Chapter 5 Basic Information on Small Hydropower Plant Development in Chui Oblast

5-1 Profile of Kyrgyzstan and Chui Oblast

5-1-1 Natural Conditions

(1) Location

Kyrgyzstan is a landlocked country located in southeast Central Asia, bordering Kazakhstan, China, Tajikistan and Uzbekistan. It lies between latitudes 39° and 43° N, and longitudes 69° and 80° E. Its land stretches 925 km from east to west and 454 km from north to south with an area of 198,500 km² (of which 191,300 km ² is land area), that is about half that of Japan and the fourth-largest in the five countries in Central Asia. (See Figure 5-1-1)

Figure 5-1-1 Location of Kyrgyzstan

Chui Oblast is located in the northern part of the country bordering with Kazakhstan. Its area is 20,200 km², which accounts for over 10% of the area of the whole country. Chui Oblast is divided by cordillera and mountains into three regions, which are Chon-Kemin valley in Chon-Kemin river basin, Chui valley in Chu river basin on the north side of Kyrgyz range and Suusamyr valley in West Karakol river basin and Suusamyr river basin on the southwest side of Kyrgyz range. Chui valley is the widest plains 700 - 900 m above sea level and a region where the capital of Kyrgyzstan, Bishkek, is located and the industry is most highly developed in the country. (See Figure 5-1-2)

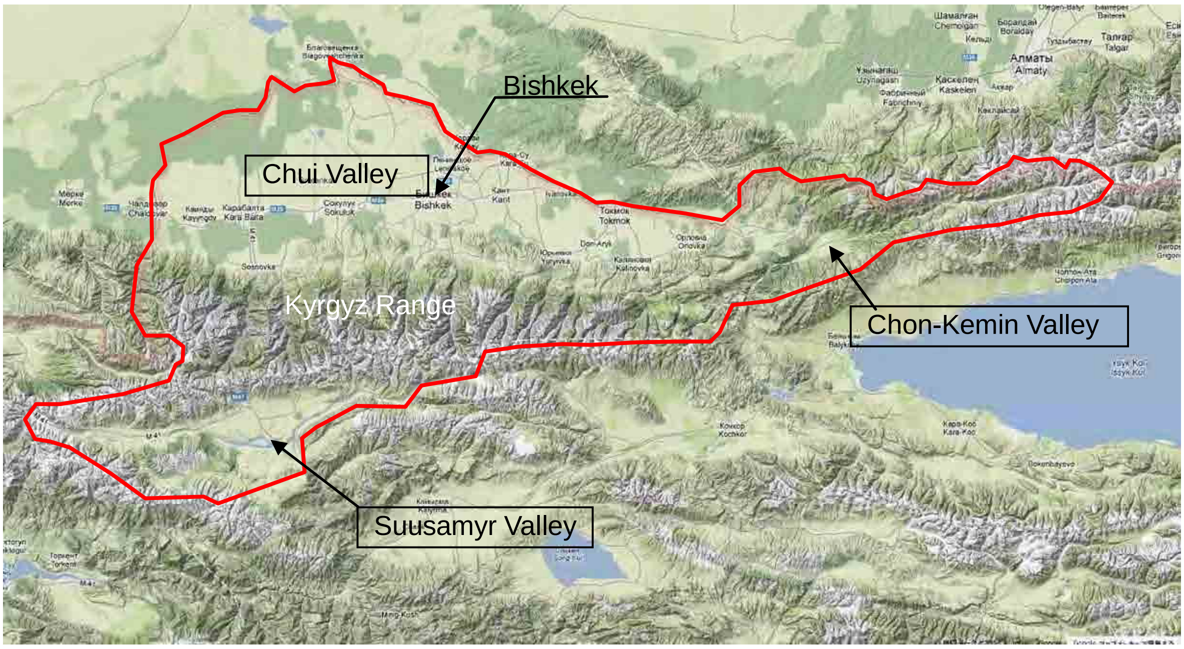


Figure 5-1-2 Location of Chui Oblast

(2) Topographical Features

Kyrgyzstan is located in the northwestern part of the Tian Shan Mountains and almost all areas of the country are covered with steep mountainous terrain. The highest mountain in the country is Peak Jengish Chokusu (Pobeda Peak; 7,439 m), which is also the highest peak of the Tian Shan Mountains. In the west of this mountain, Issyk-Kul Lake, which is the nation's largest salt lake (area 6,236 km3), is lying 1,606 m above sea level. 94% of the country is 1,000 m above sea level and more 40% is over 3,000 m above sea level. The average altitude of the country is as many as 2,750 m. Flat areas in the country are only 7.8% of the total land area. Most of the flat areas are distributed along Chu River close to the border with Kazakhstan and Talas River and in the Fergana basin located in the south of the country. In the south of Chui Oblast, Kyrgyz Range at an altitude of 4,000 m stretches from east to west. Chui valley in the north of Kyrgyz Range is formed by piedmont alluvial fans developed at the foot of Kyrgyz Range.

Major river systems in Kyrgyzstan are Syr Darya River, Chu River, Talas River, and Issyk-Kul Lake. The mountain area in the southwest of Issyk-Kul Lake is a source of Chu River flowing to the north and also a source of Naryn River (535 km) that flows to the west and merges with Syr Darya River in the Fergana Basin. The catchment area of the Naryn River is 5,911,000 km2, which accounts for about 30% of the total land area of Kyrgyzstan. Chu River System, covering the north part of the country, is located in Chui Oblast including major cities in the country, has become the center of the irrigated agriculture. Its domestic length is 336 km, of which 221 km is a border with Kazakhstan. A half of the total basin area of Chu River, 384,000 $km^{2,}$ is located in the Kazakhstan territory. Issyk-Kul Lake System in the east of Chu River is a closed basin with no outflow and its basin area is 157,000 km^2.

(3) Climate

Kyrgyz Climate is classified as the continental climate, but the climate conditions varies from place to place because the great differences in height from the high mountains to the plains have given the country a great deal of variety in its topographical features. Temperature is very different in the mountain and lowland plains (500 - 800 m), but it is generally dry and cool, in winter very cold and there is also a snowfall.

Looking at the monthly mean temperature distribution for the full year, the temperatures in the region bordering the west of Uzbekistan, the northern part of Chui Oblast and its surrounding area are the highest, around 25 ℃ around in the summer, and between -2 and -5 ℃ in winter. On the other hand, the temperatures in the Tian Shan Mountain Areas bordering China are the lowest, around 2 ℃ in summer, and below -25 ℃ in winter. However, the average temperatures in the plains are between 6 and 12 ℃ in summer, and between -10 and -20 ℃ in winter . The average temperatures in the mountainous area are between 15 and 25 ℃ in summer, and also between -5 and -10 ℃ in the winter.

Annual average precipitation in Kyrgyzstan is between 300 and 600 mm in general, but it varies depending on region and altitude. The western Fergana Mountains region has an annual average precipitation of more than 1,000 mm. the highest amount in the country, while the entire region from the areas in contact with the Chinese border to the central areas has that of between 200 and 300 mm the fewest in the country. On the other hand, with respect to snowfall, there is shown a large value as the high altitudes in both the number of days with snowfall and continuous snow cover period, and especially the mountainous regions of Fergana, Talas and Kyrgyz Mountain Ranges have a large amount of snow cover.

For Chui province, its annual average precipitation is about 400 mm, the temperature in the capital Bishkek is between -5 and 35 ℃. It is hot and dry in summers, and there is a relatively large amount of rainfall in winter. The temperatures are relatively high for the continental climate.

(4) Geology

The special feature of the geology of Kyrgyzstan is that in the northern region, the granitic zone with 120 km north-south width runs from east to west of the country. Around this zone, the Tertiary and/or Quaternary sediments spread mainly in the lowlands, and the Devon Carboniferous sediments are located in the middle.

In Chui Oblast, there are all distributions of the typical geological sediments in Kyrgyzstan, including the granite zone in the southern mountainous regions, the Tertiary and Quaternary sediments in the northern lowlands and the slight Devon Carboniferous deposit in the middle.

(5) Vegetation

A large amount of forest in Kyrgyzstan were cut down between 1925 and 1950, and the forest area dropped dramatically from 1,194,000 ha in 1930 to 691,600 ha in 1956. The current forest area is 854,900 ha, which is 4.32% of the total land area, and plays an important role as water reservoir areas for the other Central Asian countries. In Kyrgyzstan there are large differences in height from the high mountain areas to the plains. The grassland area (Steppes) is distributed below 1,500 m above sea level, the broad-leaved forest and coniferous forest between 1,500 and 4,000 m, and the alpine plant zone with perennial snow more than 4,000 m. Due to the over-grazing of livestock in the past, the Kyrgyz vegetation has changed greatly from its original vegetation. There are a few large-scale forests and vegetation communities (desert vegetation, steppe vegetation, grassland, deciduous shrubs, tall forest, etc.) are distributed in mosaic. The forests are scattered in the valley in the mountainous areas, and 50% of the coniferous-broad-leaved forest is open forest. The forest rates of Issyk-Kul, Naryn, Talas, Osh, Jalal-Abad and Chui Oblasts are 9.8%, 5.3%, 3%, 2.3%, 2.2% and 1.9%.

As for the vegetation in Chui Oblast, the northern part is covered mostly by wastelands dotted with scanty shrubs and no vegetation lands due to salt damage is mostly in the northern flat ground, while the moderate slopes of the Kyrgyz Range is covered largely by grazed pasture, and on the steep slopes at the higher altitude only juniper open forests can be found. Thornbush communities grow wild in the arid foothills area, and spruce, birch, larch, etc. are planted on a trial basis in a relatively wet place. In Chon-Kemin region, natural coniferous forests including spruce and fir and open forests of juniper are distributed.

5-1-2 Social and Economic Situation

(1) Social Situation

As Kyrgyzstan became under Russia in 1876 and a republic of Russia after the Russian Revolution, it has been strongly influenced by the Russia politically, socially and economically. Soon after the independence in 1991 associated with the collapse of the former Soviet Union, under President Akayev, Kyrgyzstan announced its reform policies which mainly consist of the market economy and democratization, and became in 1998 the first member country of WTO among the former republics of the Soviet Union. It was emphasizing the relationship with the Russian Federation, while it was trying to actively promote democracy and adoption of market economies with the support of Western countries. However, since the economy of the country, which is poor in resources, was still sluggish, the people could not enjoy the fruits of the economic reform. Under such a situation, the anti-government movement of the opposition had increased. The anti-government movement which was started in the south in the wake of the fraud in the parliamentary elections in the end of February 2005, extended finally to the capital, and this movement eventually led to the overthrow of Akayev regime in March 2005. Bakiyev former prime minister of the opposition leader was elected as the acting president and prime minister, and won the presidential election in July 2005, took office in August 2005. However, even under the Bakiyev regime, the political and economic reform had been still sluggish and the political unrest continued.

In April 2010, public discontent was growing and large-scale demonstrations occurred. Following the collisions between demonstrators and security authorities (86 casualties), President Bakiyev left the country and finally resigned. After this political change, for the purpose of prevention of spread corruption and bribe-dictatorship of President, the presidential system was abolished and the parliamentary system for the first time in the Central Asian countries has been adopted. The current President is Mr. Atambayev, who was elected in the presidential election in October 2011.

Kyrgyzstan’s population is 5,400 thousands (United Nations Population Fund 2011), and 1.1%, its population growth rate, is low as compared with the 1.9% average annual population growth rate in the 1980s. It is a multi-ethnic country with more than 80 ethnic groups living because of a variety of historical backgrounds in the country. According to the statistics in 1994, the ethnic composition was Kyrgyz: 58%, Russians: 18%, Uzbeks: 14% and others: 10%, but now it is Kyrgyz: 75%, Uzbeks: 14.3%, Russian: 7.2%, Dungans: 1.1%, Ukrainians: 0.3%, others such as Uyghurs and Tatars (Kyrgyz Statistics Committee data, 2011). The composition of Kyrgyz tends to increase, while that of Russians tends to decrease. On the other hand, religion in Kyrgyzstan is believed to be not so popular because it is a multi-ethnic nation and had been under the old socialist system, but many of the Kyrgyz people are Sunni Muslim which accounts for 75% and 20% of the Russians are Russian Orthodox Christians.

The population in Chui province is 790 thousands (Census, 2009) and accounts for about 15% of Kyrgyzstan overall. The most of the population are concentrated in the capital Bishkek and Tokmok. The ethnic composition in the oblast is Kyrgyzs: 59.1%, Russians: 20.8%, Dungans: 6.2%, others such as Uyghurs and Uzbeks (Census, 2009). Compared to other areas in Kyrgyzstan, the proportions of minorities other than Kyrgyzs are high.

Chui Oblast consists of eight (8) administrative districts of the Tokmok city as show below. Chui district and Alamedin district surround the Tokmok city and the Bishkek city respectively, but the Bishkek City does not belong to the Oblast because the Bishkek city is a special city.

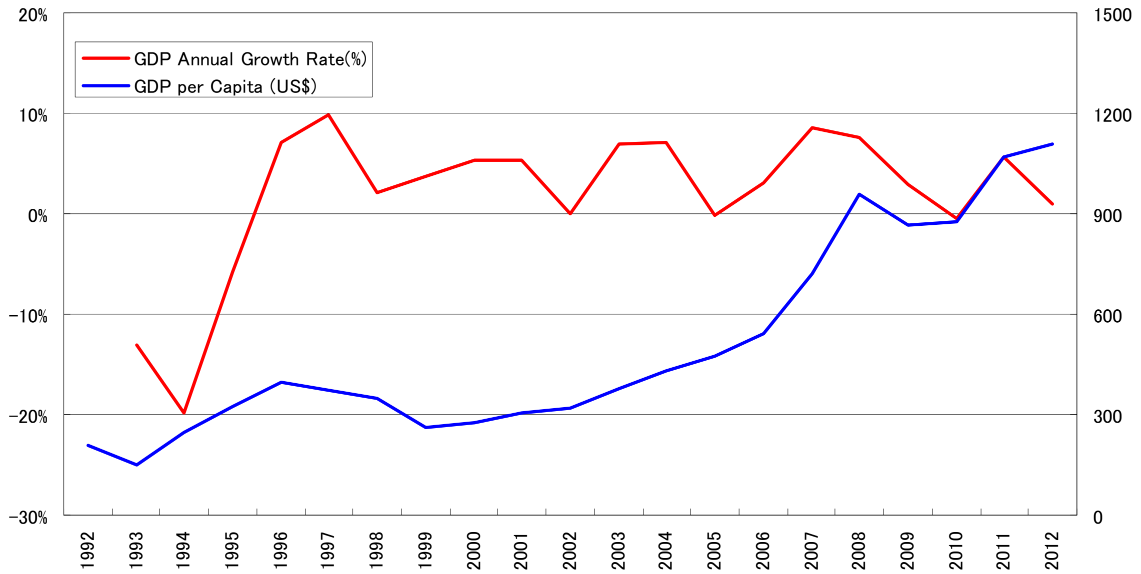
Table 5-1-1 Administrative Districts of Chui Oblast

District	Capital	Population (2009 Census)
Kemin District	Kemin	41,924
Chui District	Chui	44,753
City of Tokmok	Tokmok	53,087
Issyk-Ata District	Kant	131,503
Alamedin District	Lebedinovka	147,208
Sokuluk District	Sokuluk	158,137
Moskovsky District	Belovodskoe	83,641
Jaiyl District	Kara-Balta	90,348
Panfilov District	Kayyngdy	39,837

Source: Census 2009

(2) Economic Situations

After the independence, starting with the price liberalization in 1992, Kyrgyzstan promoted the radical market reform in accordance with IMF's recommendations of fiscal austerity. Economic slump continued in the confusion of the collapse of the former Soviet Union, but in 1996 GDP turned positive for the first time after the independence. Then, although there was a crisis including fragile financial condition under the influence of the Russian financial crisis in 1998, basically positive economic growth has been continuing. (However, negative growths were marked in 2002 and 2005 partly due to the decline in gold production in Kumtor gold mine). Not seen a direct impact of the global financial crisis, but due to the impact of the recession in Russia and Kazakhstan, which are economically close to Kyrgyzstan, remittances from overseas migrant workers have also decreased and the GDP growth has slowed since October 2008. (see Figure 5-1-3) GDP in 2011 is USD 5,920 mil. (IMF), GDP per capita USD 1,070 (IMF estimates), the economy growth rate (real GDP) 5% (IMF), and the unemployment rate 7.9% (IMF).



source: IMF - World Economic Outlook Databases(oct.2012)

Figure 5-1-3 GDP Growth Ratio and GDP per Capita

More than 20 years after the independence, Kyrgyzstan, poor in natural resources, has not been able to get on the stable trajectory in economic development, and still cannot shed its dependence on international economic assistance. It could be said that although the Kyrgyz economy of today depends on the external conditions, it remains stable at a low level by support efforts made by international aid agencies and donor countries.

