2 BASELINE SETUP OF THE AREA

2.1 River System of Himachal Pradesh

The Himalayan mountain chain has a dominant influence on the climatic conditions prevailing over Indian sub-continent. They lie in the path of rain-bearing monsoon winds and thus bring rain to a large part of India. The Himalaya houses a vast reservoir of moisture both in the form of ice, fresh-water and underground water. The rivers draining the Himalayas sustain life in the Northern part of the Indian subcontinent. The drainage system of Himalaya is very complex. It is composed both of rivers and glaciers. Himalayan River criss-cross the entire mountain chain. In fact a number of rivers are older than the mountain system. They have cut across the various mountain ranges. In Himachal, rivers from two rivers systems- Indus River System (Satluj, the Beas, the Ravi, the Chenab and the Jhelum) and Ganga River System (only river Yamuna) flow through.

Table 2.1 Indus River System

Name of River	Source	Total Stream length (km)	Drainage (km2)	Remarks
Jhelum	Northern of Pripanjal, Kashmir	400	28, 490	Indian Scetor Only
Ravi	Born in Bara Banghal, Kangra district	725	5957	Indian sector only
Chenab	Greater Himalayan Canton of Lahaul	1180	26,755	Indian sector only
Beas	Beas Kund at Southern face of Rohtang pass in Greater Himalayas (4062 m)	470	25, 900	-
Satluj	Mansarvor group of lakes in Tibet Himalayas 4630m	1050	24, 087	Indian sector only
Yamuna	Yamunotri in Gharwal hills and forms the Eastern boundary with Uttar Pradesh	1,300	359,000	Catchment area in Himachal is 2320 km²

2.1.1 Indus River System

The river Indus rises from the Tibetan plateau and enters the Himalaya in Ladakh. It enters the Kashmir region near its confluence with the river Gurtang, at an elevation of about 4200 metres. The drainage basin of the Indus river system extends from the Naga Parbat mass in the extreme North-Western part of the country to the Western slopes of the Shimla ridge in Himachal Pradesh. It includes the whole of Jammu and Kashmir and most of Himachal Pradesh. The extreme Northern tract of the Indus basin comprises of the cold desert of Ladakh, Lahaul Spiti and Pooh. South of this tract lies the higher Himalayan mountain wall. The lower and middle Himalayas occupy the central part of the Indus basin. The low rolling Shivalik hills occur along its Southern periphery.

Climatic conditions in the Indus river system vary from arctic to sub-tropical. The cold desert area remains devoid of rainfall and experiences heavy snowfall. The important rivers of this system are the Satluj, the Beas, the Ravi, the Chenab and the Jhelum. Out of these five, four flow through Himachal Pradesh and along with their tributaries draining parts of Himachal Pradesh.

2.1.2 Ganga River System

The drainage basin of the Ganga river system covers about one third of the Western Himalaya and the entire Central Himalaya. This basin extends from the Eastern face of the Shimla ridge in Himachal Pradesh to the South-Western slopes of the Kanchanjunga massif on the Nepal-Sikkim border, thereby including parts of Kinnaur, Shimla, Solan and Sirmaur district of Himachal and Garhwal, Kumaun and Nepal. The Ganga is the most sacred river of India.

The Ganga has its source near Gomukh glacier, near Gangotri (Uttar Pradesh). The Ganga is formed by two head streams namely Alaknanda and Bhagirathi. It enters the plains near Haridwar. The Yamuna meets this river at Allahbad known as Sangam. The Ganga is the master stream of the area. South of Farakka, the river divides into a number of channels to form Sunder Ban Delta (Largest in the world). The main tributaries of the Ganga system are the Yamuna, Bhagirathi and Alaknanda, Kali and its tributaries, the Ghagra, the Gandak and the Kosi River. Only river Yamuna flows through the State of Himachal Pradesh.

