13.22	33.1290	73.7990	3	4.0			ISC
207	1999	2	21	15:14:56.50	32.8330	75.8980	10	2.1			NDI
208	1999	2	23	06:56:13.89	34.0570	74.5920	25	4.8	3.9		ISC
209	1999	2	24	09:59:18.50	33.9850	75.3320	33	2.9			NDI
210	1999	2	28	00:38:02.90	32.6860	73.4220	10	2.7			NDI
211	1999	2	28	10:53:26.30	32.9550	75.8090	10	2.2			NDI
212	1999	2	28	23:28:09.60	32.8690	75.7980	10	2.1			NDI
213	1999	3	1	01:00:06.93	33.5470	75.1620	10	3.9			ISC
214	1999	4	2	10:48:07.90	33.1760	73.6940	81	3.0			NDI
215	1999	4	7	00:43:50.00	32.9220	75.8390	0	2.9			NDI
216	1999	4	9	17:59:22.40	33.1690	75.5170	5	2.7			NDI
217	1999	4	12	04:11:30.40	33.0150	75.7520	6	2.0			NDI
218	1999	4	21	06:32:17.50	32.8310	75.6600	15	3.8		3.4	NDI
219	1999	4	22	05:22:04.80	32.9960	75.7680	7	4.9			NDI
220	1999	4	22	07:19:30.40	33.1750	75.2610	6	3.7		3.3	NDI
221	1999	4	24	04:38:33.80	32.4710	72.2880	1	4.3			NDI
222	1999	4	28	13:00:43.80	33.4810	72.7930	15	5.0		5.2	NDI
223	1999	4	28	13:00:47.25	33.1900	73.2910	17	4.9	3.6		ISC
224	1999	5	8	20:59:17.40	33.4420	75.9120	15	2.7			NDI
225	1999	5	14	09:05:56.70	34.6520	73.7420	2	4.1			NDI
226	1999	5	14	09:06:00.60	33.1750	73.1360	33	3.7			ISC
227	1999	5	17	17:45:40.30	32.5590	75.5030	33	2.0			NDI
228	1999	7	12	17:43:53.30	34.4450	74.4590	33	3.0			NDI
229	1999	7	12	21:45:50.80	33.6120	75.6740	18	4.1		3.8	NDI
230	1999	7	12	21:45:58.71	33.1560	75.8170	66	3.7			ISC
231	1999	7	13	03:17:29.40	32.7760	75.5810	33	3.7			NDI
232	1999	7	15	04:29:33.45	32.6610	72.9510	36	4.2	3.5		ISC
233	1999	7	15	04:29:35.50	32.8460	72.8610	33	4.5		4.1	NDI
234	1999	7	30	19:55:08.90	33.1120	75.5240	38	2.0			NDI
235	1999	8	24	05:39:18.00	32.4200	73.5670	17	3.1			NDI
236	1999	9	18	16:30:02.50	32.9630	75.8670	9	4.1		3.8	NDI
237	1999	10	25	18:12:17.60	32.4340	75.3610	15	2.9			NDI
238	1999	10	29	01:23:03.60	33.4770	75.5290	10	3.1			NDI
239	1999	10	29	23:31:37.10	34.1880	74.0940	15	4.2		3.9	NDI
240	1999	10	31	19:03:05.90	34.9870	72.9250	33	4.2		3.8	NDI
241	1999	11	29	14:31:19.48	33.0040	75.6470	33	4.2			ISC
242	2000	1	16	12:00:57.95	33.2650	75.8240	39	4.0			ISC
243	2000	2	22	17:53:43.31	33.4280	75.7760	15	3.5			ISC
244	2000	2	25	22:23:37.70	33.2340	75.7450	33	2.2			NDI
245	2000	3	17	07:41:42.20	33.3520	75.4380	5	2.5			NDI
246	2000	4	8	12:47:00.30	33.7010	75.0800	6	2.9			NDI
247	2000	4	26	12:15:21.26	34.0390	75.2200	43	3.5			ISC
248	2000	5	28	14:52:01.31	33.7340	74.8650	58	3.7			ISC
249	2000	7	8	14:22:41.60	34.4050	73.5070	33	3.0			NDI
250	2000	7	10	23:32:27.40	33.3340	74.3460	15	2.7			NDI
251	2000	7	12	07:51:40.40	33.0640	75.8710	5	2.3			NDI

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
252	2000	7	15	00:45:12.20	33.3180	75.5730	20	2.8			NDI
253	2000	7	17	05:26:11.45	34.9320	72.9900	52	4.8	3.8		ISC
254	2000	7	23	23:13:40.50	32.7990	75.2530	33	2.5			NDI
255	2000	7	24	12:53:30.20	32.1380	75.8910	18	2.4			NDI
256	2000	7	27	01:47:06.70	33.6090	73.8450	0	2.8			NDI
257	2000	8	11	03:46:44.40	32.6050	75.5110	48	2.9		2.3	NDI
258	2000	8	14	14:46:11.80	33.0770	75.4000	14	2.7			NDI
259	2000	8	23	14:32:44.70	34.0750	74.3830	33	4.7			NDI
260	2000	8	24	01:29:08.60	33.3190	75.4200	33	3.0			NDI
261	2000	8	28	00:32:11.20	33.4440	75.2430	7	2.7			NDI
262	2000	8	31	22:46:36.70	34.1240	73.4810	33	3.2			NDI
263	2000	9	5	14:04:28.90	33.9730	75.0360	33	2.9			NDI
264	2000	9	6	02:53:03.49	34.3400	75.0920	33	3.7			ISC
265	2000	9	7	21:58:41.80	33.3240	74.8350	26	3.4			NDI
266	2000	9	26	19:39:24.95	33.4090	75.6960	9	4.4			ISC
267	2000	10	2	05:41:54.00	35.0000	76.0000	0	5.1			NDI
268	2000	10	28	16:47:01.90	32.6010	74.9060	35	2.4			NAO
269	2000	10	28	23:53:13.10	32.9040	75.1710	33	2.6			NAO
270	2000	12	22	16:55:58.20	33.3190	75.9430	5	2.9			NAO
271	2000	12	27	00:40:16.40	33.2670	75.9950	0	2.7			NAO
272	2001	1	2	04:49:27.00	32.0000	75.0000		3.7			NAO
273	2001	1	3	21:35:23.00	32.0000	75.0000		4.1			NAO
274	2001	1	5	21:35:23.00	34.0000	76.0000		4.0			NAO
275	2001	1	8	09:01:51.60	33.6910	75.6250	33	3.9		3.5	NAO
276	2001	1	8	09:01:53.85	33.4260	75.9610	38	4.0			ISC
277	2001	1	8	09:06:19.40	33.2470	75.5730	15	2.9			NDI
278	2001	1	9	03:12:27.80	33.7670	75.9670	33	2.8			NDI
279	2001	1	9	07:19:37.00	32.0000	75.0000		3.8			NAO
280	2001	1	14	04:19:20.00	33.0000	76.0000		4.3			NAO
281	2001	1	16	10:36:58.00	33.0000	75.0000		4.3			NAO
282	2001	1	20	01:15:36.00	34.0000	72.0000		3.7			NAO
283	2001	1	21	01:24:50.00	33.0000	75.0000		4.0			NAO
284	2001	1	21	08:13:25.14	34.9500	73.4590	33	3.7			ISC
285	2001	1	23	12:01:07.00	33.0000	73.0000		4.2			NAO
286	2001	1	24	12:23:53.30	32.6310	75.6330	5	2.7			NDI
287	2001	1	24	19:49:44.50	32.7720	75.8240	33	2.7			NDI
288	2001	1	25	19:23:58.00	33.0000	74.0000		3.5			NAO
289	2001	1	31	04:18:05.00	34.0000	74.0000		2.7			NAO
290	2001	2	2	21:22:59.00	32.0000	72.0000		4.0			NAO
291	2001	2	4	10:14:08.44	33.2860	75.8310	19	4.3	3.6		NAO
292	2001	2	9	03:00:56.80	34.5520	73.9600	45	3.8			ISC
293	2001	2	9	18:17:51.00	33.0000	72.0000		3.9			NAO
294	2001	2	10	01:27:06.00	34.0000	76.0000		3.9			NAO
295	2001	2	10	03:46:16.00	32.0000	75.0000		4.5			NAO
296	2001	2	10	18:57:34.00	32.0000	75.0000		3.7			NAO
297	2001	2	12	10:20:37.00	32.0000	72.0000		4.5			NAO
298	2001	2	15	21:17:09.00	33.0000	72.0000		3.7			NAO
299	2001	2	18	07:42:25.00	32.0000	72.0000		3.8			NAO
300	2001	2	18	19:35:56.00	33.0000	74.0000		4.1			NAO
301	2001	2	20	17:33:33.50	33.1240	75.9510	40	4.5	3.8		ISC
302	2001	3	1	20:56:55.00	32.0000	72.0000		3.8			NAO
303	2001	3	1	21:29:52.10	32.4150	74.9170	33	2.6			NDI
304	2001	3	6	04:24:12.00	34.0000	72.0000		4.7			NAO
305	2001	3	6	17:59:39.60	32.9070	74.7640	28	2.8			NDI
306	2001	3	11	03:19:32.00	33.0000	75.0000		3.6			NAO
307	2001	3	11	19:09:52.00	32.0000	73.0000		3.5			NAO
308	2001	3	11	20:19:06.00	32.0000	74.0000		4.4			NAO

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
309	2001	3	12	09:35:22.00	32.0000	75.0000		3.8			NAO
310	2001	3	17	18:34:54.00	34.0000	75.0000		3.9			NAO
311	2001	3	17	19:37:03.00	35.0000	75.0000		3.6			NAO
312	2001	3	19	00:35:10.00	33.0000	73.0000		4.5			NAO
313	2001	3	22	04:03:28.00	33.0000	76.0000		3.8			NAO
314	2001	3	24	14:39:10.48	33.3790	75.6720	33	3.8			ISC
315	2001	3	28	12:33:32.00	35.0000	74.0000		4.6			NAO
316	2001	4	2	19:08:50.00	32.0000	76.0000		3.5			NAO
317	2001	4	8	18:33:54.00	34.0000	73.0000		3.9			NAO
318	2001	4	9	15:00:37.74	32.6205	73.0157	0	3.8			IDC
319	2001	4	9	15:19:07.00	35.0000	74.0000		4.3			NAO
320	2001	4	13	03:25:27.10	32.7360	75.0530	76	2.5			NDI
321	2001	4	18	23:32:26.50	32.6200	74.8150	33	2.6			NDI
322	2001	4	19	22:06:50.00	32.0000	72.0000		3.8			NAO
323	2001	4	22	20:29:28.00	32.0000	75.0000		3.7			NAO
324	2001	4	22	22:47:10.00	32.0000	75.0000		3.6			NAO
325	2001	4	29	13:52:46.00	34.0000	76.0000		3.6			NAO
326	2001	4	30	00:32:15.00	33.0000	75.0000		3.8			NAO
327	2001	4	30	15:37:12.20	33.1510	75.7770	8	2.6			NDI
328	2001	5	4	06:26:42.50	34.6210	74.2410	33	3.9			ISC
329	2001	5	7	22:08:00.00	35.0000	73.0000		3.6			NAO
330	2001	5	9	03:47:52.00	33.0000	75.0000		4.3			NAO
331	2001	5	11	14:59:21.00	32.0000	73.0000		4.3			NAO
332	2001	5	18	03:06:16.00	34.0000	72.0000		3.7			NAO
333	2001	5	21	22:16:00.00	34.0000	76.0000		4.5			NAO
334	2001	5	23	18:06:39.30	32.7290	74.9190	38	2.5			NDI
335	2001	6	2	04:39:00.70	34.1203	74.2258	200	4.3			DMN
336	2001	6	3	19:47:28.00	35.0000	72.0000		3.5			NAO
337	2001	6	5	22:50:34.00	32.0000	75.0000		3.8			NAO
338	2001	6	7	04:48:12.00	32.0000	72.0000		4.0			NAO
339	2001	6	8	22:10:31.90	34.9961	73.3194	10	4.8			DMN
340	2001	6	11	14:36:12.20	34.6762	73.5251	10	4.9			DMN
341	2001	6	13	07:33:45.00	32.0000	75.0000		4.1			NAO
342	2001	6	13	19:43:28.20	33.3090	75.4900	5	3.1			NDI
343	2001	6	13	19:49:18.80	32.6960	74.8840	11	2.5			NAO
344	2001	6	15	03:56:30.00	33.0000	75.0000		3.6			NDI
345	2001	6	15	11:13:13.60	32.8870	72.1500	33	3.6			NAO
346	2001	6	16	07:43:38.00	34.0000	73.0000		4.6			NAO
347	2001	6	17	17:18:43.00	34.0000	76.0000		3.8			NAO
348	2001	6	18	14:04:50.00	35.0000	73.0000		4.0			NAO
349	2001	6	20	04:36:56.00	34.0000	73.0000		3.8			LDG
350	2001	6	23	07:49:16.00	32.0000	73.0000		3.7			NDI
351	2001	6	27	03:50:32.00	35.0000	76.0000		3.5			NDI
352	2001	6	28	23:25:09.00	32.7520	74.7670	10	3.1			NAO
353	2001	7	1	00:12:51.00	33.0000	75.0000		3.5			IDC
354	2001	7	2	20:33:05.75	34.7376	73.3292	0	3.8			NAO
355	2001	7	4	05:35:45.00	35.0000	76.0000		4.3			NAO
356	2001	7	6	15:52:38.00	33.0000	75.0000		5.1			NAO
357	2001	7	7	21:24:36.00	33.0000	76.0000		4.6			NAO
358	2001	7	11	23:52:04.00	34.0000	72.0000		4.3			NAO
359	2001	7	14	01:54:56.00	32.0000	76.0000		3.8			NAO
360	2001	7	15	05:01:38.00	32.0000	73.0000		4.0			NAO
361	2001	7	16	16:07:16.20	32.9420	73.1480	33	5.2			MOS
362	2001	7	17	02:55:32.00	33.0000	75.0000		4.0			NAO
363	2001	7	17	14:10:33.00	32.0000	72.0000		3.9			NAO
364	2001	7	18	12:22:11.60	33.4074	75.1596	345	4.5			NAO
365	2001	7	20	05:21:24.00	33.0000	73.0000		4.3			NAO

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
366	2001	7	20	13:27:28.00	33.0000	75.0000		4.0			NAO
367	2001	7	21	00:17:17.00	33.0000	75.0000		4.7			NAO
368	2001	7	25	21:47:09.00	35.0000	73.0000		3.5			NAO
369	2001	8	7	08:31:39.00	34.0000	75.0000		3.9			NAO
370	2001	8	9	01:30:01.00	32.0000	74.0000		3.8			NAO
371	2001	8	9	19:32:32.80	33.4444	75.5545	336	4.2			DMN
372	2001	8	15	00:45:06.00	33.0000	72.0000		3.7			NAO
373	2001	8	24	18:57:02.00	33.0000	73.0000		4.0			NAO
374	2001	8	25	19:54:09.00	33.0000	75.0000		4.6			NAO
375	2001	8	26	17:05:28.00	33.0000	75.0000		4.2			NAO
376	2001	8	26	17:52:17.00	32.0000	75.0000		3.7			NAO
377	2001	8	27	01:57:26.20	33.6622	74.9070	200	4.1			DMN
378	2001	8	27	03:42:48.00	33.0000	75.0000		4.8			NAO
379	2001	8	28	11:33:44.00	33.0000	74.0000		4.7			NAO
380	2001	8	30	09:02:14.00	35.0000	76.0000		4.7			NAO
381	2001	8	31	15:36:21.00	35.0000	73.0000		2.8			NAO
382	2001	9	1	05:59:51.00	33.0000	72.0000		4.3			NAO
383	2001	9	6	00:40:49.00	33.0000	75.0000		4.8			NAO
384	2001	9	8	15:48:53.00	33.0000	75.0000		4.5			NAO
385	2001	9	9	01:04:37.00	33.0000	72.0000		3.7			NAO
386	2001	9	9	01:06:26.00	32.5326	75.9245	324	4.5			DMN
387	2001	9	9	23:39:35.50	34.5198	73.1259	133	4.4			DMN
388	2001	9	14	15:18:19.00	35.0000	73.0000		4.7			NAO
389	2001	9	14	15:39:10.80	34.5967	74.6998	300	4.7			DMN
390	2001	9	14	16:28:24.00	33.0000	73.0000		3.9			NAO
391	2001	9	14	18:29:53.00	33.0000	75.0000		3.7			NAO
392	2001	9	20	20:22:53.00	34.0000	76.0000		3.8			NAO
393	2001	9	24	05:30:53.00	34.0000	73.0000		3.6			NAO
394	2001	9	24	20:15:35.00	32.0000	76.0000		3.7			NAO
395	2001	9	26	15:29:57.00	33.0000	75.0000		3.8			NAO
396	2001	9	28	04:37:57.50	33.4010	75.8300	33	5.1			MOS
397	2001	9	30	00:54:15.90	34.6835	74.0036	133	4.7			DMN
398	2001	9	30	11:29:15.00	32.0000	74.0000		4.5			NAO
399	2001	9	30	11:31:02.80	34.5649	74.8615	320	4.8			DMN
400	2001	10	5	02:36:56.00	33.0000	75.0000		4.8			NAO
401	2001	10	6	19:21:07.30	34.1863	73.4330	10	4.9			IDC
402	2001	10	7	13:57:05.00	34.0000	74.0000		3.6			NAO
403	2001	10	11	06:01:41.72	34.6092	72.4553	0	4.0			IDC
404	2001	10	14	10:35:51.00	33.0000	73.0000		3.7			NAO
405	2001	10	15	20:18:09.00	33.0000	72.0000		3.8			NAO
406	2001	10	18	17:54:26.00	35.0000	76.0000		4.3			NAO
407	2001	10	18	17:55:59.00	34.3970	75.0860	268	5.0			DMN
408	2001	10	21	13:23:29.00	34.0000	76.0000		4.2			NAO
409	2001	10	21	14:29:12.00	34.0000	72.0000		3.7			NAO
410	2001	10	21	20:17:15.10	34.9918	72.0489	10	4.7			DMN
411	2001	10	27	03:53:51.00	32.0000	75.0000		3.9			NAO
412	2001	10	28	23:16:24.00	32.0000	72.0000		3.8			NAO
413	2001	11	3	04:50:45.71	33.1522	72.6066	0	4.2			IDC
414	2001	11	6	02:19:36.00	32.0000	72.0000		3.8			NAO
415	2001	11	6	10:50:06.00	32.0000	73.0000		4.1			NAO
416	2001	11	7	05:13:08.00	33.0000	76.0000		3.9			NAO
417	2001	11	12	22:21:40.00	32.0000	73.0000		4.2			NAO
418	2001	11	13	16:35:04.00	32.0000	72.0000		4.9			NAO
419	2001	11	13	19:29:13.00	33.0000	75.0000		3.9			NAO
420	2001	11	16	12:34:21.00	32.0000	75.0000		4.1			NAO
421	2001	11	19	17:58:08.00	32.0000	72.0000		3.8			NAO
422	2001	11	23	20:42:29.00	34.0000	74.0000		6.7			NAO

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
423	2001	11	24	14:43:57.00	33.0000	74.0000		3.7			NAO
424	2001	12	9	12:08:57.00	33.0000	75.0000		4.0			NAO
425	2001	12	9	16:01:32.00	35.0000	73.0000		4.0			NAO
426	2001	12	16	05:32:32.00	33.0000	75.0000		3.5			NAO
427	2001	12	16	05:34:02.50	34.1263	73.7819	147	4.3			DMN
428	2001	12	21	20:06:41.00	33.0000	75.0000		4.2			NAO
429	2001	12	21	21:56:41.50	32.8733	74.4470	33	5.0			DMN
430	2001	12	22	03:39:13.00	34.0000	75.0000		5.0			NAO
431	2001	12	22	11:26:25.90	34.8174	72.3052	10	4.8			DMN
432	2001	12	22	12:06:59.10	34.6710	73.1330	33	4.3			MOS
433	2001	12	24	09:42:50.40	32.6147	75.2520	305	4.0			NAO
434	2001	12	28	20:58:48.75	34.6099	73.5547	0	3.8		3.1	IDC
435	2001	12	30	18:39:14.00	33.0000	75.0000		4.2			NAO
436	2001	12	31	22:20:24.00	33.0000	75.0000		5.1			NAO
437	2002	1	6	14:34:22.00	33.0000	74.0000		3.8			NAO
438	2002	1	7	13:04:18.24	33.6575	74.6155	61	3.6			IDC
439	2002	1	7	20:32:47.00	33.0000	74.0000		4.4			NAO
440	2002	1	11	01:24:49.00	34.0000	76.0000		4.4			NAO
441	2002	1	13	12:08:10.60	32.4450	75.9370	33	5.1			NAO
442	2002	1	13	12:08:35.19	34.9422	74.0524	33	4.6			MDD
443	2002	1	13	13:39:30.82	33.9197	75.5453	33	4.6			MDD
444	2002	1	19	04:38:04.00	33.0000	75.0000		3.8			NAO
445	2002	1	24	15:34:32.00	35.0000	72.0000		4.3			NAO
446	2002	2	5	05:35:56.00	32.0000	73.0000		5.1			NAO
447	2002	2	7	03:29:20.00	34.0000	72.0000		4.2			NAO
448	2002	2	8	04:02:14.00	32.0000	76.0000		3.8			NAO
449	2002	2	9	18:10:03.00	33.0000	76.0000		3.8			NAO
450	2002	2	12	23:13:56.00	33.0819	75.9476	0	3.4		2.9	IDC
451	2002	2	12	23:14:22.36	33.6144	75.8236	0	3.9		3.7	IDC
452	2002	2	14	23:44:02.00	32.0000	72.0000		4.6			NAO
453	2002	2	17	05:22:59.70	33.0400	75.8800	31	4.3		4.1	BJI
454	2002	2	18	22:33:31.00	32.0000	74.0000		4.4			NAO
455	2002	2	19	07:22:47.00	33.0000	72.0000		4.1			NAO
456	2002	2	20	01:37:50.00	35.0000	74.0000		4.0			NAO
457	2002	2	22	10:01:31.00	33.0000	75.0000		4.5			NAO
458	2002	2	22	17:27:02.00	33.0000	73.0000		4.0			NAO
459	2002	2	26	14:04:26.00	34.0000	76.0000		4.6			NAO
460	2002	3	3	12:07:11.00	32.0000	74.0000		4.7			NAO
461	2002	3	3	13:04:48.00	33.0000	75.0000		5.0			NAO
462	2002	3	3	16:31:37.00	32.0000	73.0000		3.9			NAO
463	2002	3	3	21:03:38.00	32.0000	75.0000		4.3			NAO
464	2002	3	5	14:15:03.00	33.0000	74.0000		4.0			NAO
465	2002	3	6	19:56:13.00	33.0000	75.0000		4.7			NAO
466	2002	3	7	16:59:46.00	33.0000	73.0000		3.9			NAO
467	2002	3	9	20:58:43.00	32.0000	75.0000		3.9			NAO
468	2002	3	14	10:45:36.00	33.0000	75.0000		3.8			NAO
469	2002	3	14	18:44:03.80	34.1600	75.9800	48	3.9		3.8	BJI
470	2002	3	18	04:29:14.40	32.9700	75.8900	57	4.1		4.5	NAO
471	2002	3	21	21:57:31.00	33.0000	72.0000		4.9			NAO
472	2002	3	24	10:18:09.70	32.2564	75.8423	0	3.7		3.8	IDC
473	2002	3	29	01:58:18.00	33.0000	73.0000		4.2			NAO
474	2002	3	30	21:13:21.00	32.0000	74.0000		3.8			NAO
475	2002	3	31	17:09:17.00	33.0000	75.0000		3.5			NAO
476	2002	4	3	02:23:09.00	34.0000	72.0000		4.6			NAO
477	2002	4	5	20:30:42.00	33.0000	74.0000		4.7			NAO
478	2002	4	11	16:05:58.00	33.0000	75.0000		3.9			NAO
479	2002	4	13	23:13:57.00	32.0000	75.0000		3.8			NAO

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
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481	2002	4	16	08:14:07.00	32.0000	75.0000		3.5			NAO
482	2002	4	16	23:45:39.00	33.0000	73.0000		4.3			NAO
483	2002	4	17	06:32:53.00	32.0000	75.0000		3.5			NAO
484	2002	4	18	22:12:41.90	32.9470	74.7260	33	4.8			BER
485	2002	4	21	10:41:16.00	35.0000	76.0000		4.0			MDD
486	2002	4	30	23:01:19.00	33.0000	73.0000		4.0			NAO
487	2002	5	6	09:32:10.10	34.2600	73.7000	70	3.9			BJI
488	2002	5	6	16:27:25.00	33.0000	74.0000	0	3.6			NAO
489	2002	5	8	06:30:40.00	35.0000	73.0000		4.1			NAO
490	2002	5	9	08:11:38.00	32.0000	73.0000		3.6			NAO
491	2002	5	10	06:00:49.27	33.0359	75.9810	0	3.8		3.7	IDC
492	2002	5	13	18:41:11.00	32.0000	73.0000		4.0			NAO
493	2002	5	15	15:32:54.00	35.0000	74.0000		3.8			NAO
494	2002	5	18	22:47:22.30	32.1414	73.1310	0	3.8	4.2	3.2	IDC
495	2002	5	18	22:47:44.00	35.0000	74.0000		3.5			NAO
496	2002	5	19	03:56:51.81	34.1667	74.9971	0	4.0		3.1	IDC
497	2002	5	19	08:39:52.00	35.0000	76.0000		4.1			NAO
498	2002	5	21	05:48:26.00	34.0000	74.0000		3.8			NAO
499	2002	5	23	09:19:48.00	34.0000	72.0000		3.1			NAO
500	2002	5	27	00:05:01.00	32.0000	72.0000		3.8			NAO
501	2002	6	2	05:15:16.00	33.0000	75.0000		3.6			NAO
502	2002	6	4	00:12:04.00	33.0000	72.0000		4.0			NAO
503	2002	6	6	00:32:15.00	35.0000	73.0000		3.5			NAO
504	2002	6	9	02:51:14.00	33.0000	72.0000		3.5			NAO
505	2002	6	10	23:19:47.00	33.0000	72.0000		2.8			NAO
506	2002	6	10	23:26:00.00	32.0000	75.0000		4.1			NAO
507	2002	6	16	19:47:09.48	33.5874	72.9457	0	3.8		3.2	IDC
508	2002	6	24	20:41:39.00	34.0000	72.0000		3.8			NAO
509	2002	6	25	03:21:42.00	33.0000	75.0000		3.7			NAO
510	2002	7	1	07:35:09.00	33.0000	75.0000		3.9			NAO
511	2002	7	2	05:36:33.99	33.0653	75.8859	0	3.8		3.6	IDC
512	2002	7	2	07:01:11.00	32.0000	74.0000		3.8			NAO
513	2002	7	9	02:56:47.32	32.9866	73.4734	0	3.8		2.9	IDC
514	2002	7	11	03:32:11.00	33.0000	76.0000		4.5			NAO
515	2002	7	14	21:03:28.00	34.0000	73.0000		3.6			NAO
516	2002	7	18	20:29:19.00	34.0000	72.0000		4.1			NAO
517	2002	7	22	07:55:59.00	32.0000	73.0000		3.0			NAO
518	2002	7	22	09:57:23.00	32.0000	72.0000		3.8			NAO
519	2002	8	3	15:26:12.80	33.8840	72.8450	33	4.4			MOS
520	2002	8	4	05:02:28.00	35.0000	74.0000		3.5			NAO
521	2002	8	8	20:50:27.00	33.0000	75.0000		4.2			NAO
522	2002	8	8	22:45:11.00	33.0000	72.0000		4.0			NAO
523	2002	8	14	12:06:34.00	35.0000	73.0000		3.9			NAO
524	2002	8	14	16:15:17.00	33.0000	75.0000		3.8			NAO
525	2002	8	16	01:33:08.00	35.0000	74.0000		4.0			NAO
526	2002	8	17	23:23:28.00	33.0000	72.0000		3.6			NAO
527	2002	8	18	00:32:06.60	34.0550	72.8600	33	4.5			MOS
528	2002	8	20	14:53:38.00	34.0000	73.0000		4.1			NAO
529	2002	8	20	22:51:26.00	34.0000	76.0000		3.4			NAO
530	2002	9	3	17:26:14.00	33.0000	72.0000		5.5			NAO
531	2002	9	3	21:01:06.00	33.0000	76.0000		3.9			NAO
532	2002	9	4	11:37:46.00	33.0000	76.0000		4.4			NAO
533	2002	9	9	23:46:49.00	35.0000	74.0000		3.9			NAO
534	2002	9	11	06:39:20.00	33.0000	75.0000		3.8			NAO
535	2002	9	13	04:27:22.00	32.0000	74.0000		3.7			NAO
536	2002	9	13	18:20:12.00	33.0000	72.0000		4.0			NAO