Kyrgyzstan's main industries are agriculture and animal husbandry (about 30% of GDP), mining, food processing, apparel manufacturing and commerce. Kyrgyzstan is poor in energy resources including oil and natural gas, but rich in water resources. The abundant water coming from the Tian Shan Mountains with the glaciers is used not only for agriculture in Kyrgyzstan but also for power business (power export). It has expanded trade with China as a WTO member country. Transit trade that exports the imports from China to the CIS countries has become a major pillar of the Kyrgyzstan's economy.

Chui Valley, where the capital Bishkek is located, is a plain in the northern Chui Oblast and the most developed region for industry. Main irrigation canals and railways run parallel with Chu River. It has become favorable conditions for the development in this region and make it easy to get coal from Kazakhstan. At present, natural gas pipelines have reached to Bishkek from Central Asia and Caspian Region, and contribute to the supply of energy sources. In Chui Valley, about 60% of the industrial output in Kyrgyzstan has been produced, and machinery industry, food industry, light industry, non-ferrous metal industry and construction machinery industry have been developed. The precipitation is too small, between 300 mm and 600 mm per year, to grow crops. In order to overcome this small rainfall for the agriculture, the irrigation facilities including Chui Big Canals have been in place and the agriculture in this region has been well-developed. Chui Valley is covered by alluvial fans that were formed by Chu River and its tributaries, but there are a few areas that are covered by gravel unstable for agriculture, and the majority has become a fertile soil with ocher. The main agricultural products in this region are wheat such as grain, gourd, fruit such as grape, tobacco and sugar beet. In this region, the stockbreeding also is thriving and the pig farming reaches 70% of the entire Kyrgyzstan.

5-2 Hydrological, Meteorological, Topographical and Geological Information

5-2-1 Hydrological and Meteorological Information

The climate of Chui Valley, which is located in the northern part of Chui Oblast and accounts for most of the Oblast, belongs to a humid continental climate (Dfa) in the Köppen climate classification. California has clear skies around 170 days a year. Bishkek, which is located almost in the center of the valley, has clear skies as many as 322 days a year on average. The average temperature in January is -2.6 ℃, the average temperature in July is 25.9 ℃, the annual average temperature 11.3 ℃, and the annual precipitation about 400 mm. In summer, the weather stays fine, and it is pretty hot in the daytime, but cool in the morning and the night. Clear skies continues during the summer, during the day be hot pretty cool morning and evening. In winter, it is cold and often snows, and there may be a heavy snow. The record maximum and minimum temperatures are 42.8 ℃ and -34.0 ℃ respectively.

In Kyrgyzstan, many stations for observation of hydrological, meteorological data have been installed. since the former Soviet Union era. The stations are classified into Hydropost and Meteostation Meteopoint. River flows are measured at the Hydroposts (gauging stations), while weather observation items are observed at the Meteostations and the Meteopoints. Figure 5-2-1 shows the locations of the Hydroposts in Chui Oblast. As shown in this figure, 14 Hydroposts can be found, and most of them are installed along the tributaries flowing from the northern slopes of the Kyrgyz Range to Chui Valley. However, since around 2000, observations at many of the Hydroposts, have reportedly been stopped because of lack of maintenance. Detailed river flow data, including the daily flows for the long period in the past, at the Hydroposts is kept in the Kyrgyz Hydromet.

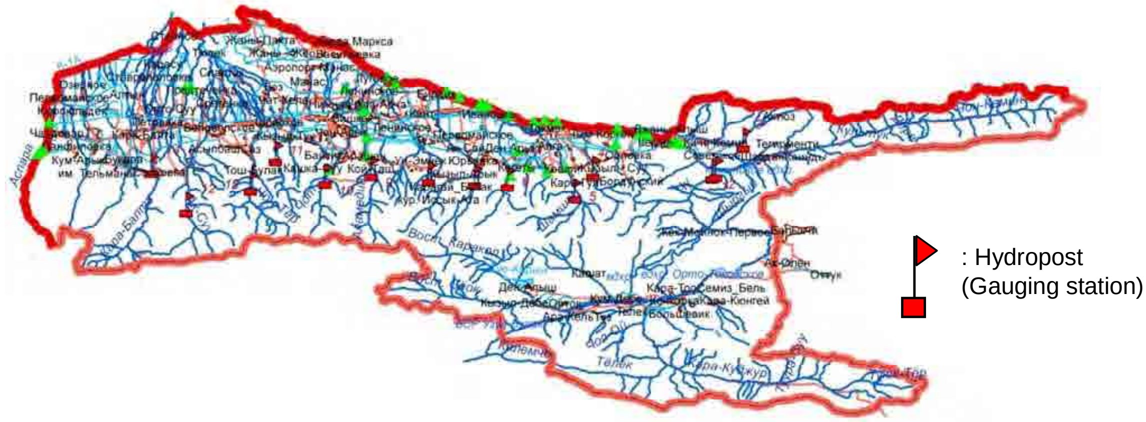


Figure 5-2-1 Locations of Hydroposts in Chui Oblast

(1) Precipitation

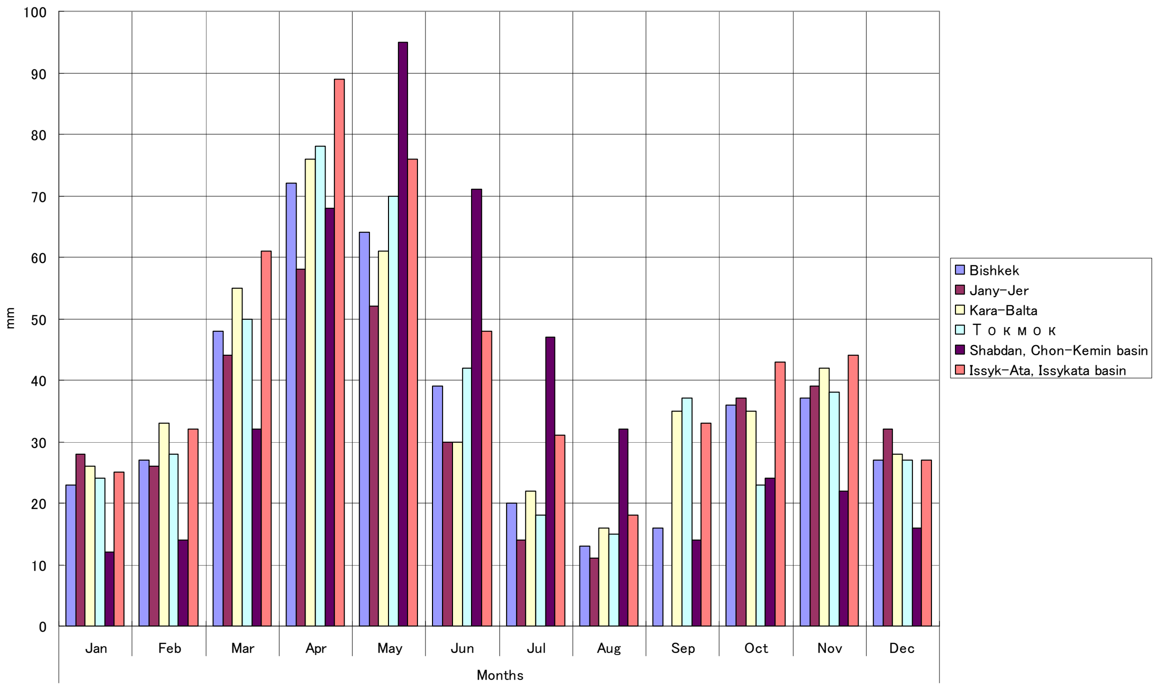
The average monthly precipitations observed in the capital Bishkek and other places in Chui Oblast are shown in Table 5-2-1 and Figure 5-2-2. Except for the observed values at Shabdan located in Chon-Kemin Valley far away from Chui Valley, there is no significant difference in the precipitations observed at the different places. The amount of precipitation from March to May of the year is the highest, while that from July to September of the year is the lowest. The amount of the annual precipitation in this region is around 400 mm, which is an average value in whole Kyrgyzstan and one fourth of the amounts observed in Japan.

Table 5-2-1 Average Monthly Precipitations in Chui Oblast

(unit: mm)

Station	Months												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Bishkek	23	27	48	72	64	39	20	13	16	36	37	27	422
Jany-Jer	28	26	44	58	52	30	14	11	0	37	39	32	383
Kara-Balta	26	33	55	76	61	30	22	16	35	35	42	28	340
Токмок	24	28	50	78	70	42	18	15	37	23	38	27	344
Shabdan (Chon-Kemin)	12	14	32	68	95	71	47	32	14	24	22	16	340
Issyk-Ata	25	32	61	89	76	48	31	18	33	43	44	27	389
Average	23	27	48	74	70	43	25	18	23	33	37	26	370

Source: Kyrgyz Hydromet



Source: Kyrgyz Hydromet

Figure 5-2-2 Average Monthly Precipitations in Chui Oblast

(2) Temperature

Daily temperatures in Bishkek are shown in Table 5-2-2.

Table 5-2-2 Temperatures in Bishkek

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C	3.2	4.9	11.2	18.5	23.6	29.0	31.7	30.9	25.5	17.8	11.0	5.0	17.7
Daily mean °C	−2.6	−0.8	5.3	12.3	17.4	22.4	24.9	23.8	18.5	11.0	4.7	−0.9	11.3
Average low °C	−7.1	−5.2	0.4	6.4	11.1	15.6	17.9	16.4	11.3	5.0	−0.1	−5.1	5.6

Source: Pogoda.ru.net

(3) River Discharge

Based on the river discharge records at five (5) gauging stations installed along the rivers flowing from the north slopes of Kyrgyz Range to Chui Valley, specific discharges per 100 km^2 for several rivers were calculated. The approximate locations of these five gauging stations, the specific discharges at these gauging stations for eight (8) years from 1992 to 1996, 1999 and from 2001 to 2002, and their average values, are shown in Figure 5-2-3, Table 5-2-3 and Figure 5-2-4 respectively. The discharge records for the period between 1997 and 2000 are missing for some reason.

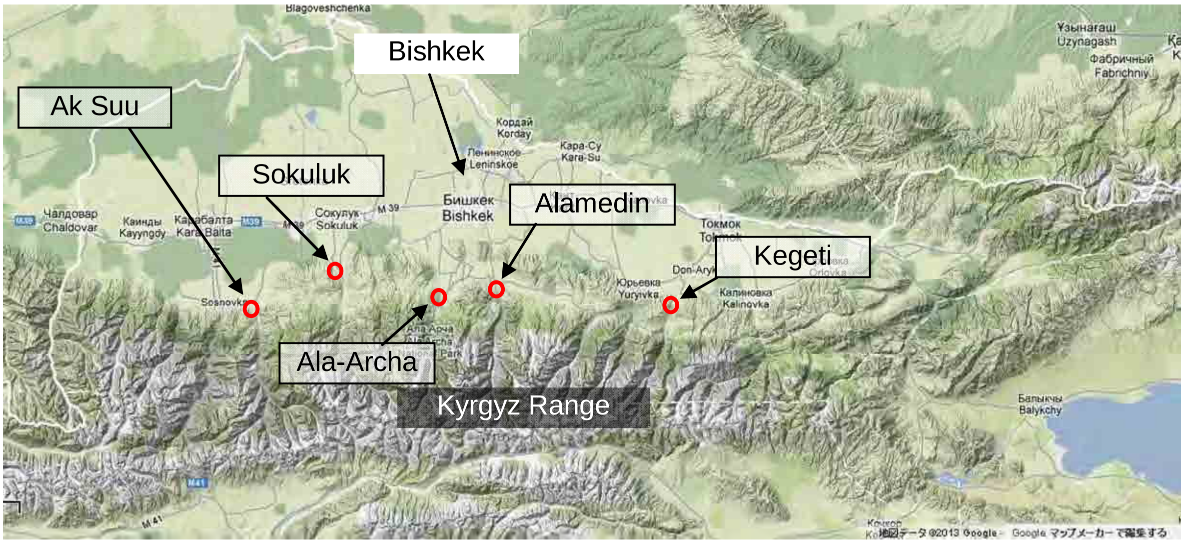


Figure 5-2-3 Locations of Gauging Stations for River Discharge Records

Table 5-2-3 Specific Discharge at Gauging Stations

（m3/s/100km2）（1992-1996, 1999, 2001-2002)