2.1.3 Satluj River in Himachal Pradesh

Satluj rises from beyond Indian borders in the Southern slopes of the Kailash mountain near Mansarover lake from Rakas lake, as Longcchen Khabab river (in Tibet). It is the largest among the five rivers of Himachal Pradesh. It enters Himachal at Shipkila (altitude is 6,608 meters) and flows in the South-Westerly direction through Kinnaur, Shimla, Kullu, Solan, Mandi and Bilaspur districts. Its coarse in Himachal Pradesh is 320 km. from Rakastal, with famous tributaries viz. the Spiti, the Ropa, the Taiti, the Kashang, the Mulgaon, the Yula, the Wanger, the Throng and the Rupi as right bank tributaries, whereas the Tirung, the Gayathing, the Baspa, the Duling and the Soldang are left bank tributaries. The prominent human settlements that have come on the banks of the Satluj River are Namgia, Kalpa, Rampur, Tattapani, Suni and Bilaspur. Its total length is 1,448 km. It leaves Himachal Pradesh to enter the plains of Punjab at Bhakhra, where the world's highest gravity dam has been constructed on this river. Its total catchment area in Himachal Pradesh is 20,000 sq. km. Its vedic name is Satudri and Sanskrit name Shatadru. The Satluj finally drains into the Indus in Pakistan. The catchment area of about 50,140 km. of Satluj River is located above the permanent snow line at an altitude of 4,500 metres. The upper tracts of the Satluj valley are under a permanent snow cover.