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
537	2002	9	16	06:09:40.00	32.0000	73.0000		4.0			NAO
538	2002	9	18	04:46:38.00	32.0000	72.0000		3.9			NAO
539	2002	9	22	19:57:07.00	33.0000	74.0000		4.3			NAO
540	2002	10	1	02:50:51.00	33.0000	72.0000		5.3			NAO
541	2002	10	2	23:28:30.00	35.0000	75.0000		4.3			NAO
542	2002	10	4	14:59:54.00	33.0000	73.0000		3.9			NAO
543	2002	10	5	11:47:16.00	35.0000	73.0000		4.2			NAO
544	2002	10	10	15:27:00.00	32.0000	76.0000		4.6			NAO
545	2002	10	10	17:25:05.00	33.0000	73.0000		3.8			NAO
546	2002	10	17	04:29:45.00	32.0000	73.0000		4.4			NAO
547	2002	10	17	14:24:03.00	34.0000	72.0000		4.6			NAO
548	2002	10	21	13:49:10.00	33.0000	72.0000		3.7			NAO
549	2002	10	29	11:00:58.00	34.0000	76.0000		5.1			NAO
550	2002	10	30	03:12:30.00	35.0000	76.0000		3.6			NAO
551	2002	11	1	22:55:05.00	33.0000	76.0000		3.9			NAO
552	2002	11	1	22:55:18.56	34.7529	73.6430	0	3.8		2.9	IDC
553	2002	11	1	22:57:44.73	34.9448	73.6945	0	4.1		2.9	IDC
554	2002	11	2	04:55:07.00	35.0000	76.0000		4.0			NAO
555	2002	11	2	15:23:17.00	33.0000	76.0000		4.6			NAO
556	2002	11	3	04:47:17.00	33.0000	76.0000		4.0			NAO
557	2002	11	3	06:11:11.00	34.0000	76.0000		4.1			NAO
558	2002	11	3	14:48:07.00	33.0000	75.0000		3.8			NAO
559	2002	11	3	18:53:05.00	32.0000	72.0000		3.8			NAO
560	2002	11	4	05:18:47.00	35.0000	76.0000		4.1			NAO
561	2002	11	4	22:03:36.00	34.0000	76.0000		3.9			NAO
562	2002	11	5	11:59:20.00	33.0000	76.0000		4.2			NAO
563	2002	11	8	02:22:05.00	33.0000	76.0000		4.2			NAO
564	2002	11	8	02:51:22.00	33.0000	76.0000		3.7			NAO
565	2002	11	11	09:17:04.06	34.1842	75.3474	0	4.0			IDC
566	2002	11	13	18:40:45.00	35.0000	72.0000		3.4			NAO
567	2002	11	13	21:17:12.00	33.0000	72.0000		3.7			NAO
568	2002	11	16	14:18:36.00	35.0000	72.0000		3.9			NAO
569	2002	11	19	04:30:09.00	34.0000	76.0000		3.8			NAO
570	2002	11	20	19:22:26.00	32.0000	75.0000		3.9			NAO
571	2002	11	20	22:28:31.80	34.8068	74.3212	0	3.9		2.9	IDC
572	2002	11	20	22:50:17.00	34.0000	74.0000		4.0			NAO
573	2002	11	21	00:02:01.00	34.0000	76.0000		4.1			NAO
574	2002	11	21	03:10:22.00	34.0000	75.0000		3.8			NAO
575	2002	11	22	07:10:30.00	34.0000	76.0000		4.3			NAO
576	2002	11	22	09:12:12.60	33.4080	73.5240	33	4.5			MOS
577	2002	11	24	09:35:25.34	32.4224	73.1631	0	4.0		2.9	IDC
578	2002	11	24	12:56:47.00	34.0000	76.0000		4.5			NAO
579	2002	11	24	14:57:52.20	34.9015	73.7414	0	3.8		3.0	IDC
580	2002	11	25	11:06:18.00	33.0000	76.0000		4.2			NAO
581	2002	11	28	14:07:19.00	33.0000	72.0000		4.7			NAO
582	2002	11	30	19:19:49.00	35.0000	75.0000		3.9			NAO
583	2002	12	2	00:56:51.00	33.0000	72.0000		4.2			NAO
584	2002	12	4	10:29:35.00	33.0000	75.0000		4.3			NAO
585	2002	12	11	04:54:33.00	35.0000	75.0000		4.1			NAO
586	2002	12	17	10:28:08.00	33.3288	75.8066	46	3.6	3.0	3.2	IDC
587	2002	12	19	15:22:50.00	32.0000	75.0000		4.0			NAO
588	2002	12	19	16:13:32.21	33.4550	73.2430	0	3.9		3.5	IDC
589	2002	12	20	18:57:33.00	33.0000	75.0000		4.0			NAO
590	2002	12	23	00:12:41.00	33.0000	72.0000		5.2			NAO
591	2002	12	23	02:19:32.00	32.0000	73.0000		4.2			NAO
592	2002	12	29	07:29:17.00	33.0000	76.0000		3.7			NAO
593	2002	12	29	20:15:48.57	34.8821	73.8705	0	4.0		2.6	IDC

Sr No	Date			Time	Latitude	Longitude	Depth	Magnitude			Source
	Year	Month	Day	GMT	N	E	Km	mb	MS	ML	
594	2002	12	31	01:07:45.00	33.0000	75.0000		3.7			NAO

Seismicity Pattern

The microseismic data of the region indicate that the region is very active on a microseismic level with frequent earthquakes of magnitude greater than 4.

The largest earthquake recorded by regional network is the Kangra earthquake of magnitude Ms=8.0 occurred on 4th April 1905 about 200 km southeast of the project. Two earthquakes of magnitude greater than 6 have also been recorded in this area.

Figure 8 shows distribution of seismicity with depth in the region as recorded by Mangla microseismic network. Major concentration of earthquakes is within upper 20 km. It is important to note that all the events having magnitude 5 or greater are originated within shallow depth (< 20 km). This aspect of seismicity depicts that seismic forces are active at shallow depth, which increases earthquake hazard within this region. Majority of the events falls within focal depths less than 30 km. Though, events with magnitude greater than 5 do not seem to occur beyond 30 km depth, nevertheless, events with magnitude 4 to 5 do occur at depths upto as much as 60 km. There is only one earthquake that was located at focal depth of 79.3 km.

From the spatial point of view, number of earthquakes is quite less south of latitude 32.5o. This low level of seismicity may be true as no prominent causative seismotectonic feature is recognized in the plain areas of Punjab due to thick alluvial cover. However, another factor for this reduced level could be the fact that no local seismic network properly covers this area. Generally the spread of earthquake epicentres seems to be random for magnitudes less than 4. However, for the events having magnitudes more than 4, most of these show association with local tectonic features except in Potwar and Punjab plain (**Figure 8**). The concentration of events in zone near latitude 34.0o and longitude 72.75o may be associated with Tarbela reservoir induced effect. The concentration of events west of Abbotabad appears to be partially associated with HLSZ (Hazara Lower Seismic Zone) as suggested by Seeber et al.[44] extending northwest-southeast from Hazara thrust system of faults except the event of February 25, 1996 of magnitude 5.2 with focal depth of five kilometers located only four kilometers downstream of Tarbela dam, which was an induced event. Lot of seismicity is associated with MBT and other faults of the Hazara thrust system, which indicates that these faults are active. In Salt Range, a lot of seismicity appears to be associated with Kahuta fault and Dil Jabba thrust, therefore indicating these faults as seismically active. A concentration of seismic activity is seen along river Jhelum north of Mangla. This could probably be associated with the mapped portion of the Jhelum fault, which is also considered as a possible extension of Dil Jabba thrust along the axis of the syntaxial bend, as suggested by the study of fault plane solutions of a few earthquakes in this area. This association of seismicity suggests that this portion of Jhelum fault upto Kahuta may be considered as active tectonic feature. Another concentration of epicenters is seen northeast of Mangla, which could be associated with Riasi fault and a possible associated fault closer to Mangla.

[44] Seeber, L., et al; Seismicity of the Hazara arc in northern Pakistan; Decollement vs. basement faulting; Geodynamics of Pakistan (1979).

Further towards northeast, lot of seismicity is associated with Riasi thrust, MBT and other tectonic features of the Himalayan range.

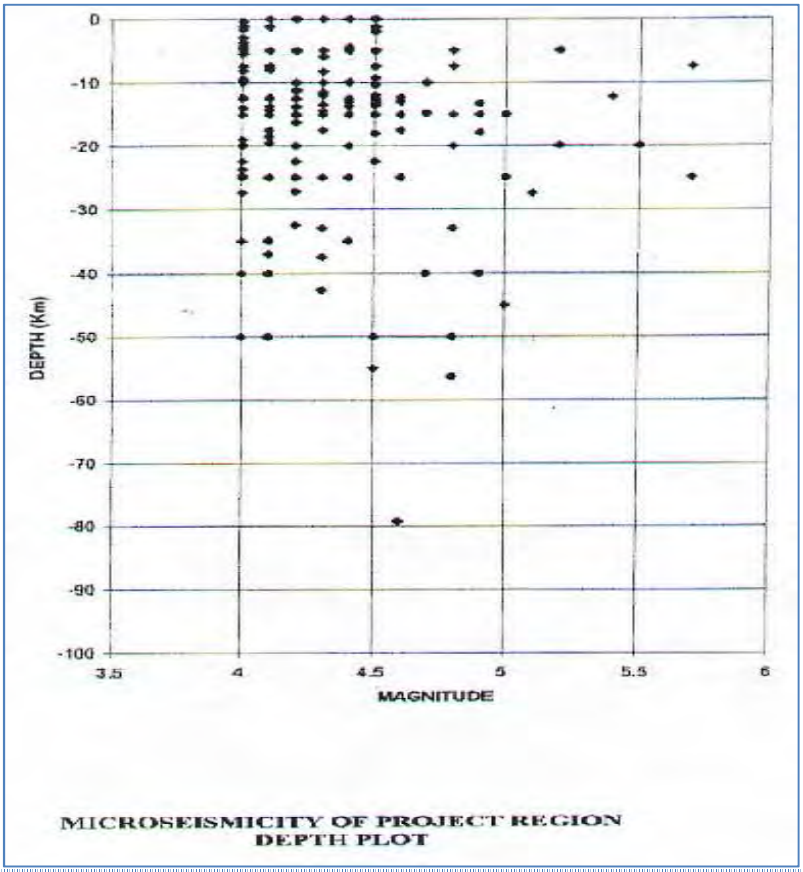


Figure 8: Microseismicity of the Project Region Depth plot

Seismotectonic Setting

Seismotectonic Model

Based on the synthesis of geological and seismicity data described above, a seismotectonic model of the project region is presented below which provides the basis for seismic hazard analysis for the Project.

The Project site is located near the base of Himalayan range where major tectonic features of this gigantic range are present. The other prominent tectonic feature is the presence of Hazara-Kashmir syntaxial bend which is very sharp near Muzaffarabad and gradually dies out southwards. All geological features show NW-SE trend towards east of the syntaxial bend while these have NE-SW trend on the western side of the syntaxial bend.

The seismotectonic features that have been considered critical for the seismic hazard to the Project include:

i. Himalayan Frontal Thrusts i.e. Main Boundary Thrust (MBT) and Riasi Thrust and associated parallel faults, having NW-SE trend and located east of the syntaxial axis;

ii. Jhelum Fault, trending N-S, and running along the axis of the syntaxial bend; and
iii. Dil Jabba thrust, Kahuta Fault and Salt Range Frontal Thrust, all have NE-SW trend and located west of the axis of the syntaxis.

The entire region is dominated mainly by thrust type of faults that do have some strike- slip component at places also. These faults are considered active because of association of observed seismicity with these faults (**Figure 7**). The faults critical to the project are discussed below:

Project Area Faults

The main tectonic features controlling the seismic hazard for the Project are as follows:

a) Main Boundary Thrust

Main Boundary thrust is the main frontal thrust of the Himalayan range which runs along the Himalayan arc for about 2500 km from Assam in the east to Kashmir in the west. Near the Project site, it takes a northwest trend due to the syntaxial bend. Near it surface trace, it dips towards northeast at steep angle but becomes sub-horizontal in the subsurface away from the surface trace. Seeber et al.[45] have shown that the series of large earthquakes which occurred along the Himalayan range are probably related to slip along this sub-horizontal surface, termed as detachment. The MBT is seismically active and have seismic potential to generate large earthquakes. The closest distance of MBT from project site is 40 km towards northeast.

b) Riasi Thrust

Another important fault of the Himalayan front is the Riasi Thrust which is a branch of the MBT and runs almost parallel to MBT for a distance of about 220 km. Lot of observed seismicity can be associated with this fault. This fault passes at a distance of only 8 km northeast of the Project site. Near the site, it has a trend of NW-SE, dipping towards northeast away from the site. Because of its close association with the MBT and recorded seismicity, this fault is considered as an active tectonic feature.

c) Jhelum Fault

This is a north-south trending left lateral strike-slip fault with steep dip towards east. Kazmi[46] has shown that this fault may extend from north of Muzaffarabad to near Jhelum towards south along the axis of the syntaxial bend. The mapped length of this fault is, however, limited to about 20 km only between Mangla and Kahuta (**Figure 4**). The alignment of observed seismicity along this fault suggests that this fault may extend towards south up to the northeastern termination of Dil Jabba thrust. A 50 km length of this fault is taken as active with nearest trace at 30 km west of the project site.

[45] Seeber L. et al; Seismicity and continental subduction in the Himalayan arc, in Zagros – Hindukush Himalayas; Geodynamics Evolution, A.G.U. Geodynamics Services, Vol.3 (1981).
[46] Farah, A., De Jong, K.A; Geodynamics of Pakistan: An introduction; Geodynamics of Pakistan, Geological Survey of Pakistan (1979).

d) Dil Jabba Thrust:

Dil Jabba Thrust is a north east trending fault present near the eastern side of Salt Range with a surface trace 86 km long. This thrust dips towards northwest and terminates on the western side of River Jhelum. Some disturbance of Quaternary deposits has been reported near the surface trace of this fault and epicenters of many earthquakes can be associated with this fault, therefore indicating that this fault is seismically active. Its eastern termination is at a distance of about 35 km from the Project site.

e) Kahuta Fault:

This fault is present north of Dil Jabba Thrust and runs parallel to it. This fault starts northwest of GT Road and terminates near the axis of the syntaxis. It length is about 50 km. Because of its similarity with Dil Jabba Thrust and observed seismicity of the area, this fault is also taken as active.

Seismic Hazard Evaluation

Both probabilistic as well as deterministic hazard evaluation procedures were employed for seismic hazard analysis of the project in accordance with the ICOLD guidelines[47].

Probabilistic Approach

Methodology

In probabilistic hazard evaluation method, the seismic activity of seismic source (line or area) is specified by a recurrence relationship, defing the cumulative number of events per year versus the magnitude. Distribution of earthquake is assumed to be uniform within the source zone and independent of time[48].

The principle of the analysis is to evaluate at the site of interest the probability of exceedence of a ground motion parameter (e.g. acceleration) due to the occurrence of a strong event, at a certain distance from the site. This approach combines the probability of exceedence of the earthquake size (recurrence relationship), and probability on the distance from the epicenter to the site.

Each source zone is split into elementary zones at a constant distance from the site. Integration is carried out within each zone by summing the effects of the various elementary zones taking into account the attenuation effect with distance. Total hazard is obtained by adding the influence of various sources. The results are expressed in terms of a ground motion parameter associated to the total number of expected events per year (i.e. the inverse of the return period), or in terms of annual hazard.

A seismic hazard model is developed based on findings of the seismotectonic synthesis. The seismic hazard model relies upon the concept of seismotectonic zones. Each zone is defined as a zone with homogenous seismic and tectonic features, inferred from geological, tectonic and seismic data.

[47] International Commission on Large Dams (ICOLD); Guidelines for selecting seismic parameters for large dams, Paris (1989).
[48] Cornell, C.A.; Engineering seismic risk analysis, Bull. Seism. Soc .Am., Vol.58, No.5 (1968).

These zones are first defined, then a maximum earthquake and an earthquake recurrence equation is elaborated for each of these source zones.

The seismic parameters attached to the various seismic zones are a recurrence relationship relating the number of events for a specific period of time to the magnitude, the maximum earthquake giving an upper bound of potential magnitude in the zone, and an attenuation relationship representing the decrease of acceleration with distance.

Seismic Source Modeling

For the definition of seismic sources, either line (i.e. fault) or area sources can be used for modeling. Because of uncertainty in the epicentral locations, it is difficult to relate the recorded earthquakes to the faults present in the area and to develop recurrence relationship for each fault. The area around the site was therefore divided into six seismic zones (area sources) based on their homogeneous tectonic and seismic characteristics. These zones are MBT, Riasi, Hazara, Potwar, Salt Range and Punjab seismic zones (**Figure 9**).

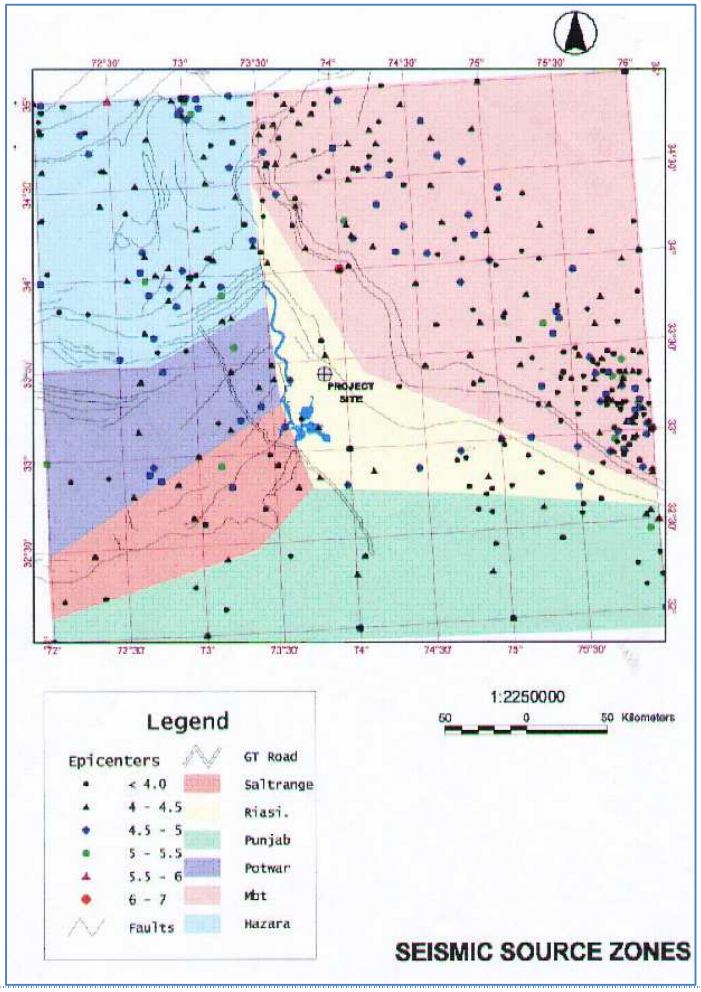


Figure 9: Seismic Source Zones

Each of these areas was assigned a maximum magnitude potential. As the shallow earthquakes are of more concern to seismic hazard, the minimum depth of the earthquakes is taken as 5 km for all

sources except Punjab seismic zone where the minimum depth of earthquakes is taken as 30 km. The source parameters used in probabilistic hazard analysis are given in **Table 3**.

Table 3: Source Parameters for Probabilistic Analysis

Source Zone	*Minimum Magnitude M0*	*No. of Earthquakes of Mb >= M0*	*Activity Rate No. /Year*	*b-value*	*Maximum Potential Magnitude Mb*
Main Boundary Thrust (MBT)	4.0	146	1.5052	0.81	8.3
Riasi	4.0	40	0.4124	1.03	7.5
Hazara	4.2	55	0.5670	1.28	7.0
Potwar	4.0	33	0.3402	0.93	7.0
Salt Range	4.2	7	0.0722	0.82	7.0
Punjab	4.0	35	0.3608	0.85	6.0

Magnitude–Frequency Relationship

A general equation that described earthquake recurrence may be expressed as follows:

$$N(m) = f(m, t) \quad (1)$$

Where N (m) is the number of earthquakes with magnitude equal to or greater than m, and t is time period

The simplest form of equation (1) that has been used in most engineering applications is the well known Richter's law which states that the cumulated number of earthquakes occurred in a given period of time can be approximated by the relationship

$$\log N(m) = a - b\,m \quad (2)$$

Equation (2) assumes spatial and temporal independence of all earthquakes, i.e. it has the properties of a Poisson model. Coefficient a is related to the total number of events occurred in the source zone and depends on its area, while coefficient b represents the coefficient of proportionality between log N(m) and the magnitude. Coefficients a and b can be derived from seismic data relative to the source of interest.

The composite list of earthquakes given in **Table 2** for the window 32.0oN to 35.0oN and 72.0oE to 76.0oE covering an area within about 200 km radius of the project provided the necessary data base for the computation of b-value for each seismic source zone.

The seismic data from 1904-2002 contain magnitude values in the form of surface wave, body wave or local magnitude scales. Since attenuation relationships are based on magnitudes of given type, a single scale must be selected. All the magnitudes above 4 were therefore converted to body wave (mb) by using the following equations as suggested by Ambraseys and Bommer[49]:

$$0.87\,(mb) - 0.50\,(Ms) = 1.91$$

[49] Ambraseys N.N. & Bommer J.J.; Uniform magnitude re-evaluation for the strong motion database of Europe and adjacent areas, European Earthquake Engineering, Vol.4 No.2 (1990).

0.82 (Ml) – 0.58 (Ms) = 1.20

Where mb is body–wave magnitude, Ms is surface-wave magnitude and Ml is local magnitude.

The converted body wave magnitudes values are given is **Table 2**. Separate list of earthquakes occurring within each seismic zone was extracted from the composite list through GIS software. Magnitude-frequency plot was then drawn and b-values were calculated for each zone through regression analysis of data. The b–values and activity rate for the six seismic zones used in the probabilistic analysis are shown in **Table 3**.

Attenuation Relationships

Because of lack of sufficient strong–motion data covering a larger range of magnitudes and distances, attenuation relationships for the South Asian region could not be developed. For probabilistic hazard analysis, the attenuation equations of Boore et al.[50], Idriss[51], Sadigh[52] and Abrahamson-Silva[53] have been used. As the Project is founded on rock, the average shear wave velocity up to 30 meters depth was taken as 800 m/sec, which was observed at proposed Kalabagh damsite for similar rock formations.

Results of Peak Ground Acceleration (PGA)

The probabilistic hazard analysis was carried out by using EZ-FRISK software developed by Risk Engineering Inc. of Colorado, USA. The parameters for all the six seismic zones (area sources) given in **Table 3** were fed to the software. The results of the hazard analysis are presented in **Figure 10** in the form of total hazard at the Project site in terms of annual frequency of exceedence of peak horizontal ground acceleration.

[50] Boore et al.; Equations for estimating horizontal response spectra and peak acceleration from western north American earthquakes: A summary of recent work, Seism. Res. Letters, Vol. 68 (1997).
[51] Idriss, I. M.; Procedure for selecting earthquakes ground motions at rock sites, National Institute of Standards and Technology, NIST GCR 93-625 (1993).
[52] Sadigh K. et al.; Attenuation relationships for shallow crustal earthquakes based on California strong motion data, Seism. Res. Letters, Vol. 68 (1997).
[53] Abrahamson, N.A. and Silva W.J.; Empirical response spectral attenuation relations for shallow crustal earthquakes, Seism. Res. Letters, Vol. 68 (1997).

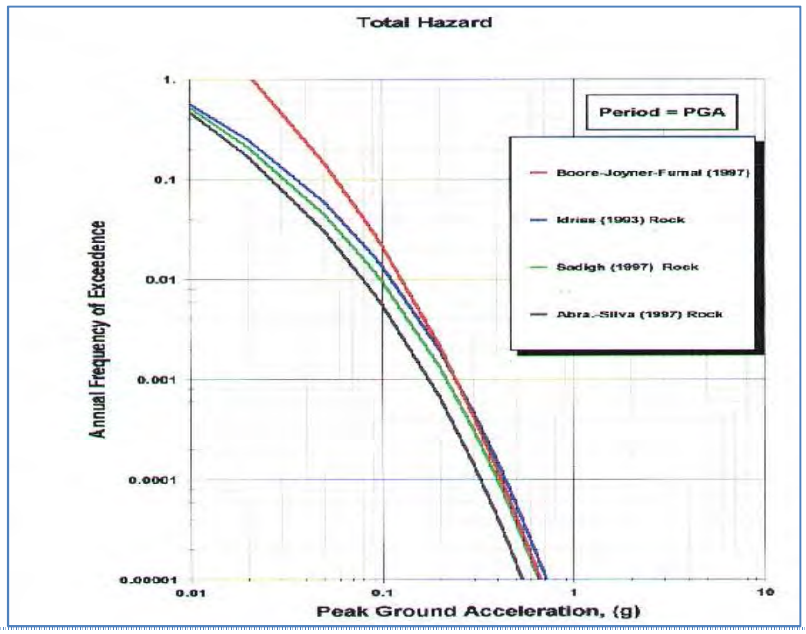


Figure 10: Total Hazard Plot

Deterministic Approach

Methodology

In the deterministic procedure, critical seismogenic sources, like capable fault, representing a threat to the Project are identified and a maximum magnitude assigned to each of these faults. The capability of the faults is ascertained through observation of historical and instrumental seismic data and geological criteria such as the rupture length – magnitude relationship or fault movement - magnitude relationship. The maximum seismic design parameter is obtained by considering the most severe combination of maximum magnitude and minimum distance to the Project site, independently of the return period.

Maximum Earthquake Potential

Table 4 gives the various active faults present around the Project site and their lengths. The maximum rupture length of the faults has generally been taken as 50% of the total length. The Main Boundary Thrust (MBT) is a long active feature extending all along the Himalayan front from Assam to Kashmir, its maximum rupture length has been taken same as that observed in Kangra earthquake of 1905.

The maximum potential magnitude of each of these faults (**Table 4**) was calculated on the basis of fault rupture length and rupture area using various available relationships[54] and a maximum magnitude was selected accordingly for each of these active tectonic features as shown in **Table 4**.

[54] Slemmons, D.B., Bodin, P., and Zhang Xiaoyi ; Determination of earthquake size from surface faulting events, Proc . Seminar on Seismic Zonation, Guangzhou, China, State Seismological Bureau (Beijing) (1987).