Hydropost	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Kegeti (C.A: 256km2)	1992	0.32	0.29	0.26	0.33	0.71	1.59	2.28	1.80	1.14	0.68	0.54	0.42	0.86
	1993	0.29	0.28	0.26	0.29	0.87	2.34	3.43	2.42	1.45	0.98	0.64	0.49	1.15
	1994	0.28	0.29	0.31	0.29	0.94	1.97	2.67	2.60	1.87	0.83	0.63	0.39	1.09
	1995	0.32	0.29	0.23	0.19	0.42	1.09	2.06	2.39	1.31	0.75	0.60	0.35	0.83
	1996	0.31	0.24	0.20	0.32	0.74	1.92	2.21	2.49	1.25	0.93	0.72	0.46	0.98
	1999	0.41	0.53	0.41	0.28	0.59	1.68	3.92	3.47	2.27	0.89	0.53	0.45	1.29
	2001	0.38	0.34	0.33	0.34	0.82	1.62	2.05	2.42	1.28	0.78	0.61	0.42	0.95
	2002	0.34	0.31	0.27	0.50	1.30	2.58	2.66	2.86	1.68	0.68	0.50	0.36	1.17
	Average	**0.33**	**0.32**	**0.28**	**0.32**	**0.80**	**1.85**	**2.66**	**2.56**	**1.53**	**0.82**	**0.60**	**0.42**	**1.04**
Alamedin (C.A: 317km2)	1992	0.69	0.66	0.63	0.61	1.25	2.99	6.78	5.21	2.58	1.22	0.78	0.65	2.00
	1993	0.76	0.80	0.79	0.85	1.34	4.38	6.88	5.05	3.25	1.59	1.03	0.89	2.30
	1994	0.83	0.77	0.75	0.73	1.35	4.95	7.19	6.37	2.85	1.28	0.91	0.70	2.39
	1995	0.69	0.69	0.67	0.66	1.26	2.74	6.12	6.25	3.10	1.92	1.01	0.80	2.16
	1996	0.76	0.68	0.61	0.57	0.90	3.28	5.02	6.09	2.75	1.55	0.90	0.68	1.98
	1999	0.53	0.52	0.51	0.53	1.15	2.58	5.55	6.69	4.45	1.93	1.09	0.91	2.20
	2001	0.68	0.63	0.61	0.61	1.93	4.38	6.03	4.92	2.88	1.24	1.07	0.91	2.16
	2002	0.74	0.65	0.55	0.76	1.62	4.32	6.28	6.50	3.12	1.81	1.19	0.91	2.37
	Average	**0.71**	**0.68**	**0.64**	**0.66**	**1.35**	**3.71**	**6.23**	**5.88**	**3.12**	**1.57**	**1.00**	**0.81**	**2.20**
Ala-Archa (C.A: 233km2)	1992	0.67	0.61	0.59	0.68	1.22	2.88	6.70	5.58	2.71	1.43	1.02	0.91	2.08
	1993	0.76	0.73	0.68	0.76	1.21	4.33	5.45	4.19	2.54	1.17	0.86	0.76	1.95
	1994	0.69	0.64	0.63	0.70	1.61	4.06	7.55	6.35	2.71	1.18	0.92	0.76	2.32
	1995	0.68	0.65	0.69	0.83	1.61	3.12	7.17	7.17	2.82	1.50	1.10	0.86	2.35
	1996	0.71	0.63	0.62	0.77	1.12	3.67	5.11	6.18	2.59	1.30	0.87	0.67	2.02
	1999	0.83	0.79	0.73	0.70	1.05	2.91	6.78	6.65	3.21	1.55	1.12	0.97	2.27
	2001	0.70	0.63	0.57	0.70	1.98	4.64	6.57	5.88	2.44	1.33	0.99	0.85	2.27
	2002	0.83	0.78	0.81	1.00	1.64	5.28	6.70	7.47	2.77	1.67	1.19	1.09	2.60
	Average	**0.73**	**0.68**	**0.66**	**0.77**	**1.43**	**3.86**	**6.50**	**6.18**	**2.73**	**1.39**	**1.01**	**0.86**	**2.23**
Ak Suu (C.A: 426km2)	1992	0.54	0.50	0.49	0.55	1.30	3.12	3.54	1.91	1.21	0.91	0.74	0.71	1.29
	1993	0.64	0.59	0.58	0.61	0.80	3.38	3.40	1.70	1.37	0.79	0.66	0.68	1.27
	1994	0.66	0.56	0.52	0.59	1.24	2.46	3.15	2.14	1.04	0.94	0.88	0.75	1.24
	1995	0.68	0.62	0.57	0.54	0.91	1.84	2.93	1.97	0.85	0.73	0.66	0.60	1.07
	1996	0.57	0.54	0.47	0.57	0.66	2.70	3.47	2.68	1.29	0.95	0.77	0.69	1.28
	1999	0.62	0.57	0.54	0.53	0.81	1.84	3.38	2.79	2.01	1.14	0.91	0.78	1.32
	2001	0.60	0.55	0.50	0.46	1.34	2.33	2.31	1.99	1.09	0.81	0.70	0.62	1.11
	2002	0.55	0.50	0.47	0.54	1.15	3.31	3.80	2.93	1.38	0.87	0.73	0.66	1.41
	Average	**0.61**	**0.55**	**0.52**	**0.55**	**1.02**	**2.62**	**3.25**	**2.27**	**1.28**	**0.89**	**0.76**	**0.69**	**1.25**
Sokuluk (C.A: 535km2)	1992	0.39	0.35	0.33	0.37	0.73	2.22	4.73	3.60	1.89	1.01	0.79	0.69	1.42
	1993	0.59	0.50	0.44	0.52	0.93	3.51	4.96	3.03	1.80	0.98	0.77	0.73	1.56
	1994	0.60	0.51	0.47	0.50	1.28	3.12	5.30	4.76	1.33	0.65	0.54	0.50	1.63
	1995	0.48	0.46	0.44	0.47	0.55	2.20	4.53	4.11	1.44	0.79	0.61	0.50	1.38
	1996	0.47	0.48	0.47	0.58	0.81	3.14	4.53	4.67	2.41	1.35	0.97	0.82	1.73
	1999	0.76	0.70	0.61	0.55	1.16	2.07	5.30	4.56	2.13	1.20	0.85	0.67	1.71
	2001	0.58	0.53	0.49	0.49	1.63	3.51	4.96	3.97	1.85	0.83	0.68	0.62	1.68
	2002	0.54	0.49	0.46	0.65	1.36	3.65	4.59	4.76	2.30	1.47	0.93	0.78	1.83
	Average	**0.55**	**0.50**	**0.46**	**0.52**	**1.06**	**2.93**	**4.86**	**4.18**	**1.90**	**1.03**	**0.77**	**0.66**	**1.62**
Average		0.59	0.55	0.51	0.56	1.13	2.99	4.70	4.21	2.11	1.14	0.83	0.69	1.67

Source: Kyrgyz Hydromet

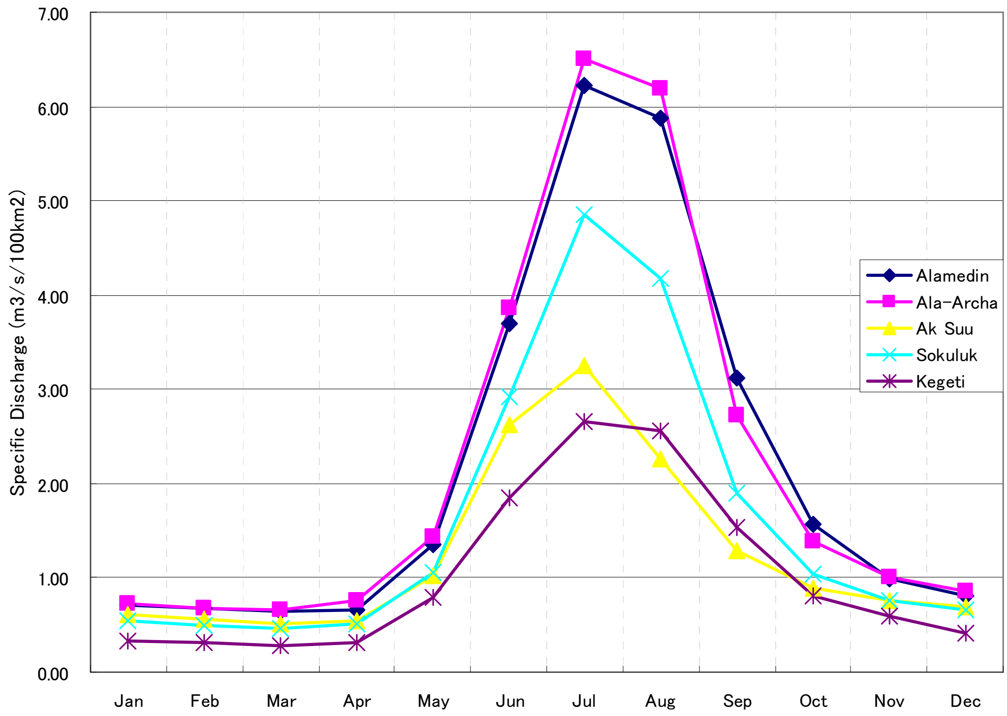


Figure 5-2-4 Specific Discharge ($m^3/s/100km^2$) at Hydroposts

As shown in Figure 5-2-4, the discharge patterns at different gauging stations tend to be similar in seasonal changes. The discharges are small during the winter period from January and March and large during the summer period from June to August. On the other hand, the discharge values vary greatly from river to river although the basins of the gauging stations are close to each other within 50 km radius.

(4) Correlation between River Discharge, Precipitation and Temperature

The Correlation between the specific discharges (average values in Table 5-2-3) and the precipitations (average values in Table 5-2-1) and the correlation between the specific discharges and temperatures (average values for Bishkek in Table 5-2-2) are shown in Figure 5-2-5 and Figure 5-2-6 respectively.

In general there is a high correlation between river discharges and precipitations, but the river discharges have a poor correlation with the precipitations as shown in Figure 5-2-5. On the other hand, as shown in Figure 5-2-6, the river discharges seem to have a better correlation with the temperatures than that with the precipitations. Such a correlation indicates that the melting of snow and/or glaciers in the alpine areas has a significant impact on the river discharges. The differences in the proportion of snow cover and glacier areas in the river basin may lead to major differences in the river discharges at different basins, especially in summer.

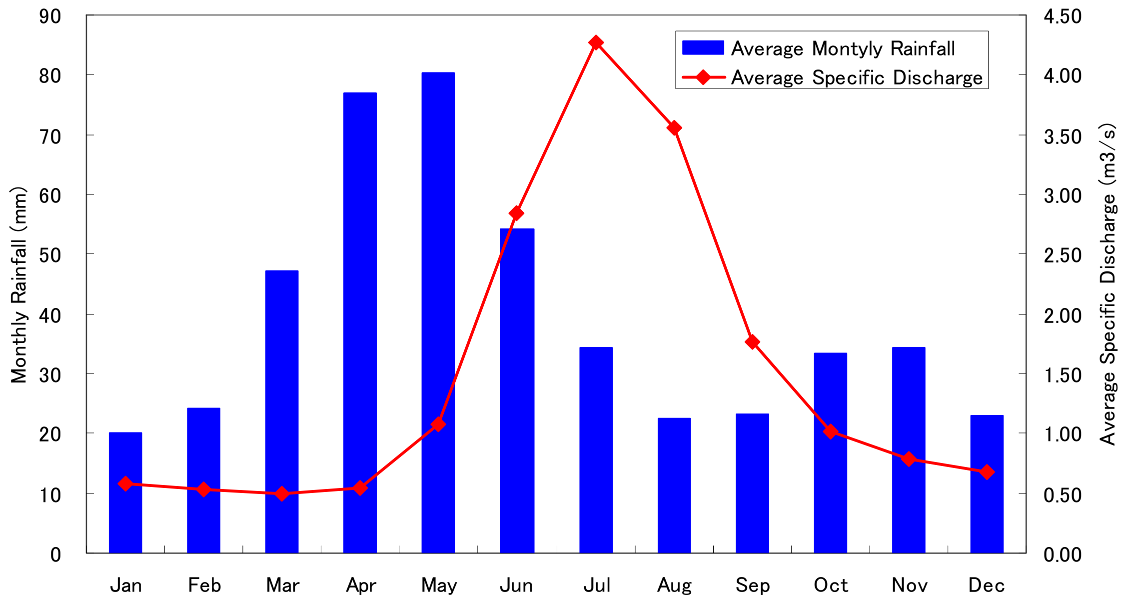


Figure 5-2-5 Specific Discharge and Precipitation

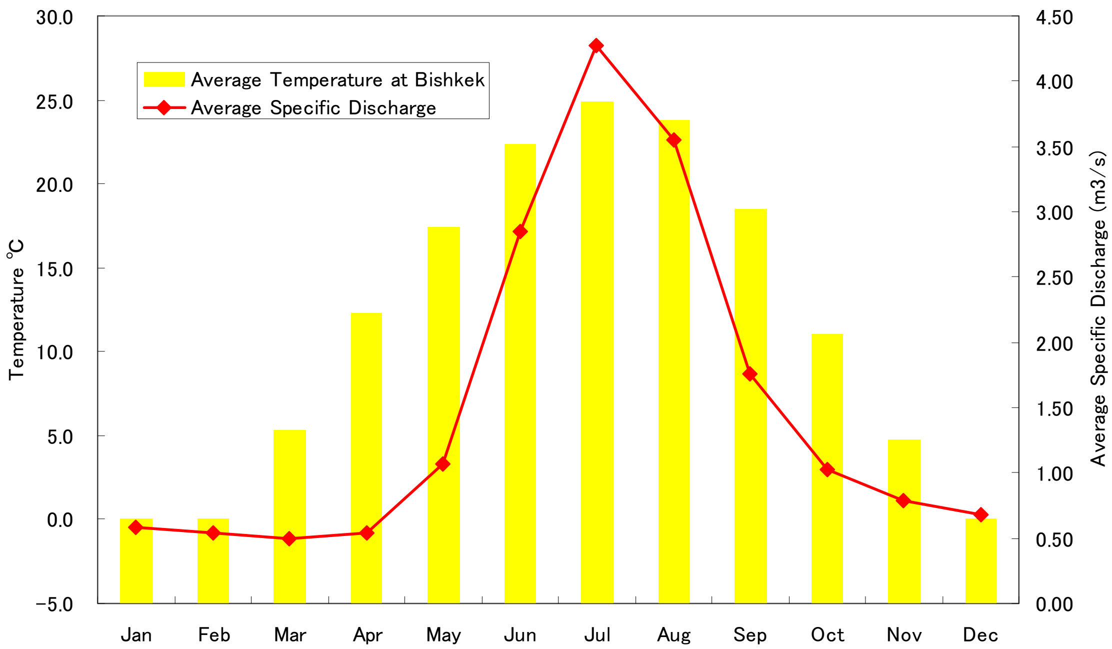


Figure 5-2-6 Specific Discharge and Temperature

5-2-2 Topographical and Geological Conditions

(1) Overview

Kyrgyz Range consisting of the mountains more than 3,500 m above sea level stretches east to west in the southern part of Chui Oblast. Chu River flows first from the southeastern part of the Kyrgyz Range, then goes around the eastern end of range to flow to the south, and finally flows to the west-northwest through around the border with Kazakhstan. The largest tributary of Chu River is Chon-Kemin River, which flows down through the elongated valley (Chon-Kemin Valley) located in the east end of Chui Oblast and flows into Chu River at the east end of Kyrgyz Range or at uppermost of Chui Valley. In the north slopes of Kyrgyz Range, there are a large number of mountain valleys lying south to north as tooth comb, through which mountain river run. These mountain rivers flow valleys, these rivers start to flow from the steep alpine zone, then run through alluvial fans forming Chui Valley, and finally flow into Chu River. (See Figure 5-2-7)

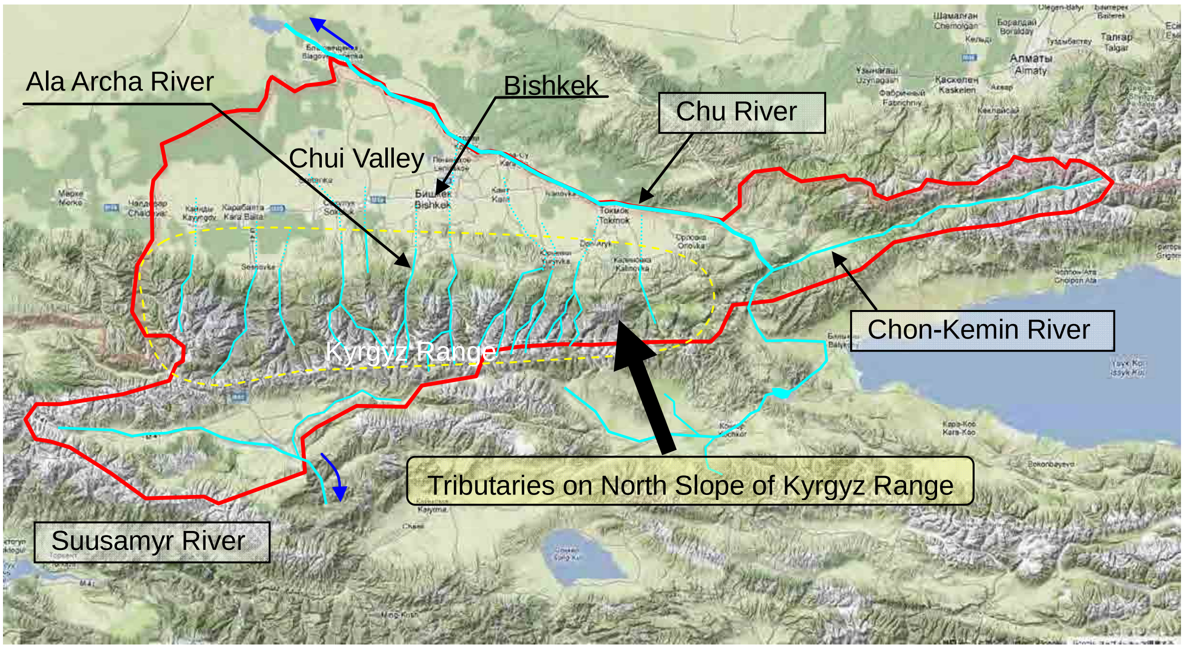


Figure 5-2-7 Topography and Rivers in Chui Oblast

(1) Rivers in the north slopes of Kyrgyz Range

Figure 5 2-6 shows the longitudinal profile of Ala Archa River, which is a typical river, running in the central part of Kyrgyz Range, flowing down through Chui Valley into Chu River. As the altitude of the river decreases, the river gradient is getting gentler, just like a profile of a general river. The geology along the rivers varies according to the altitude, and is rock composed of granite, etc., in the high mountain areas, mudflow deposition at 1,500 – 1,300 m above sea level, and alluvial fans at lower than 1,300 m above sea level. (see Photo 5-2-1, 5-2-2 and 5-2-3) Since the river alluvial fan is a gravel-rich soil with a high permeability, many of the rivers that flow down from the north slope of the Kyrgyz Range, flow into the underground when reaching the after running through the mountain valleys. The catchment areas at the tops of the alluvial fans are 200 - 500 km^2.