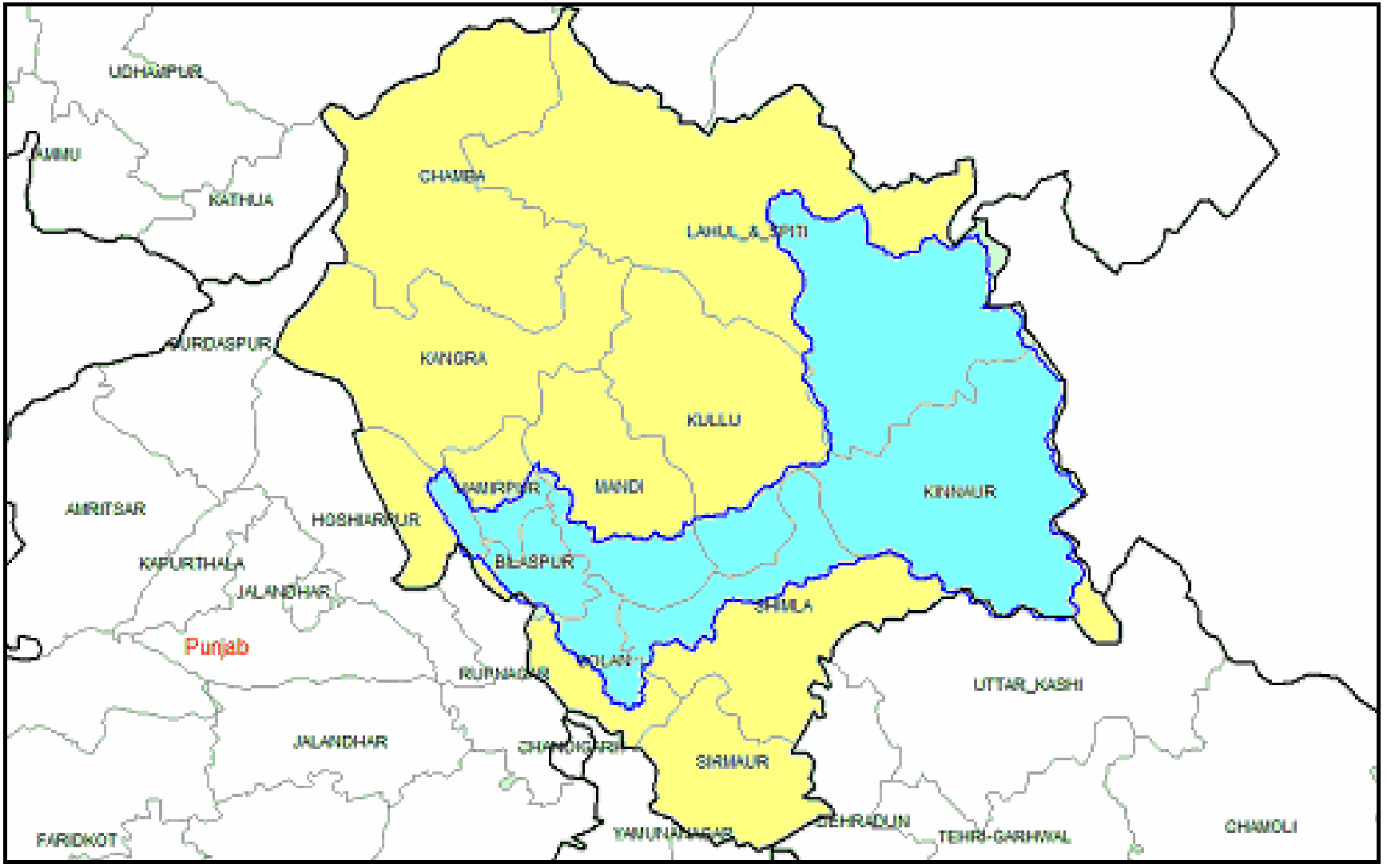

Fig 2.1 Geographical Location of the Satluj Basin in Himachal Pradesh

Important Tributaries of river Satluj

a) Spiti River

The Spiti River originates from Kunzum range and Tegpo and Kabzian streams are its tributaries. Water draining the famous Pin valley area are also a part of the Spiti river system. Its position across the main Himalayan range deprives it from the benefit of the South-West monsoons that causes widespread rain in most parts of India from June to September. The river attains peak discharge in late summers due to glacier melting. After flowing through Spiti valley, the Spiti River meets Satluj at Namgia in Kinnaur district traversing a length of about 150 km. from the North-West beyond that it flows in South-West direction in the Pradesh. Huge mountain rise to very high elevations on either sides of the Spiti River and its numerous tributaries. The mountains are barren and largely devoid of a vegetative cover. The main settlements along the Spiti River and its tributaries are Hansi and Dhankar Gompa.

b) Baspa River

Baspa is an important tributary of the river Satluj in its upper courses. The Baspa is joined by many smaller channels draining snowmelt waters. The Baspa River has cut across the main Himalayan range. Thereafter it empties itself into the river Satluj in district Kinnaur. Baspa originates from the Baspa hills, joins it from the left bank near Karcham. Satluj River leaves Kinnaur district in the West near Chauhra and enters Shimla district.

c) The Nogli Khad

It joins Satluj just below Rampur Bushahar. The river Satluj enters Mandi district near Firnu village in the Chawasigarh and passes through the areas of Mahunm, Bagra, Batwara, Derahat and Dehar. Practically the whole of the ancient Suket state except Jaidevi and Balh circles drains into Satluj. The main tributaries of the Satluj in district Mandi are Siun, Bahlu, Kotlu, Behna, Siman, Bantrehr, Khadel and Bhagmati.

d) Soan River

The Soan River rises from the Southern slopes of the Shivalik range also known as Solasinghi range in the tract to the East of the Beas gap across the Southern periphery of the Kangra valley. It joins the boundary of Himachal Pradesh and Punjab. Its gradient is not very steep and the slopes of the Soan catchment vary from gentle to steep. In the summer the discharge drops drastically, while during monsoon it is in spate.

A detailed map showing various tributaries joining Satluj has been provided in Chapter- 4.

2.2 Hydro Power Potential in Himachal Pradesh

The State has been hallowed by tremendous hydropower potential. A comparative overview with regard to hydropower potential of various river basins in the state has been presented below (refer Table 2.2). The total potential of various river basins in the State in terms of power generation is estimated to be 20463.5 MW approx. As of June, 2003, Himachal Pradesh had 145 Hydro Electric projects worth Rs.47, 479 crore in various stages of planning and implementation. Table 2.3 gives an overview of capacities of different ongoing and proposed projects hydroelectric projects on river Satluj in Himachal Pradesh.

Table 2.2 Hydropower potential in various River Basins of Himachal Pradesh

S.No	River Basin	Identified potential MW
1.	Satluj	9728.25*
2.	Beas	4293
3.	Ravi	2181
4.	Chenab	3301
5.	Yamuna	960
Total		**20463.5 MW**

Source: EIA for Rampur HEP, H.P, Year 2005
**SJVNL , Infra/ Consultancy division, Oct, 2005*

Table 2.3 Hydropower potential of Satluj Basin in Himachal Pradesh

S. No	Name	Installed Capacity (MW)	Status
1.	Bhakra dam	1325.00	Under Operation
2.	Chaba	1.75	
3.	Nigli Stage I	2.50	
4.	Ganwi stage I	22.50	
5.	Sanjay vidyut Pariyogna	120.00	
6.	Rukti HEP	1.50	
7.	Rongtong	2.00	
8.	Baspa II	300.00	
9.	Nathpa Jhakri	1500.00	
	Sub Total	**3275.25**	
10.	Bhaba	4.50	Under Construction
11.	Ganwi II	10.00	
12.	Kashang	66.00	
13.	Kol dam	800.00	
14.	Karcham Wangtoo	1000.00	
	Sub Total	**1880.50**	
15.	Rampur	412.00	DPR prepared
16.	Shongtong karcham	402.00	
	Sub Total	**814.00**	
17.	Kashang II	60.00	Under Investigation
18.	Kashang III	132.00	
19.	Sorang	60.00	
20.	Luhri	700.00	
21.	Khab	636.00	
	Sub Total	**1588.00**	
22.	Yangthang Khab	261.00	PFR's prepared