Table 4: Maximum Potential Magnitudes of Critical Faults

Tectonic Feature	Fault Length (Km)	Fault Rupture Length (Km)	Rupture Length Basis				Rupture Area Basis				Selected Max. Mag.
			Slemmons 1982	Patwardhan et al. 1975	Tocher, Seed & Housner	Wells Coppersmith 1994	Rupture Area		Wells & Coppersmith 1994	Wyss 1979	
							Lgt. (Km)	Wdt. (Km)			
Main Boundary Thrust (MBT)	1200	300	8.0	8.0	8.1	8.2	300	150	8.6	8.8	8.3
Riasi Thrust	220	110	7.4	7.4	7.3	7.5	100	40	7.6	7.7	7.5
Jhelum Fault	50	25	6.6	6.6	6.7	6.6	25	15	6.6	6.7	6.6
Dil Jabba Thrust	86	43	7.0	7.0	7.0	7.0	43	15	6.8	7.0	7.0
Kahuta Fault	50	25	6.6	6.6	6.7	6.6	25	15	6.6	6.7	6.6

Results of PGA

Horizontal Peak Ground Acceleration (PGA) at the project site induced by each seismic source was computed considering that maximum earthquake can occur at the closest distance from the site. The computed accelerations using several attenuation relationships of common use in engineering practice are summarized in **Table 5**. This table shows that the maximum accelerations at the site are caused by Riasi thrust being at a closest distance of 8 km from the site.

Table 5: Peak Horizontal Accelerations

Tectonic Feature	Max. Magnitude	Closest Distance to Fault (Km.)	Computed Accelerations (g) Median (50-percentile)					
			Boore, Joyner & Fumel 1997	Ambraseys et al. 1996	Idriss 1993	Sadigh et al. 1997	Ambraseys & Bommer 1991	Campbell & Bozorgnia 1993
Main Boundary Thrust (MBT)	8.3	40	0.21	0.24	0.27	0.26	0.18	0.24
Riasi Thrust	7.5	8	0.41	0.59	0.53	0.57	0.49	0.43
Jhelum Fault	6.6	30	0.09	0.11	0.12	0.11	0.10	0.13
Dil Jabba Thrust	7.0	35	0.12	0.12	0.16	0.12	0.10	0.14
Kahuta Fault	6.6	40	0.08	0.08	0.11	0.09	0.07	0.09

Seismic Design Parameters

Design seismic parameters are selected herein on the basis of the results provided by probabilistic and deterministic approaches, and in compliance with the recommendations of ICOLD[55].

OBE Acceleration

According to ICOLD guidelines, "Operating Basis Earthquake (OBE) represents the level of ground motion at the dam site at which only minor damage is acceptable. The dam, appurtenant structures and equipment should remain functional and damage easily repairable from the occurrence of

[55] International Commission on Large Dams (ICOLD); Guidelines for selecting seismic parameters for large dams, Paris (1989).

earthquake shaking not exceeding the OBE". Because of its definition, the OBE is best determined by using probabilistic procedures, for instance, such as specifying a 50% probability of not being exceeded in 100 years, the corresponding return period is equal to 144 years. In any case the OBE accelerations are significantly lower than those for MCE.

Figure 10 shows the results of probabilistic analysis for Gulpur Hydropower project obtained through EZ-FRISK software as total hazard in terms of annual frequency of proximity exceedence of peak ground accelerations. The source contribution analysis shows that maximum contribution to total hazard is from Riasi source zone. Keeping in view the proximity of the most critical tectonic feature, the recommended OBE acceleration for the project structures is 0.24g with a return period of 1000 years.

MCE Acceleration

According to ICOLD guidelines, "the MCE is the largest reasonable conceivable earthquake that appears possible along a recognized fault or within a geographically defined tectonic province, under the presently known or presumed tectonic framework". This definition is inspired by that of Seed[56]: "the largest rationally conceivable event that could occur in the tectonics environment in which the project is located". The MCE can be evaluated through a deterministic or a probabilistic procedure. If the probabilistic seismic hazard evaluation is used, the MCE is linked to a very long return period for this event.

For Gulpur Hydropower Project, the most critical tectonic feature controlling the MCE is the Riasi thrust which is causing maximum accelerations at the project site (**Table 5**). Various attenuation relationships give peak horizontal accelerations ranging from 0.41g to 0.59g. For the peak horizontal acceleration associated with MCE, an average value of 0.50g is selected. This value is conservative but selected in view of the proximity of the most critical tectonic structure from the project.

Conclusions and Recommendations

The seismic hazard evaluation for Gulpur Hydropower Project was carried out on the basis of understanding of local tectonic environment, desk studies of faults in the vicinity of the Project and synthesis of available seismological and tectonic data to evaluate the capability of active tectonic features and assigning ground motion associated with them. The main conclusions based on the present study are as follows:

- The project site is located close to the Riasi Thrust which is a branch of MBT, the main source of destructive earthquakes in the Himalayan region.
- The critical surface tectonic features around the Project site are MBT and Riasi thrusts towards east and Dil Jabba Thrust, Kahuta Fault and Jhelum Fault towards west of the Project.
- Historical record shows that earthquakes in this region have caused maximum intensity of VIII-IX several times in the past. The instrumentally recorded seismicity shows that faults in this area are seismically active. Several epicenters of recorded earthquakes can be associated with the known faults of the area.

[56] Seed, H. B.; The selection of design earthquake for critical structures. Bull. Seis. Soc. Am., Vol.72 (1982)

- Seismic hazard evaluation was carried out in accordance with the ICOLD guidelines for selecting seismic design parameters using both probabilistic as well as deterministic approaches.
- The probabilistic approach was used to select the Operating Basis Earthquake (OBE) using the instrumentally recorded earthquake data for the last century. For the project life of 100 years, recommended OBE acceleration is 0.24g.
- Based upon the deterministic evaluation, peak horizontal ground acceleration of 0.50g associated with Maximum Credible Earthquake (MCE) is recommended for the Project.

Annexure 2: Hydrometeorological Data

There are number of meteorological stations within and in the vicinity of the catchment area where data is available for meteorological parameters. These include Sehr Kakota, Plandari, Mangla, Bagh, Rawalakot and Khandar. However, Kotli is the representative station for which meteorological parameters like temperature, precipitation, humidity and evaporation are available since 1952. These climatic parameters are narrated in the following paragraphs.

Temperature

Record of maximum and minimum temperatures at Kotli starting from 1952 are available with Pakistan Meteorological Department. Monthly mean maximum and minimum temperatures are presented in **Tables 1** and **2** respectively. These tables show that average of monthly mean maximum temperature varies between 17.6°C in January to 38.4°C in June, whereas monthly mean minimum temperature ranges between 4.8°C in January and 24.9°C in June.

Table 1: Monthly Mean Maximum Temperature at Kotli (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1952	-	-	-	-	-	-	-	32.6	34.3	32.0	26.9	20.1	29.18
1953	16.1	21.2	27.1	31.9	37.2	39.6	33.9	32.5	32.2	30.4	25.0	22.5	29.13
1954	15.2	17.3	24.2	31.8	37.8	39.2	36.1	35.0	32.7	28.3	24.0	20.3	28.49
1955	17.4	22.6	25.5	29.3	32.6	40.8	36.2	30.7	32.2	29.4	26.1	19.1	28.49
1956	17.2	21.9	22.8	30.8	40.1	37.7	31.7	30.0	33.4	27.8	24.3	19.1	28.07
1957	14.6	18.3	22.5	25.6	31.7	37.1	37.4	33.1	32.2	29.4	23.1	17.3	26.86
1958	18.3	20.7	25.3	33.6	35.3	39.3	34.0	32.6	31.7	30.3	25.7	18.8	28.80
1959	16.7	16.7	25.7	30.8	33.7	39.7	32.4	32.5	31.6	30.2	23.2	20.2	27.78
1960	17.7	24.2	21.6	28.8	37.3	40.6	35.6	32.7	33.7	31.9	25.4	20.7	29.18
1961	17.6	16.8	24.8	28.4	35.5	38.8	34.0	33.4	32.3	29.6	22.6	18.4	27.68
1962	18.3	19.9	24.6	30.8	35.9	39.6	36.1	33.9	31.3	30.4	24.8	19.3	28.74
1963	20.3	23.9	23.6	27.7	33.2	39.3	36.1	33.1	32.4	31.8	24.1	21.7	28.93
1964	14.4	19.2	26.9	30.6	34.5	38.2	33.3	32.9	31.7	32.2	26.7	18.9	28.29
1965	18.6	16.4	23.8	24.4	32.8	38.2	35.5	32.9	34.6	31.6	25.5	20.9	27.93
1966	21.2	21.0	24.1	27.8	35.5	37.4	35.3	32.8	30.9	29.6	25.8	20.3	28.48
1967	18.7	21.8	23.4	28.7	34.6	39.4	34.3	32.2	32.8	29.5	23.9	18.4	28.14
1968	15.1	18.2	25.1	31.1	32.9	39.6	34.6	32.8	35.6	29.4	25.0	19.2	28.22
1969	17.4	18.8	28.4	29.4	32.8	40.1	35.0	33.2	33.2	30.6	27.4	23.4	29.14
1970	18.8	20.7	23.4	34.4	38.2	38.1	35.9	32.8	32.2	31.4	25.0	22.5	29.45
1971	18.7	21.3	27.4	32.2	35.2	35.3	32.7	32.3	33.3	31.7	25.7	21.3	28.93
1972	19.1	16.6	24.9	28.9	35.7	39.5	35.5	33.1	32.1	29.7	25.6	18.6	28.28
1973	16.3	20.9	23.2	32.5	36.1	37.2	33.3	37.6	32.6	30.2	26.1	20.0	28.83
1974	16.8	17.6	26.5	32.7	35.6	37.0	34.5	33.9	34.3	32.3	27.0	17.9	28.84
1975	17.3	18.2	23.6	31.0	35.4	37.9	33.2	32.7	32.1	32.2	26.1	21.5	28.43
1976	18.6	16.9	23.2	28.8	35.4	37.3	34.1	30.5	32.2	30.9	27.3	20.7	27.99
1977	16.5	22.9	30.3	30.1	32.8	36.3	32.5	32.3	33.4	31.2	27.2	20.2	28.81
1978	17.6	19.5	21.5	31.1	39.7	38.1	31.5	32.6	32.9	32.1	25.0	22.8	28.70
1979	20.3	19.3	22.1	32.7	33.1	38.8	34.6	33.7	33.6	33.0	27.2	21.4	29.15
1980	17.4	19.2	22.2	32.9	38.3	38.4	33.7	33.7	33.9	31.7	26.0	20.3	28.98
1981	16.4	18.9	21.2	30.9	35.6	38.0	32.7	33.0	32.6	30.5	25.3	21.4	28.04
1982	17.8	15.9	19.1	28.3	30.7	37.1	36.1	32.1	33.3	30.1	23.9	18.3	26.89
1983	16.0	18.6	21.0	25.7	32.2	36.0	34.5	32.5	32.5	29.4	26.2	20.4	27.08
1984	18.8	17.5	27.0	30.2	39.8	39.4	32.6	32.3	31.2	30.7	24.2	18.9	28.55
1985	17.4	23.3	28.5	32.2	39.1	40.7	33.4	33.0	33.1	29.4	23.3	18.6	29.33
1986	18.7	19.2	22.1	29.9	32.3	37.7	32.8	31.7	32.8	29.2	25.2	18.9	27.54
1987	20.4	21.0	23.5	30.8	29.3	37.1	37.3	34.9	34.1	29.8	28.5	22.8	29.13
1988	20.2	22.4	23.2	32.8	38.7	38.0	29.4	32.1	32.3	30.0	25.7	20.2	28.75
1989	17.4	19.0	23.5	29.1	35.7	38.3	34.2	32.5	34.3	31.6	25.2	19.2	28.33

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1990	19.3	18.7	21.5	28.4	37.1	38.7	33.9	32.1	32.5	29.6	26.4	18.8	28.08
1991	17.0	18.5	23.6	26.6	34.1	37.8	36.7	33.0	31.8	30.3	25.3	19.6	27.86
1992	16.2	19.2	22.5	29.1	33.2	37.7	33.8	32.5	31.5	30.3	24.9	20.5	27.62
1993	16.0	22.7	21.8	31.2	37.6	38.5	33.2	36.1	32.8	33.2	27.1	22.9	29.43
1994	18.5	19.0	27.2	29.0	36.5	39.2	32.7	31.7	32.8	30.2	25.8	17.8	28.37
1995	16.6	18.5	23.4	27.0	35.9	40.1	32.1	31.6	32.6	29.5	24.8	17.6	27.48
Average	**17.65**	**19.64**	**24.11**	**30.00**	**35.27**	**38.44**	**34.15**	**32.85**	**32.76**	**30.56**	**25.44**	**20.04**	**28.42**

Table 2: Monthly Mean Minimum Temperature at Kotli (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1952	-	-	-	-	-	-	-	22.6	22.4	17.9	10.2	5.2	15.66
1953	4.8	9.6	15.3	18.7	24.1	26.4	24.8	23.1	21.6	16.7	10.1	7.3	16.88
1954	4.9	8.8	12.4	18.7	23.7	26.2	24.4	24.3	22.6	15.5	10.8	4.9	16.43
1955	4.8	7.8	14.8	16.4	20.7	27.0	24.2	23.3	22.1	17.0	9.8	6.3	16.18
1956	5.6	7.5	12.7	18.3	26.1	25.8	23.6	22.7	22.8	17.0	8.9	5.7	16.39
1957	5.0	6.3	11.6	15.2	19.7	24.0	25.8	23.6	21.3	16.9	11.4	6.8	15.63
1958	6.6	7.0	13.1	19.8	22.6	26.2	24.8	22.9	22.3	16.9	8.9	7.1	16.52
1959	5.4	6.6	12.8	17.8	22.0	26.2	23.2	-	23.2	18.3	10.2	5.9	15.60
1960	4.4	9.6	11.3	16.1	23.2	26.8	24.7	24.5	22.2	16.7	9.4	4.3	16.10
1961	5.7	6.1	12.6	16.9	21.9	25.7	24.9	24.3	23.2	16.1	9.5	4.0	15.91
1962	3.8	8.3	12.7	18.5	22.8	25.9	25.7	23.7	21.1	16.1	9.8	5.1	16.13
1963	2.5	9.1	12.1	16.7	20.7	25.4	24.8	24.0	21.3	18.6	11.9	5.2	16.03
1964	3.8	6.9	13.2	17.6	20.7	25.8	24.2	24.6	21.8	16.3	8.5	6.2	15.80
1965	6.5	7.6	11.4	15.0	19.8	24.9	24.6	22.5	21.9	18.4	12.1	4.2	15.74
1966	4.1	9.6	12.5	16.2	21.6	26.1	24.2	23.3	20.6	16.7	9.6	3.2	15.64
1967	3.6	9.2	11.3	16.4	20.9	26.4	24.6	23.5	21.8	16.0	10.8	7.1	15.97
1968	5.1	6.1	11.8	17.2	20.3	25.9	24.7	23.1	22.7	16.2	10.2	5.6	15.74
1969	4.3	7.8	14.5	17.1	20.9	25.1	24.4	24.2	21.4	17.9	11.4	4.3	16.11
1970	4.7	7.7	12.4	20.1	24.2	25.2	24.9	23.9	21.9	18.2	9.3	5.1	16.47
1971	2.9	7.2	13.7	18.9	22.2	24.4	23.9	23.7	20.6	16.7	10.1	4.0	15.69
1972	5.1	5.8	12.8	16.5	22.1	25.6	24.2	23.0	20.6	16.4	11.2	6.9	15.85
1973	4.9	8.9	11.7	18.6	23.8	26.1	24.8	23.9	22.5	16.3	10.1	4.7	16.36
1974	4.3	6.3	13.5	19.7	22.2	22.3	24.5	23.9	21.6	15.7	9.2	6.4	15.80
1975	6.0	6.6	11.6	17.8	21.3	24.5	23.3	23.5	20.9	17.3	8.3	4.9	15.50
1976	5.6	7.7	11.5	16.0	21.7	23.5	24.8	22.4	21.3	16.8	9.7	4.4	15.45
1977	4.5	6.4	14.0	17.8	20.0	24.2	24.2	23.7	21.3	17.9	12.3	7.3	16.13
1978	5.1	7.7	10.7	17.7	24.6	26.1	24.1	23.7	21.1	17.1	11.2	4.9	16.17
1979	5.5	7.6	10.5	19.0	20.3	24.9	25.3	23.0	20.0	16.7	12.6	7.5	16.08
1980	6.5	8.8	11.4	18.3	23.7	25.1	24.1	23.5	20.8	17.3	10.8	6.3	16.38
1981	5.7	8.7	11.5	17.6	22.4	24.5	24.5	23.8	20.5	16.5	9.9	3.6	15.77
1982	5.2	6.6	9.8	15.9	18.8	23.5	24.5	23.4	20.2	16.9	11.2	7.4	15.28
1983	4.4	6.6	10.3	14.6	19.9	22.2	22.5	23.8	22.1	15.0	8.7	4.4	14.54
1984	2.4	5.7	13.5	17.2	24.1	26.3	23.5	23.8	19.8	14.7	9.3	5.1	15.45
1985	6.1	7.2	13.2	16.8	21.0	24.3	23.3	20.9	17.6	11.6	6.2	3.6	14.32
1986	0.2	3.2	6.5	12.7	15.3	20.6	20.0	20.8	20.5	16.1	10.7	5.6	12.68
1987	4.6	7.4	12.2	16.7	18.1	23.0	24.1	23.6	21.6	15.6	8.6	4.6	15.01
1988	6.7	7.9	12.0	19.1	24.5	25.2	24.3	23.6	21.8	15.7	9.9	5.4	16.34
1989	4.2	6.3	11.5	15.3	21.0	24.0	23.9	22.6	21.5	15.7	10.5	6.3	15.23
1990	7.2	7.5	9.9	15.7	22.7	25.1	23.9	23.6	22.8	15.2	10.1	5.2	15.74
1991	4.4	7.8	11.5	14.8	20.3	23.6	24.5	23.6	21.5	14.0	7.9	6.4	15.03
1992	6.0	6.3	10.8	14.4	18.8	23.0	23.8	24.2	20.6	15.4	9.3	6.6	14.93
1993	4.2	8.0	9.2	16.6	-	-	23.4	23.6	21.1	14.7	9.7	4.2	13.47
1994	5.8	6.5	9.5	11.7	15.3	25.1	24.4	24.4	20.3	14.6	9.5	6.4	14.46
1995	3.3	6.6	10.6	14.8	21.3	25.5	24.2	23.8	20.8	16.1	8.3	6.1	15.12
Average	**4.80**	**7.37**	**11.90**	**16.90**	**21.46**	**24.94**	**24.20**	**23.44**	**21.40**	**16.35**	**9.96**	**5.49**	**15.63**

Precipitation

Monthly rainfall data at Kotli is given in **Table 3** which shows an average precipitation of 1,237 mm/year over the period of 1952-2012. Minimum rainfall occurs in November with an average of 24 mm while the maximum rainfall months are July and August with the average values of 266 mm and 270 mm respectively.

Table 3: Mean Monthly Rainfall at Kotli (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1960	62.0	1.5	194.3	47.2	7.6	12.4	349.8	301.8	47.8	0.0	5.3	51.6	1081.3
1961	152.7	94.7	49.0	142.5	34.0	74.2	366.5	250.7	229.6	96.8	29.0	28.2	1547.9
1962	16.0	118.4	60.2	82.5	20.3	56.6	202.7	286.5	129.8	3.6	70.1	70.4	1117.1
1963	0.0	26.2	109.2	136.1	59.4	90.4	238.5	156.0	99.3	7.6	49.5	45.7	1017.9
1964	233.9	29.5	28.7	90.7	44.2	26.9	338.3	278.4	105.9	0.0	10.9	75.2	1262.6
1965	111.0	189.5	77.0	165.4	123.7	29.5	281.7	131.1	10.2	14.0	58.2	7.1	1198.4
1966	0.0	181.6	107.9	57.7	118.4	83.1	321.1	272.3	178.6	120.9	0.5	48.8	1490.9
1967	0.0	127.5	169.9	93.2	30.0	21.8	265.7	317.5	127.8	51.1	11.4	196.1	1412.0
1968	140.2	106.2	80.3	69.3	119.1	54.1	195.3	292.0	104.3	79.0	47.5	39.1	1326.4
1969	26.4	83.1	105.4	108.7	63.0	45.5	267.2	239.0	63.2	40.1	0.0	0.0	1041.6
1970	69.6	48.0	56.1	16.0	29.2	165.4	146.6	356.9	203.5	32.3	0.0	8.1	1131.7
1971	13.7	91.2	11.4	99.8	72.6	243.3	219.2	337.6	17.3	7.9	40.6	5.8	1160.4
1972	84.3	119.4	82.3	51.1	37.6	62.0	326.9	333.5	110.7	31.2	21.3	73.7	1334.0
1973	110.7	100.1	101.6	41.4	69.3	91.7	341.4	466.6	133.4	27.2	0.0	42.9	1526.3
1974	95.4	78.2	50.0	25.4	16.3	125.0	234.8	201.4	43.0	4.9	0.0	53.4	927.8
1975	65.0	97.4	78.5	35.2	62.6	53.5	305.4	370.9	160.1	0.0	0.0	0.0	1228.6
1976	116.9	231.3	124.1	95.7	35.3	83.7	481.5	547.5	149.9	55.4	0.0	8.0	1929.3
1977	175.8	5.9	0.0	96.8	119.7	171.1	279.7	305.8	80.2	54.2	50.1	67.4	1406.7
1978	82.1	31.1	256.6	38.3	16.7	204.0	350.7	510.4	80.2	2.5	52.3	0.0	1624.9
1979	86.3	97.5	203.1	35.8	45.9	62.8	81.5	316.1	55.8	11.4	35.3	33.8	1065.3
1980	65.5	68.4	67.4	17.8	21.3	180.0	105.4	107.1	103.2	55.0	32.2	30.5	853.8
1981	152.4	161.4	328.0	14.0	53.6	21.0	291.4	112.6	49.9	10.2	4.6	0.0	1199.1
1982	106.6	128.9	270.6	252.2	86.0	48.2	189.6	269.4	73.4	33.0	85.6	50.7	1594.2
1983	108.5	101.3	179.7	274.0	53.9	37.6	323.5	490.2	121.9	93.8	0.8	4.6	1789.8
1984	2.0	88.0	67.5	53.6	28.9	85.0	244.6	476.2	86.6	0.0	45.5	39.2	1217.1
1985	71.7	16.3	14.0	65.1	55.4	4.8	453.8	186.0	117.0	72.1	0.0	200.7	1256.9
1986	14.0	125.4	198.6	122.1	30.9	52.2	240.2	216.2	55.0	64.3	93.7	115.8	1328.4
1987	8.6	111.9	100.0	42.1	133.2	41.9	94.2	156.4	59.4	46.8	0.0	0.0	794.5
1988	18.6	102.9	175.0	25.6	6.5	126.0	711.0	301.8	81.6	12.2	0.0	115.2	1676.4
1989	116.8	27.3	141.9	47.4	26.9	45.8	345.2	142.7	47.2	46.2	45.9	61.5	1094.8
1990	35.7	185.5	266.5	36.3	11.4	69.9	247.1	352.7	66.4	28.2	15.7	309.3	1624.7
1991	23.9	127.5	98.3	171.8	20.3	86.7	212.1	263.2	168.8	2.4	0.0	59.3	1234.3
1992	211.4	121.5	236.8	61.6	73.5	45.5	176.5	228.1	212.1	42.0	46.1	9.0	1464.1
1993	63.2	60.0	187.4	33.0	3.0	61.0	169.4	94.0	77.2	1.0	47.0	0.0	796.2
1994	56.2	73.6	56.6	79.9	65.0	161.6	500.0	305.0	25.0	30.0	0.0	152.0	1504.9
1995	66.6	154.0	87.6	77.2	14.0	103.0	387.0	412.5	41.9	45.0	59.0	1.3	1449.1
1996	81.6	126.0	130.7	35.0	71.0	144.2	78.0	337.6	40.8	49.0	2.0	5.0	1100.9
2003	13.7	279.3	85.1	26.6	18.5	104.3	178.8	149.2	99.8	7.1	26.9	26.9	1016.2
2004	137.8	23.2	5.6	78.5	75.2	67.4	165.3	197.5	23.4	38.9	24.9	43.7	881.4
2005	98.1	151.7	96.8	3.8	18.1	21.1	193.5	89.9	51.7	15.8	2.0	0.0	742.5
2006	91.9	50.5	67.1	17.8	63.4	139.5	381.0	308.3	72.6	32.8	57.3	128.7	1410.9
2007	1.3	160.3	247.7	21.1	47.2	100.8	161.3	188.2	64.3	0.0	7.1	4.1	1003.4
2008	156.7	60.2	10.7	120.7	55.6	244.9	265.2	134.4	76.7	68.8	2.5	101.6	1298.0
2009	62.2	97.8	52.6	46.0	5.8	34.5	132.3	142.0	9.7	2.8	33.5	5.6	624.8
2010	21.6	122.2	69.6	15.2	65.8	65.3	304.5	182.1	53.1	55.1	4.3	18.3	977.1
2011	8.9	120.1	152.4	97.8	78.2	132.6	140.2	196.1	217.4	13.2	1.3	0.0	1158.2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	97.3	50.8	11.7	79.0	17.5	39.9	217.4	417.1	168.9	7.6	12.2	91.5	1210.9
Average	**75.2**	**101.2**	**113.9**	**73.3**	**49.5**	**85.6**	**266.0**	**270.8**	**93.5**	**32.2**	**24.1**	**51.7**	**1236.9**

Evaporation

Evaporation data for a number of stations is available including Kotli, Mangla, Sehr Kakota, Khandar, Plandri, Bagh and Palak. However, reservoir evaporation given in Mangla Dam Raising Study is preferred because it has been worked out from the existing reservoir and as such includes all the losses and gains including evaporation. The data is therefore considered representative of the proposed Gulpur Reservoir and hence adopted in the Study. This data is presented in **Table 4**. This table depicts that mean monthly evaporation varies between 46 mm in December to 229 mm in June, while mean annual evaporation is 1,427 mm.

Table 4: Mangla Reservoir Observed Lake Evaporation (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	-	-	-	-	-	-	-	-	108	86	65	48	-
1984	59	68	150	187	327	242	110	108	91	93	57	43	1,534
1985	41	82	137	167	287	281	153	113	117	90	62	45	1,575
1986	45	59	93	157	198	244	142	109	118	82	55	33	1,333
1987	44	55	79	154	144	205	186	156	124	94	70	44	1,354
1988	56	80	108	197	275	232	142	117	106	91	46	37	1,487
1989	46	71	100	157	234	224	156	113	121	110	62	36	1,432
1990	52	52	91	151	215	224	154	120	99	85	61	39	1,341
1991	41	58	91	115	190	227	210	142	130	104	70	51	1,428
1992	57	66	131	144	194	211	177	153	76	0	45	40	1,294
1993	60	74	94	126	178	191	165	152	123	94	66	58	1,382
1994	62	65	125	157	209	260	134	103	108	92	46	29	1,391
1995	39	56	102	116	221	235	128	112	133	107	62	44	1,357
1996	60	64	94	181	230	175	180	105	115	103	70	52	1,427
1997	37	71	119	125	197	220	178	121	123	85	53	86	1,415
1998	45	114	91	152	235	272	170	125	104	100	66	38	1,511
1999	38	57	117	203	277	252	156	117	104	90	160	45	1,614
2000	39	62	116	201	226	196	130	119	92	92	65	54	1,390
Average	**48**	**68**	**108**	**158**	**226**	**229**	**157**	**123**	**111**	**89**	**66**	**46**	**1,427**

Streamflow and Sediment Data

A stream gauging station on Punch River is being maintained at Rehman Bridge by SWHP of WAPDA since 1960. Measurements include stream flows and suspended sediment concentrations. Rehman Bridge Gauging Station is located just downstream of Bann Nullah about 5 Km south east of Kotli Town. **Figure 1** shows that between Rehman Bridge gauge site and proposed weir site, there are no major tributary/nallahs joining the main river, thus discharge and sediment data available at Rehman Bridge gauge is considered directly applicable for the Project. The data have been collected up to the year 2002 and used in the present study.