Looking at these rivers for finding small hydropower plant (hereinafter referred as to SHPP) potential sits, the potential sites are limited to a small stretch which is upper than the alluvial fans (higher than 1,300 m above sea level) ,and lower than 2,000 above sea level where roads exist, (the stretch indicated by a red dashed line in Figure 5-2-5), in consideration that most of existing SHPPs have been constructed in the sites with a river gradient of more than 1/25, there is need for access road, and the intake point should not be located at subterranean river.

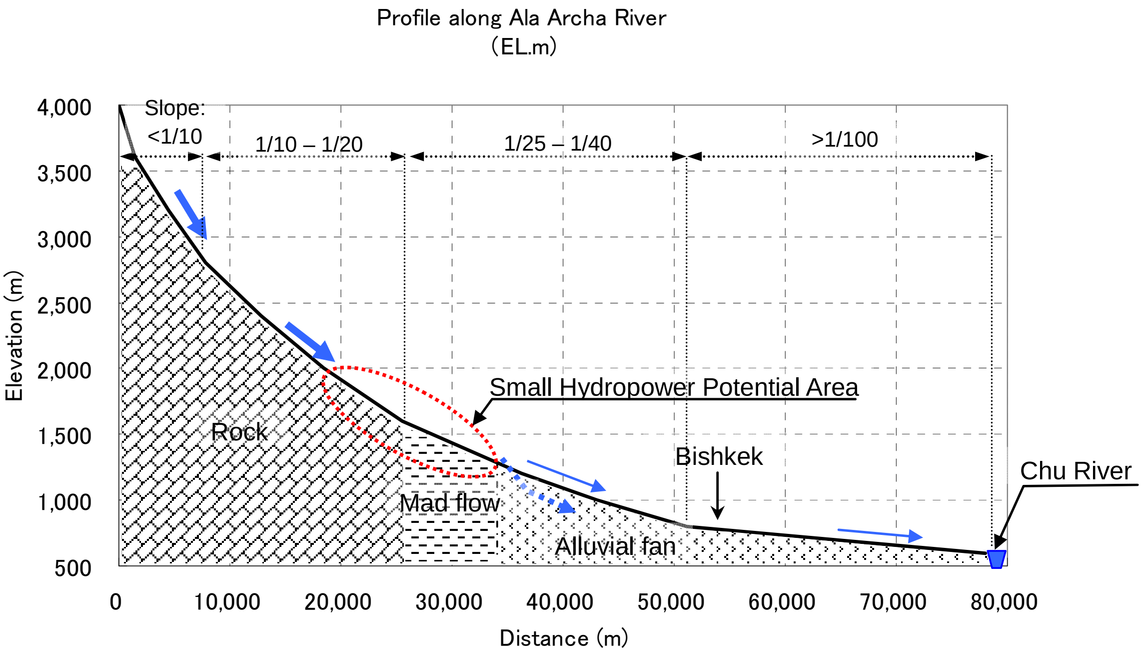


Figure 5-2-8 Longitudinal Profile for Ala Archa River

Photo 5-2-1 Rock around EL. 1,900 m (Kegeti)

Photo 5-2-2 Mudflow Hills (Sokuluk)

Photo 5-2-3 Top of Alluvial Fan (Djardy-Kainda)

5-3 Water Usage Conditions

5-3-1 Irrigation System

Chui Valley is covered with alluvial fans which were formed by Chu River and its tributaries, but there are only small places unstable for agriculture, and most of the valley is covered by the fertile soil including loess. Such arable farmland is 624,000ha, of which as many as 370,000 ha of the farmland is irrigated through the irrigation system including weirs, canals and reservoirs by taking the water from Chu River and its tributaries.

Major Irrigation Canals include the East Big Chui Canal, which takes the water from Chu River at upstream of Tokmok and flows down to the capital Bishkek, the South Big Chui Canal, which is branched from the East Big Chui Canal, and the West Big Chui Canal, which take the water at downstream of Chui River. In the upstream of Chu River, there is Orto-Tokoy Reservoir for the irrigation, which does not discharge any water to Chu River in winter to store the water for water supply to the irrigation system during the irrigation period. There are many irrigation canals which directly take the water at around river mouths of rivers flowing from the northern slopes of Kyrgyz Range. In such rivers including Alamedin, Shamsi and Ala-Arch River, reservoirs are constructed for intake water and water storage of irrigation system.

Photo 5-3-1 West Big Chui Canal in Bishkek

Photo 5-3-2 Irrigation Intake Facility at Ak Suu River

Since Chui Valley is covered by alluvial fans with a high permeability and has the well-developed irrigation system, in most of the natural rivers running through the valley, the river discharges decreases or become completely nothing. Such river conditions in the Chui Valley make it unfeasible to construct hydropower plants utilizing natural rivers in the valley in general.

5-3-2 Hydropower Plants utilizing Irrigation System

As mentioned in the previous section, the potential for hydropower projects utilizing natural rivers in Chui Valley is low, while more than30 m^3/s of water discharge flows in the major irrigation canals and the SHPPs well-utilizing this discharge are operated by Chakan GES as shown in Table 5-3-1.

Table 5-3-1 Small Hydropower Plants well-utilizing irrigation canals

	Name of plant	Capacity (MW)	Irrigation canal utilized by hydropower plant
1	Lebedinovka	7.6	West Big Chui Canal
2	Alamedin No.1	2.2	
3	Alamedin No.2	2.5	
4	Alamedin No.3	2.1	
5	Alamedin No.4	2.1	
6	Alamedin No.5	6.4	
7	Alamedin No.6	6.4	
8	Alamedin Midget	0.4	
9	Bystrovka	8.7	Name unknown
Total		38.4	

Source: Chakan GES

5-3-3 Water Usage from Chu River

Chu River is an international river flowing through the border of Kazakhstan and Kyrgyzstan. The agreement on the distribution of discharge for both the Republics was signed in February 1992. At present, the proportion of the annual water usage from Chu River and its tributaries is determined at 58% for Kyrgyzstan, and 42% for Kazakhstan, and the total annual amount of the river discharge is 6.5 billion m^3, of which 3.85 billion m^3 is used by Kyrgyzstan. If there is a need for a change in water use from the river, it is necessary to review the agreement through consultations between the two countries.

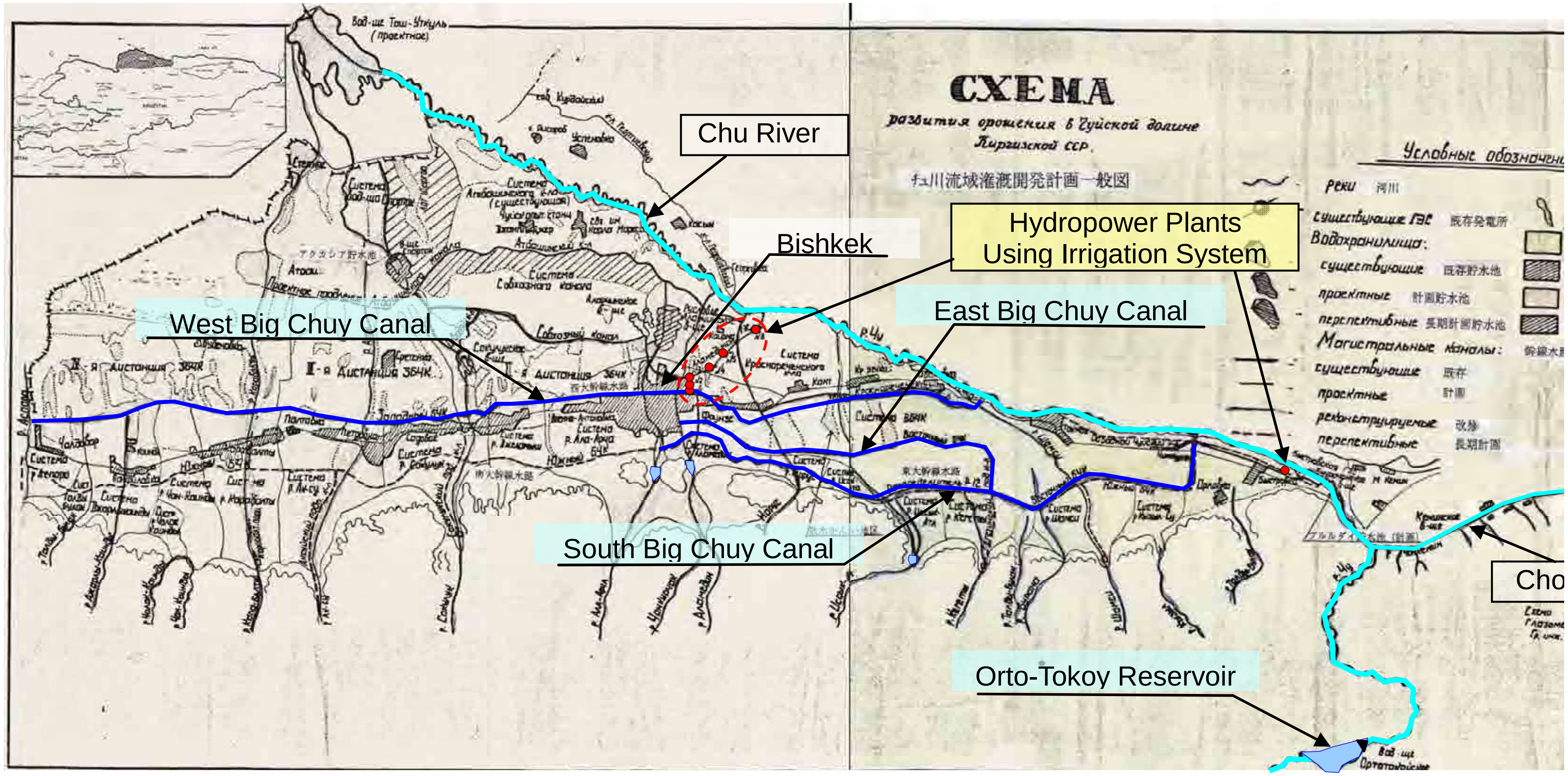


Figure 5-3-1 General Plan for Irrigation System in Chu River Basin

5-4 Status of the Power Sector

The electrification ratio in Kyrgyz is virtually 100% except for the 21 unelectrified villages. These villages are located only in Batken and Jalal-Abad Oblast; however, there is no unelectrified villages identified in Chui Oblast, the target for the survey. The residents who live in peripheral area receive power from 0.4kV low voltage distribution lines coming from 10/0.4kV or 6/0.4kV transformers. The 10 or 6 kV middle voltage distribution feeders come from the nearby 35/10kV or 35/6kV distribution substations (Photo 5-4-1).

In winter, forced outage is exerted by the emergency load shedding in order to restrict overload and protect 35kV distribution facilities in Bishkek city and its suburban area, a load center in Chui Oblast. According to JSC Severelectro, both Alamedin and Sokuluk districts, the largest power-consuming areas, are likely to be affected by frequent forced outage in winter. As mentioned in the section 2-4-3, according to MEI, taking into consideration the usual demand of the feeders for which power disconnections were done by distribution companies, it can be estimated that the total disconnected power was approximately 200 MW for peak power demands in January 2012. However, the JICA Survey Team was not able to obtain the detailed information on the number of households which became the target of the emergency load shedding, the total power interrupted, and the power interruption duration time to figure out the power necessary to cover the actual demand of the area due to constraints on data provision by JSC Severelectro. The other areas, specifically, the villages or communities near the hydropower potential sites have not experienced the forced outage even in winter because of its small power consumption. JICA Survey Team member conducted interview with villagers near Kegeti, Chon-Kemin, and Sokuluk-1 SHPP potential sites during the site investigation. Villagers of Bululu village near Sokuluk-1 potential site voiced dissatisfaction with the current power supply condition in that periodical forced outages for 2 to 3 hours per day have been exerted in winter. On the other hand, Villagers near Kegeti and those who live in Shabdan region, located at about 16km downstream of Chon-Kemin potential site and relatively large community with 1,200 to 1,500 households, answered that they have not experienced forced outage caused by tight supply-demand condition.

According to JSC Severelectro, the service area of which covers entire Chui Oblast, the capacity of the transformers of 35kV distribution substations nearby listed candidate SHPP potential sites is enough for connecting a SHPP with 1-2 MW output.

Photo 5-4-1 10kV Distribution Line (Left) and 10/0.4kV Transformer (Right) in Kegeti Village

5-5 Transmission, Distribution, and Transportation Condition

5-5-1 Requirements for Connection of Small Hydropower Plants to the Grid

The government-approved documentation No.476 in 2009 established the order and procedure of registration documents for the construction of technological connection to electric networks of SHPPs, and the order of acceptance of completed construction of SHPPs[1]. According to the regulation, the winner of the tender for the construction of SHPP (hereinafter referred to as "the owner of the document") should contact the owner of the electrical lines (JSC Severelectro falls under the category of the owner in Chui Oblast.) and the authorized body on Energy for registration of the contract according to the rate of payment for technological connection, of the amounts required to finance activities carried out in network and the power output of SHPP, and for obtaining technical specifications defining the technical requirements of the switchgear equipment, and hydro automation and relay protection. The owner of electrical networks is required to issue the terms of reference (hereinafter referred to as TOR) to the owner of the document within ten days after the agreement to pay according to the rate for technical connection. The TOR issued by the owner of the electrical network is supposed to contain requirements binding in the design of SHPP, and include the following:

- Requirements on equipment connections: switchgear, relay protection and automation
- Hydro equipment and hydro units of frequency and voltage (only for machines with unit capacity of 500kW and above)
- Demands to the account of electric energy in the volume requirements of the rules for electrical and other regulatory and technical documents
- Requirements for the technological means of communication
- Level of the short-circuit and that in removing
- Requirements that define the reservation of electrical equipment performed by the owner of the electric network for the grid connection of SHPP to the grid
- Scheme to the point of connection to the grid owner

SHPP in Chui Oblast and the existing distribution grid of JSC Severelectro are connected to 10kV, 6kV, or 0.4kV distribution lines depending on the scale of the power output, and on the distance to the existing distribution substations or ground-based transformers as the connection point. Practically, there is no such example of grid connection through a 35kV high voltage distribution line from a SHPP with the output of 1-2MW by stepping up to 35kV at the transformer in the hydropower station. Also, the proponent of the hydropower station has to bear the construction cost for new access distribution line to the connection point of JSC Severelectro.