S. No	Name	Installed Capacity (MW)	Status
23.	Jang Thopan	480.00	
24.	Thopan powari	480.00	
25.	Tidong –I	60.00	
26.	Tidong II	70.00	
	Sub Total	**1351.00**	
27.	Kuling Lara	40.00	
28.	Lara	60.00	
29.	Mane Nadang	70.00	
30.	Lare Sumita	104.00	Projects yet to be studied
31.	Sumta Kathang	130.00	
32.	Chango Yangthang	140.00	
33.	Ropa	60.00	
34.	Baspa-I	210.00	
35.	Bharari	5.50	
	Sub Total	**819.00**	
	Grand Total	**9728.25 MW**	

Source: SJVNL, Infra/ Consultancy Division Oct, 2005

2.3 Project Area

The goal of the present study is to assess the cumulative impacts of all operational and proposed hydroelectric projects on the area. Hence, entire stretch of river Satluj including Spiti at upstream has been considered under project area for the purpose of assessment. Emphasis has been given on RHEP and NJHEP project areas to examine and understand the share of impacts, among aggregate impacts.

The area of influence of Nathpa-Jhakri Hydroelectric project (NJHEP) falls in between longitude 77^0 35' 35'' and 77^0 57' 57'' and latitude 31^0 23' 56'' and 31^0 33' 55''. The Hindustan Tibet Road (NH-22) connects the project site with the country. The nearest broad gauge railhead is at Kalka located at an approximate distance of 280 km from the project site. This road lies on the left bank of the river Satluj, and it is on this side that all the NJHEP project components are situated. The Kalka-Shimla-Narkanda-Rampur-Jhakri-Nathpa road was mainly used for the transportation of various equipment and materials during the construction phase of NJHEP. A road called Rampur Bye-pass road was also constructed as an alternate for transportation of heavy equipment. The site has reasonably good telecommunication and power facilities

The area of influence of Rampur Hydroelectric project (RHEP) falls in between longitude 77^o35' to 70^o43'N and latitude 31^o23' to 31^o30'. The catchment area of Rampur HEP includes Rampur range, Bahli range, Machhada catchment of Nankhari Range and parts of Sarahan range viz. (Two blocks of 15/20 of Phancha and Jhagori, Bhagawat Beat of Sarahan Block) in Rampur Forest division and Nirmand range, Nither & Margi of Nither Range in Ani Forest Divison.

2.4 Key features of various Hydro power Schemes on the river Satluj in Himachal Pradesh

The Government of India and State Government of Himachal Pradesh have identified the Satluj River as one of the main sources of hydroelectric projects. The total hydro-power potential of Satluj river basin as estimated is 9728.25 MW out of which 5515.75 MW is being harnessed through projects that are either under operation or in construction stages (refer Table 2.3). In this particular section, key features of main hydro- power projects that are in varying stages of planning, construction, completion and operation have been discussed (refer Fig 2.2). The main hydroelectric power plants and dams are:

Khab, Kinnaur District

The Khab HEP located in the Northern Power region is conceived as a run-of-river development on the river Satluj to tap the hydroelectric potential of the upper reaches of river Satluj as it enters into the Indian Territory. The project envisages the construction of 275 m high concrete gravity dam with 12.6 km long and 9 m dia tailrace tunnel and would generate 1020 MW of electricity with a tentative construction cost of 14000 Crores. It is envisaged that the cost will be shared by downstream benefitting projects due to storage of silt which increases life of downstream reservoirs. For the scheme, diversion works on the river are located at 310 d/s of Khab, the confluence of river Satluj and river Spiti in District Kinnaur of State, about 300km from Shimla.