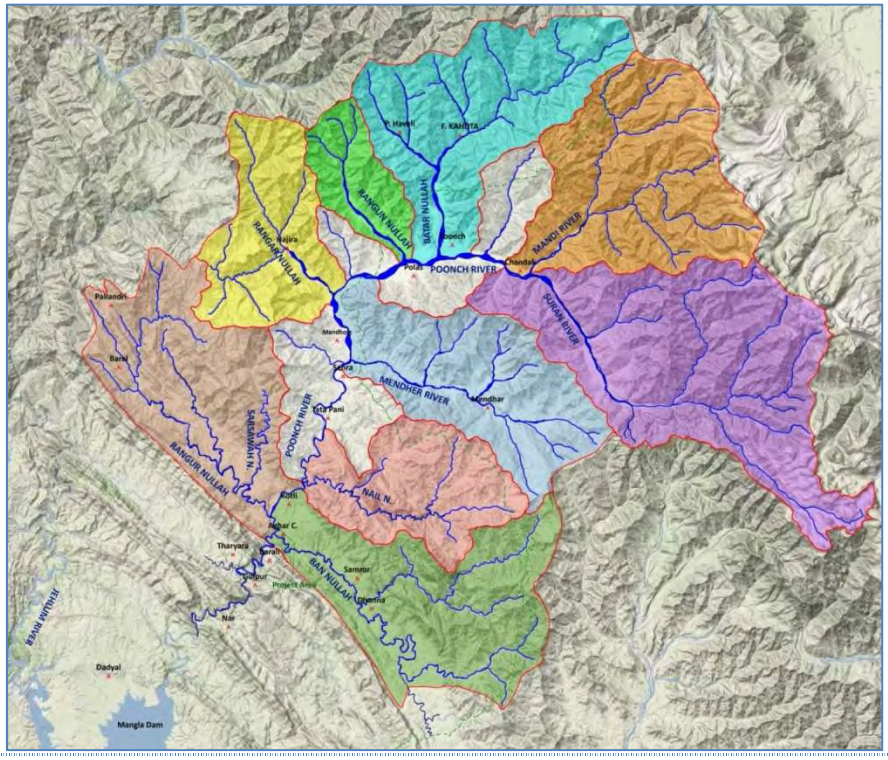


Figure 1: Catchment and Drainage of Poonch River

Annexure 3: Water Availability Study

The objective of water availability study is to assess the magnitude of water for power generation during different periods of the year. This is done by formulating a 10 daily/ monthly time series from the daily mean flow data recorded at Rehman Bridge for the period of record from 1960 to 2002.

Consistency of Data

Before a data set is used for formulation of a time series, it is required that consistency of the record is checked. For this purpose, Basic Screening Procedure of Hydrological Data recommended by Dahmen and Hall[57] has been adopted using a statistical approach to test for absence of trend and for stability of mean and variance of the mean annual flows. From the analysis, it was found that there is no trend and mean as well as variance of annual flows are stable. This shows that the time series of flows recorded at Rehman Bridge is consistent and homogeneous with no obvious trend on mean annual basis.

Inflow Time Series

Streamflow record of Punch River at Rehman Bridge for the period 1960 to 2011 available in the form of mean daily flows has been used for formulation of inflow time series. Mean monthly discharges computed from the mean daily flows are given in **Table 1**, which shows a minimum value of 12 cumecs observed in January 1966 and maximum value of 830 cumecs in September 1992. Mean monthly flows (in cumecs) are graphically shown in **Figure 1** and monthly runoff (in MCM) in **Figure 2**. These figures depict that mean monthly flows vary between 41 cumecs (106 MCM) in November to 264 cumecs (963 MCM) in August.

Table 1: Summary of Mean Monthly Flows of Punch River at Rehman Bridge (1960-2002)

Year	Mean Monthly Flow (Cumecs)												Annual Flow		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Cumecs	MCM	(MAF)
1960	38	39	161	113	81	56	330	233	74	30	20	16	100	3,160	2.56
1961	48	97	85	208	75	111	297	238	324	73	51	40	137	4,327	3.51
1962	22	53	78	159	83	70	155	143	122	45	33	32	83	2,617	2.12
1963	23	35	123	138	142	122	212	267	85	19	20	30	102	3,220	2.61
1964	156	85	107	138	87	77	331	361	126	43	21	33	131	4,146	3.36
1965	55	159	129	293	194	146	224	147	61	26	21	15	122	3,851	3.12
1966	12	94	153	143	141	138	239	286	354	120	35	29	145	4,587	3.72
1967	23	69	216	191	127	104	226	254	124	49	29	104	127	4,002	3.24
1968	115	145	160	140	91	103	171	272	68	55	42	26	116	3,666	2.97
1969	27	71	165	137	166	107	189	254	62	52	27	18	107	3,365	2.73
1970	26	33	76	73	53	76	114	297	257	54	23	17	92	2,898	2.35
1971	14	30	42	67	70	186	206	289	84	30	28	21	89	2,817	2.28
1972	27	85	137	106	98	72	181	196	121	60	36	43	97	3,067	2.49
1973	110	144	267	157	97	116	196	456	149	53	26	24	150	4,727	3.83
1974	35	74	101	76	53	119	158	111	45	26	15	17	69	2,180	1.77
1975	17	69	138	132	109	98	213	490	239	55	30	20	135	4,255	3.45
1976	52	190	217	197	151	147	355	665	177	60	31	25	190	5,996	4.86
1977	68	57	61	101	119	119	409	281	141	84	51	66	131	4,120	3.34
1978	74	95	362	201	163	166	452	456	155	67	75	35	193	6,086	4.93
1979	24	68	280	144	91	107	120	219	137	62	52	44	113	3,555	2.88
1980	59	98	168	110	97	147	133	150	75	44	45	33	97	3,054	2.48

[57] Dahmen E.R. & M.J. Hall (1990): "Screening of Hydrologic Data", International Institute for Land Reclamation and Improvement (ILRI), Publication 49.

Year	Mean Monthly Flow (Cumecs)												Annual Flow		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Cumecs	MCM	(MAF)
1981	74	181	315	217	130	80	293	202	52	36	26	20	136	4,274	3.47
1982	23	53	270	265	190	120	197	324	59	41	53	42	137	4,321	3.50
1983	65	83	283	396	221	143	226	303	194	57	46	25	171	5,380	4.36
1984	20	30	57	104	68	100	130	375	234	63	40	35	105	3,320	2.69
1985	49	54	56	80	78	69	231	219	63	63	45	98	93	2,923	2.37
1986	46	99	304	257	169	148	224	319	86	72	114	171	168	5,302	4.30
1987	70	94	169	160	214	164	110	119	58	79	38	33	109	3,441	2.79
1988	33	50	234	127	71	75	633	353	112	65	45	51	155	4,910	3.98
1989	75	46	142	169	110	91	271	198	84	54	44	42	111	3,508	2.84
1990	54	108	338	180	142	106	162	271	115	49	29	164	144	4,535	3.68
1991	91	193	256	339	120	113	163	124	161	49	30	31	139	4,372	3.54
1992	113	140	277	325	217	149	183	364	830	220	162	144	260	8,215	6.66
1993	143	93	246	189	162	193	324	128	102	36	43	26	141	4,440	3.60
1994	36	68	81	180	141	133	485	427	190	69	41	110	165	5,192	4.21
1995	71	132	180	209	136	134	484	352	103	46	33	35	160	5,051	4.10
1996	77	186	357	203	173	263	193	378	115	70	33	25	173	5,469	4.43
1997	25	26	104	172	100	125	213	482	198	112	86	88	145	4,579	3.71
1998	67	282	380	340	161	94	194	98	72	35	24	22	147	4,621	3.75
1999	54	61	92	84	59	58	108	168	122	54	39	25	77	2,430	1.97
2000	50	73	64	76	75	80	195	277	102	44	31	29	92	2,901	2.35
2001	22	21	27	56	65	133	231	219	93	39	28	20	80	2,524	2.05
2002	33	63	94	80	77	103	81	210	123	39	25	21	79	2,490	2.00
2003	17	293	268	176	63	73	122	106	111	36	26	30	109	3,428	2.78
2004	67	83	53	53	84	70	80	113	59	52	36	42	66	2,086	1.69
2005	64	250	284	191	124	112	199	90	74	53	43	32	126	3,958	3.21
2006	64	89	108	106	116	89	206	346	161	44	68	187	133	4,187	3.40
2007	49	80	402	234	161	156	167	127	74	32	22	19	127	4,018	3.26
2008	77	73	92	145	104	203	193	283	103	48	34	84	120	3,794	3.08
2009	61	135	95	155	107	71	121	140	90	37	30	22	88	2,782	2.26
2010	19	157	140	97	121	98	241	355	128	61	30	24	123	3,868	3.14
2011	25	138	210	203	147	111	109	187	266	105	74	43	134	4,239	3.44
Maximum	**156**	**293**	**402**	**396**	**221**	**263**	**633**	**665**	**830**	**220**	**162**	**187**	**260**	**8215**	**6.66**
Minimum	**12**	**21**	**27**	**53**	**53**	**56**	**80**	**90**	**45**	**19**	**15**	**15**	**66**	**2086**	**1.69**
Runoff	**144**	**272**	**375**	**343**	**168**	**207**	**553**	**575**	**785**	**201**	**147**	**172**	**194**	**6129**	**4.97**
Mean	**53**	**100**	**177**	**165**	**119**	**116**	**225**	**264**	**141**	**57**	**41**	**47**	**126**	**3966**	**3.22**

Remarks: Cumecs: Cubic Meters per Second MCM: Million Cubic Meters MAF:Million Acre-Foot

Figure 1: Mean Monthly Flows of Punch River at Rehman Bridge (1960-2011)

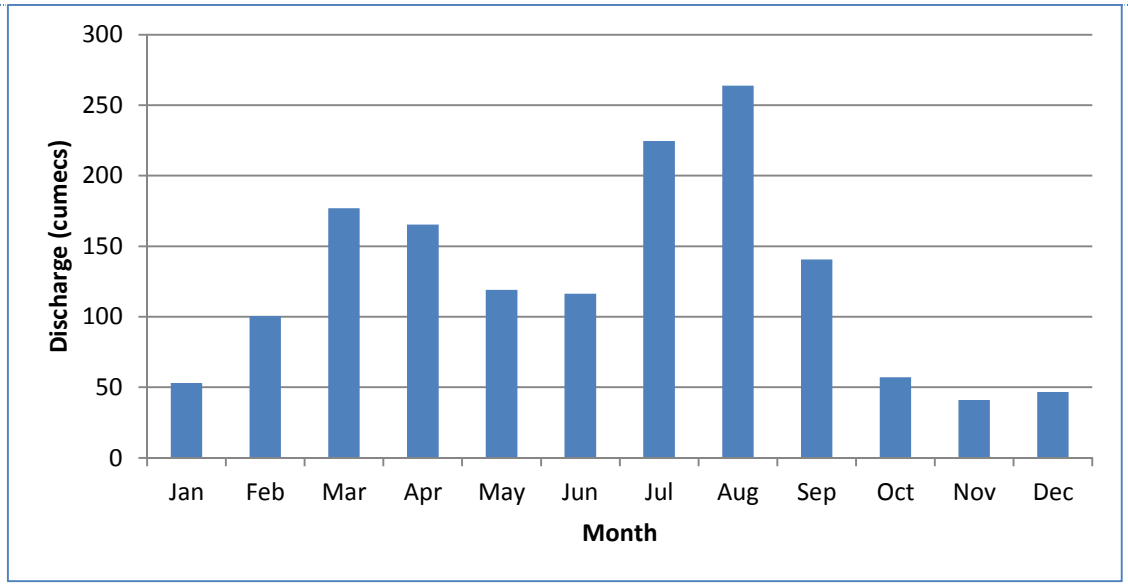


Figure 2: Mean Monthly Runoff of Punch River at Rehman Bridge (1960-2011)

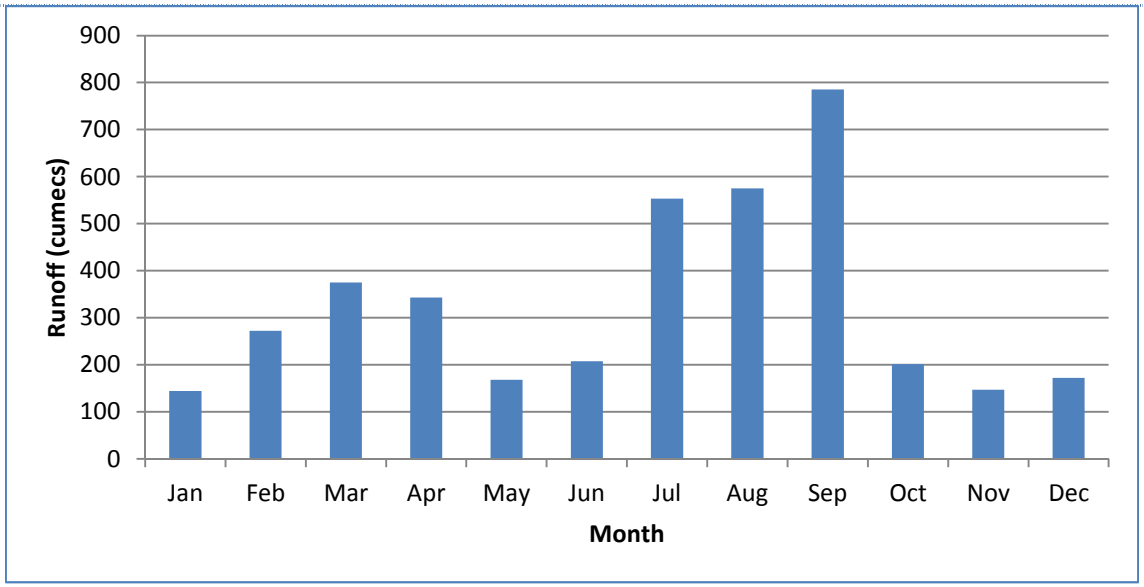
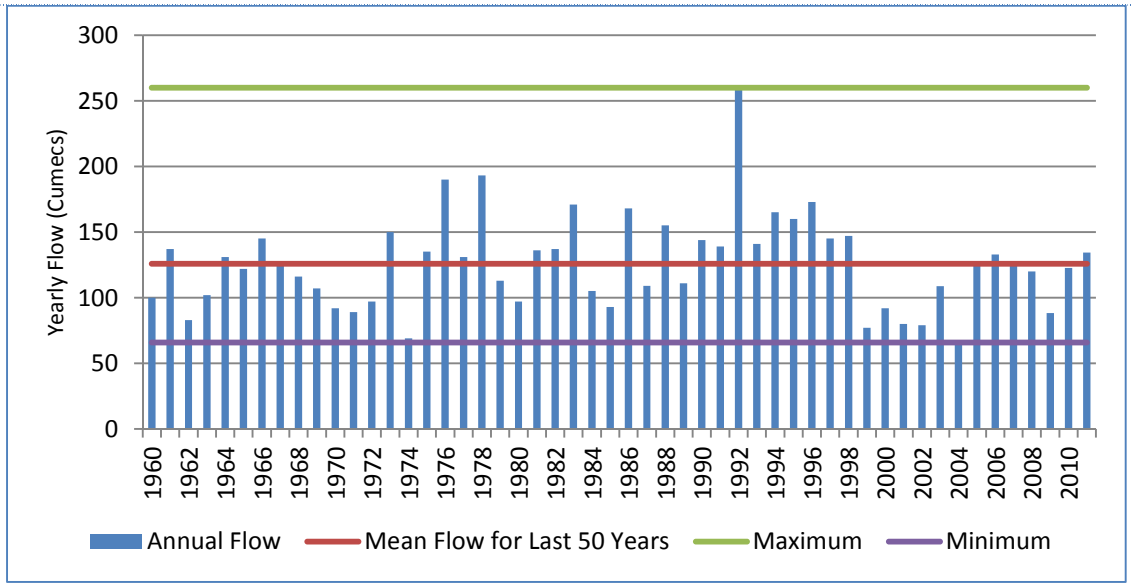


Figure 3: Mean Annual Flows of Punch River at Rehman Bridge (1960-2011)



Mean annual flows also presented in **Table 1** and **Figure 3** show mean annual value of 128 cumecs with corresponding runoff of 4,044 MCM (3.28 MAF). The minimum mean annual flow of 69 cumecs (2,180 MCM) was recorded in 1974 while the maximum mean annual flow of 260 cumecs (8,215 MCM) observed in 1992.

Flow Duration Curve

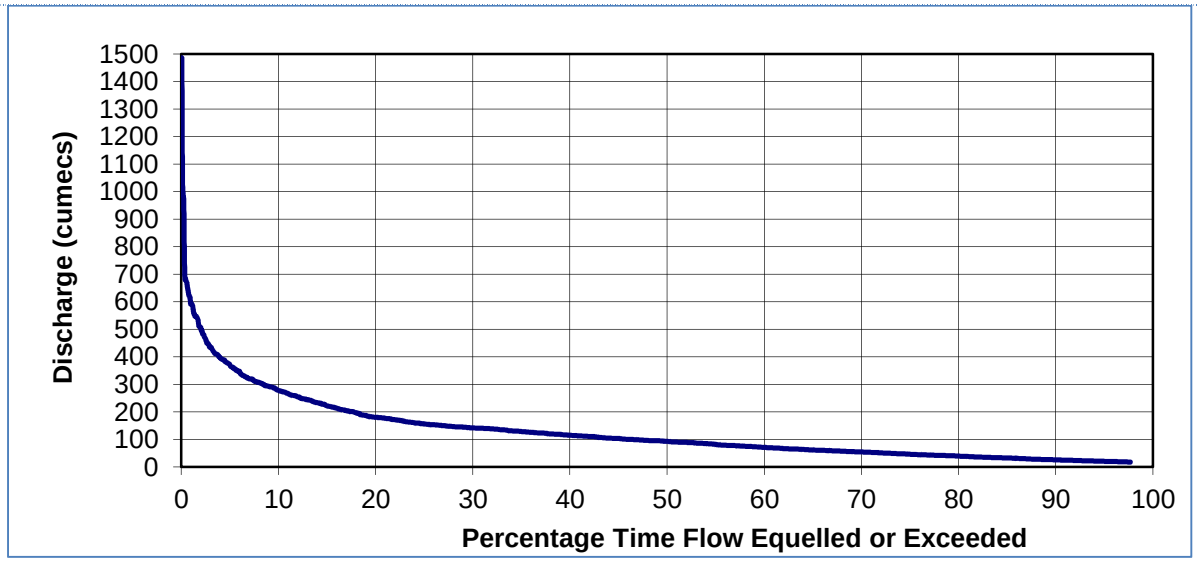
For possible capacity sizing of a power plant a flow duration data is required to represent time variability of water discharge. A flow duration curve represents relationship between magnitude and frequency of daily, 10 daily or monthly stream flows for a particular river basin at a particular

location. This provides estimation of cumulative percentage of time a given streamflow was equaled or exceeded over the given period of time.

In the present study, a flow duration curve has been prepared using 10 daily mean flow time series. The flow duration curve thus developed is presented in **Figure 4**. It can be seen from the curve that flow has following distribution:

Time Exceeded	*10%*	*20%*	*30%*	*40%*	*50%*	*60%*	*70%*	*80%*	*90%*
Flow m^3/s	279	180	142	115	92	71	55	40	26

Figure 4: Flow Duration Curve of Punch River at Rehman Bridge (1960-2002)



Annexure 4: Environmental Monitoring Report

1. Introduction

Sustainable Solutions Pvt. Ltd hired the services of SGS Pakistan (Pvt.) Ltd. to conduct an environmental monitoring at its project sites Azad Jammu & Kashmir. A comprehensive environmental monitoring was conducted at mutually agreed sampling points in the project area. This report is prepared on the basis of assessment conducted at project site. Field survey was carried out on August 26-30, 2013 for ambient air quality monitoring, meteorological conditions, noise level monitoring, lux monitoring and sampling & analysis of drinking water & soil samples from mutually agreed sampling points.

1.1 Study Objectives

The objective of the study is to:

- Comply with the regulatory requirements of the project;
- Monitor air, water, soil, noise level and lux at periodic intervals in project area;
- Ensure effective implementation of EMP.

1.2 Scope of Services

Scope of services covered following main components:

- Ambient Air Quality Monitoring
- Weather Conditions
- Noise Level Monitoring
- Lux Monitoring
- Drinking Water & Soil Sampling & Analysis

1.2.1 Ambient Air Quality Monitoring

In accordance to USEPA National Ambient Air Quality standards (NAAQS) the following priority pollutants were monitored in the ambient air.

- Carbon Monoxide (CO)
- Oxides of Nitrogen (NO_X)
- Sulphur Dioxide (SO_2)
- Particulate Matter (PM_{10})

In addition to above mentioned parameters, the meteorological conditions were also monitored in order to interpret ambient air quality. For the purpose following parameters would be monitored:

- Ambient Temperature
- Relative Humidity
- Barometric Pressure
- Wind Direction
- Wind Velocity

1.2.2 Noise Level Monitoring

Noise level using portable digital sound meter was monitored at same location where the ambient air quality was monitored. The duration of monitoring was according to the standard at sampling points.

1.2.3 Instant Lux Monitoring

Light monitoring was conducted at only one point i.e near community area.

1.2.4 Drinking Water & Soil Sampling

Twenty five drinking water and five soil samples were collected from mutually agreed sampling points and submitted to SGS labs for analysis according to parameters as per contract.

Analysis Parameters and Analysis Methods:

The collected drinking water samples were microbiologically and chemically analyzed according to APHA and USEPA methods.

Table 1a: Drinking Water Analysis Parameters & Methods (Microbiological Analysis)

Sr.#	*Parameters*	*Procedure Reference*
01	Total Coli form	APHA-9222 B
02	Total Colony Count	APHA-9215 B
03	Faecal E. Coli	APHA-9222 D
04	Faecal Streptococci/Enterococci	APHA-9230 C

Table 1b: Drinking Water Analysis Parameters & Methods (Chemical Analysis)

Sr.#	*Parameter*	*Method*	
		Technique	*Reference*
01	pH	Electrometric	APHA-4500H^+ B
02	Total Dissolved Solids (TDS)	Gravimetric	APHA-2540 C
03	Total Hardness	Gravimetric	APHA-2540 C
04	Chloride (Cl)	Titration	APHA-4500Cl^- B
05	Alkalinity, Total as $CaCO_3$	Titration	APHA-2320 B
06	Sulphate (SO_4)	Gravimetric	APHA-4500-SO4 C
07	Sodium (Na)	AAS/ICP-OES	APHA-3111/3120 B
08	Potassium (K)	AAS/ICP-OES	APHA-3111/3120 B
09	Iron (Fe) as Total	AAS/ICP-OES	APHA-3111/3120 B
10	*Arsenic (As)	AAS/ICP-OES	APHA-3111/3120 B
11	Lead (Pb)	AAS/ICP-OES	APHA-3111/3120 B

Table 2: Soil Analysis Parameters & Methods (Chemical Analysis)

Sr.#	*Parameter*	*Method*	
		Technique	*Reference*
01	Sulphate $(SO_4)^{2-}$	Gravimetric	In-House
02	Solids, Total dissolved (TDS)	Gravimetric	In-House
03	Cadmium (Cd)	AAS/ICP-OES	USEPA 3050 B
04	Total Phosphorous	Colorimetric	Based on APHA-4500 P C
05	Chromium Total (Cr)	AAS/ICP-OES	USEPA 3050 B

Sr.#	Parameter	Method	
		Technique	Reference
06	Iron (Fe) as Total	AAS/ICP-OES	USEPA 3050 B
07	Aluminium (Al)	AAS/ICP-OES	USEPA 3050 B
08	Lead (Pb)	AAS/ICP-OES	USEPA 3050 B
09	Total Nitrogen	Instrumental	Based on APHA-4500 N_{org} B

Test conducted at Sub Contracted Lab SGS Karachi.

APHA= American Public Health Association

1.3 Schedule

Detailed Environmental monitoring was conducted at the mutually agreed sites in the project area from August 26-30, 2013.

2. Methodology

Following is the brief description of methodology adopted for this environmental assessment:

2.1 Ambient Air Quality Monitoring

Ambient air quality of the selected locations was monitored for the estimation of carbon monoxide, nitrogen dioxide, sulphur dioxide and particulate matter concentrations.

2.1.1 Carbon Monoxide

Carbon monoxide at the project site was monitored using automatic portable analyzer. Measurement range of the analyzer is 1-100 ppm. Continuous data was recorded for duration of 8 hrs and hourly average is reported.

2.1.2 Nitrogen Dioxide

A measured volume of air is bubbled through a solution sample for duration of 8 hrs. The nitrogen dioxide absorbed in the solution is analyzed by colorimeter for NO2 concentration in ambient air.

2.1.3 Sulphur Dioxide

A measured volume of air is bubbled through a solution sample for 8 hrs duration. The solution after bubbling is analyzed by spectrophotometer and amount of SO2 is calculated.

Table 3: Methodology of Ambient Air Quality Monitoring

Air Pollutant	*Monitoring Technique*	*Method*	*Measurement Range*	*Lowest Detection Limit*
Carbon monoxide (CO)	Automatic Potable Analyzer	40 CFR 50, App. C (US-EPA)	1 -100 ppm	1 ppm
Sulfur Dioxide (SO_2)	Calorimetric Improved West & Gaeke (Sod. Tetrachloro Mercurate) Method	40 CFR 50, App. A (US-EPA)	0.01-0.4 ppm 25 ug/m^3 to 1000 ug/m^3	0.01 ppm
Nitrogen Dioxide (NO_2)	Griess Saltzman Method	ISO 6768	0.01-0.4 ppm 25 ug/m^3 to 1000 ug/m3	0.01 ppm
Particulate Matter (PM_{10})	High Volume PM_{10} Sampler	40 CFR 50, App. J (US-EPA)	2 - 750 ug/m^3	2 ug/m^3

2.1.4 Particulate Matter (PM_{10})

Particulate matter concentration in terms of PM10 was monitored in the ambient air with the help of high Volume PM10 sampler. Measurement range of the equipment is 2-750 u.g/m3 with lowest detection limit of 2 ug/m3. PM 10 sampling was conducted for 24 hours at mutually agreed sampling locations with the help of fibreglass filters. The filters were properly stored and placed in the vacuum desiccators and transported to SGS Pakistan (Pvt) Limited Environmental Laboratory for estimation of PM10.

2.2 Meteorological Conditions

In addition to the mutually agreed parameters for ambient air quality, weather conditions were also monitored continuously for 24 hours with the help of mobile weather station. Selection of sampling points was made considering the wind direction at the mutually agreed sampling site.

2.3 Noise Level Monitoring

24 hours noise level monitoring was conducted at mutually agreed locations using portable Digital Sound Meter. Sound Pressure Level (SPL) measurements (in dB) were performed utilizing Sound Level Meter (European Class 1 Standard) complying with standards IEC60051 TYPE 1 IE60804 TYPE 1 JIS C 1505 in accordance to SGS Standard Operating Procedures (SOP).The Noise level monitoring was conducted at mutually agreed monitoring points.