As the typical situations, the following cases are considered:

1) An existing distribution line of JSC Severelectro passes nearby a new SHPP.
2) A terminal pole or transformer of JSC Severelectro is located nearby a new SHPP.
3) There is no existing distribution line of JSC Severelectro near a new SHPP.

For case 1), it is unusual to connect the new access distribution line to the existing distribution line to make a T-shape junction at the pole using special clamps. For case 2), it is considered reasonable to construct an access distribution line between the new SHPP and the terminal pole to connect to the existing distribution line. For case 3), either construction of an access distribution line from the new SHPP to the nearest distribution substation or construction of an access distribution line to the nearest terminal point of the existing distribution line can be chosen depending on the distance. With either pattern, the proponent of the hydropower station is supposed to ask for confirmation of technical conditions as well as to seek for JSC Severelectro's direction on the optimal connection method before it starts design of the facility in question. As mentioned above, JSC Severelectro, the owner of the

[1] Position on the order of construction, acceptance and grid connection of SHPPs to the grid, approved by the Government of Kyrgyz Republic, 2009, No.476

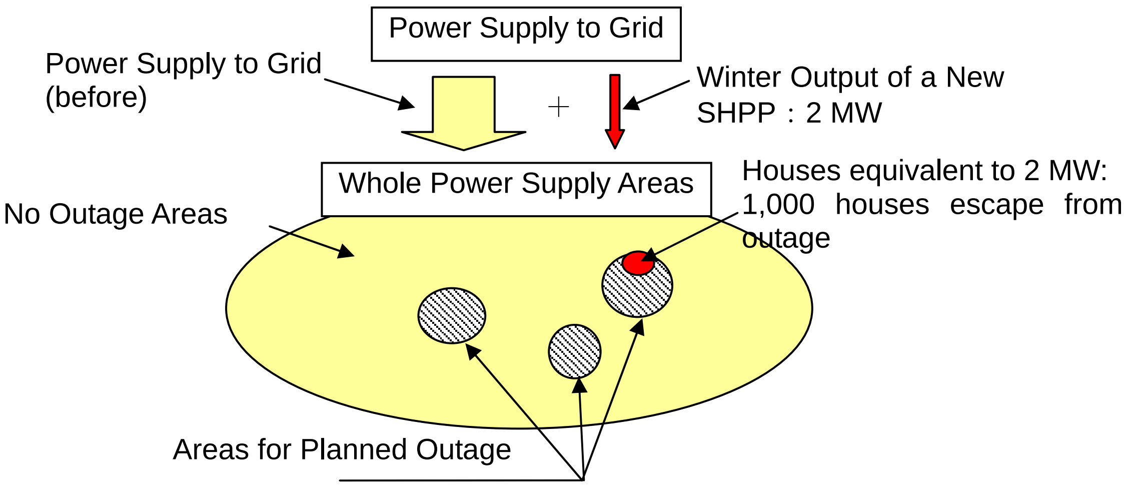
electric network, is supposed to provide the proponent with the confirmatory results as to technological constraints such as overload of conductors of existing distribution lines and/or substation equipment by connecting the new SHPP. Therefore, the configuration of the access distribution facility instructed by Severelectro may not necessarily be the cost minimum structure. For example, the proponent of the SHPP has to select the option to construct a long access distribution line to an existing distribution substation far from the hydropower station even if there is a terminal pole of the existing distribution line close to the hydropower station due to capacity limit of the conductor.

5-6 Beneficiaries of Small Hydropower Plants

As mentioned in the previous section, there is no unelectrified area in Chui Oblast, and electric power is supplied to all the areas through the grid. Therefore, any new SHPPs to be constructed in the Oblast will be connected to the grid and the power generated by the SHPPs is supplied to the grid, which covers all the areas in Chui Oblast. The areas where power supply conditions are improved by the new SHPP is not limited to only the areas near the SHPP. The new SHPP may be to contribute to increase in power supply capacity in the entire grid.

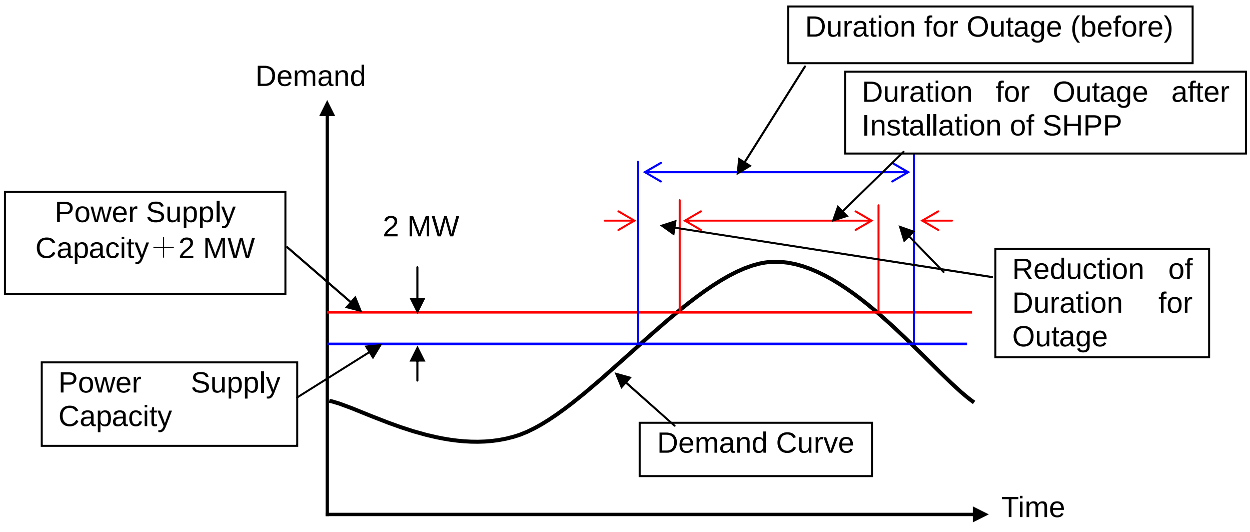
As mentioned in the Chapter 2, a planned outage of approximately 200 MW was performed in the northern region, and in winter such planned outages caused by lack of power supply to the grid system have been often performed recently. Since the scale of electricity demand for planned outage targeted areas is equivalent to the amount of power supply deficit, a newly constructed SHPP connecting to the grid leads to reduction of areas being forced to suffer from power outage and/or outage duration. (see below)

(Example) In case that a SHPP with an installed capacity of 5 MW and a winter output of 2 MW is constructed, the amount of power supply deficit decreases by 2 MW. → The number of houses equivalent to "2 MW" escape from outage. (assuming electrify demand per house is 2 kW, 2,000kW ÷ 2 kW＝1,000 houses)



Conceptual Picture representing effect for reduction of outage areas by a new SHPP installation when outage has to be performed due to lack of total power supply

In addition, timing on when electricity demand exceeds power supply (= when planned outage starts being performed) is delayed for some time for 2 MW supply capacity increase, while timing on when electricity demand decreases below power supply capacity (= when planned outage finishes being performed) is some time earlier for 2 MW supply capacity increase, and eventually outage duration is shortened in the areas where outage are planned. (see picture below)



Conceptual Picture representing effect for reduction of outage duration by a new SHPP installation when outage has to be performed due to lack of total power supply

The bigger the power output of SHPP in winter is, the higher such effect for reduction of planned outage by SHPP is. However, it should be noted that as shown in Figure 5-2-4, rivers flowing through the north slope of Kyrgyz Range have a smallest flow discharge in winter throughout of the year, and such river flow discharges (seasonal change in discharge) have a disadvantage for power supply deficit in winter.

As for the other positive effects by SHPP, when power supply deficit does not occurred, increase of power supply capacity in the power grid system is expected to lead to the positive effects for the entire power grid system or whole Kyrgyzstan, such as the followings:

1) Stabilization for power grid system, including stabilization of voltage and frequency
2) Reduction of fuel consumption in coal fired power plants, which is correspondent to increased power by SHPP (reduction of coal import, reduction of CO2 emission, etc.)
3) Increase of electric power export

5-7 Past Small Hydropower Development

In order to contribute to the study on the potential sits for SHPPs, the technical features and tendencies of SHPPs in Kyrgyzstan are clarified by the information on the SHPPs developed so far and the site investigations on the existing SHPPs.

5-7-1 Overall Features of Past Small Hydropower Development

Only twelve (12) SHPPs throughout Kyrgyzstan, with a total output of 42 MW, are currently in operation, but in the past, a large number of SHPPs had been built in the country for the period from the 1930s to the 1960s. As many as 161 SHPPs have been abolished since the 1970s. However, it is believed that such a abolishment of a large number of the SHPPs was carried out for rationalization of power facilities after starting operation of Toktogul hydropower plant, a large-scale hydropower plant, not because many of the SHPPs had some technical problems at that time. Kyrgyzstan may, therefore, be said a region with conditions suitable for small hydropower development in general.

Table 5-7-1 Small Hydropower Plants in Operation

	Name of plant	Capacity (MW)	Year of putting in operation	Location (Oblast)	Remarks
1	Lebedinovka	7.6	1928-1958	Chui	Utilizing irrigation canal
2	Alamedin No.1	2.2		- ditto -	- ditto -
3	Alamedin No.2	2.5		- ditto -	- ditto -
4	Alamedin No.3	2.1		- ditto -	- ditto -
5	Alamedin No.4	2.1		- ditto -	- ditto -
6	Alamedin No.5	6.4		- ditto -	- ditto -
7	Alamedin No.6	6.4		- ditto -	- ditto -
8	Alamedin Midget	0.4		- ditto -	- ditto -
9	Bystrovka	8.7		- ditto -	- ditto -
10	Kalinin	1.4	1954	- ditto -	Rehabilitation
11	Issyk-Ata	1.6	2008	- ditto -	Rehabilitation
12	Naiman	0.6	2005	Osh	Utilizing irrigation canal
Total		42.0			

Source: MEI

The average output of the 161 abolished SHPPs is 0.274 MW, only 10 plants had an output capacity of more than 1.0, and 120 plants corresponding to three-quarters of the whole, had an output of below 0.3 MW. Very small-scale hydropower plants accounted for the majority. Judging from their output capacities, many of SHPPs in the past may have been designed and installed as interdependent power system (off-grid), which is not connecting to the grid, for the purpose of village-level electrification. Such SHPPs were likely to take the same water amount as a droughty discharge of the river, constantly throughout the year. According to the information, most of the facilities in the abolished power plants have been removed and have no trace of their original forms.

As shown in Table 5-7-1, 11 plants of the 12 plants in operation, and 43 plants or more than a quarter of the 161 abolished plants, are located in Chui Oblast. Many of them, except for power plants of JSC Chakan GES, are located in the rivers flowing on the north slopes of Kyrgyz Range.

5-7-2 Site Investigation on Existing Small Hydropower Plants

(1) Existing Issyk-Ata Small Hydropower Plant

The Issyk-Ata SHPP is one of a few SHPPs which have been developed recently in the country. It is located in Issyk-Ata River, which is in the east of Bishkek and flows down to Chui Valley through a north slope of Kyrgyz Range and was redeveloped in 2008 with utilizing an abolished SHPP. There is a new potential site in the upstream of this plant. In order to distinguish between this new potential site and the existing power plant in this report, the new potential site and the existing power plant are referred to as Issyk-Ata-2 and Issyk-Ata-1 respectively.

The Issyk-Ata-1 is a SHPP, which was constructed by a private company related to "Directorate of Small and Medium Scale Power Generation Development" with a Green Found from a German bank. It is connected to the grid and its generated power is sold to the distribution company.

Major technical features of the plant facilities are as follows.

Installed Capacity:	2 x 800 kW ＝1.6 MW
Discharge	3.6 m^3/s
Head	approx. 60 m
Length of Headrace	approx. 2,500 m
Length of Penstock	approx. 130 m
Type of Water Turbine	Vertical Francis

The route map to the existing power plant, the location map of the power plant and the longitudinal profile of Issyk-Ata River are shown in Figure 5-7-1, Figure 5-7-2 and Figure 5-7-3 respectively.