Karcham Wangtoo Hydroelectric Project (1000MW), Kinnaur District

The Karcham Wangtoo Hydroelectric Project will utilise the head available between the tail waters of Baspa Hydroelectric. Project Stage-II and head waters of Nathpa-Jhakri Hydroelectric Project. The project envisages a concrete gravity dam about 43 m high above the river bed (approx. 98 m high above the deepest foundation level). The dam will have 6 sluice spillway bays of size 9m (W) x 9m(H). The other main component of the Project are: 10.48 m diameter, 17.2 km long head race tunnel, 4.75m dia. 4 nos. pressure shafts, an underground power-house with 4 x 250 MW installed capacity, transformer hall and 909 m long 10.48 m dia tail race tunnel. The diversion of river is envisaged by construction of a Diversion tunnel.

Bhaba Hydel Project, Kinnaur District

The 120 MW Sanjay Vidyut Pariyojna of Bhaba Hydel Project is complete. The project includes a weir across the Bhaba Khad, a right bank tributary of Satluj with a desilting basin, a small reservoir 2.5m (finished), 8.4 km long head race tunnel, 5m dia underground surge shaft, underground pressure shaft, and underground power-house on right bank of Satluj river. The project was commissioned by HPSEB in the year 1989.

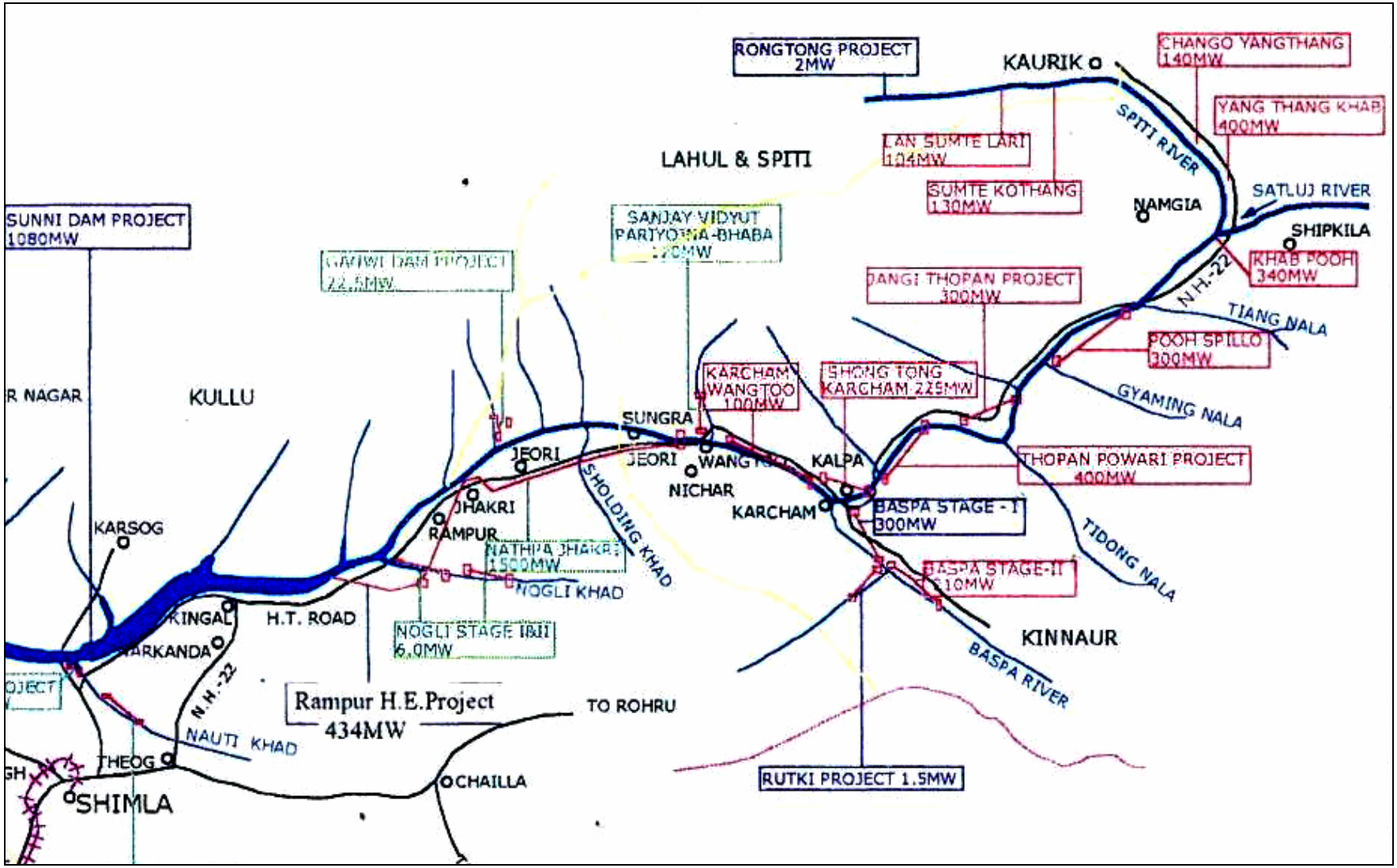

Fig 2.2 Various Hydro Power projects in the study stretch along Satluj River

Baspa Hydroelectric Project, Kinnaur District

It is located about 200 km from Shimla on NH-22 and envisages construction of a 10 m. high barrage across river Baspa, 8 km long and 4 m diameter head-race tunnel and underground powerhouse and has installed capacity of 300 MW. Project is complete and is commissioned.

Sorang Hydropower Project, Kinnaur District

The proposed Sorang hydroelectric project is a run-of-the-river type development on Sorang Khad, a tributary of Satluj River, in Kinnaur District. The project consists of construction of trench weir across Sorang Khad at an elevation of + 1943.50 m. The water flow directed shall be fed through + 1.540 km. long HRT and 183 m long pressure shaft and 970 m long buried Penstock to a under ground powerhouse on the left bank of Tikkadda Khad near the confluence with Satluj river. The Project thus utilizes a head rated of 