2.4 Instant Lux Monitoring

Instant Lux level using digital lux meter was monitored at mutually agreed sampling point Instant Lux level measurement was performed according to standard operating procedures and obtained results are attached as Annexure-IV of the report.

2.5 Water

Following methodology was adopted for water sampling and analysis:

2.4.1 Sample Collection and Preservation

The water samples were collected from mutually agreed sampling points based on the sampling technique in accordance to the SOP based on the recognized methods of United State Environmental Protection Agency (USEPA) and American Public Health Association (APHA) for water sampling and analysis. The collected water samples were preserved in appropriate containers as per APHA Guidelines. A shipping container (Ice box with eutectic cold packs instead of ice) with maintained temperature of 4° C ±5 °C was used for transporting the samples from the collection site to the SGS environmental laboratory.

2.4.2 Sample Identification and Chain of Custody

The collected samples were labelled and assigned a unique sample identification number, sampling date and time of collection. All the relevant information (sample location, time of collection, sample identification, temperature, pH, collected by, preservation techniques etc) was recorded immediately on the Chain of Custody form signed by SGS field Analyst.

2.4.3 Analysis Methods

Water & soil samples were collected from mutually agreed locations and were analyzed for parameters using APHA and USEPA methods for water analysis. Detail of parameters and analysis methods are described in 1.2.4 section of the report.

3. Results and Discussion

SGS Pakistan (Pvt.) Ltd. conducted a comprehensive environmental monitoring at mutually agreed sampling points. Scope of this assessment covered monitoring of ambient air quality, weather conditions, noise level monitoring, lux monitoring and sampling and analysis of drinking water & soil from mutually agreed sampling points. The monitoring and analysis results are given as Annexure I to VI.

The results of ambient air quality monitored are given in Annexure-ll of the report. National Environmental Quality Standards (NEQS) for Ambient Air given in Table 4 are used for comparison.

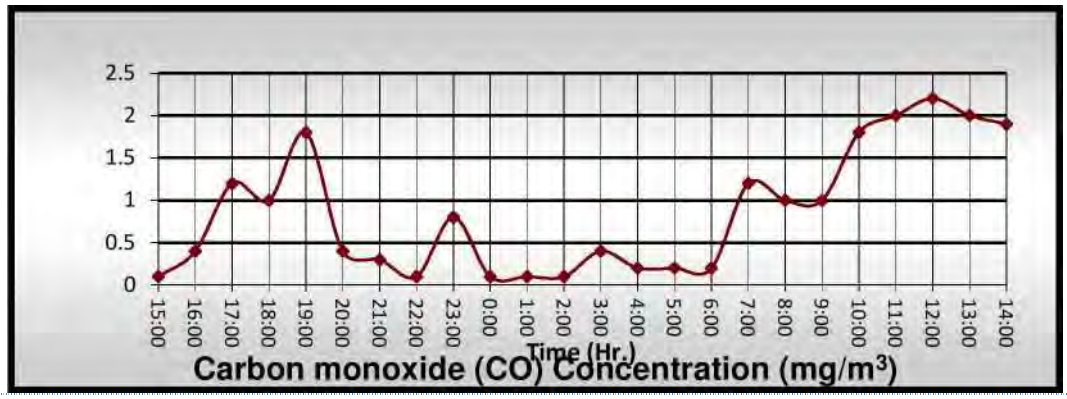
Table 4: National Environmental Quality Standards (NEQS) for Ambient Air

Pollutants	*Time-Weighted Average*	*Effective from 1st July 2010*	*Effective from 1st January 2013*
SO2	Annual Average*	80 ug/m^3	80 ug/m^3
	24 hrs**	120 ug/m^3	120 ug/m^3
NO2	Annual Average*	40 ug/m^3	40 ug/m^3
	24hrs**	80 ug/m^3	80 ug/m^3
Respirable Particulate Matter (PM_{10})	Annual Average*	200 ug/m^3	120 ug/m^3
	24 hrs**	250 ug/m^3	150 ug/m^3
	24 hrs**	40 ug/m^3	35 ug/m^3
Carbon Monoxide (CO)	8hrs**	5 mg/m^3	5 mg/m^3
	1 hr	10 mg/m^3	10 mg/m^3

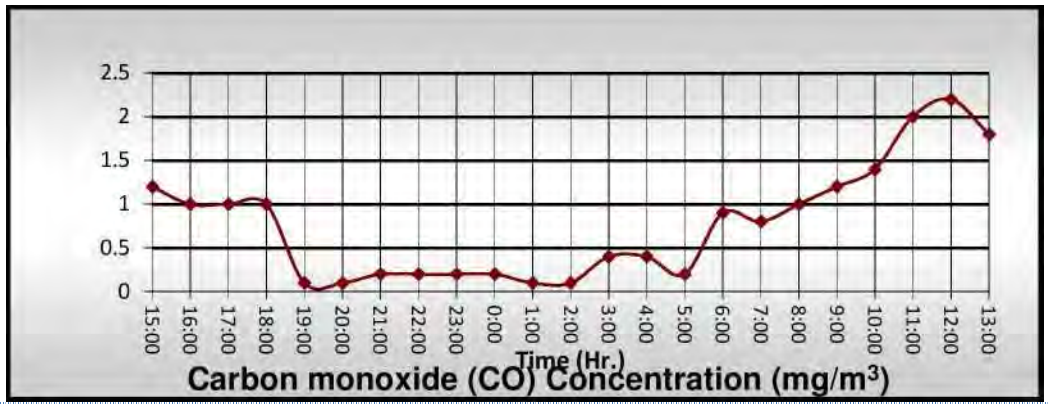
*Annual arithmetic mean of minimum 104 measurements in a year, taken twice a week 24 hourly at uniform interval.

**24 hourly/ 8 hourly values should be met 98% of the year 2% of the time. It may exceed but not on two consecutive days.

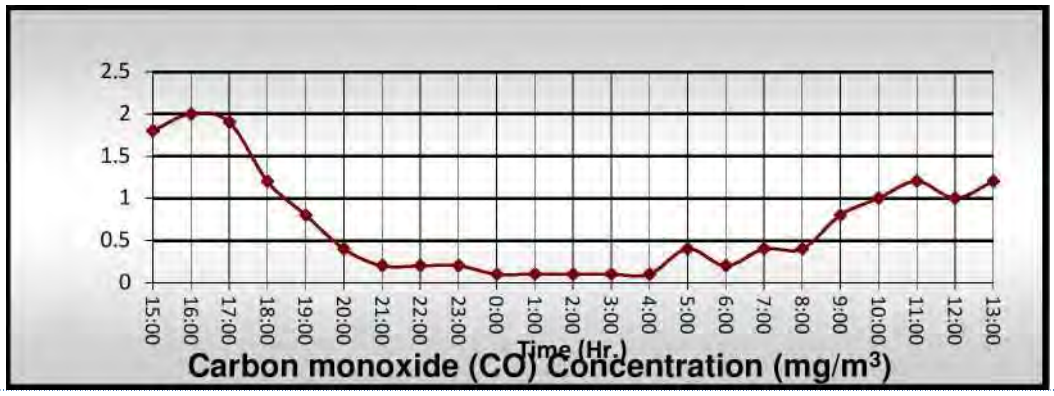
The average concentration of carbon monoxide (CO) for 08 hrs according to the National Environmental Quality Standards (NEQS) for Ambient Air should not exceed from 5.0 mg/m3. The values obtained are in compliance with National Environmental Quality Standards (NEQS). Graph 1, 2, 3 and 4 shows prevailing concentrations of CO in mg/m3 at project site during 24 hrs of monitoring.



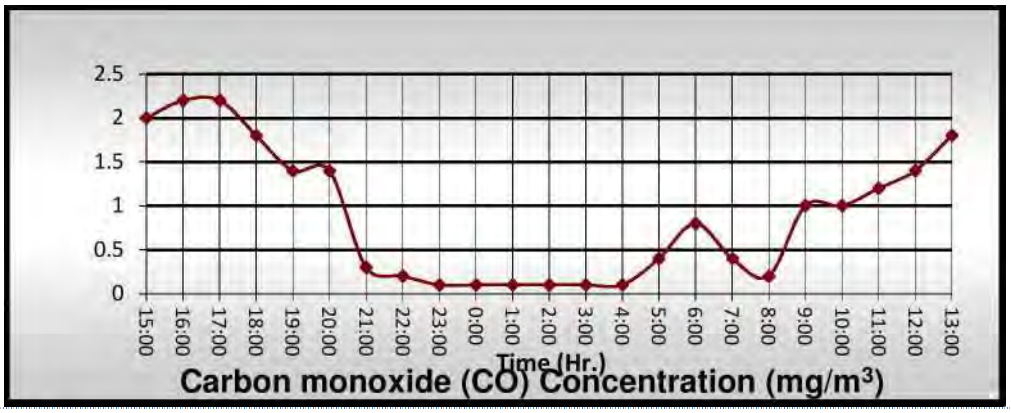
Graph 1: CO Concentration during 24 Hrs. Monitoring at Proposed Power House Site



Graph 2: CO Concentration during 24 Hrs. Monitoring at Proposed Camp Area



Graph 3: CO Concentration during 24 Hrs. Monitoring at Weir Site



Graph 4: CO Concentration during 24 Hrs. Monitoring at Proposed Batching Plant Site

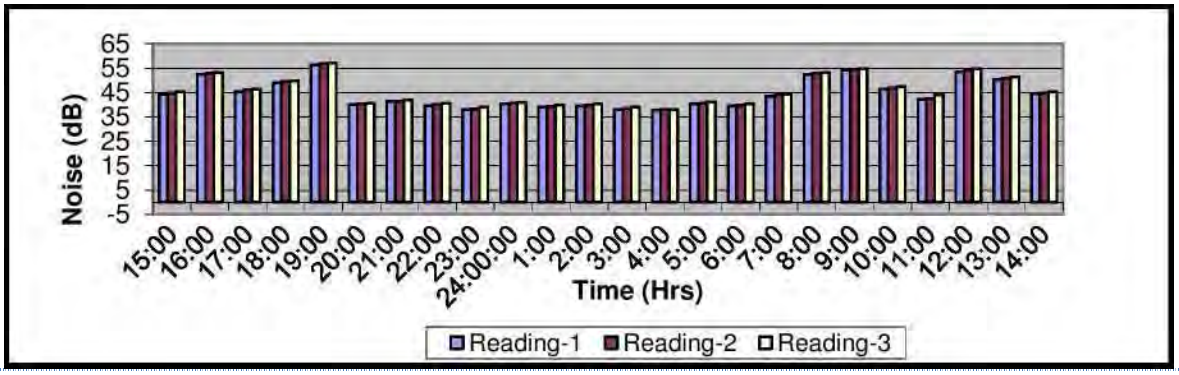
Average 24 hrs concentrations in Environmental Quality Standards (NEQS) for Ambient Air for Nitrogen Dioxide (NO2) is 80 ug/m^3 and average concentrations of Nitrogen Dioxide (NO_2) measured during monitoring were found in compliance with National Environmental Quality Standards. According to standard the 24 hrs concentration of Sulphur Dioxide (SO_2) in ambient air should not exceed from 120 ug/m^3, while concentration obtained was found within limit of National Environmental Quality Standards (NEQS).

The ambient particulate matter PM10 was found 97.14 ug/m^3 at proposed power house site, 87.90ug/m3 at proposed camp area, 75.19 ug/m^3 at proposed weir site and 66.77ug/m3 at proposed batching plant are within standard value of 150 ug/m^3.

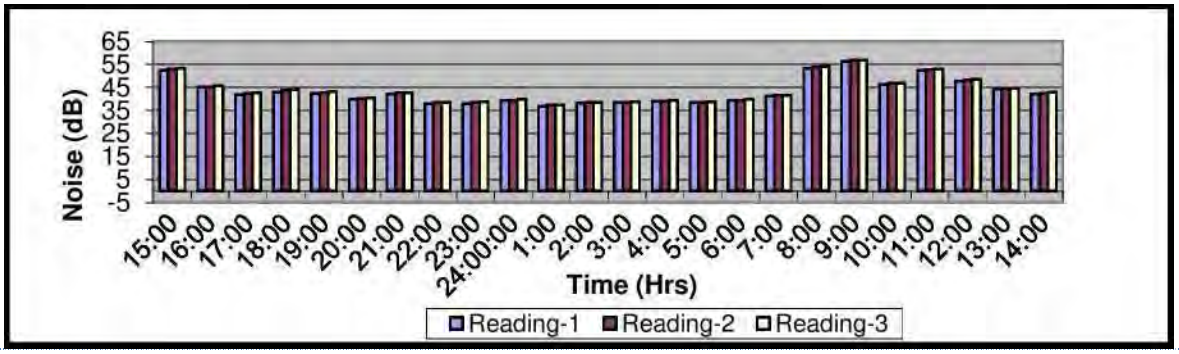
Table 5: Average Obtained Concentrations of Priority Pollutants

Parameter	*Unit*	*LDL*	*Proposed Power House Site*	*Proposed Camp Area*	*Proposed Weir Site*	*Proposed Batching Plant*
Nitrogen Dioxide (NO_2)	ug/m^3	5.0	<5.0	<5.0	<5.0	<5.0
Sulphur Dioxide (SO_2)	ug/m^3	5.0	<5.0	<5.0	<5.0	<5.0
Carbon Monoxide (CO)	mg/m^3	0.01	0.85	0.82	0.72	0.93
Particulate Matter (PM_{10})	ug/m^3	2.00	97.14	87.90	75.19	66.77

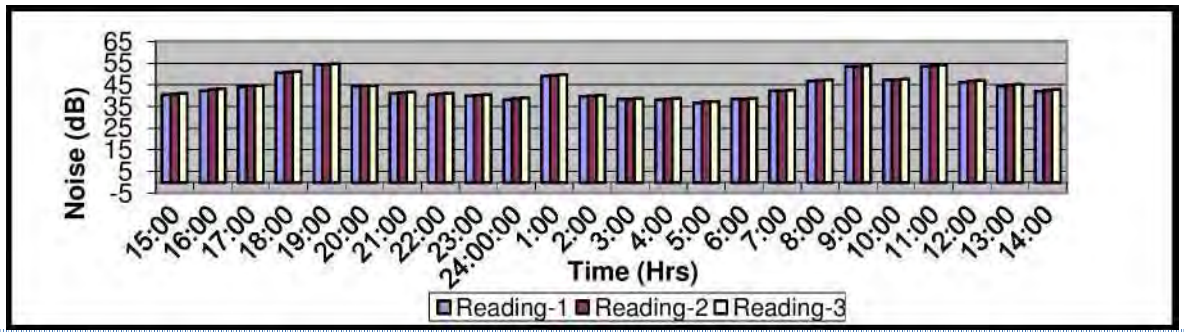
Noise level monitoring was conducted at the same location where the ambient air quality was monitored. Results were attached as Annexure-lll of the report. The noise level was found in range of 59.7 to 68.1 (dB.A) at proposed power house site, 37.0 to 57.0 (dB.A) at proposed camp site, 37.3 to 54.8 (dB.A) at proposed weir site and 35.9 to 48.9 (dB.A) at proposed batching plant. Graph 5, 6, 7 and 8 shows the values obtained during noise level monitoring at project sites respectively.



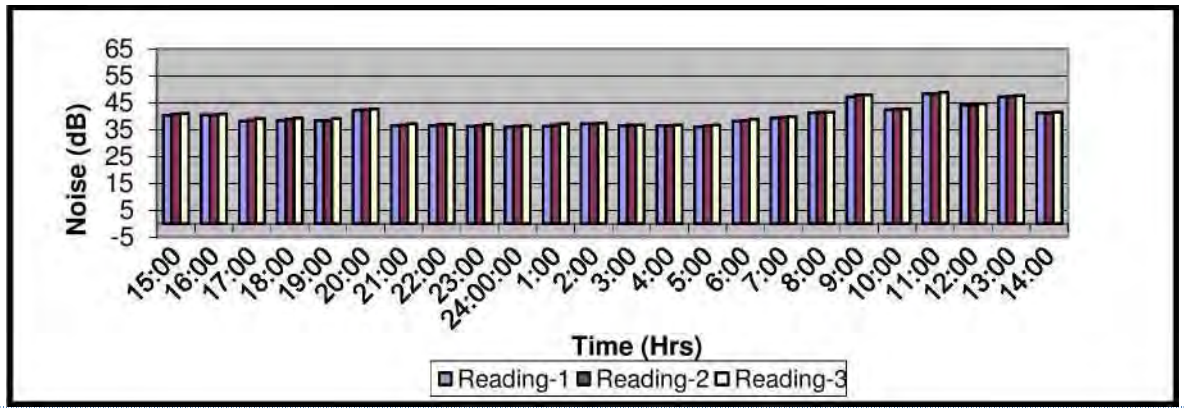
Graph 5: Variation of Noise with Time at Proposed Power house Site



Graph 6: Variation of Noise with Time at Proposed Camp Area



Graph 7: Variation of Noise with Time at Proposed Weir Site



Graph 8: Variation of Noise with Time at Proposed Batching Plant

Lux monitoring was also monitored from mutually agreed source. The monitoring results are tabulated as Annexure-IV.

Twenty five drinking water & five soil samples were also collected and submitted to SGS labs for the analysis as per contract. The analysis results are attached as Annexure -V & Annexure VI of the report.

4. Meteorological Data

4.1 Meteorological Data

- Client : Sustainable Solutions Pvt. Ltd
- Sampling Point : Proposed Power House Site
- Date of Intervention : August 26 & 27, 2013

Time	Temperature	Wind Direction	Wind Speed	Humidity	Barometric Pressure
	°C		m/s	%	mm of Hg
15:00	34	W	5.4	63	742.1
16:00	34	W	4.3	60	742.3
17:00	33	W	4.7	58	741.4
18:00	32	WE	5.9	68	741.8
19:00	30	WE	5	70	741.3
20:00	30	WE	3.8	72	741
21:00	29	W	3	78	742.2
22:00	28	W	4.7	79	742.7
23:00	28	W	5.8	80	742.8
24:00	27	W	5.3	84	742.6
01:00	26	W	4.8	80	742.5
02:00	25	W	4.6	78	742.9
03:00	24	W	4.2	65	742.4
04:00	24	WE	4	63	742
05:00	26	WE	4.8	62	742.1
06:00	26	WE	5.3	60	742.5
07:00	26	WE	4.9	58	742.7
08:00	27	W	4.5	57	742.3
09:00	28	W	3	55	742.4
10:00	30	W	3.8	53	742.7
11:00	30	WE	3.1	52	742.8
12:00	30	WE	3	50	742.6
13:00	33	W	2.9	48	742.8
14:00	33	W	3.8	45	742.9

4.2 Meteorological Data

- Client : Sustainable Solutions Pvt. Ltd
- Sampling Point : Proposed Camp Area
- Date of Intervention : August 27 & 28, 2013

Time	Temperature	Wind Direction	Wind Speed	Humidity	Barometric Pressure
	°C		m/s	%	mm of Hg
15:00	36	W	2.7	52	740.3
16:00	36	W	2.8	55	740.8
17:00	34	W	4.5	54	740.1
18:00	34	WE	4.9	57	741.0
19:00	32	E	5.2	58	741.8
20:00	30	E	5.0	58	741.6
21:00	28	W	4.6	59	741.2
22:00	27	E	3.8	63	742.0
23:00	26	E	2.0	64	742.8
24:00	26	E	1.8	66	741.6
01:00	24	WE	1.8	67	741.5
02:00	24	E	1.3	69	741.1
03:00	23	E	1.0	75	741.7
04:00	22	E	0.8	74	741.3
05:00	20	WE	2.4	78	740.6
06:00	20	W	2.8	78	740.4
07:00	20	W	3.7	82	740.9
08:00	21	W	2.2	80	741.2
09:00	22	WE	4.0	64	741.7
10:00	24	WE	4.3	62	742.0
11:00	26	WE	5.3	60	742.3
12:00	27	W	5.0	55	742.9
13:00	30	W	5.1	52	742.1
14:00	32	W	4.7	50	742.8

4.3 Meteorological Data

- Client : Sustainable Solutions Pvt. Ltd
- Sampling Point : Proposed Weir Site
- Date of Intervention : August 28 & 29, 2013

Time	Temperature	Wind Direction	Wind Speed	Humidity	Barometric Pressure
	°C		m/s	%	mm of Hg
15:00	36	N	5.3	40	742.7
16:00	36	N	4.6	45	742.1
17:00	37	N	5.5	48	742.0
18:00	34	NW	4.0	52	742.5
19:00	33	N	3.8	52	742.9
20:00	30	N	1.0	53	742.8
21:00	27	N	3.2	55	742.7
22:00	26	N	1.8	57	742.6
23:00	25	N	1.4	60	742.3
24:00	24	NW	2.4	61	742.2
01:00	24	NW	2.2	63	742.8
02:00	23	NW	2.0	64	742.4
03:00	23	N	1.7	68	742.6
04:00	22	N	2.8	67	742.0
05:00	22	N	2.2	65	742.3
06:00	22	N	5.0	64	742.8
07:00	24	N	4.2	63	743.3
08:00	28	N	3.9	61	743.2
09:00	31	NE	3.5	59	743.6
10:00	32	NE	3.0	58	743.8
11:00	33	N	4.6	57	743.9
12:00	34	N	5.1	55	744.0
13:00	35	NE	5.4	53	744.5
14:00	36	NE	4.8	52	744.4

4.4 Meteorological Data

- Client : Sustainable Solutions Pvt. Ltd
- Sampling Point : Proposed Batching Plant
- Date of Intervention : August 29 & 30, 2013

Time	Temperature	Wind Direction	Wind Speed	Humidity	Barometric Pressure
	°C		m/s	%	mm of Hg
15:00	37	E	2.8	42	740.8
16:00	36	E	2.4	43	740.0
17:00	36	E	4.5	45	740.4
18:00	33	E	4.3	46	741.0
19:00	30	E	4.0	48	741.3
20:00	29	E	5.2	53	741.9
21:00	28	NE	5.4	56	740.7
22:00	26	NE	4.8	58	740.8
23:00	25	NE	3.1	59	740.6
24:00	24	E	2.0	60	740.9
01:00	23	E	1.9	62	740.2
02:00	22	E	1.4	63	740.5
03:00	21	E	0.9	65	742.8
04:00	20	E	1.8	68	742.3
05:00	22	E	1.2	69	742.7
06:00	24	NE	1.1	66	742.0
07:00	25	NE	2.6	64	741.9
08:00	28	NE	2.8	63	741.8
09:00	29	NE	3.5	60	741.6
10:00	29	E	4.8	57	741.7
11:00	30	E	4.6	56	741.5
12:00	32	E	4.0	55	741.9
13:00	34	E	4.4	54	741.4
14:00	34	E	4.1	52	741.8

5. Ambient Air Quality Monitoring Data

5.1 Ambient Air Quality

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Power House Site
- Date of Intervention : August 26-27, 2013

Parameter	Unit	Duration	LDL	Average Obtained Concentration
Carbon Monoxide (CO)	mg/m^3	24 Hours	0.01	0.85
Nitrogen Dioxide(NO_2)	ug/m^3	24 Hours	5.0	<5.0
Sulfur Dioxide (SO_2)	ug/m^3	24 Hours	5.0	<5.0
Particulate Matter (PM_{10})	ug/m^3	24 Hours	2.00	97.14

ug/m^3: micrograms per cubic meter
mg/m^3: milligram per cubic meter
LDL: Lowest Detection Limit

5.2 Ambient Air Quality

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Camp Area
- Date of Intervention : August 27-28, 2013

• Parameter	Unit	Duration	LDL	Average Obtained Concentration
Carbon Monoxide (CO)	mg/m^3	24 Hours	0.01	0.82
Nitrogen Dioxide(NO_2)	ug/m^3	24 Hours	5.0	<5.0
Sulfur Dioxide (SO_2)	ug/m^3	24 Hours	5.0	<5.0
Particulate Matter (PM_{10})	ug/m^3	24 Hours	2.00	87.90

ug/m^3: micrograms per cubic meter
mg/m^3: milligram per cubic meter
LDL: Lowest Detection Limit

5.3 Ambient Air Quality

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Weir Site
- Date of Intervention : August 28-29, 2013

Parameter	Unit	Duration	LDL	Average Obtained Concentration
Carbon Monoxide (CO)	mg/m^3	24 Hours	0.01	0.72
Nitrogen Dioxide(NO_2)	ug/m^3	24 Hours	5.0	<5.0
Sulfur Dioxide (SO_2)	ug/m^3	24 Hours	5.0	<5.0
Particulate Matter (PM_{10})	ug/m^3	24 Hours	2.00	75.19

ug/m^3: micrograms per cubic meter
mg/m^3: milligram per cubic meter
LDL: Lowest Detection Limit

5.4 Ambient Air Quality

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Batching Plant
- Date of Intervention : August 29-30, 2013

Parameter	Unit	Duration	LDL	Average Obtained Concentration
Carbon Monoxide (CO)	mg/m^3	24 Hours	0.01	0.93
Nitrogen Dioxide(NO_2)	ug/m^3	24 Hours	5.0	<5.0
Sulfur Dioxide (SO_2)	ug/m^3	24 Hours	5.0	<5.0
Particulate Matter (PM_{10})	ug/m^3	24 Hours	2.00	66.77

ug/m^3: micrograms per cubic meter
mg/m^3: milligram per cubic meter
LDL: Lowest Detection Limit

6. Noise Level Monitoring Data

6.1 Noise Level Monitoring

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Powerhouse Site
- Date of Intervention : September 26-27, 2013

Sr.#	Time (Hrs)	Reading 1 (dBA)	Reading 2 (dBA)	Reading 3 (dBA)
1.	15:00	44.2	44.8	45.3
2.	16:00	52.5	52.9	53.3
3.	17:00	45.4	46.0	46.3
4.	18:00	49.1	49.6	49.8
5.	19:00	56.3	56.8	57.1
6.	20:00	40.1	40.4	40.6
7.	21:00	41.3	41.5	41.9
8.	22:00	39.5	40.2	40.6
9.	23:00	38.0	38.3	39.1
10.	24:00	40.3	40.5	40.9
11.	01:00	39.1	39.4	39.8
12.	02:00	39.5	39.9	40.3
13.	03:00	38.0	38.4	39.0
14.	04:00	37.8	38.1	38.0
15.	05:00	40.3	40.6	41.1
16.	06:00	39.5	39.9	40.4
17.	07:00	43.4	43.9	44.3
18.	08:00	52.5	52.9	53.3
19.	09:00	54.1	54.5	54.8
20.	10:00	46.3	46.9	47.4
21.	11:00	42.1	42.5	43.9
22.	12:00	53.5	54.1	54.8
23.	13:00	50.3	50.9	51.4
24.	14:00	44.5	44.8	45.3

6.2 Noise Level Monitoring

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Camp Area
- Date of Intervention : September 27-28, 2013

Sr.#	Time (Hrs)	Reading 1 (dBA)	Reading 2 (dBA)	Reading 3 (dBA)
1.	15:00	52.4	53.0	53.2
2.	16:00	45.1	45.3	45.8
3.	17:00	42.0	42.5	42.6
4.	18:00	43.1	43.8	44.0
5.	19:00	42.5	42.6	43.2
6.	20:00	39.8	40.2	40.4
7.	21:00	42.3	42.6	42.8
8.	22:00	38.1	38.4	38.6
9.	23:00	38.0	38.6	38.7
10.	24:00	39.3	39.4	39.8
11.	01:00	37.0	37.3	37.5
12.	02:00	38.2	38.4	38.6
13.	03:00	38.4	38.5	38.9
14.	04:00	39.0	39.1	39.3
15.	05:00	38.4	38.6	38.8
16.	06:00	39.4	39.5	39.8
17.	07:00	41.2	41.5	41.7
18.	08:00	53.4	53.9	54.1
19.	09:00	56.3	56.9	57.0
20.	10:00	46.4	46.8	46.9
21.	11:00	52.4	52.7	53.0
22.	12:00	47.8	48.3	48.5
23.	13:00	44.3	44.6	44.7
24.	14:00	42.3	42.5	42.9