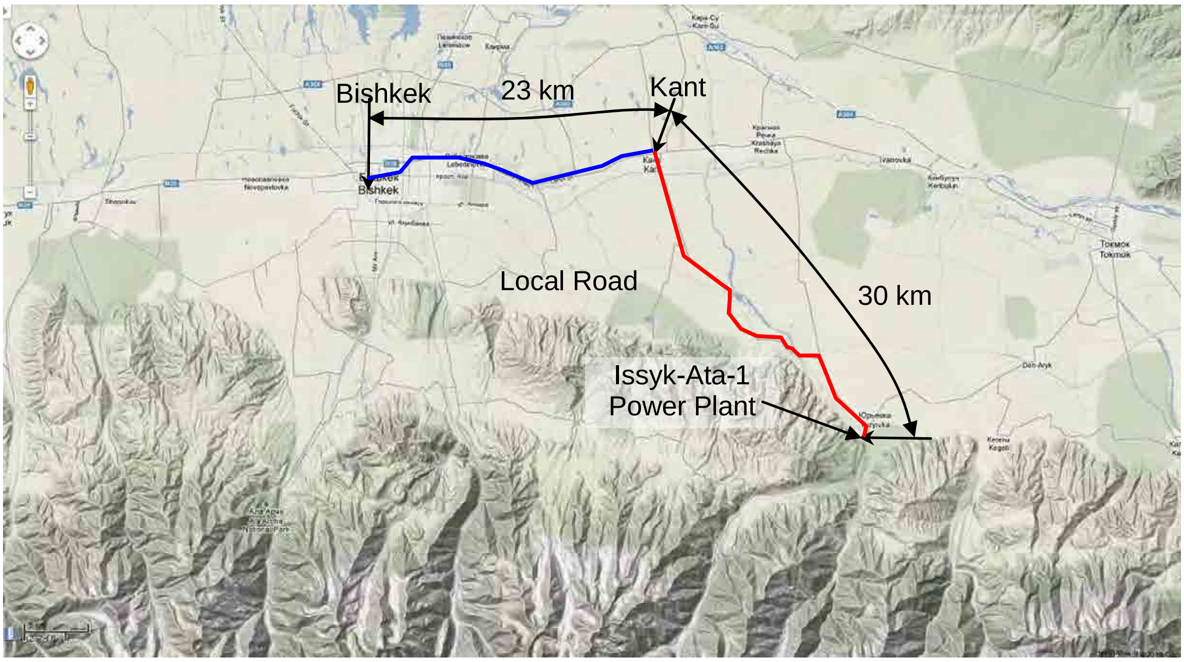


Figure 5-7-1 Route Map to Issyk-Ata Site

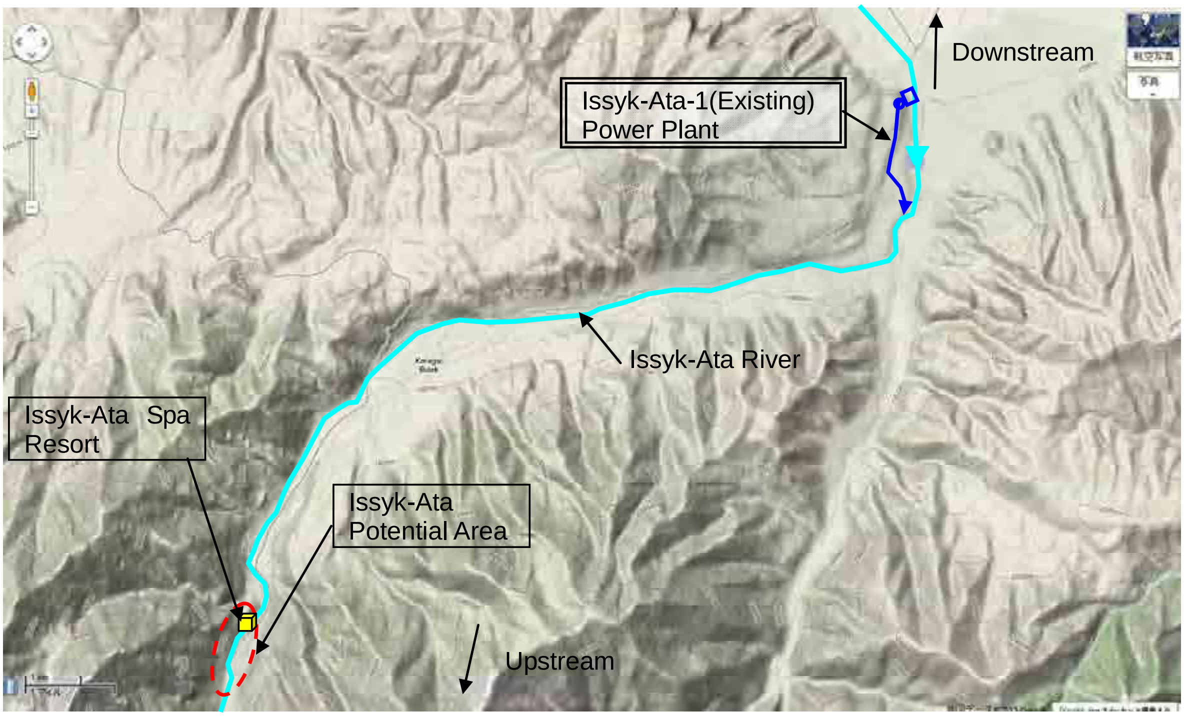


Figure 5-7-2 Location of Existing Issyk-Ata Power Plant

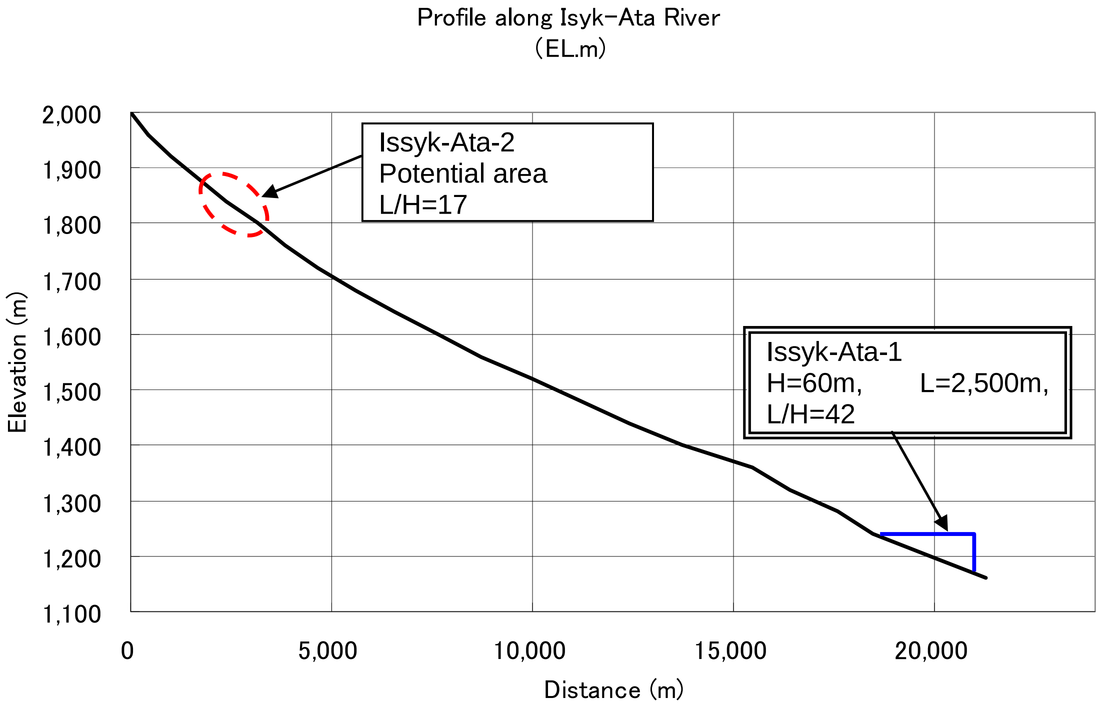


Figure 5-7-3 Longitudinal Profile of Issyk-Ata River

The information from interview with a person involved in the power plant is shown below.

- Since only a few facilities for the abolished SHPP remain, almost all the facilities needed to be newly constructed. However, since the concrete structure for spillway from head tank remained, it will be used with repairing it.
- The wheeling rate to the transmission company is paid through the JSC Severelectro, which has the grid the power plant is directly connected to.
- (For personnel) The power plant is operated on four (4) shifts (a person per shift) around the clock. A master manages the operation. Two workers are in charge of maintenance for the waterway (removing sediments, etc.). Since some facilities are ice-covered in winter, two more workers are added. The canal is open now, but it will be covered in the future to prevent the land from sliding into the canal. After covering the canal, it is expected that the workers for maintenance of the canal will be required no-longer. In addition, one personnel is secured as a person to respond in emergency situations.
- As admiral staff, Director, Deputy Director, Accountant, Procurement, and Financial Specialist are stationed.
- The generated electricity is sold to JSC Severelectro and the consumer who made a contract with this company.
- German experts dispatched by the support of the German bank conducted training for plant operation.
- For EIA, it was necessary to check the checkpoints from the various ministries. Building is easy, but it was very hard to get all the permits.
- Before construction, during construction, and after operation, any complaints have not received from neighboring residents or personnel concerned. In fact, the power supply was not stable in winter, but now it is stable without any power cut-off in this neighborhood.

The results of the investigation on the facilities for Issyk-Ata-1 power plant are shown below.

- The intake facility is located near the top of the alluvial fan, about 1,250 m above sea level. The headrace was constructed by open-cutting a mud flow sediment layer.
- The indicator showing ratio between waterway length and head (height deference): L/H is 42 (= slope: 1/42). The gradient is too gentle as that for a SHPP, and the headrace length is 2,500 m, which is relatively long. If the power plant were entirely a new project, it would be economically unfeasible due to the high construction costs for the long waterway.
- The type of the intake weir is a type, which is common for irrigation intake in Kyrgyzstan. Since only the surface water is taken to the waterway in this intake facility, a settling basin, which is usually installed between intake weir and headrace, has been omitted.
- An operator is stationed at the intake facility.

Photo 5-7-1 Intake Weir for Issyk-Ata-1

Photo 5-7-2 Intake Weir for Issyk-Ata-1

- The headrace is constructed by utilizing the place for open-canal of the abolished power plant. The headrace near the intake is constructed with precast concrete panels, but the headrace in almost all the stretches is unlined open canal and there is no surface protection for the slope on the side of the headrace. It seems that entry of the land from sliding into the canal constantly occurs.
- Because a reservoir for irrigation is located downstream of the intake, it seems that the amount of intake water for the generation is forced to be limited during irrigation period.
- Remaining spillway from head tank of the abolished SHPP is used for the new SHPP, while exposed penstock for the new SHPP was newly installed.
- A 35kV substation is located adjacent to the power plant.


Photo 5-7-3 Headrace near Intake


Photo 5-7-4 Issyk-Ata-1 Power Plant
(Powerhouse, penstock and spillway from Headtank, seem from right)


Photo 5-7-5 Inside Powerhouse (Turbine, Generator)


Photo 5-7-6 35kV substation

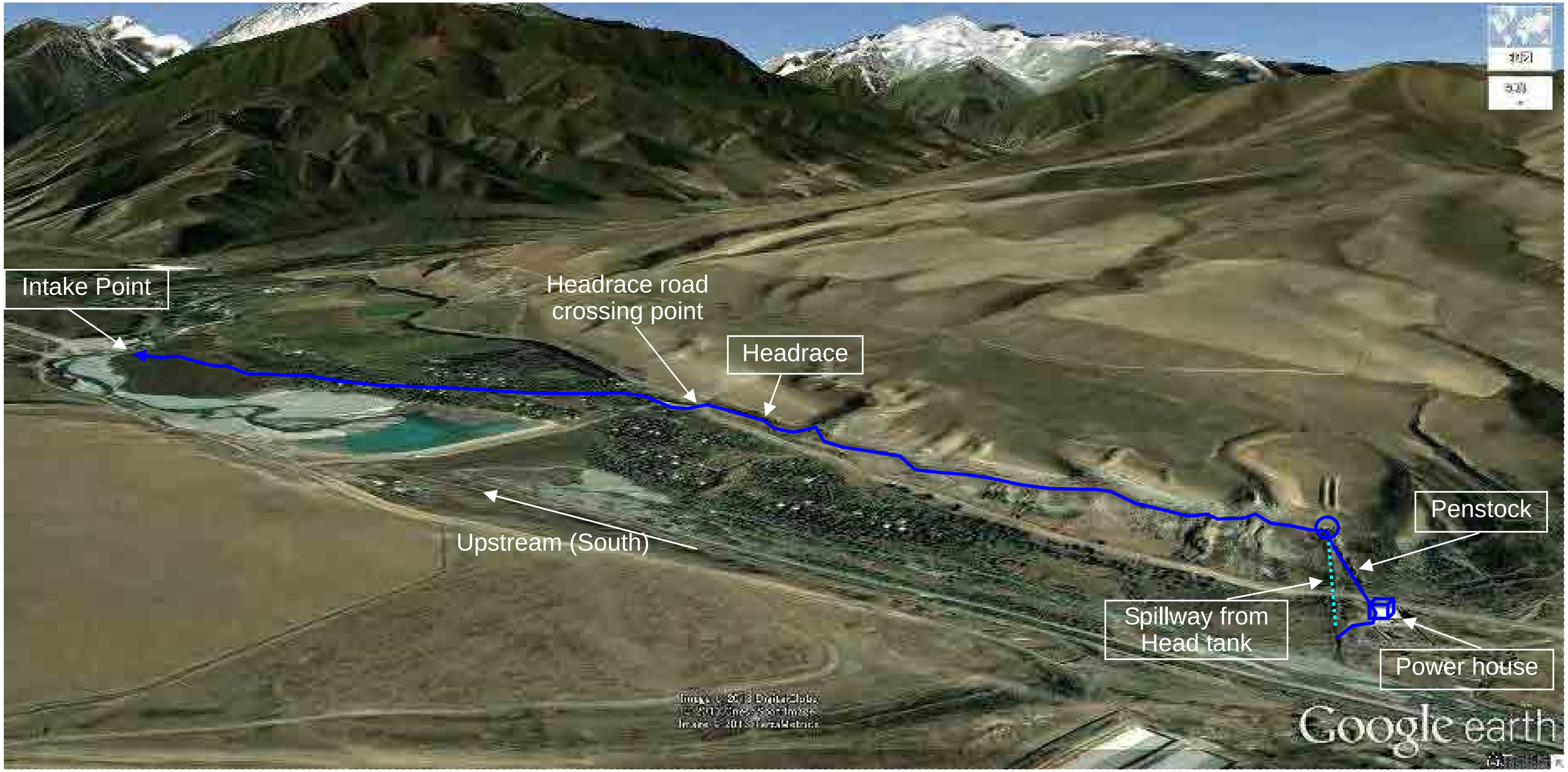


Figure 5-7-4 Bird View for Issyk-Ata Redevelopment Site

(2) Sokuluk-2 Small Hydropower Plant

The Sokuluk-2 SHPP is one of the thirteen (13) SHPPs to be reconstructed at the places of abolished power plants, which were approved in 2008 by Presidential Decree No.365, (of total 41 sites, new; 28 sites, reconstructed; 13 sites) and under construction by a private investment (as of April, 2013). The abolished Sokuluk-2 SHPP is a power located downstream of two SHPPs which were constructed in a cascade array in 1962 plant. The features for the abolished power plant and reconstruction plan in the list approved by Presidential Decree No.365 are shown in Figure 5-7-2.

Table 5-7-2 Features for Sokuluk-2 Small Hydropower Plant

Name	Abolished Plant		New Plan	
	Installed Capacity	Commission Year	Installed Capacity	Resource
Sokuluk-2	1.16 MW	1962	1.73 MW	Presidential Decree No.365
			1.20 MW (0.6 MW x2)	Hearing at site

The site of Sokuluk-1 SHPP, which was constructed in a cascade together with Sokuluk-2, is located in the right bank, 3.3 km upstream of Sokuluk-2. Sokuluk-5 potential site, which is planned as a pilot project in the EBRD's master plan on small hydropower development, is located 1.9 km downstream of the intake weir of Sokuluk-2.

The route map to Sokuluk site and the location map of each power plant are shown in Figure 5-7-5, and Figure 5-7-6.