667.15 m. to produce 100 MW of power. The power generated at Sorang HEP is propose to be fed into HPSEB 220/66KW substation at Kotla near Jeori and Kunihar in Distt. Solan. The present power supply position in the Northern Region indicates that there is shortage of peak power as well as energy of varying degree in most of the states. The anticipated power supply position in the year 2006-2007 indicates that the gap between the demand and supply would increase further in the coming years.

Table 2.4 Salient Features of key Hydro-Electric projects

Name of the project	Location		Hydrology		
	District	River	Catchment area (sq. Kms)	Average runoff in 90% dependable year	Average runoff in 50% mean year
Khab	Kinnaur	Satluj	44,000	4413 Mm^3	7138 Mm^3
Karcham Wangtoo	Kinnaur	Satluj	48,755	112558 cumec-day	75697 cumec day
Nathpa-Jhakri	Kinnaur	Satluj	49,820	7689 Mm^3	9596 Mm^3
Rampur	Shimla/ Kullu	Satluj	50,880	-	-
Luhri	Kinnaur	Satluj	52,403	9341 Mm^3	12074 Mm^3

Source: PFR Khab project, Year, 2004; EIA for Updation of NJHEP, Year 2003; Report on Karcham Wangtoo Project, Year 2005; EIA for Rampur HEP, Year 2005; PFR Luhri HEP, Year 2004

Ghanvi-I, Shimla District (22.50 MW)

Ghanvi -I hydroelectric project is a run-of-the-river scheme on Ghanvi khad a tributary of Satluj River in Shimla District of Himachal Pradesh. The project consists of a trench weir across Ghanvi Khad near village Ghanvi, vortex tube type desilting arrangement, power channel, underground forebay, surface/underground surge shaft, surface/underground penstock and a underground power house on the left bank of

Ghanvi khad. The project has been commissioned in the year 2000. The development and operating scheme of Ghanvi-I & II is very similar to that of Sorang Hydroelectric Project.

Ghanvi –II, Shimla District (10 MW)

Ghanvi-II hydroelectric project is being conceived as a run-of-the-river scheme on Ghanvi khad a tributary of Satluj River in Shimla District of Himachal Pradesh. The project consists of a trench weir across Ghanvi khad near village Rungcha, vortex type desilting arrangement, storage reservoir, 1.4 km long head race tunnel, underground surge shaft, surface/underground penstock and an underground power house on the left bank of Ghanvi Khad.