6.3 Noise Level Monitoring

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Weir Site
- Date of Intervention : September 28-29, 2013

Sr.#	Time (Hrs)	Reading 1 (dBA)	Reading 2 (dBA)	Reading 3 (dBA)
1.	15:00	40.5	40.7	41.0
2.	16:00	42.3	42.8	43.1
3.	17:00	44.1	44.5	44.6
4.	18:00	50.7	50.9	51.3
5.	19:00	54.4	54.5	54.8
6.	20:00	44.3	44.6	44.7
7.	21:00	41.0	41.4	41.6
8.	22:00	40.4	40.8	41.2
9.	23:00	39.8	40.3	40.5
10.	24:00	38.1	38.6	38.9
11.	01:00	49.1	49.4	49.6
12.	02:00	39.5	39.9	40.3
13.	03:00	38.4	38.5	38.7
14.	04:00	38.0	38.4	38.6
15.	05:00	36.7	37.2	37.3
16.	06:00	38.3	38.5	38.8
17.	07:00	42.3	42.4	42.7
18.	08:00	46.7	46.9	47.2
19.	09:00	53.4	53.6	53.9
20.	10:00	47.2	47.3	47.7
21.	11:00	53.4	53.7	54.0
22.	12:00	46.2	46.8	47.1
23.	13:00	44.3	44.9	45.3
24.	14:00	42.1	42.5	42.8

6.4 Noise Level Monitoring

- Client : Sustainable Solutions Pvt. Ltd.
- Sampling Point : Proposed Batching Plant
- Date of Intervention : September 29-30, 2013

Sr.#	Time (Hrs)	Reading 1 (dBA)	Reading 2 (dBA)	Reading 3 (dBA)
1.	15:00	40.3	40.7	41.0
2.	16:00	40.5	40.6	40.8
3.	17:00	38.1	38.7	39.2
4.	18:00	38.5	38.9	39.4
5.	19:00	38.3	38.5	39.1
6.	20:00	42.3	42.5	42.7
7.	21:00	36.4	36.8	37.1
8.	22:00	36.5	36.9	37.0
9.	23:00	36.3	36.5	37.0
10.	24:00	35.9	36.2	36.5
11.	01:00	36.2	36.8	37.1
12.	02:00	37.1	37.2	37.5
13.	03:00	36.5	36.7	36.8
14.	04:00	36.4	36.6	36.8
15.	05:00	36.0	36.4	36.7
16.	06:00	38.2	38.5	38.9
17.	07:00	39.4	39.7	39.9
18.	08:00	41.2	41.4	41.5
19.	09:00	47.2	47.9	47.9
20.	10:00	42.4	42.6	42.8
21.	11:00	48.4	48.5	48.9
22.	12:00	44.2	44.2	44.7
23.	13:00	47.3	47.5	47.8
24.	14:00	41.2	41.3	41.6

7. Instant Lux Monitoring

7.1 Light Monitoring Report

- Client : Sustainable Solutions Pvt. Ltd.
- Monitoring Date : August 30, 2013
- Place of Intervention : Kotli Azad Jammu & Kashmir

Sr. #	Sampling Point	Method / Technique	Unit	Results
01.	Near Community Area	Illuminance Meter	LUX	1165

8. Water Analysis Report

8.1a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): M.Asif S/O M. Sadiq (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$2.9x10^5$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	8
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	4

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.1b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): M.Asif S/O M. Sadiq (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.57	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	427.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	346.5	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	324.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	29.35	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	27.16	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.022	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	31.10	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.52	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.2a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mr. Abdullah S/O M. Hussain (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.6x10^3$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	2
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	Absent

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.2b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mr. Abdullah S/O M. Hussain (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.61	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	410.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	356.4	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	313.2	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	24.46	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	23.87	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.037	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.02	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	31.94	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.515	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.3a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mr. Waseem S/O Abdul Karim (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$2.1x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	6
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	2

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.3b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mr. Waseem S/O Abdul Karim (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.64	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	424.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	366.3	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	324.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	29.35	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	27.16	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.061	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.033	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	32.76	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.619	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.4a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mr. lrshad S/O M. Nazir (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.7x10^5$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	7
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	1

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.4b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mr. lrshad S/O M. Nazir (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.58	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	726.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	514.8	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	486.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	53.81	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	53.50	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.061	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	<0.02	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	82.12	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	9.282	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.5a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mr. Afaq S/O Mr. Haider (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$3.9x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	58
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	Absent

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.5b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mr. Afaq S/O Mr. Haider (Gulhar Colony)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.55	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	701.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	475.2	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	464.4	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	48.92	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	61.17	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.052	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	81.28	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	8.716	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.6a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Barali Spring
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$2.9x10^5$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	56
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	41
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	Absent

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.6b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Barali Spring
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.66	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	640.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	405.9	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	486.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	19.56	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	41.57	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.027	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.033	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	83.76	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	3.869	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.7a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Barali (Spring Neeara)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$4.2x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	49
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	2

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.7b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Barali (Spring Neeara)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.70	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	618.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	425.7	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	507.6	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	19.56	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	47.33	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.041	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	83.60	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	3.805	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.8a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Dharang Spring
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$2.8x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	79
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	2
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	16

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.8b CHEMICAL LABORATORY TEST REPORT

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Dharang Spring
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.68	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	832.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	356.4	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	378.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	127.19	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	171.63	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.021	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	0.034	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.700	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	191.85	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	7.026	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.9a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): M. Shafiq S/O M. Usman (Dharang)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$7.3x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	64
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	12

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.9b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): M. Shafiq S/O M. Usman (Dharang)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.79	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	716.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	504.9	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	399.6	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	58.70	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	49.39	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.052	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.038	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	56.64	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.995	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.10a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mr. Haider S/O M. Abdullah (Dharang)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.5x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	37
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	8

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.10b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mr. Haider S/O M. Abdullah (Dharang)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.81	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	698.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	495.0	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	378.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	53.81	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	51.45	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.025	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.029	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	57.06	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	5.00	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.11a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mandi Juzvi (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.1x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	45
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	11

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.11b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mandi Juzvi (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.69	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	595.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	455.4	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	351.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	44.02	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	48.56	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.040	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.075	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	47.74	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.912	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.12a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mandi Juzvi (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$9.9x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	52
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	24

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.12b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mandi Juzvi (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.16	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	590.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	455.4	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	356.4	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	39.13	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	59.68	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.038	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	48.0	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.778	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.13a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Mandi Juzvi (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$9.1x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	48
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	48

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.13b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Mandi Juzvi (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.17	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	600.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	455.4	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	351.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	44.02	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	59.68	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.021	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	48.06	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.775	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.14a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Hill Kalan (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.1x10^5$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	70
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	12
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	48

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.14b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Hill Kalan (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.72	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	601.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	485.10	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	351.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	44.02	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	56.38	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.041	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.033	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	48.20	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.798	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.15a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Hill Kalan (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$6.2x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	74
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	18

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.15b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Hill Kalan (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.80	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	580.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	435.6	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	340.2	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	44.02	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	52.27	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.546	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	47.84	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.753	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.16a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Hill Kalan (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.4x10^5$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	65
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	6
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	12

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.16b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Hill Kalan (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.80	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	590.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	504.9	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	334.8	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	39.13	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	51.45	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.026	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	47.66	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.763	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.17a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Hill Khurd (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$1.1x10^5$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	55
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	4
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	14

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.17b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Hill Khurd (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.45	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	589.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	485.10	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	351.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	44.02	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	46.51	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.080	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.024	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	48.46	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.784	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.18a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Hill Khurd (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$9.5x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	57
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	40

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.18b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Hill Khurd (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.62	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	866.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	346.50	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	361.8	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	132.08	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	171.22	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.023	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	0.018	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.333	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	190.95	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	6.358	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.19a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Hill Khurd (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$8.3x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	63
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	18
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	22

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.19b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Hill Khurd (Spring Water)
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.67	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	602.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	485.10	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	351.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	44.02	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	51.45	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.040	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.028	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	47.50	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	4.774	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.20a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Jamal Pur
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$3.9x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	TNTC
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	16

cfu: colony forming unit TNTC: Too Numerous To Count

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.20b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Jamal Pur
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.83	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	498.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	386.10	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	324.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	24.46	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	25.51	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.021	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.027	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	31.10	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.710	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.21a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Jamal Pur
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$4.3x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	14
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	Absent
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	62

cfu: colony forming unit

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.21b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Jamal Pur
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.52	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	494.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	405.9	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	329.4	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	24.46	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	22.63	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.101	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.030	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	32.28	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.710	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.22a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Jamal Pur
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$4.9x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	TNTC
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	24
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	50

cfu: colony forming unit TNTC: Too Numerous To Count

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.22b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Jamal Pur
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.67	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	508.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	366.30	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	313.2	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	29.35	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	24.28	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.021	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.039	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	32.20	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.708	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.23a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Aghar Colony
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$6.5x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	TNTC
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	40
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	68

cfu: colony forming unit TNTC: Too Numerous To Count

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.23b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Aghar Colony
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.63	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	508.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	396.0	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	324.0	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	19.56	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	23.87	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	0.041	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.038	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	33.92	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.690	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.24a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Aghar Colony
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$4.2x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	TNTC
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	34
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	44

cfu: colony forming unit TNTC: Too Numerous To Count

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.24b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Aghar Colony
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.80	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	506.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	386.10	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	334.8	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	29.35	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	20.58	NS
07	Lead (Pb) $^{+2}$	APHA-3111 B	mg/L	0.01	0.041	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.029	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	31.24	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.670	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

8.25a Microbiological Analysis Report

- Job No: ENV- LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample: Drinking Water
- Marking (If Any): Aghar Colony
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr.#	Parameter	Procedure	Permissible Limits	Results
01	Total Colony Count	APHA: 9215 B	< 500 cfu / ml	$4.3x10^4$
02	Total Coli Forms	APHA: 9222 B	0 cfu / 100ml	TNTC
03	Faecal Coli Forms (E.Coli)	APHA: 9222 D	0 cfu / 100ml	58
04	Faecal Streptococci/ Enterococci	APHA: 9230 C	0 cfu / 100ml	30

cfu: colony forming unit TNTC: Too Numerous To Count

NOTE:

WHO/USEPA Guidelines for Drinking Water states that Total or Faecal Coli forms must be absent and are not tolerated in Potable water.

8.25b Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address: Sustainable Solutions Pvt. Ltd Peshawar
- Description of Sample: Drinking Water
- Marking (If Any): Aghar Colony
- No. of sample: 01
- Sample Condition upon Receipt: Satisfactory
- Sample Collection Date: 30-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results	Limits As Per NEQS
01	pH @ 25 °C	APHA-4500H^+ B	-	0.1	7.81	6.5-8.5
02	Solids, Total dissolved (TDS)	APHA-2540 C	mg/L	5.0	494.0	<1000
03	Hardness, Total as $CaCO_3$	APHA-2340 B & C	mg/L	0.5	386.10	<500
04	Alkalinity, Total as CaCO3	APHA-2320 B	mg/L	0.5	334.8	NS
05	Chloride $(Cl)^{-1}$	APHA-4500Cl^- B	mg/L	0.5	24.46	<250
06	Sulfate $(SO4)^{-2}$	APHA-4500-SO_4 C	mg/L	5.0	23.46	NS
07	Lead (Pb $)^{+2}$	APHA-3111 B	mg/L	0.01	<0.01	≤0.05
08	Arsenic $(As)^{+3}$	APHA-3120 B	mg/L	0.005	< 0.005	0.01
09	Total Iron as $(Fe)^{+3/+2}$	APHA-3111 B	mg/L	0.02	0.046	NS
10	Sodium $(Na)^{+1}$	APHA-3111 B	mg/L	1.0	31.50	NS
11	Potassium $(K)^{+1}$	APHA-3111 B	mg/L	0.2	2.69	NS

REMARKS: LDL: Lowest Detection Limit NS: Not Specified

9. Analysis Report

9.1 Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address : Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample : Soil Sample
- Marking (If Any): (Barali)
- No. of sample: 01
- Sample Condition Upon Receipt: Satisfactory
- Sample Collection Date: 29-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results
1.	Total Nitrogen (TKN)	Based on APHA-4500 N_{org} B	mg/kg	0.1	1.53
2.	Total Phosphorous	Based on APHA-4500 P C	mg/kg	0.05	2.0
3.	Cadmium $(Cd)^{+2}$	USEPA 3050 B	mg/kg	0.50	3.55
4.	Total Chromium (Cr)	USEPA 3050 B	mg/kg	0.50	19.32
5.	Lead $(Pb)^{+2}$	USEPA 3050 B	mg/kg	0.50	75.16
6.	Total Iron as $(Fe)^{+3/+2}$	USEPA 3050 B	mg/kg	0.02	27153.91
7.	Aluminium $(Al)^{+2}$	USEPA 3050 B	mg/kg	0.5	<0.5
8.	Sulfate $(SO4)^{-2}$	In-House /Gravimetric	mg/kg	5.0	*
9.	Total Dissolved Solids (TDS)	In-House /Gravimetric	mg/kg	5.0	*

Remarks: LDL: Lowest Detection Limit <: Less Than. *: Result Will Follow Soon

9.2 Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address : Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample : Soil Sample
- Marking (If Any): (Gulhar)
- No. of sample: 01
- Sample Condition Upon Receipt: Satisfactory
- Sample Collection Date: 29-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results
1.	Total Nitrogen (TKN)	Based on APHA-4500 N_{org} B	mg/kg	0.1	3.02
2.	Total Phosphorous	Based on APHA-4500 P C	mg/kg	0.05	1.72
3.	Cadmium $(Cd)^{+2}$	USEPA 3050 B	mg/kg	0.50	<0.50
4.	Total Chromium (Cr)	USEPA 3050 B	mg/kg	0.50	15.76
5.	Lead $(Pb)^{+2}$	USEPA 3050 B	mg/kg	0.50	95.19
6.	Total Iron as $(Fe)^{+3/+2}$	USEPA 3050 B	mg/kg	0.02	21934.86
7.	Aluminium $(Al)^{+2}$	USEPA 3050 B	mg/kg	0.5	<0.5
8.	Sulfate $(SO4)^{-2}$	In-House /Gravimetric	mg/kg	5.0	*
9.	Total Dissolved Solids (TDS)	In-House /Gravimetric	mg/kg	5.0	*

Remarks: LDL: Lowest Detection Limit <: Less Than. *: Result Will Follow Soon

9.3 Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address : Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample : Soil Sample
- Marking (If Any): (Mandi Juzvi)
- No. of sample: 01
- Sample Condition Upon Receipt: Satisfactory
- Sample Collection Date: 29-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results
1.	Total Nitrogen (TKN)	Based on APHA-4500 N_{org} B	mg/kg	0.1	1.86
2.	Total Phosphorous	Based on APHA-4500 P C	mg/kg	0.05	2.60
3.	Cadmium $(Cd)^{+2}$	USEPA 3050 B	mg/kg	0.50	<0.50
4.	Total Chromium (Cr)	USEPA 3050 B	mg/kg	0.50	25.27
5.	Lead $(Pb)^{+2}$	USEPA 3050 B	mg/kg	0.50	77.76
6.	Total Iron as $(Fe)^{+3/+2}$	USEPA 3050 B	mg/kg	0.02	25545.50
7.	Aluminium $(Al)^{+2}$	USEPA 3050 B	mg/kg	0.5	<0.5
8.	Sulfate $(SO4)^{-2}$	In-House /Gravimetric	mg/kg	5.0	*
9.	Total Dissolved Solids (TDS)	In-House /Gravimetric	mg/kg	5.0	*

Remarks: LDL: Lowest Detection Limit <: Less Than. *: Result Will Follow Soon

9.4 Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address : Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample : Soil Sample
- Marking (If Any): (Jamal Pur)
- No. of sample: 01
- Sample Condition Upon Receipt: Satisfactory
- Sample Collection Date: 29-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results
1.	Total Nitrogen (TKN)	Based on APHA-4500 N_{org} B	mg/kg	0.1	1.38
2.	Total Phosphorous	Based on APHA-4500 P C	mg/kg	0.05	2.60
3.	Cadmium $(Cd)^{+2}$	USEPA 3050 B	mg/kg	0.50	<0.50
4.	Total Chromium (Cr)	USEPA 3050 B	mg/kg	0.50	28.65
5.	Lead $(Pb)^{+2}$	USEPA 3050 B	mg/kg	0.50	100.90
6.	Total Iron as $(Fe)^{+3/+2}$	USEPA 3050 B	mg/kg	0.02	26119.6
7.	Aluminium $(Al)^{+2}$	USEPA 3050 B	mg/kg	0.5	<0.5
8.	Sulfate $(SO4)^{-2}$	In-House /Gravimetric	mg/kg	5.0	*
9.	Total Dissolved Solids (TDS)	In-House /Gravimetric	mg/kg	5.0	*

Remarks: LDL: Lowest Detection Limit <: Less Than. *: Result Will Follow Soon

9.5 Chemical Laboratory Test Report

- Job No: ENV - LHR - 495 / 2013
- Client Name / Address : Sustainable Solutions Pvt. Ltd Peshawar
- Description Of Sample : Soil Sample
- Marking (If Any): (Weir Site)
- No. of sample: 01
- Sample Condition Upon Receipt: Satisfactory
- Sample Collection Date: 29-08-13
- Environmental Conditions: Temperature: NA Humidity: NA

Sr. #	Parameters	Method	Unit	LDL	Test Results
1.	Total Nitrogen (TKN)	Based on APHA-4500 N_{org} B	mg/kg	0.1	1.80
2.	Total Phosphorous	Based on APHA-4500 P C	mg/kg	0.05	2.36
3.	Cadmium $(Cd)^{+2}$	USEPA 3050 B	mg/kg	0.50	<0.50
4.	Total Chromium (Cr)	USEPA 3050 B	mg/kg	0.50	26.11
5.	Lead $(Pb)^{+2}$	USEPA 3050 B	mg/kg	0.50	76.69
6.	Total Iron as $(Fe)^{+3/+2}$	USEPA 3050 B	mg/kg	0.02	25842.05
7.	Aluminium $(Al)^{+2}$	USEPA 3050 B	mg/kg	0.5	<0.5
8.	Sulfate $(SO4)^{-2}$	In-House /Gravimetric	mg/kg	5.0	*
9.	Total Dissolved Solids (TDS)	In-House /Gravimetric	mg/kg	5.0	*

Remarks: LDL: Lowest Detection Limit <: Less Than. *: Result Will Follow Soon

10. Standards

10.1 National Environmental Quality Standards (NEQS) for Ambient Air

Concentration in Ambient Air

Pollutants	Time-Weighted Average	Effective from 1st July 2010	Effective from 1st January 2013	Method of measurement
SO_2	Annual Average*	80 ug/m^3	80 ug/m^3	-Ultraviolet Fluorescence Method
	24 hrs**	120 ug/m^3	120 ug/m^3	
NO	Annual Average*	40 ug/m^3	40 ug/m^3	Gas Phase Chemiluminescence
	24 hrs**	40 ug/m^3	40 ug/m^3	
NO_2	Annual Average*	40 ug/m^3	40 ug/m^3	Gas Phase Chemiluminescence
	24 hrs**	80 ug/m^3	80 ug/m^3	
O_3	1 hr	180 ug/m^3	130 ug/m^3	Non Dispersive UV Absorption Method
Suspended Particulate Matter (SPM)	Annual Average*	400 ug/m^3	360 ug/m^3	High Volume Sampling (average flow rate not less than 1.1 m3/minute)
	24 hrs**	550 ug/m^3	500 ug/m^3	
Respirable Particulate Matter (PM_{10})	Annual Average*	200 ug/m^3	120 ug/m^3	-β Ray Absorption Method
	24 hrs**	250 ug/m^3	150 ug/m^3	
Respirable Particulate Matter ($PM_{2.5}$)	Annual Average*	25 ug/m^3	15 ug/m^3	-β Ray Absorption Method
	24 hrs**	40 ug/m^3	35 ug/m^3	
	1 hr	25 ug/m^3	15 ug/m^3	
Lead (Pb)	Annual Average*	1.5 ug/m^3	1 ug/m^3	ASS Method after sampling using EPM 2060 or equivalent Filter paper
	24 hrs**	2 ug/m^3	1.5 ug/m^3	
Carbon Monoxide (CO)	8hrs**	5 ug/m^3	5 ug/m^3	Non Dispersive Infra Red (NDIR) Method
	1 hr	10 ug/m^3	10 ug/m^3	

*Annual arithmetic mean of minimum 104 measurements in a year, taken twice a week 24 hourly at uniform interval.

**24 hourly/ 8 hourly values should be met 98% of the in a year 2% of the time. It may exceed but not on two consecutive days.

Standards for Drinking Water (Bacterial)

Properties/ parameters	Standard values for Pakistan	Who Standards	Remarks
All water intended for drinking (e. Coli or Thermo tolerant Coliform Bacteria)	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample	Most Asian countries also follow WHO standards
Treated water entering the distribution system (e. Coli or Thermo tolerant Coliform and total Coliform Bacteria)	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample	Most Asian countries also follow WHO standards
Treated water in the distribution system (e. Coli or Thermo tolerant Coliform and total Coliform Bacteria)	Must not be detectable in any 100 ml sample. In case of large supplies where sufficient samples are examined, must not be present in 95% of the samples taken through out any 12-month period	Must not be detectable in any 100 ml sample. In case of large supplies where sufficient samples are examined, must not be present in 95% of the samples taken through out any 12-month period	Most Asian countries also follow WHO standards

National Standards for Drinking Water

Properties/ parameters	Standard values for Pakistan	Who Standards	Remarks
Physical			
Colour	< 15 TCU	< 15 TCU	
Taste	Non objectionable /Acceptable	Non objectionable /Acceptable	
Odour	Non objectionable /Acceptable	Non objectionable /Acceptable	
Turbidity	<5NTU	<5NTU	
Total Hardness as CaCO3	< 500mg/l		
TDS	<1000	<1000	
pH	6.5-8.5	6.5-8.5	
Chemical			
Essential Inorganic	**mg/Litre**	**mg/Litre**	
Aluminium (Al)	<0.2	0.2	
Antimony (Sb)	< 0.005 (P)	0.2	
Arsenic (As)	< 0.05 (P)	0.01	Standards for Pakistan similar to most Asian developing countries
Barium (Ba)	0.7	0.7	
Boron (B)	0.3	0.3	
Cadmium (Cd)	0.01	0.003	Standards for Pakistan similar to most Asian developing countries
Chloride (Cl)	<250	250	
Chromium (Cr)	<0.05	0.05	
Copper (Cu)	2	2	
Toxic inorganic			
Cyanide (CN)	<0.05	0.07	Standards for Pakistan similar to most Asian developing countries
Fluoride (F)*	<1.5	1.5	
Lead (Pb)	<0.05	0.01	
Manganese (Mn)	<0.5	0.5	
Mercury (Hg)	< 0.001	0.001	
Nickel (Ni)	<0.02	0.02	
Nitrate (NO3)	<50	50	
Nitrite (NO2)	<3(P)	3	
Selenium (Se)	0.01 (P)	0.01	
Residual Chlorine	0.2-0.5 at consumer end 0.5-1.5 at source		
Zinc (Zn)	5.0	3	Standards for Pakistan similar to most Asian developing countries
Organic			

Pesticides mg/L		PSQCA No. 4639-2004. Page No. 4 Table No. 3 Serial No. 20-58 may be Consulted***	Annex II
Penolic Compounds (as Phenols) mg/L		< 0.002	
Polynuclear aromatic hydrocarbons (as PAH) g/L		0.01 (by GC/MS method)	
Radio Active			
Alpha Emitters bq/L or pCi	0.1	0.1	
Beta Emitters	1	1	

Annexure 5A: Species Checklist and Auxiliary Data

Exhibit 5A.1: The Chorotypes assigned to the respective species and their symbols

Kingdom	*Origin*	*Symbol Used*
Holarctic/Circumpolar	Eurasian	EURAS
	Irano-Turanian Pamir High mountain sub-group of IRAN	IRAN PAMIR
	Centralasiatic	CAS
	Eastasiatic or Sino-Japanese	EAS
	Southeast Asiatic	SE.AS
	Himalayan	HIMAL
	West Himalayan	W.HIM
	Endemic	ENDEM
	Tibetan	TIBET
Tropical	Indian	INDIAN
	Indo-Malayan	INMAL
	Subtropical	SUBTR
	Tropical	TROP
-	Introduced or Cultivated	INTR
	Cosmopolitan	COSMO

Exhibit 5A.2: The number of GCPs used to map the respective landcover class

S. No	*Landcover*	*Code*	*No of GCPs*
1	Agriculture	AGR	300
2	Riverine	RIV	80
3	Open areas	OPA	68
4	Settlements	SET	87
5	Broadleave (Sparse)	BLS	182
6	Broadleave (Medium)	BLM	78
7	Broadleave (Dense)	BLD	39
8	Conifer (Sparse)	CNS	123
9	Conifer (Medium)	CNM	34
10	Conifer (Dense)	CND	29
Grand Total			1020

Exhibit 5A.3: List of plant species found in the area

GROUP
Family
Species

MON
Araceae
Sauromatum venosum (Aiton) Kunth
Cyperaceae

Cyperus niveus Retz.
Cyperus rotundus L.
Eriophorum comosum (Wallich) Nees
Liliaceae
Agave cantula Roxb.
Asparagus adscendens Roxb.
Orchidaceae
Harbennaria digitata Lidle.
Poaceae
Apluda mutica var. mutica L.
Arundo donax L.
Bothriochloa pertusa (L.) A. Camus
Brachiaria ramosa (Linn) Stapf
Cenchrus ciliaris L.
Cenchrus pennisetiformis Hochst & Steud
Chrysopogan serrulatus Trin
Cynodon dactylon (L.) Pers.
Desmostachya bipinnata (L.) Stapf
Dichanthium annulatum (Forssk.) Stapf
Digitaria bicornis (Lamk.) Roem & Schult. ex Loud
Echinochloa colona (L.) Link
Eragrostis poaeoides Beauvois
Heteropogon contortus (L.) Beauvois ex Roemer & Schultes
Imperata cylindrica var. cylindrica (L.) Beauvois
Paspalidium flavidum (Retz.) A. Camus
Phragmites karka (Retz.) Trin. ex Steudel
Poa annua L.
Polypogon monspeliensis (L.) Desf.
Setaria glauca (L.) Beauvois
Sorghum halepense (L.) Beauvois
Zea mays L.
ANG
Acanthaceae
Barleria cristata L.
Dicliptera roxburghiana Nees in Wall.
Justicia adhatoda L.
Amaranthaceae
Achyranthes aspera L.
Amaranthus viridis L.
Pupalia lappacea (Linn.) Juss.
Anacardiaceae
Mangifera indica L.
Apiaceae
Unknown 1
Unknown 2
Apocynaceae
Carissa opaca Stapf ex. Haines
Nerium indicum Miller
Asclepiadaceae

Calotropis procera (Aiton) Dryand.
Cynanchum atratum Bunge
Periploca aphylla subsp. aphylla Decne.
Tylophora hirsuta (Wall.) Wight
Asteraceae
Artemisia scoparia Besser
Bidens bipinnata L.
Conyza bonariensis (L.) Cronq.
Conyza canadensis (L.) Cronq.
Conyza japonica L.
Conyza stricta Willd.
Erigeron belloides Benth. ex Clarke.
Parthenium hysterophorus L.
Sonchus arvensis L.
Taraxacum officinale Wigg.
Xanthium strumarium L.
Bombacaceae
Bombax ceiba L.
Boraginaceae
Cynoglossum lanceolatum Forssk.
Heliotropium europaeum L
Lithospermum arvense L.
Trichodesma indicum (L.) R. Br.
Brassicaceae
Capsella bursa-pastoris (L.) Medic
Cardamine impatiens L.
Lepidium sativum L.
Cannabiaceae
Cannabis sativa L.
Celasteraceae
Gymnosporia royleana (Wall.) ex Laws
Celtaceae
Celtis australis L.
Chenopodiaceae
Chenopodium album subsp. album L.
Commelinaceae
Commelina benghalensis L.
Convolvulaceae
Convolvulus arvensis L.
Evolvulus alsinoides (Linn.) Linn.
Ipomoea carnea subsp. fistulosa Jacquem
Ipomoea purpurea (L.) Roth.
Cuscutaceae
Cuscuta reflexa var. reflexa Roxb.
Ebenaceae
Diospyros lotus L.
Euphorbiaceae
Euphorbia hirta L.
Euphorbia indica Lam.