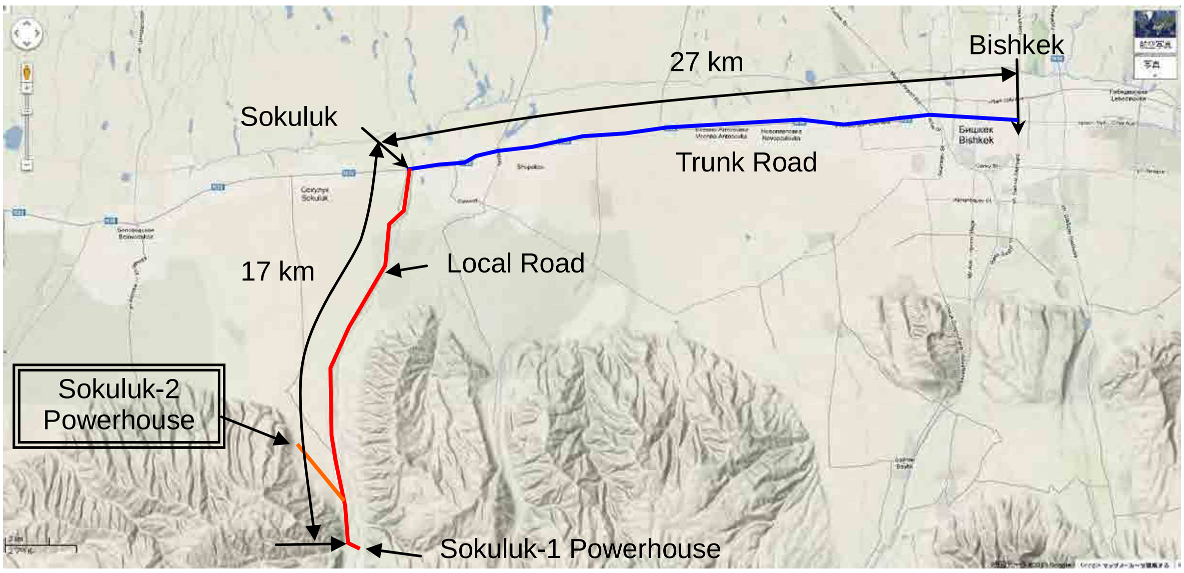


Figure 5-7-5 Route Map to Sokuluk Site

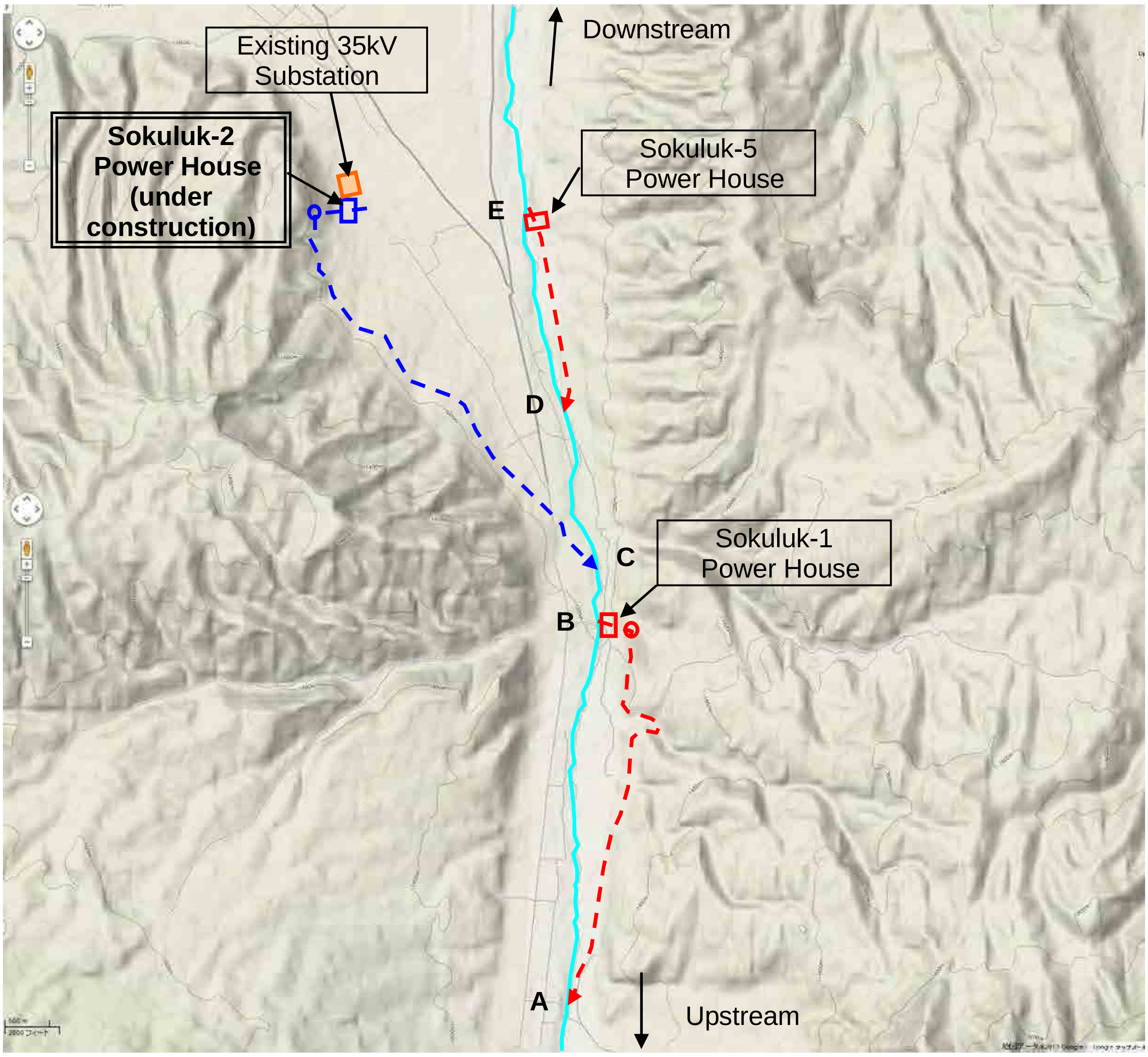


Figure 5-7-6 Location of Sokuluk-1&2 and Sokuluk-5

The information from interview with a person involved in the power plant is shown below.

- The Sokuluk-2 abolished power plant was built in 1965. At the same place as the abolished plant, a new SHPP is now under construction by a local investment.
- The power plant was scheduled to be completed in September, 2012, but it is likely to be completed in September 2013.
- The equipment (including water turbine and generator) is purchased from Chine.
- The power plant will be connected to a 35kV substation of JSC Severelectro adjacent to the power plant.

The longitudinal profile of Sokuluk River is shown in Figure 5-7-7.

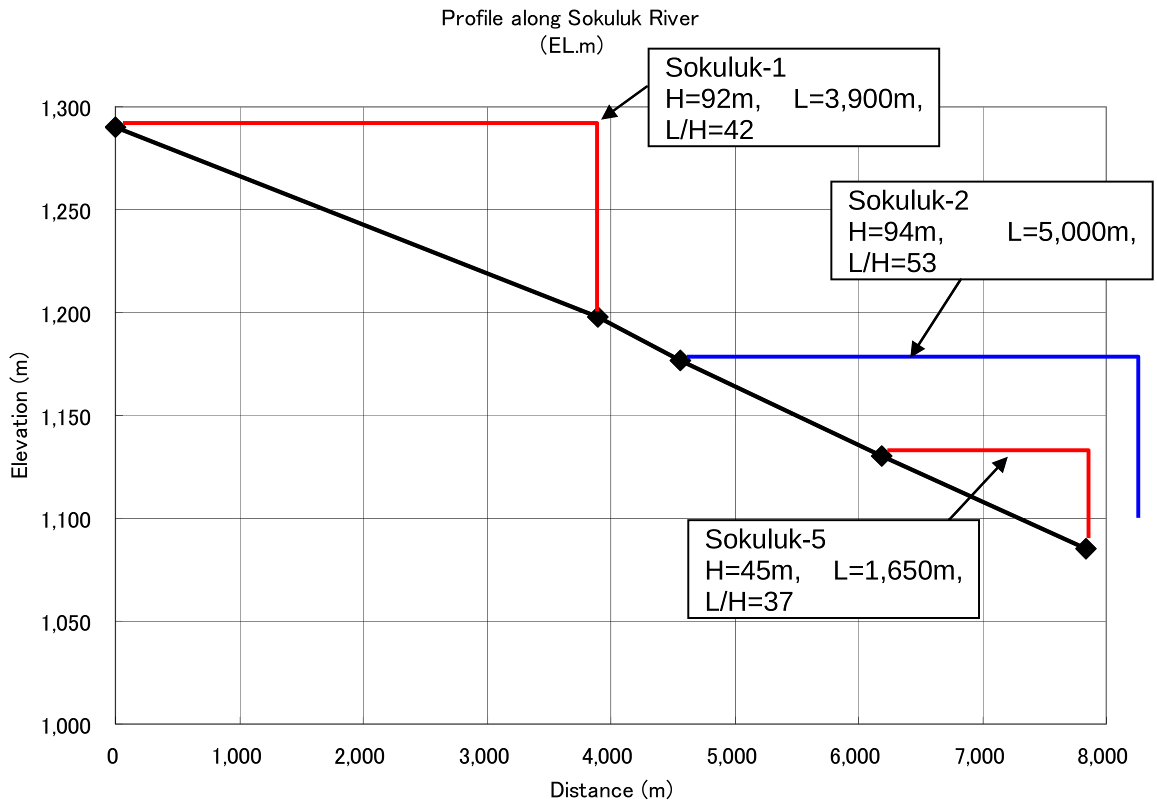


Figure 5-7-7 Longitudinal Profile of Sokuluk River

The results of the investigation on the facilities for Sokuluk-2 power plant are shown below.

- The intake facility is located at the top of alluvial fan, about 1,180 m above sea level.
- The indicator showing ratio between waterway length and head (height deference): L/H is 53 (= slope: 1/53). The gradient is too gentle as that for a SHPP, and the headrace length is 5,700 m, which is relatively long. If the power plant were entirely a new project, it would be economically unfeasible due to the high construction costs for the long waterway.
- The headrace is constructed by utilizing the place for open-canal of the abolished power plant. The headrace in all the stretches is unlined open canal and there is no surface protection for the slope on the side of the headrace. It seems that entry of the land from sliding into the canal constantly occurs. (see Figure 5-7-8 and Photo 5-7-7)

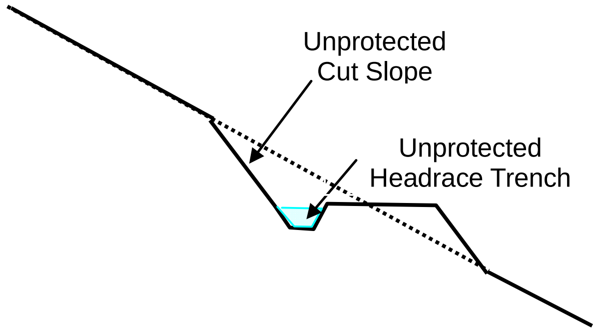


Figure 5-7-8 Cross-Section of Headrace

Photo 5-7-7 Headrace Open-channel

- Penstock for the abolished power plant was removed, but the concrete spillway from head tank remains, and is likely to be used for the new power plant.

Photo 5-7-8 Slope for Penstock and Spillway from Head Tank

- The sub-structure of the powerhouse for the abolished power plant is used for that of the new powerhouse, while only the super-structure of the powerhouse is newly built. Only a few people were working at the construction site. (visited in February 2013)

Photo 5-7-9: Powerhouse

Photo 5-7-10 Inside of Powerhouse

Photo 5-7-11: 35kV Substation adjacent to Powerhouse

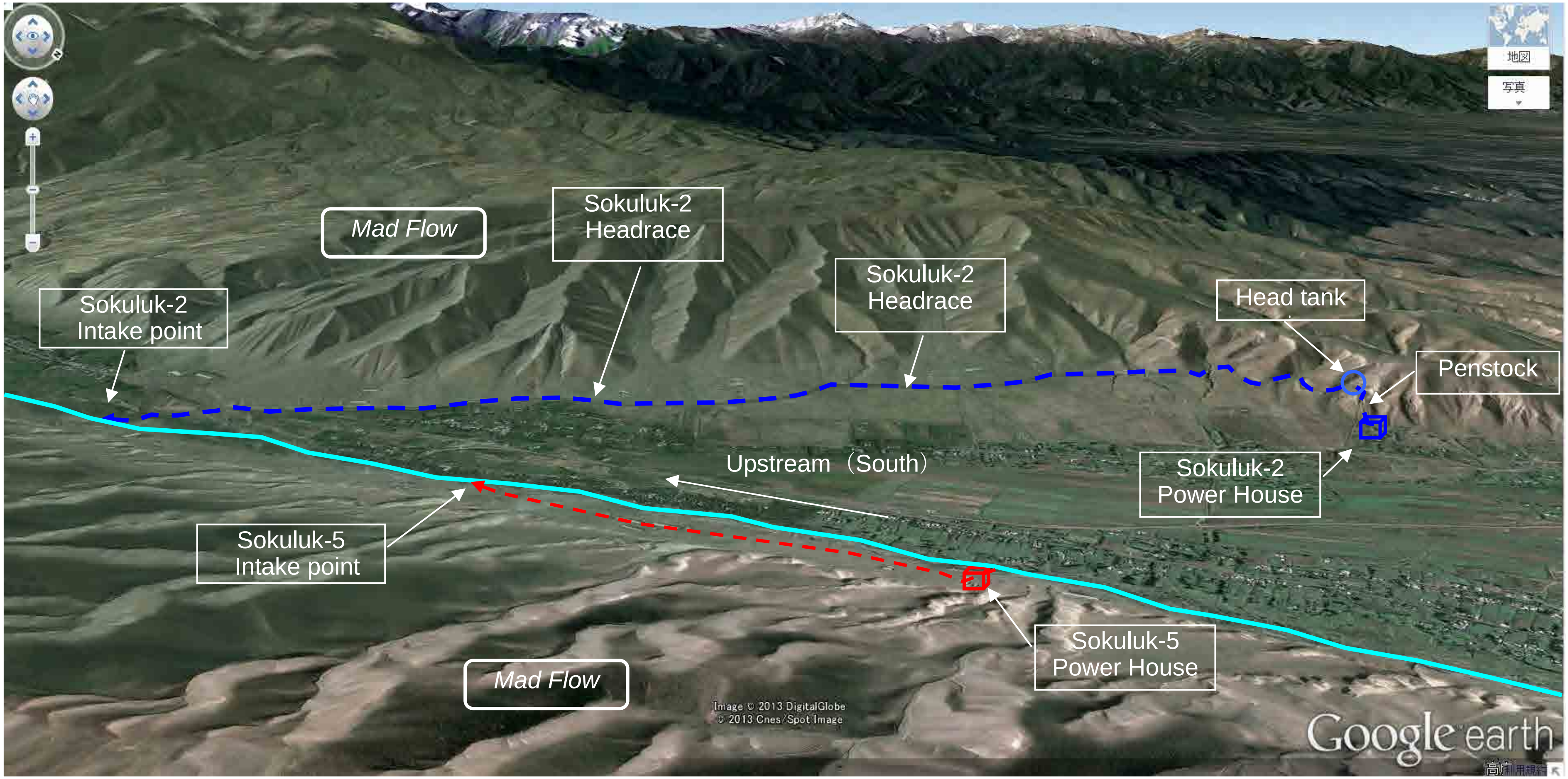


Figure 5-7-9 Bird View for Sokuluk Reconstructed Power Plant

(3) Alamedin Cascade Small Hydropower Plants

Alamedin cascade small power plants are eight (8) cascade SHPPs utilizing the West Big Chui Canal which is one of major irrigation canals flowing from east to west in Chui Valley, located near the capital Bishkek, and operated by JSC Chakan GES, a state-owned company. The locations, and the installed capacity and year of putting in operation, are shown in Figure 5-7-10 and Table 5-7-3 respectively.