Nathpa-Jhakri Hydel Project, Kinnaur District

This project is the largest run-of-the river scheme on the river Satluj to harness the Satluj River for hydel power jointly undertaken by Haryana & Himachal governments and is. It is located 140 km from Shimla on NH-22 and includes construction of a 60.5 m. high gravity dam built on Satluj at Nathpa, a 27-28 km. long and 10.5 m. diameter head-race tunnel on the left bank and an underground powerhouse at Jhakri, with an installed capacity of 1500 MW (6 x 250). The catchment area at Nathpa Dam site in 49,820 sq. km. The plant will utilize the available 425m gross head between Nathpa & Jhakri. Project is complete and running with full capacity. The salient features are:

- The Nathpa Jhakri Power Project is under operation since 2003 and has a generation capacity of 1500 MW.
- The project is also utilizing the water of an intervening stream, i.e. Sholding khad through a trench weir and a drop shaft.
- The energy generation is of the order of 7425 GWH in a 50% mean year and nearly 6700 GWH in a 90% dependable year. The project has been completed at a cost of Rs.8656 crores.

Rampur Hydroelectric Project, Shimla-Kullu District

SJVNL has envisaged a 412 MW Rampur Hydro Electric project (RHEP), downstream of NHJEP to tap the hydropower potential of the Satluj River between Jhakri and Bael village. The proposed project is conceived as a tailrace development from the 1500 MW Nathpa-Jhakri HE Project (NJHEP). The Rampur project is designed to divert 405 cumec of de-silted water of the Satluj from the tailrace pool of NJHEP through 15 km headrace tunnel to a surface power station near Bael. The water from Rampur Intake structure shall be conveyed to the right bank through a cut & cover Conduit, 10.50 m dia HRT of 15.08 Km length terminating into a 140 m high, 38 m dia Surge Shaft. The length of HRT on left bank is 484 m before it crosses the river Satluj with a 43.2 m long Cut and Cover Conduit. The water will further enter into three underground penstocks 5.4 m dia each bifurcating into six Branch Tunnels each of 3.8 m diameter, to feed six generating units in a surface Power House equipped with Francis turbines driven generating unit each of 68.67 MW capacity. On comple-

tion, the project would utilise a gross head of 138 m to generate approximately 1969 GWH of design energy in a 90% dependable year. It will then return the water to the river. The salient features are:

- The project uses water from the Nathpa Jhakri project, and thus the Rampur scheme will not involve the construction of a dam or a reservoir, and no further land will be inundated.
- It envisages diversion of the entire 383.88 cumecs of desilted water from Tail Race Outfall of Nathpa Jhakri Hydro Electric Project (NJHEP) located on the left bank of river Satluj at Jhakri.

Luhri Hydroelectric Project (465 MW), Kinnaur District

The Luhri HEP is foreseen as run-of-the-river developments on Satluj River, in the reach between Luhri and Chaba villages in Shimla district of Himachal Pradesh just downstream of confluence of Behna khad with Satluj River near Luhri. The project site is about 80km from Shimla and is an upstream development to the proposed Kol dam electric project on Satluj River. The project envisages construction of a 60M high (above sea bed) concrete gravity dam on the river near the village Nathan for diversion of a design discharge of 477 cumecs, through 4 intakes and underground desilting arrangement into a 15.50 km long, 10.50m finished diameter head race tunnel on the right bank of the river. A gross head of 127m is available at the power station, which shall be utilised to generate 465 MW (3X 155 MW) of power.

Kol Dam

800 MW Kol Dam hydro electric project in Himachal Pradesh to be set up by National Thermal Power Corporation at an estimated cost of Rs 5300 crore is located in Distt Bilaspur. It envisages to utilize power potential of Satluj. The project involves construction of 163 m high rockfill dam across river Staluj 6 km upstream from existing Dehar power station and installation of four units each of 200 MW. The power generated will be evacuated to power deficient northern region through 400 KV integrated transmission system lines constructed for Nathpa Jhakhri and Kol dam projects.

Bhakra Dam

The construction of this project was started in the year 1948 and was completed in 1963. It is 740 ft. high above the deepest foundation as straight concrete dam being more than three times the height of Qutab Minar. Bhakra Dam is the highest Concrete Gravity dam in Asia and Second Highest in the world. There are two power houses namely Left Bank Power Plant and Right Bank Power Plant. It is a Concrete straight gravity with Height above the deepest foundation equal to 225.55 metres (740 feet) Its Height above river bed is 167.64 metres (550 feet). The elevation at top of dam above mean sea level is equal to 518.16 metres (1700 feet). The total installed capacity of left bank power plant is 450 MW - 5 units of 90 MW each and of the right bank power plant is 600 MW - 5 units of 120 MW each. The facility uses the Satluj River to supply drinking and irrigation water for portions of six states.