Euphorbia prostrata Ait.
Mallotus philippensis (Lam.) Muell.-Arg.
Phyllanthus amarus Schum. & Thonn.
Flacourtiaceae
Flacourtia indica (Burm.) Merrill
Geraniaceae
Geranium nepalense Sweet
Geranium rotundifolium L.
Geranium wallichianum D. Don ex Sweet
Juglandaceae
Juglans regia L.
Labiatae
Ajuga bracteosa var. bracteosa Wall.
Ajuga bracteosa var. densiflora Wall.
Calamintha umbrosa (M. Bieb.) Fisch. & Mey
Colebrookea oppositifolia Smith
Mentha royleana Benth.
Micromeria biflora var. biflora (Buch.-Ham. ex D. Don) Benth.
Otostegia limbata (Benth.) Boiss.
Plectranthus rugosus Wall. ex. Bth.
Salvia sp.
Leguminoseae
Acacia modesta Wall.
Acacia nilotica subsp. indica (L.) Willd.
Albizia lebbeck (L.) Benth.
Astragalus leucocephalus Grah. ex Benth.
Cassia fistula L.
Cassia obtusifolia Linn.
Cassia occidentalis L.
Dalbergia sissoo Roxb. ex DC.
Desmodium monotorium (Houtt) Merril
Dumasia villosa var. villosa DC.
Indigofera linifolia (Linn.f.) Retz.
Lespedeza juncea (L. f.) Pers.
Medicago sativa L.
Melilotus parviflora Desf.
Mimosa himalayana Gamble
Rynchosia minima (L.) DC.
Uraria picta (Jacquin) Desv. ex DC.
Lytheraceae
Woodfordia fruticosa (L.) Kurz.
Malvaceae
Hibiscus trionum Linn.
Malvastrum coromandelianum (L.) Garcke
Sida cordifolia L.
Martyniaceaae
Martynia annua Linn.
Meliaceae
Cedrela serrata Royle.

Cedrela toona Roxb. ex Wild
Melia azedarach L.
Menispermaceae
Cissampelos pareira var. hirsuta L.
Tinospora cordifolia (DC.) Miers.
Moraceae
Broussonetia papyrifera (L.) L'H {rit. ex Vent.
Ficus auriculata Lour.
Ficus benghalensis L.
Ficus carica subsp. carica L.
Ficus religiosa L.
Morus alba L.
Morus nigra L.
Morus serrata Roxb.
Muscaceae
Musca sapientum L.
Myrsinaceae
Myrsine africana L.
Myrtaceae
Eucalyptus camaldulensis Dehnh
Nyctaginaceae
Alternanthera pungens Kunth
Boerhavia procumbens (Roxb.) Hk.F
Oleaceae
Olea ferruginea Royle
Onagraceae
Oenothera rosea L'H rit. ex Aiton
Oxalidaceae
Oxalis corniculata L.
Palmaceae
Phoenix sylvestris Roxb.
Polygalaceae
Polygala abyssinica R. Br. ex Fresen.
Polygonaceae
Polygonum plebejum R.Br
Polygonum sp.
Rumex chalepensis D. Don
Punicaceae
Punica granatum L.
Ranunculaceae
Thalictrum javanicum Bl.
Rhamnaceae
Zizyphus jujuba Lam.
Zizyphus mauritiana Lam.
Zizyphus nummularia (Burm. f.) Wight & Arn.
Zizyphus oxyphylla Edgew.
Rosaceae
Duchesnea indica var. microphylla (Andr.) Focke
Fragaria nubicola Lindl. ex Lacaita

Pyrus communis L.
Rubus ellipticus Smith
Rubus ulmifolius Schott.
Rubiaceae
Galium acutum Edgew.
Galium aparine var. aparine L.
Rubia cordata Thunb
Salicaceae
Populus alba L.
Populus caspica Bornm.
Populus ciliata Wall. Ex Royle
Populus nigra L.
Salix acmophylla Boiss.
Sapindaceae
Dodonaea viscosa (L.) Jacq.
Scrophulariaceae
Kickxia ramosissima (Wall) Janchen.
Linaria dalmatica (L.) Mill.
Verbascum thapsus L.
Veronica anagallis-aquatica L
Simarubaceae
Ailanthus altissima (Miller) Swingle
Solanaceae
Datura stramonium L.
Physalis divaricata D. Don
Solanum nigrum L.
Solanum surattense Burm. f.
Withania somnifera (L.) Dun.
Tiliaceae
Corchorus olitorius L.
Grewia optiva J. R. Drumm. ex Burret
Urticaceae
Debregeasia salicifolia (D. Don) Rendle
Verbenaceae
Callicarpa macrophylla Vahl
Vitex negundo L.
Violaceae
Viola sp
Vitaceae
Cissus carnosa (L) Lamk.
GYM
Pinaceae
Pinus roxburghii Sarg.
PTE
Pteridaceae
Adiantum capillus-veneris L.
Adiantum incisum Forssk.
Dryopteris pallida Formin

Exhibit 5A.4: Association of species with different Habitat types in GHP

Habitat	Broad leaved forest (Fb)				Coniferous forest (Fc)			Mix Forest (Fm)		Shrubland (S)			Open land (O)			Cultivated land (C)				Urban (U)			Riverine (R)		
Sub-category	FBL	FBO	FBR	FBS	FCS	FCO	FCL	FMS	FMO	SI	SO	SP	OS	OT	OR	CK	CB	CC	CP	UG	UT	UW	RS	RSS	RSR
Shannon Diversity																									
Species ▼																									
Aca mod		+																							
Aca nil		+																							
Ach asp										+	+		+		+		+					+	+		
Aga can																	+	+							
Ail alt																			+						
Aju bra													+												
Aju bra													+												
Alb leb		+																					+		
Ama vir																	+	+				+			
Apl mut		+		+	+								+				+								
Aru don		+				+							+		+										
Asp fil																									
Asp fil																									
Bar cri		+		+							+		+		+										
Bid bip				+									+		+					+					
Boe dif														+	+								+		
Bom cei																							+		
Bot per				+									+				+						+		
Bra ram														+		+	+								
Cal mac						+					+														
Cal pro																	+					+			+
Can sat													+	+			+	+				+			
Cap bur													+			+	+								
Car imp											+				+								+		
Car car			+	+									+		+										
Cas fis											+		+						+						
Cas obt		+											+	+			+					+			
Cas occ		+											+	+			+					+			
Cel aus																				+					

Habitat	Broad leaved forest (Fb)				Coniferous forest (Fc)			Mix Forest (Fm)		Shrubland (S)			Open land (O)			Cultivated land (C)				Urban (U)			Riverine (R)		
Sub-category	FBL	FBO	FBR	FBS	FCS	FCO	FCL	FMS	FMO	SI	SO	SP	OS	OT	OR	CK	CB	CC	CP	UG	UT	UW	RS	RSS	RSR
Shannon Diversity																									
Species ▼																									
Che alb													+				+	+				+	+		
Cis par		+										+			+										
Cis adn	+																								
Col opp		+									+		+												
Com ben				+												+	+							+	
Con arv										+	+	+			+		+				+				
Con bon													+	+			+								
Con can													+				+						+		
Con jap		+											+		+										
Con str													+			+	+								
Cus ref												+													
Cyn aur											+														+
Cyn dac													+	+		+	+			+					
Cyn lan													+	+			+								
Cyp niv		+		+									+		+		+								
Cyp rot														+		+	+					+	+		
Dal sis																			+				+		
Dat str														+			+					+			
Deb sal		+			+								+		+										
Des ele		+				+					+		+												+
Des bip				+										+									+		
Dic ann													+	+		+	+								
Dio lot																									
Dum vil		+		+																					
Ech col													+			+	+						+		
Eri bel													+		+		+								
Eri com													+		+										
Euc cam																				+					
Eup hir		+											+		+	+	+				+				+

Habitat	Broad leaved forest (Fb)				Coniferous forest (Fc)			Mix Forest (Fm)		Shrubland (S)			Open land (O)			Cultivated land (C)				Urban (U)			Riverine (R)		
Sub-category	FBL	FBO	FBR	FBS	FCS	FCO	FCL	FMS	FMO	SI	SO	SP	OS	OT	OR	CK	CB	CC	CP	UG	UT	UW	RS	RSS	RSR
Shannon Diversity																									
Species ▼																									
Eup pro													+		+						+		+		
Evo als				+	+						+		+		+										
Fic aur															+				+						
Fic ben																			+						
Fic rel																			+		+				
Fla ind																									
Fra nub											+		+												
Gal acu													+												
Gal apa				+	+			+					+												
Ger nep		+											+	+			+								
Ger wal		+				+		+	+		+														
Gre opt		+																							
Hab dig				+																					
Het con		+											+		+	+							+		
Imp cyl				+	+								+	+		+	+			+					
Ind lin														+	+		+						+		+
Ipo car				+															+			+			
Ipo pur																	+			+		+			
Jug reg																			+				+		
Jus adh											+		+						+			+			
Kic ram													+												
Lep sat																+	+								
Les jun																							+		
Lit arv															+		+								
Mal phi											+														
Man ind																	+								
Mar ann		+									+			+									+		
Med sat																+		+							
Mel aze																			+	+			+		

Habitat	Broad leaved forest (Fb)				Coniferous forest (Fc)			Mix Forest (Fm)		Shrubland (S)			Open land (O)			Cultivated land (C)				Urban (U)			Riverine (R)		
Sub-category	FBL	FBO	FBR	FBS	FCS	FCO	FCL	FMS	FMO	SI	SO	SP	OS	OT	OR	CK	CB	CC	CP	UG	UT	UW	RS	RSS	RSR
Shannon Diversity																									
Species ▼																									
Mel alb													+			+	+								
Mic bif													+		+								+		
Mor alb		+																	+						
Mor ser		+																	+				+		
Myr afr		+		+							+		+												
Ner ind																			+						
Oen ros																	+								
Oxa cor																+	+				+	+			
Par hys																						+			
Pas fla								+	+				+				+				+	+	+		
Phr kar		+											+	+		+	+						+		
Phy ama													+				+								
Phy div														+			+					+			
Pin rox					+																				
Ple rug		+		+									+		+										
Poa ann					+								+				+								
Pol aby				+									+		+										
Pol ple		+											+		+	+	+						+		
Pol mon																+	+						+		
Pop cil								+											+				+		
Pop nig																			+						
Pun gra											+								+	+					
Rub wal		+																							
Rub ell		+									+						+								
Sau ven															+										
Set gla				+											+	+	+								
Sid cor													+	+											
Sid cor																	+								
Sol nig																	+				+	+			

Habitat	Broad leaved forest (Fb)				Coniferous forest (Fc)			Mix Forest (Fm)		Shrubland (S)			Open land (O)			Cultivated land (C)				Urban (U)			Riverine (R)		
Sub-category	FBL	FBO	FBR	FBS	FCS	FCO	FCL	FMS	FMO	SI	SO	SP	OS	OT	OR	CK	CB	CC	CP	UG	UT	UW	RS	RSS	RSR
Shannon Diversity																									
Species ▼																									
Sol sur														+	+							+			
Sor hal																		+							
Tha jav		+		+	+								+										+		
Tin sin	+	+																				+			
Tri ind		+		+																					
Tyl hir	+						+								+										
Ura pic		+																							
Ver tha		+																							
Ver ana										+	+		+		+		+					+	+		
Vit neg																	+	+							
Woo fru																			+						
Xan str													+												
Zea may													+												
Ziz mau		+																					+		
Ziz num																	+	+				+			

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land				Urban				Riverine			
0	Fb	FB	FBL	FBO	FBR	FBS	Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RSS	RSR
Aca mod	5	1	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Aca nil	5	1	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Ach asp	5	0	0	0	0	0	3	0	0	0	0	0	0	3	1	1	0	3	1	0	1	4	0	1	0	0	3	0	0	1	3	1	0	0
Aga can	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	1	0	3	0	0	0	3	0	0	0
Ail alt	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	0	0	0
Aju bra	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land					Urban				Riverine			
0	Fb	FBL	FBO	FBR	FBS		Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RS	RR
Aju bra	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Alb leb	5	1	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Ama vir	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	1	0	3	0	0	1	3	0	0	0
Apl mut	5	0	0	1	0	1	3	1	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Aru don	5	0	0	1	0	0	3	0	1	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Asp fil	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Asp fil	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Bar cri	5	0	0	1	0	1	3	0	0	0	0	0	0	3	0	1	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Bid bip	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	1	0	0	3	0	0	0
Boe dif	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	1	4	0	0	0	0	3	0	0	0	3	1	0	0
Bom cei	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Bot per	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	1	0	0	3	0	0	0	3	1	0	0
Bra ram	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	1	1	0	0	3	0	0	0	3	0	0	0
Cal mac	5	0	0	0	0	0	3	0	1	0	0	0	0	3	0	1	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Cal pro	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	0	0	1	3	0	0	1
Can sat	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	1	1	0	3	0	0	1	3	0	0	0
Cap bur	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	1	1	0	0	3	0	0	0	3	0	0	0
Car imp	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	0	0	1	4	0	0	0	0	3	0	0	0	3	1	0	0
Car car	5	0	0	0	1	1	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Cas fis	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	1	0	0	4	0	0	0	1	3	0	0	0	3	0	0	0
Cas obt	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	1	0	0	3	0	0	1	3	0	0	0
Cas occ	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	1	0	0	3	0	0	1	3	0	0	0
Cel aus	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	1	0	0	3	0	0	0

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land					Urban				Riverine			
0	Fb	FB	FBL	FBO	FBR	FBS	Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RS	RR
Che alb	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	1	1	0	3	0	0	1	3	1	0	0
Cis par	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	1	3	0	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Cis adn	5	0	1	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Col opp	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	1	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Com ben	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	1	1	0	0	3	0	0	0	3	0	1	0
Con arv	5	0	0	0	0	0	3	0	0	0	0	0	0	3	1	1	1	3	0	0	1	4	0	1	0	0	3	0	1	0	3	0	0	0
Con bon	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Con can	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	1	0	0	3	0	0	0	3	1	0	0
Con jap	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Con str	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	1	1	0	0	3	0	0	0	3	0	0	0
Cus ref	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	1	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Cyn aur	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	1
Cyn dac	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	1	1	0	0	3	1	0	0	3	0	0	0
Cyn lan	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Cyp niv	5	0	0	1	0	1	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	1	0	0	3	0	0	0	3	0	0	0
Cyp rot	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	1	1	0	0	3	0	0	1	3	1	0	0
Dal sis	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	1	0	0
Dat str	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	0	1	0	0	3	0	0	1	3	0	0	0
Deb sal	5	1	0	1	0	0	3	1	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Des ele	5	1	0	1	0	0	3	0	1	0	0	0	0	3	0	1	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	1
Des bip	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Dic ann	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	1	1	0	0	3	0	0	0	3	0	0	0
Dio lot	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Dum	5	0	0	1	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land					Urban				Riverine			
0	Fb	FB	FBL	FBO	FBR	FBS	Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RS	RR
vil																																		
Ech col	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	1	1	0	0	3	0	0	0	3	1	0	0
Eri bel	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	1	0	0	3	0	0	0	3	0	0	0
Eri com	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Euc cam	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	1	0	0	3	0	0	0
Eup hir	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	1	1	0	0	3	0	1	0	3	0	0	1
Eup pro	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	1	0	3	1	0	0
Evo als	5	0	0	0	0	1	3	1	0	0	0	0	0	3	0	1	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Fic aur	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	1	4	0	0	0	1	3	0	0	0	3	0	0	0
Fic ben	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	0	0	0
Fic rel	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	1	0	3	0	0	0
Fla ind	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Fra nub	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Gal acu	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Gal apa	5	0	0	0	0	1	3	1	0	0	1	1	0	3	0	0	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Ger nep	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Ger wal	5	0	0	1	0	0	3	0	1	0	2	1	1	3	0	1	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Gre opt	5	1	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Hab dig	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Het con	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	1	0	0	0	3	0	0	0	3	1	0	0
Imp cyl	5	0	0	0	0	1	3	1	0	0	0	0	0	3	0	0	0	3	1	1	0	4	1	1	0	0	3	1	0	0	3	0	0	0
Ind lin	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	1	4	0	1	0	0	3	0	0	0	3	1	0	1
Ipo car	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	1	3	0	0	0

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land					Urban				Riverine			
0	Fb	FB	FBL	FBO	FBR	FBS	Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RS	RR
Ipo pur	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	1	0	1	3	0	0	0
Jug reg	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	1	0	0
Jus adh	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	1	0	0	4	0	0	0	1	3	0	0	1	3	0	0	0
Kic ram	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Lep sat	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	1	1	0	0	3	0	0	0	3	0	0	0
Les jun	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Lit arv	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	1	4	0	1	0	0	3	0	0	0	3	0	0	0
Mal phi	5	1	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Man ind	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Mar ann	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	1	0	3	0	1	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Med sat	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	1	0	1	0	3	0	0	0	3	0	0	0
Mel aze	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	1	0	0	3	1	0	0
Mel alb	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	1	1	0	0	3	0	0	0	3	0	0	0
Mic bif	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	1	0	0
Mor alb	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	0	0	0
Mor ser	5	1	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	1	0	0
Myr afr	5	0	0	1	0	1	3	0	0	0	0	0	0	3	0	1	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Ner ind	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	0	0	0
Oen ros	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Oxa cor	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	1	1	0	0	3	0	1	1	3	0	0	0
Par hys	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	1	3	0	0	0
Pas fla	5	0	0	0	0	0	3	0	0	0	2	1	1	3	0	0	0	3	1	0	0	4	0	1	0	0	3	0	1	1	3	1	0	0

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land				Urban				Riverine			
0	Fb	FB	FBL	FBO	FBR	FBS	Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RS	RR
Phr kar	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	1	1	0	0	3	0	0	0	3	1	0	0
Phy ama	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Phy div	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	0	1	0	0	3	0	0	1	3	0	0	0
Pin rox	5	0	0	0	0	0	3	1	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Ple rug	5	0	0	1	0	1	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Poa ann	5	0	0	0	0	0	3	1	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Pol aby	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Pol ple	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	1	1	0	0	3	0	0	0	3	1	0	0
Pol mon	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	1	1	0	0	3	0	0	0	3	1	0	0
Pop cil	5	1	0	0	0	0	3	0	0	0	1	1	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	1	0	0
Pop nig	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	1	3	0	0	0	3	0	0	0
Pun gra	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	1	0	3	0	0	0	4	0	0	0	1	3	1	0	0	3	0	0	0
Rub wal	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Rub ell	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	1	0	3	0	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Sau ven	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Set gla	5	0	0	0	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	0	1	4	1	1	0	0	3	0	0	0	3	0	0	0
Sid cor	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Sid cor	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	0	0	0	3	0	0	0
Sol nig	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	0	1	1	3	0	0	0
Sol sur	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	1	4	0	0	0	0	3	0	0	1	3	0	0	0
Sor hal	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	1	0	3	0	0	0	3	0	0	0
Tha jav	5	0	0	1	0	1	3	1	0	0	0	0	0	3	0	0	0	3	1	0	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Tin sin	5	0	1	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	1	3	0	0	0
Tri ind	5	0	0	1	0	1	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Tyl hir	5	0	1	0	0	0	3	0	0	1	0	0	0	3	0	0	0	3	0	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0

	Broad leaved forest						Coniferous forest				Mix Forest			Shrubland				Open land				Cultivated land					Urban				Riverine			
0	Fb	FB	FBL	FBO	FBR	FBS	Fc	FCS	FCO	FCL	Fm	FMS	FMO	S	SI	SO	SP	O	OS	OT	OR	C	CK	CB	CC	CP	U	UG	UT	UW	R	RS	RS	RR
Ura pic	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	0	0	0	0	3	0	0	0	3	0	0	0
Ver tha	5	0	0	0	0	0	3	0	1	0	0	0	0	3	0	0	0	3	1	0	1	4	0	1	0	0	3	0	0	0	3	0	0	0
Ver ana	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Vit neg	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	1	0	0	3	0	0	1	3	0	0	0
Woo fru	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	0	1	4	0	0	0	0	3	0	0	0	3	0	0	0
Xan str	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	1	0	4	0	1	0	0	3	0	0	1	3	0	0	0
Zea may	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	1	0	3	0	0	0	3	0	0	0
Ziz mau	5	0	0	1	0	0	3	0	0	0	0	0	0	3	0	0	0	3	1	1	0	4	0	0	0	0	3	0	0	0	3	1	0	0
Ziz num	5	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	3	0	0	0	4	0	0	0	0	3	0	0	0	3	1	0	0

Exhibit 5A.5: Landuse at Project Facilities

Component	Code	Area (Hectare)	UCL	AGR	RIV	OPA	SET	BLS	BLM	BLD	CNS	CNM	CND
Study area (Polygon)	SA	25707.695	799.541	5562.344	303.515	1269.516	4294.065	3484.192	800.600	28.612	5292.298	3500.617	372.395
Project components		318.330	38.573	59.368	54.947	9.413	43.570	94.043	16.588	0.101	0.000	0.000	0.000
		1.238%	4.824%	1.067%	18.104%	0.741%	1.015%	2.699%	2.072%	0.355%	0.000%	0.000%	0.000%
Reservoir	RES	298.216	37.972	52.808	54.486	8.831	42.123	86.277	15.631	0.088			
Weir		2.242	0.424		0.333		0.212	1.152	0.121				
Camping Site (P)	CSP	2.738		2.296		0.088		0.353					
Camping Site (T)	CST	0.353						0.088	0.265				
Camping Site (W)	CSW	2.119		1.325		0.177		0.530	0.088				
Batching Plant	BCH	1.060	0.088	0.971									
M&E Yard	MEY	2.031					0.353	1.678					
Switch Yard	SWY	0.265						0.265					
Spoil Tip #1	ST1	0.000											
Spoil Tip #2	ST2	1.766		1.678				0.088					
Spoil Tip #3	ST3	1.060			0.088	0.265	0.088	0.530	0.088				
Spoil Tip #4	ST4	2.119	0.088				0.530	1.501					
		Length (km)											
Road #1	R#1	1.618		0.119	0.040		0.079	0.343	0.066				
Road #2	R#2	1.766					0.026	0.461	0.198	0.013			
Road #3	R#3	0.667				0.013	0.079	0.171	0.013				
Road #4	R#4	1.588		0.105		0.013	0.026	0.369	0.119				
Road #5	R#5	0.397				0.026	0.026	0.105					
Road #6	R#6	0.566		0.066			0.026	0.132					

R#1 Thalla road Bridge to Spoil Tip #2, R#2 Rehman Bridge to Spoil Tip #1 and mouth of headrace tunnel, R#3 Rehman Bridge to Weir, R#4
Kotli-Mirpur road to Spoil Tip #3, R#5 Kotli-Mirpur road to Weir, R#6 Kotli-Mirpur road to Batching Plant

Exhibit 5A.6: List of field equipment and supplies used to collect benthic macor invertebrates fauna from Poonch River

Field equipment / supplies
▪ Kick-net (500 µ opening mesh)
▪ Standard D-frame dip nets, 500 µ opening mesh, 0.3 m width (~ 1.0 ft frame width and handle stick at least 2meters)
▪ Sieve bucket, with 500 µ opening mesh (for sieving)
▪ 2.5 liters 95% ethanol will be converted to 70 % (750 mL of 95% ethanol topped up to 1 L with water = 70% ethanol)
▪ Sample containers (air tight & leak proof plastic jars of 500 ml capacity)
▪ Leak proof glass vials 35ml for sample preservation
▪ Sample container sticking labels
▪ Forceps (tweezers)
▪ Waders (chest-high or hip boots)
▪ Rubber gloves (arm-length)
▪ Global Positioning System (GPS) Unit

Exhibit 5A.7: Benthic macro invertebrate collection stations along with date, sampling equipment and co-ordinates

Stations (Locality Name)	*Date*	*Sampling Method*	*Co-ordinates*
S_1 (Agar Jamalpur)	13th August 2013	D frame dip net	33° .50168 N, 73°.88085 E & 33° .49997 N, 73°.88346 E
S_2 (Gheri Mandi)	13th August 2013	D frame dip net	33° .50185 N, 73°.87933 E
S_3 (Mandian)	14th August 2013	D frame dip net	33° .51896 N, 73°.88577 E
S_4 (Sarsawa Rangar Nullah)	14th August 2013	D frame dip net	33° .50528 N, 73°.87213 E
S_5 (Barali Bridge)	15th August 2013	Surber Net	33° .50528 N, 73°.87213 E
S_6 (Bhan Nullah)	16th August 2013	Surber Net	33° .483115 N, 73°.883593 E

Exhibit 5A.8: Different Models tested for Jackal and their AIC values, likelihood and number of parameters.

Model	*AIC*	*deltaAIC*	*AIC wgtModel*	*Likelihood*	*no.Par.*	*-2*LogLike*
psi(road-qd),p(terr)	138.78	0	0.3852	1	4	130.78
psi(.),p(terr)	140.4	1.62	0.1713	0.4449	3	134.4
psi(slop),p(terr)	141.24	2.46	0.1126	0.2923	5	131.24
psi(.),p(habt+terr)	141.88	3.1	0.0818	0.2122	6	129.88
psi(road),p(terr)	142.06	3.28	0.0747	0.194	5	132.06
psi(ndvi),p(terr)	142.36	3.58	0.0643	0.167	5	132.36
psi(sett-qd),p(terr)	142.38	3.6	0.0637	0.1653	4	134.38
psi(.),p(.)	143.01	4.23	0.0465	0.1206	2	139.01

Exhibit 5A.9: Different Models tested for Fox and their AIC values, likelihood and number of parameters.

Model	*AIC*	*deltaAIC*	*AIC wgtModel*	*Likelihood*	*no.Par.*	*-2*LogLike*
psi(.),p(terr)	60.01	0	0.3183	1	3	54.01
psi(.),p(terr+dist)	60.57	0.56	0.2406	0.7558	6	48.57

Model	*AIC*	*deltaAIC*	*AIC wgtModel*	*Likelihood*	*no.Par.*	*-2*LogLike*
psi(sett-qd),p(terr)	61.76	1.75	0.1327	0.4169	4	53.76
psi(ndvi),p(terr)	62.2	2.19	0.1065	0.3345	5	52.2
psi(slop),p(terr)	62.53	2.52	0.0903	0.2837	5	52.53
psi(elev),p(terr)	63.4	3.39	0.0584	0.1836	5	53.4
psi(.),p(.)	63.59	3.58	0.0531	0.167	2	59.59

Exhibit 5A.10: Evidence of goat poisoning and common leopard killing in forests adjacent to the project area. Information was provided by a local game guard.

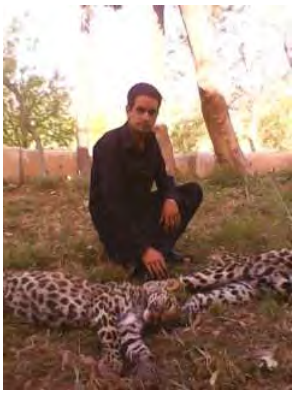
a. Poisoned goat

b. Killed cubs

c. Killed animal

d. Face of killed one

e. Killed cubs



f. With wildlife gaurd

Exhibit 5A.11: List of Mammals observed and/ or collected from the Study area Exhibit

Sr. No.	*Scientific Name*	*Order/ Family*	*English Names*	*Local name*	*IUCN Status*	*Abundance*
1.	*Mus booduga*	Rodentia/ Muridae	Little Indian field mouse	Choohi	Least Concern (LC)	Common (C)
2.	*Rattus rattus*	Rodentia/ Muridae	Common Rat	Chooha	LC	C
3.	*Rattus pyctoris*	Rodentia/ Muridae	Turkestan Rat	Chooha	LC	C
4.	*Funambulus pennantii*	Rodentia/Petromidae	Palm Squirrel	Gulehri	LC	C
5.	*Lepus nigricollis*	Lagomorpha/ Leporidae	Indian Hare	Siah	LC	C
6.	*Herpestes edwardsii*	Carnivora/ Herpestidae	Common India Mongoose	Neola	LC	C
7.	*Herpestes javanicus*	Carnivora/ Herpestidae	Mongoose	Neola	LC	C
8.	*Lutrogale perspicillata*	Carnivora/ Mustelidae	Common Otter	Ludhar	Vulnerable	Rare
9.	*Hemiechinus collaris*	Insectivora/ Erinaceidae	Long-eared hedgehog	Kundyara Chooha	LC	C
10.	*Hystrix indica*	Rodentia/ Hystricidae	Indian crested porcupine	Seh	LC	C
11.	*Vulpes bengalensis*	Carnivora/ Canidae	Bengal Fox	Loomri	LC	C
12.	*Canis aureus*	Carnivora/Canidae	Asiatic Jackal	Gidar	LC	C
13.	*Suncus murinus*	Insectivora/Soricidae	Common Shrew	Kees	LC	C
14.	*Rousettus leschenaultii*	Chiroptera/Pteropidae	Fulvous Fruit Bat	Chamgadar	LC	C
15.	*Scotophilus heathii*	Chiroptera/ Vespertilionidae	Common Yellow-bellied Bat	Chumgadar	LC	C
16.	*Pipistrellus kuhlii*	Chiroptera/ Vespertilionidae	Kuhl's Pipistrelle	Chumgadar	LC	C
17.	*Pipistrellus tenuis*	Chiroptera/ Vespertilionidae	Least pipistrelle	Chumgadar	LC	C

Exhibit 5A.12: Reptile and Amphibian Species Found in the Study Area

Sr. No.	*Zoological Name*	*Common Name*	*Observation Records*	
			Direct	*Indirect*
1	*Bufo stomaticus*	Indus valley toad	√	-
2	*Bufo melanostictus*	Hazara toad	√	-
3	*Microhyla ornata*	Ant Frog	√	-
4	*Euphlyctis cyanophlyctis*	Skittering frog	√	-
5	*Fejevarya limnocharis*	Alpine cricket frog	√	-
6	*Hoplobatrachus tigerinus*	Bullfrog	√	-
7	*Lissemys punctata andersoni*	Indian flap-shell turtle	-	Interviews
8	*Laudakia agrorensis*	Agrore valley agama	√	-
9	*Laudakia himalayana*	Himalayan agama	√	-
10	*Eublepharis macularius*	Fat-tailed gecko	√	-
11	*Hemidactylus flaviviridis*	House gecko	√	-
12	*Hemidactylus brookii*	Spotted house gecko	√	-
13	*Indogekko rohtasfortai*	Rohtas gecko	√	-
14	*Ophisops jerdonii*	Rugose spectacled lacerta	√	-
15	*Eutropis dissimilis*	Striped grass skink	√	-
16	*Varanus bengalensis*	Bengal monitor	√	-
17	*Typhlops ductuliformes*	Slender blind snake	-	Interviews
18	*Eryx johnii*	Common sand boa	-	Interviews
19	*Xenochrophis piscator*	Checkered keel-back	-	Interviews
20	*Bungarus caeruleus*	Common krait	√	-
21	*Naja oxiana*	Brown cobra	-	Interviews

Exhibit 5A.13: Checklist of Avian Fauna

Order	*Family*	*Common Name*	*Scientific Name*	*IUCN*	*Status*
Passeriformes	Laniidae	Bay backed shrike	*Lanius vittatus*	-	SB
		Rufous-backed or long tailed shrike	*Lanius schach*	-	YRR
	Corvidae	Tree pie	*Dendrocitta vagabunda*	-	YRR
		House crow	*Corvus splendens*	-	YRR
		Large billed crow	*Corvus macrorhynchos*	-	YRR
		Common raven	*Corvus corax*	-	YRR
		Black headed jay	*Garrulus lanceolatus*	-	YRR
	Dicruridae	Black drongo	*Dicrurus macrocercus*	-	YRR
	Sturnidae	Indian myna	*Acridotheres tristis*	-	YRR
	Pycnonotidae	White cheeked bulbul	*Pycnonotus leucogenys*	-	YRR
		Red vented bulbul	*Pycnonotus cafer*	-	YRR
		Asian Black Bulbul	*Hypsipetes leucocephalus*	-	YRR
	Motacillidae	White wagtail	*Motacilla alba*	-	WV
		White browed wagtail	*Motacilla madaraspatensis*	-	YRR
		Paddy field pipit	*Anthus rufulus*	-	YRR
		Tree pipit	*Anthus trivialis*	-	SB
	Nectaribiidae	Purple sun bird	*Cinnyris asiaticus*	-	YRR
	Muscicapidae	Pied bush chat	*Saxicola caprata*	-	YRR
	-	Common bush chat	*Saxicola torquata*	-	PM
	-	Indian robin	*Luscinia brunnea*	-	YRR
		Oriental magpie robin	*Copsychus saularis*	-	YRR
	-	Blue caped redstart	*Phoenicurus caeruleocephala*	-	SB
	-	White-tailed Stonechat	*Saxicola leucurus*	-	YRR
	Timaliidae	Jungle babbler	*Turdoides striatus*	-	YRR
	-	Common babbler	*Turdoides caudatus*	-	YRR
	-	Striated laughing thrush	*Garrulax striatus*	-	YRR
	Sylviidae	Lesser whitethroat	*Sylvia curruca*	-	WV
	Alaudidae	Indian bush lark	*Mirafra erythroptera*	-	YRR
	Passeridae	House sparrow	*Passer domesticus*	-	YRR
	Cisticolidae	Striated prinia	*Prinia crinigera*	-	YRR
		Grey brested prinia	*Prinia hodgsonii*	-	YRR
		Rufous- fronted prinia	*Prinia buchanani*	-	YRR

Order	Family	Common Name	Scientific Name	IUCN	Status
		Graceful prinia	*Prinia gracilis*	-	YRR
	Sylviidae	Blunt winged warbler	*Acrocephalus concinens*	-	SB
		Oriental white eye	*Zosterops palpebrosus*	-	YRR
	Turdidae	Blue whistling thrush	*Myophonus caeruleus*	-	SB
	Monarchidae	Asian paradise flycatcher	*Terpsiphone paradisi*	-	SB
	Sturnidae	Brahminy Starling	*Sturnia pagodarum*	-	YRR
	Estrildidae	Scaly-breasted munia	*Lonchura punctulata*	-	YRR
	Paridae	Great tit	*Parus major*	-	YRR
Galiformes	Phasianidae	Black partridge	*Melanoperdix niger*	V	YRR
Columbiformes	Columbidae	Oriental turtle dove	*Streptopelia orientalis*	-	YRR
Coraciiformes	Alcedinidae	White throated kingfisher	*Halcyon smyrnensis*	-	YRR
	Coraciidae	Indian roller	*Coracias benghalensis*	-	YRR
	Upupidae	Common hoopoe	*Upupa epops*	-	SB
	Meropidae	Green bee eater	*Merops orientalis*	-	YRR
Falconiformes	Accipitridae	White rumped vulture	*Gyps bengalensis*	CE	YRR
		Himalayan griffon	*Gyps himalayensis*	Lc	YRR
		Egyptian vulture	*Neophron percnopterus*	End	W
		Shikra or Indian sparrow hawk	*Accipiter badius*	LC	YRR
		Eurasian sparrow hawk	*Accipiter nisus*	-	SB
		Tawny eagle	*Aquila rapax*	-	YRR
		Black kite	*Milvus migrans*	-	YRR
	Falconidae	Common kestrel	*Falco tinnunculus*	-	YRR
Apodiformes	Apodidae	House swift	*Apus affinis*	-	YRR
Piciformes	Picidae	Scaly billed woodpecker	*Picus squamatus*	-	YRR
		Brown fronted woodpecker	*Dendrocopos auriceps*	-	YRR
Cuculiformes	Cuculidae	Pied cuckoo	*Clamator jacobinus*	-	SB
-	-	Asian koel	*Eudynamys scolopaceus*	-	SB
Psittaciformes	Psittacidae	Rose ringed parakeet	*Psittacula krameri*	-	SB
Strigiformes	Strigidae	Spotted owlet	*Athene brama*	-	YRR

Key: LC= Least Concern; NT= Near Threatened; YRR+= Year Round Resident; WV= Winter Visitor; SB=Summer Breeding; PM= Passage Migrant (Data Source of residential status: Grimmett et al., 2008)

Annexure 5B: Description of Species of Concern

Fish Species

Species Bearing IUCN Status and having Commercial Importance

Tor Putitora (Golden Mahasher)

Status: Endangered (Year of assessment, 2010)

Justification: *Tor putitora* is a widely distributed species in south and Southeast Asia, with a restricted area of occupancy. However, the species is under severe threat from overfishing, loss of habitat, decline in quality of habitat resulting in loss of breeding grounds, and from other anthropogenic effects that have directly resulted in declines in its harvest. In addition, with several dams planned for construction in future in the Himalayan region, they could have a more drastic effect on tor populations blocking their migrations and affecting their breeding. Inferring population declines from observed cases with that of the trends across the entire distribution range, the species is estimated to have declined by more than 50% in the past and if the current trends continue and with the new dams being built, the population may decline even up to 80% in the future. The species is therefore assessed as Endangered and is in need of urgent conservation efforts to save it from becoming locally extinct in several locations.

Geographic Range: The species has been reported from across the Himalayan region and elsewhere in south Asia and southeast Asia, ranging from Afghanistan, Pakistan, India, Nepal, Bangladesh, Bhutan, Sri Lanka, Myanmar, western Iran to eastern Thailand.

Population: It is the most common and popular fish of the Himalaya and is also sometimes known as the golden, yellow-finned, grey-hound or the thick-lipped Mahasher. It grows up to 2.7 m. Since it is a heavily fished species, population declines in the entire range is inferred to be anywhere between 40-50% over the last ten years. Catches have declined in most of the areas due to overfishing.

Habitat and Ecology: The fish inhabits the montane and submontane regions, in streams and rivers. T. putitora is distributed in mid hills stretches of Himalayan region. It inhabits rapid streams with rocky bottom, riverine pools and lakes. The fish is a column feeder in freshwater found in pH ranges 7.4-7.9 and in subtropical condition 15°C-30°C. It is omnivorous in nature during their adult stage

and feed on periphytic algae and diatoms in juvenile stage. The feeding and breeding habitats are lost almost throughout their distributional range.

Major Threat(s): The population of the fish is fast depleting and at present is chiefly localized to certain major river systems (Poonch River and Lower Swat River in Pakistan) and is fast approaching extinction in the streams and lakes of Himalayas. Large fishes are only found in some of the perennial pools. This species is declining from its natural habitat due to urbanization, illegal encroachment, over fishing and chemical and physical alterations of their natural habitats. The stress on the population is not only due to its over exploitation, but also due to the rise in developmental activities, especially the growing number of hydroelectric and irrigation projects which have fragmented and deteriorated its natural habitat.

Commercial Importance: It is the most common Mahasher of the Himalayas. It has afforded lucrative source of sport for the anglers all along the Himalayas since long. It grows up to 2.7m and weighs up to 54 Kg. The commercial fishery of Putitor Mahasher consists largely of individuals either ascending streams for breeding or the spent ones returning to perennial reservoirs. The population of this fish is fast depleting and at present is chiefly localized to certain rivers only. This most attractive sport fish with excellent food value is fast approaching extinction in the streams and lakes of Pakistan and India.

Cyprinus carpio (Common Carp)

Status: Vulnerable A2ce (Year of assessment, 2008)

Justification: The native populations are slowly but continuously declining due to river regulation. Also hybridization with domesticated introduced stocks, East Asian congeners and their hybrids is a serious long term threat for the species. However, superficially pure carp are still abundant in the lower parts of rivers within its native range. Very few stocks remain genetically unpolluted as a result of this long lasting process. The average age of the spawners is estimated to be between 20-25 years, as they are a long lived species (up to 50 years). Although no population data exists, it is suspected that in the past 60 to 75 years within the species native range, a population decline of over 30% has occurred due to hybridization with introduced stock and river channelization and dams impacting the species as they need flooded areas at very specific times to successfully spawn.

Distribution: Afghanistan, Armenia, Austria, Azerbaijan, Bulgaria, China, Croatia, Georgia, Germany, Hungary; Iran, Kazakhstan, Kyrgyzstan, Moldova, Pakistan, Romania, Russian Federation, Serbia, Slovakia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

Habitat and Ecology: Warm, deep, slow-flowing and still waters, such as lowland rivers and large, well vegetated lakes. It has been introduced in all types of water bodies. Spawns along shores or in backwaters. Successful survival of larvae only takes place in very warm water, among shallow submerged vegetation.

Biology: Males reproduce for the first time at 3-5 years, females at 4-6. The fish lives up to 50 years and usually spawns every year. Age of maturity is related to latitude and altitude. It spawns in May-June at temperatures above 18°C. Adults often make considerable spawning migrations to suitable backwaters and flooded meadows. Individual females spawn with a few males in dense vegetation. The sticky eggs are attached to water plants or other submerged objects. Larvae and juveniles inhabit warm and shallow flooded river margins or backwaters, feeding mostly on very small zooplankton (rotifers). Reproductive success is restricted to years when the water level starts rising in May and when high temperatures and flooding of terrestrial vegetation last for a long period during May and June. Juveniles and adults feeds on a wide variety of benthic organisms and plant material. It is most active during dusk and dawn. The fish is very tolerant of low oxygen concentrations.

Major Threat(s): River regulation (they require flooded areas to spawn) and hybridization with introduced stocks is a major threat.

Commercial Importance: The carp is a bottom dwelling fish and mostly found at the bottom of water bodies. The growth of the carp is very rapid, particularly in favorable habitats. It can attain an enormous size of 110 cm and can weigh up to 40 kg. Its rapid growth tasty flesh, good reproductive ability and modest requirements have led to the carp's becoming the stable fish of warm water fisheries. It surpasses all other fishes in breeding ability, resistance to disease, and high quality of its flesh; these characteristics, as its cleverness, adroitness and gameness on the hook also make it very popular among anglers.

Botia rostrata (Twin-banded Loach)

Status: Vulnerable A2cd (Year of assessment, 2010)

Justification: *Botia rostrata* is widespread in the hill streams across its range but faces threats such from destructive fishing practices and from the ornamental trade and habitat destruction due to sand and boulder mining. Population estimates of this species records a decline of more than 60% in five years. In some other areas, it is inferred that the species may have undergone more than 30% decline in its entire population. It is therefore assessed as Vulnerable.

Range Description: The species is recorded from the Brahmaputra basin in India and Bangladesh and the Indus drainage from Pakistan.

Population: Population estimates of this species were carried out in different parts of its distribution range. Catch frequency of *Botia rostrata* was 60% during 2004 but during 2009 it came down to 20% probably because it is a much sought after species firstly due to its good taste and secondly due to its ornamental value.

Habitat and Ecology: This species is reported to live in medium to fast current waters.

Commercial Importance: This fish carries no any importance as food fish but it is an ornamental fish and being exploited for aquarium trade.

Ompok bimaculatus (Butter catfish)

Status: Near Threatened (Year of assessment, 2010)

Justification: A widespread species that has undergone significant decline due to overexploitation as a food fish. The data shows declines throughout its range from overfishing and the species is assessed as Near Threatened with urgent need for taxonomic, harvest and population studies.

Range Description: *Ompok bimaculatus* is widely distributed in Pakistan, India, Sri Lanka, Bangladesh and Myanmar. However, given the uncertainties surrounding the identity of this species, it is possible that its range is more geographically circumscribed.

Population: This species is relatively abundant throughout its distribution. No empirical data on declines in its entire range is available, however, there are reports showing an average population decline of 29.3% over a period of four decades (1960-2000) for this species in some areas of its distribution. The average decline per decade since 1980 is about 60%. However, the difficulty in extrapolating data from a localized study and the taxonomic uncertainties surrounding the populations from throughout the subcontinent make it difficult to definitively consider this species to be in decline.

Habitat and Ecology: Inhabits plains and submontane regions, and is found in rivers, lakes, tanks and ponds.

Major Threat(s): Overexploitation of this species for food is a major threat and has resulted in marked population declines. The effects of other potential anthropogenic threats such as habitat destruction and competition from alien species need to be further ascertained.

Commercial Importance: It is considered a very tasty fish and is highly priced. It attains a length of 50 cm and weighs up to 200 grams.

Species not Bearing IUCN status but of Commercial Importance:

The species Tor putitora, Sperata seenghala, Clupisoma garua, Schizothorax plagiostomus (richardsonii), Cyprinus carpio and Mastacembelus armatus are commercially important species. Size and weights of these species are given in Table 2. Brief description of the commercially important species viz., *Tor putitora*, *Cyprinus carpio, Schizothorax plagiostomus* has already given above. Brief description of some of the other commercially important species is given below:

Clupisoma garua (Garua Bachwa)

Brief Description: Body elongate and compressed, abdominal edge keeled between pelvic fin and vent. Mouth is subterminal and teeth in villiform bands on jaws. Barbels in four pairs, the nasal barbells not reaching the eye while maxillary barbells extending o base of pelvic fins. Adipose fin is absent in adults.

Commercial importance: This fish is common in the rivers of Indus plain and grows to 60 cm and having a weight up to 500 grams. It is considered a good tasty food fish throughout its range. It is popular among the people who relish fishes without bones and so it fetches a good price. It is, however, not a good game fish as it is animal feeder.

Distribution: It is found in Pakistan, India, Bangladesh, and Nepal.

Biology: It inhabits large fresh water and tidal rivers. Feeds on insects, shrimps, other crustaceans and small fish.

Labeo dyocheilus (Dhi, Torki)

Brief Description: Body elongated and snout projecting beyond mouth with distinct lateral lobes. Mouth is wide and inferior with thick lips. Lower lip with an interrupted fold joined to isthmus by a narrow bridge. Barbels one short maxillary pair.

Commercial importance: This is a medium sized fish. It grows up to 90 cm and attains a weight of 5 kg. It is common species of Himalayas.

Distribution: Found in Pakistan, India, Bangladesh, Nepal, and Mekong basins.

Biology: Lives in clear active currents of large rivers. A migratory species spending winters in lower reaches of the Himalayan rivers while migrates upstream for breeding and feeding.

Mastacembelus armatus (Tire-track Spiny Eel)

Brief Description: The fish has dorsal spines from 33- 40 and dorsal soft rays from 67-82, anal soft rays 67 – 83. Body dull is brown with 1-3 darker longitudinal zigzag lines. These lines are more or less connected to form a reticulated pattern.

Commercial importance: This species attains a length of 90 cm and weighs up to 500 grams and is the largest spiny eel. It is very popular and a tasty food fish.

Distribution: Pakistan to Viet Nam and Indonesia.

Biology: A fish of economic importance species, both as food and aquarium trades. Lives in highland streams to lowland wetlands. Usually found in streams and rivers with sand, pebble, or boulder substrate. Seldom leaves the bottom except when disturbed. Also occurs in still waters, both in coastal marshes and dry zone tanks. Reported to occur in areas with rocky bottoms but enter canals, lakes and other floodplain areas during the flood season. It forages on benthic insect larvae, worms and some submerged plant material.

Endemic Fish Fauna of the Gulpur Hydropower Project Area

Schistura punjabensis (Hillstream Loach)

Brief Description: The dorsal and the ventral profiles in this hill stream loach run almost parallel to each other. The head is sub-triangular and depressed; its lower surface is greatly flattened. The caudal fin is longer than the head. The eyes are not visible from below and for a greater part lie in the anterior half of the head. There are six barbells, the inner maxillary are almost as long as the

diameter of the eye while the others are much longer. Well-developed lips, which are continuous at the angles, border the mouth; the lower lip is provided with a free labial fold, which is widely interrupted, and the lip itself is divided in the middle. The lateral line is complete and the body is devoid of scales. There are from eleven to thirteen dark bands on the body but not meeting on the abdomen.

Distribution: Endemic in Pakistan and distributed in Punjab and Kashmir

Biology: Occurs in small streams and rivers with gravelly bottom. Apparently non-migratory and widespread in hill streams

Commercial Importance: This fish carries no any importance as food fish but it is an ornamental fish and being exploited for aquarium trade.

Barilius pakistanicus (Pakistani Chilwa)

Brief Description: A small sized fish, body laterally compressed and both the profiles arched. Head is triangular and pointed. Snout short and point¬ed, eyes lateral and situated in the anterior half of head. Mouth large and antero-superior; its gape extending below the level of middle of the eye; its lower jaw longer than the upper jaw and symphysial knob present, lower jaw with a pair of longitudinal hard folds, covered with hard papillae running on the ventral side but not meeting each other in front. Groove present around the angle of mouth. Nostrils are much nearer to the eye than to the tip of snout. Barbels two pairs, rostral pair much longer than maxillary one which may extend up to the posterior margin of eye. Dark brown on the dorsal side, 9-15 vertical dark bands extending below lateral line. Sometimes number of bands on one side is more than on the other side.

Distribution: Endemic to Pakistan. Found in hilly areas of Punjab, Azad Kashmir, Hazara, Vale of Peshawar, Kohi Sulaeman and Indus drainage of Balochistan.

Biology: Lives in hill streams with gravelly and rocky bottom. It is carnivorous fish living on aquatic insects. It breeds during Monsoon season.

Commercial Importance: This fish carries no any importance as food fish but it is an ornamental fish and being exploited for aquarium trade.

Reptile Species Account

Out of the 21 recorded herps at the project site, six species (Agrore valley agama, Himalayan agama, Rohtas gecko, Bengal monitor, slender blind snake and Checkered keel-back snake) were found important being the CITES species as well as from conservation point of view whereas; two species were found important due to being problem species in the area. The two problem species are the venomous snakes including Common Krait (*Bungarus caeruleus*) and Brown Cobra (*Naja oxiana*). These two snake species are also important because these can be life threat to human as well as the livestock in the area due to their bites. A brief description of the important species is given below.

Bungarus caeruleus (Schneider, 1801), (Common Krait)

This snake is locally known as Sang Choor and considered a deadly poisonous snake. It belongs to the Family Elapidae that includes all deadly poisonous snakes. During the survey, one specimen was collected at one of the study site. Different local residents, wildlife watchers and farmers interviewed during the survey also pointed out its existence in the area.

Diagnostic Characters: Dorsal color is jet black to deep blue. A series of 3-9 light vertebral spots on anterior part of the body followed by a 38-56 narrow transverse bands usually in pairs. Ventral side of the body is white. This snake frequents open grass lands, semi deserts with alluvial soil. It is common in the marginal vegetation along tilled fields and extends into barns, farms, grooves and gardens. It lives in holes and crevices in the ground, piles of cut vegetation, bricks and debris etc. It is a nocturnal snake active just after sunset until dawn. Its food consists of toads, frogs, snakes, lizards and mice. A deadly poisonous snake in the area and killed by local residents whenever seen.

Fig. 3: Common Krait (*Bungarus caeruleus*) © M. Younus, SLF

Naja oxiana (Echwald, 1831) (Brown Cobra)

This snake is locally known as Bhoora Naag and considered a deadly poisonous snake. This snake also belongs to the Family Elapidae that includes all deadly poisonous snakes. Different local residents, wildlife watchers and farmers interviewed during the survey pointed out its existence.

Fig. 4: Brown Cobra (*Naja oxiana*) © Waseem, PWF

Diagnostic Characters: Dorsal color is light yellow to light brown and with or without a hood mark. Ventrum is clouded with dark. The brown cobra inhabits dry wastelands where it lives in holes and crevices in uneven ground. In mountainous areas it lives in caverns and holes in rocks. It feeds on rodents, birds, snakes and lizards and often enters inhabited houses attracted by rodents.

Xenochrophis piscator (Schneider, 1799) Checkered Keeled back Snake

Diagnostic Characters: Head is slightly flattened and distinct from neck, supra-labials are 8-10 with 4th and 5th in eye and infra-labials are 9-10. Ventrals are 135-152 and sub-caudals 62-78. Dorsum is light green, grey or light reddish brown with five rows of blackish blotches. These blotches are smaller than inter-spaces and often fused with each other to form a reticulation. This pattern is more marked in the anterior half of the body and fades posteriorly. Ventrum is white or cream color. It is quite common in all major drainage systems in the upper and lower indus valley.

Habitat: This snake is more common in large ponds with thick emergent vegetation. It confines itself to side pools avoiding the main stream. In winter when most of the water bodies are dry, this snake is helpless and is killed in large numbers by people and other animals like mongoose and kites. Water visiting birds are said to take a high toll on young snakes. The snakes that have survived attacks usually have broken tails which is common in this species.

Habits: This semi aquatic snake is strong and active moving briskly both on land and in water. It is reported to move in jumps on land. It is known to be bad tempered; when cornered it rears up and flattens its body ready to bite. It strikes with great determination and rapidity, bites viciously holding on with such tenacity that it is difficult to dislodge and leaves nasty wounds. During winter it is diurnal whereas in summer, it becomes crepuscular and nocturnal. It is often seen swimming close to the upper warmer layers of pond in winter and basks on dry ground.

Fig. 5: Checkered Keeled back Snake © Waseem, PWF

Food: It feeds on fishes, frogs, and tadpoles. The prey is ambushed with the large teeth of the snake that play an important role in retaining a firm hold on slippery prey and subduing it.

Breeding: This snake breeds from February to May. Around 50-80 eggs measuring 27-31 mm by 15-18 mm in dimensions are laid in adhering clusters in holes away from water.

Himalayan Rock Agama Laudakia himalayana (Steindachner, 1869)

Five specimens of Himalayan Rock Agama (*Laudakia himalayana*) were collected from the study area. Laudakia himalayana is distributed from western Himalayas to Tajikistan. In Pakistan the species has been recorded from northern areas around Gilgit and Chitral (Khan M. S., 2006). Khan W. A., (2006) recorded it

Fig. 6: Himalayan Rock Agama © Waseem, PWF

from Qarchenai, Dhee and Shimshal valleys and also from Aagh, Zoi Saam, Toghraqeen, Padekishk and Arbab Kook nullahs at different elevations from 3000 m to 4000 m in Karakorum mountain ranges.

Diagnostic Characters: *Laudakia himalayana* is a diurnal and herbivore lizard. It breeds during May and June and juveniles can be seen by July and August. During the present study apart from adult individuals several juveniles were also observed. A grayish dorsal color was observed with light spots in large numbers without any specific sequence. Posterior side of head and neck was bearing small spinose scales. Tail was dorso-ventrally flattened at its base while rounded along rest of the part.