Table 5-7-3 Alamedin Cascade Small Hydropower Plants

	Name of plant	Capacity (MW)	Year of putting in operation
1	Lebedinovka	7.6	1943
2	Alamedin No.1	2.2	1945
3	Alamedin No.2	2.5	1948
4	Alamedin No.3	2.1	1951
5	Alamedin No.4	2.1	1952
6	Alamedin No.5	6.4	1957
7	Alamedin No.6	6.4	1958
8	Alamedin Midget	0.4	1928

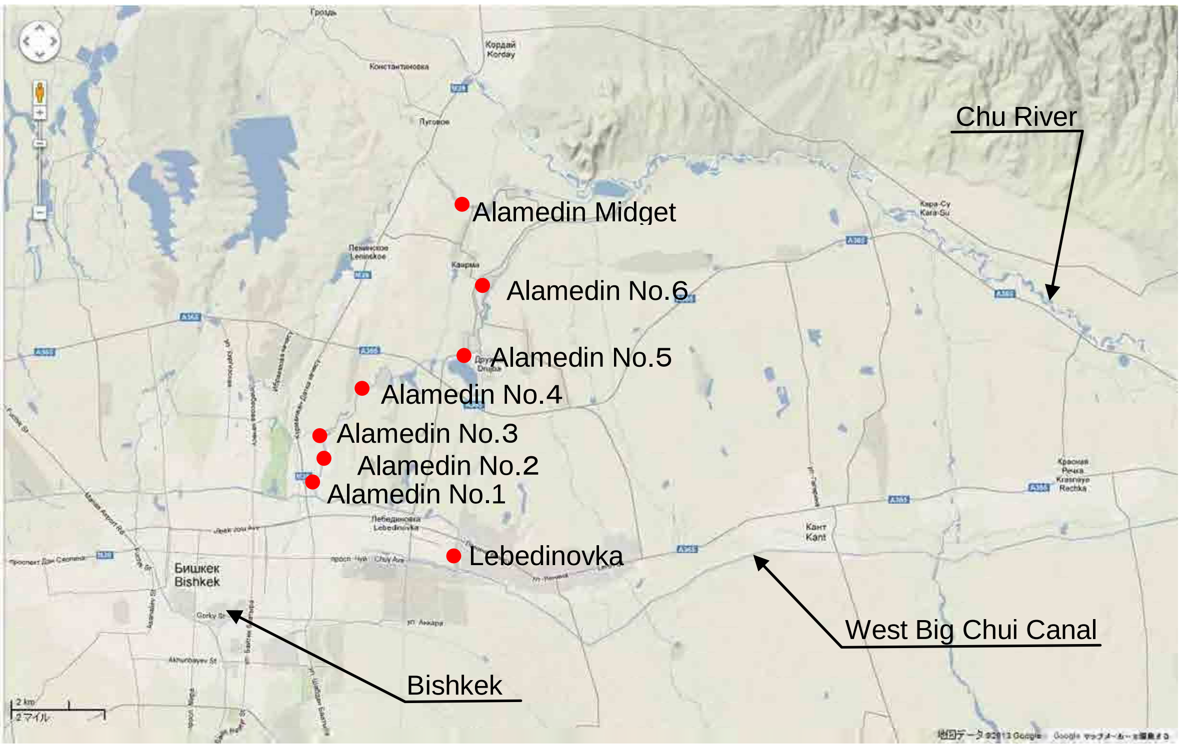


Figure 5-7-10 Locations of Alamedin Cascade Small Hydropower Plants

The information from interview with relevant persons in Chan GES is shown below.

- ♦ Chakan GES, having 250 employees, is only state-owned company in the country to operate and maintain 9 SHPPs. (re-nationalized in 2010)

- Lebedinovka power plant-

- ♦ Major features are, total installed capacity P = 7.6 MW（No.1 : 4.0MW + No.2 : 3.6 MW）, head H = approx. 27 m（Intake water level: EL.760.20 m – Outlet water level: EL.733m）, and design maximum discharge Q = 40 m^3/s（No.1 : 19 m^3/s＋No.2 : 21 m^3/s）.
- ♦ Conditions on water turbines are as follows:
  - ✧ No.1 unit (Vertical Francis Turbine, GE, Commencement in 1948) has a problem with the major shaft, and then has to be operated with a decreased maximum output.
  - ✧ No.2 unit (Horizontal Francis Turbine, made in Sweden, Commencement in 1943) had a problem with the major shaft, and is currently at a stop.
- ♦ The designed maximum discharge for the power plant is 40 m^3/s, but the amount of inflow has been decreased compared with that in the past and current inflow is about 30 m^3/s at maximum. It is, therefore, impossible to operate at a full power.
- ♦ Since the inflow has been decreased and facility troubles have occurred, JSC Chakan GES has a plan to repair and renovate Lebedinovka power plant.
- ♦ JSC Chakan GES has eight (8) cascade power plants with a total installed capacity of about 30 MW, located along a major irrigation canal. Of these power plants, only No.2 power unit of Lebedinovka power plant is forced to stop its operation at present.

- Operation and Maintenance-

- ♦ The periodic inspections are carried out; internal inspection (every four years) and external inspection (annually).
- ♦ When the frequency lowers to 48 Hz or less, load connecting to 6 kV bus is sledded. When the frequency lowers to 46 Hz, the 33kV CB is cut-off. (generator stop). Since the governor has no frequency regulation function, individual operation is not carried out.
- ♦ Operation command is conveyed from Alamedin no.3 power plant to all the power plants through telephone. One operator is stationed at each power plant. Alamedin No.3 power plant receives orders from JSC Severelectro. In the 1950s, SCADA system was introduced, but it was broken in 1995, and has been unable to be used until now.
- ♦ Personnel for maintenance are ready in Alamedin No.3 power station.
- ♦ New employees are trained by experienced staff for one month after joining the company, and to take the examination. After that, they are trained on the job training. The company has no training center, but prepared the manual for operation and maintenance.
- ♦ Total employees are about 250 persons. Of them, 100 persons are for management and 150 persons are for engineering.
- ♦ One of transmission lines from Alamedin No.5 power plant is directly connected to the grid in Kazakhstan.
- ♦ There are two head engineers under a chief engineer. One is in charge of 8 Alamedin cascade power plant, and another is in charge of Bystrovka power plant.

The results of the investigation on the facilities for the power plants are shown below.

- The head between the West Big Chui Canal near Bishkek and Chu River in the north is well-utilized for power generation by installing 8 hydropower plants.
- In Lebedinovka power plant, a bypass-waterway has been constructed. The bypass-waterway makes it possible to discharge all the amount of the canal flow to downstream even when the power plant is stopped.
- There is no settling basin between the intake and the penstock, because the canal in front of the intake is expected to function just like a settling basin. Since there is no sand flush facility in the

canal near the intake, the sediments in the canal has to be removed by dredging every several years.

Photo 5-7-12: Bypass Discharge Facility

Photo 5-7-13 Intake Facility

- In many of these hydropower plants, the natural ground on the tailrace side was widely excavated to make the length between the intake and the powerhouse (or penstock length) shorter.

Photo 5-7-14: Excavated Tailrace

- Although water turbines and generators at every power plant are very old and have not yet been replaced, no big problem in appearance is found. However, only the No.2 unit of Lebedinovka power plant is currently not in operation due to the mechanical problem.

Photo 5-7-15: Inside of Powerhouse

Photo 5-7-16: Overhead Traveling Crane

- A 35kV switchyard is located adjacent to the power station and is connected to JSC Severelectro's 35kV distribution grid. The distribution facilities are designed to meet the installed capacity of the power station (7.6MW), there is virtually no overload problem even after rehabilitation of the power station.

Photo 5-7-17 Step-up Transformer of Power Station (6/35kV)

Photo 5-7-18 35kV Distribution Line

Photo 5-7-19 Connection to Switchyard

5-7-3 Overall Features of Existing Small Hydropower Plants

- SHPPs now in operation are only power plant utilizing irrigation canal or reservoir, or power plants reconstructed at the places of the abolished power plants. There is no existing SHPP which takes water from a natural river and was constructed at a new site.
- Output scale: small, 1.6 MW at maximum except for power plants owned by Chakan GES.
- Location: Except for power plants owned by Chakan GES, many of the existing power plants are located in the rivers flowing through the north slopes of Kyrgyz Range. L/H of the power plants reconstructed at the places of abolished power plants is more than 25. The gradient is too gentle and the headrace is relatively too long. If the power plant were entirely a new project, it would be economically unfeasible due to the high construction costs for the long waterway. However, utilizing remaining facilities of the abolished power plant contributes to reducing construction costs.
- Distinctive facilities: the efforts for facility simplification such as the adoption of intake facility with a settling function and unlined headrace are found, while it is still required to expend substantial manpower to remove the land from sliding into the open headrace as long as open-headrace is not covered.
- At the beginning, the power plants were put into operation with the technical support from foreign countries, but now only local people can operate and maintain the power plant facilities without a big problem.

Chapter 6 Selection of Promising Potential Sites and Issues for Implementation

6-1 Selection of Potential Sites to be Surveyed

In order to identify promising SHPP potential sites in Chui Oblast, the candidate sites to be surveyed were selected based on the following information.

1) Relevant information obtained from KSTC
2) SHPP potential sites approved by the Presidential Decree No.365 (2008)
3) EBRD's small hydropower master plan (Strategic Planning for Small and Medium Sized Hydropower Development)
4) Renovation plan for existing SHPP by JSC Chakan GES

KSTC has accumulated much information on SHPP potential sites since it has been carried out basic surveys on SHPP potential sites and surveys of existing conditions on abolished SHPPs as an institute under MEI. The Government of Kyrgyz Republic submitted the application form for grand aid from Japan in 2012, which is to request the construction of SHPP in Kegeti Valley of Chui Oblast. The Kegeti SHPP mentioned in the application form has been planned based on the information from KSTC. Other than Kegeti site, KSTC provided the information on two potential sites, which are a potential site for reconstruction hydropower upon an abolished plant called "Djardy-Kainda" and a green field potential site located upstream of existing Issyk-Ata SHPP.

As mentioned in the "Chapter 3, 3-4 Small Hydropower Development Plan", the Presidential Decree No.365 shows 41 SHPP potential sites across the country. (see Figure 3-4-1) Of these sites, 8 potential sites belong to Chui Oblast. Of 8 sites in Chui Oblast, 5 sites are new sites, and remaining 3 sites are sites for reconstruction hydropower upon abolished plants. However, since Chon-Kemin site of 5 new sites consists of 3 cascade power plants, the number of potential sites in Chui Oblast is 7 for new sites and totally 10 for all the sites in the oblast.

As mentioned in the "Chapter 3, 3-4 Small Hydropower Development Plan", in the reports of EBRD's small hydropower master plan, 20 candidate sites are firstly extracted as promising sites from 158 candidate sites across the country and then 4 candidate sites are selected, as the most promising potential sites to be implemented as pilot projects in near future, from the above-mentioned extracted promising 20 candidate sites. 4 promising sites of the 20 promising sites are located in Chui Oblast, and one site of these 4 promising sites in the oblast is one of the 4 most promising potential sites.

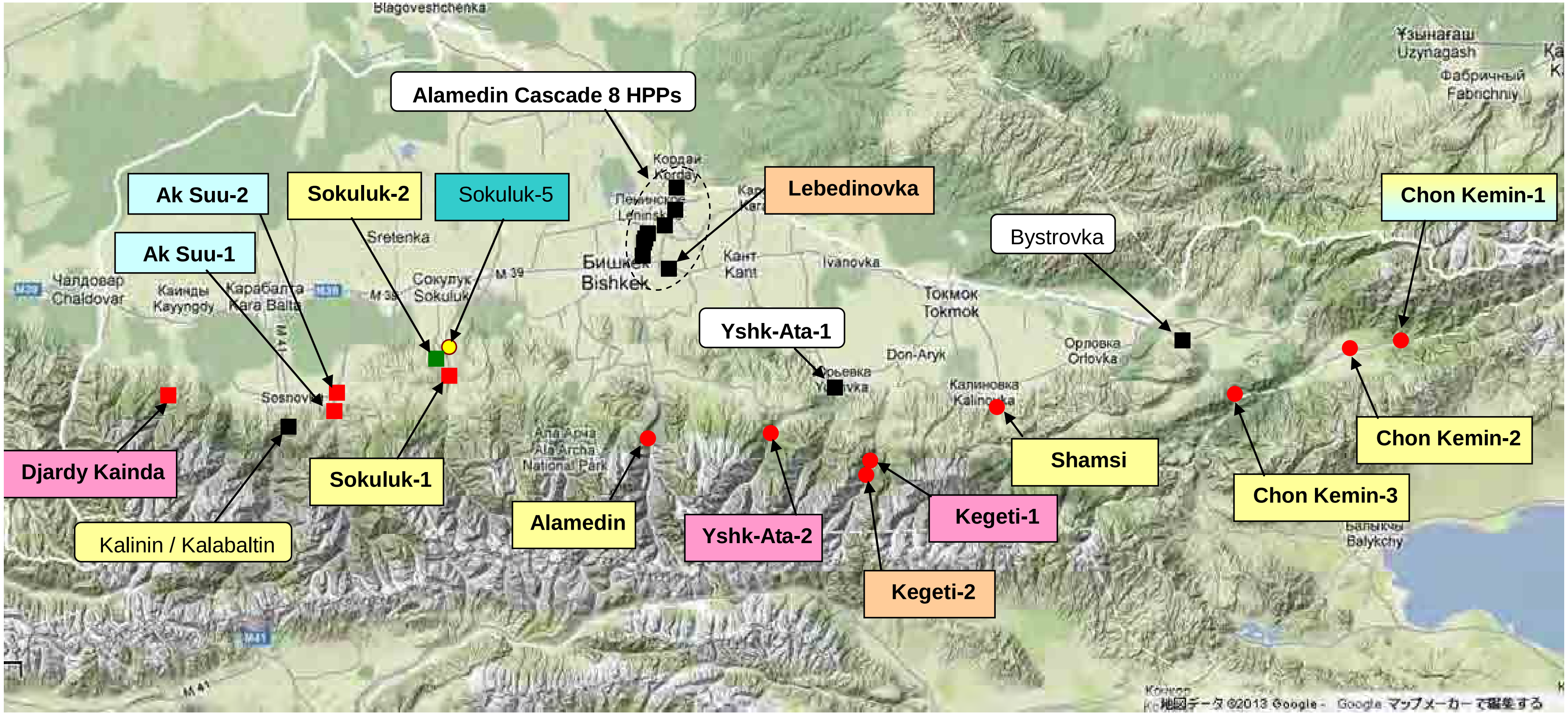
As reported in the "Chapter 5, 5-7-2 Site Investigation on Existing SHPPs", existing Lebedinovka power plant at present has problems of reduction in power output and generation due to deteriorated facilities and troubles occurred on the both two power units. Since there is a possibility that power output and generation will be substantially increased by replacing and/or renovation of turbine and generator in the power plant, the renovation plan of this SHPP also is selected as one of potential sites to be surveyed.

All the potential sites to be surveyed, selected based on the above-mentioned information, are summarized as shown in Table 6-1-1. As mentioned in the "Chapter 3, 3-4 Small Hydropower Development Plan", most of the available information on potential sites in the country is generally not detailed. For example, such information includes no information that makes it possible to indentify the site location and/or facility layout. It is impossible to make even a brief evaluation of the sites based on such poor information. Therefore, it is required to carry out site survey on all the selected sites. However, as sown in Table 6-1-1, a total of 5 sites, which are the sites where the negative information for development has been indentified until this stage or the sites located in Suusamyr Valley far removed from Chui Valley, are excluded from the sites to be surveyed. As a result, the Survey Team carried out the site surveys on a total of 12 sites (17 sites minus 5 excluded sites). Locations of existing SHPPs and potential sites in Chui Oblast are shown in Figure 6-1-1.

Table 6-1-1 Small Hydropower Potential Sites in Chui Oblast

No	Name of Site	Source	Output (MW)	Type	Identified Major Issues	Candidates to be surveyed*1
1	**Kegeti**	KSTC	2.4	New		○
2	**Djardy-Kainda**	KSTC	1.2	Reconstruction		○
3	**Issyk-Ata-2**	KSTC	3.6	New		○
4	**Sokuluk-1**	Presidential Decree No.365	2.0	Reconstruction		○
5	Sokuluk-2	Presidential Decree No.365	1.2	Reconstruction	Under construction	×
6	Sokuluk-5	EBRD 4 most promising site	1.5	New	A pilot project selected in EBRD's support program	×
7	**Alamedin**	Presidential Decree No.365	3.2	New		○
8	**Shamsi**	Presidential Decree No.365	2.4	New		○
9	**Chon-Kemin-1**	Presidential Decree No.365/ EBRD 20 promising site	5.0	New		○
10	**Chon-Kemin-2**	Presidential Decree No.365	5.0	New		○
11	**Chon-Kemin-3**	Presidential Decree No.365	5.0	New		○
12	Kalinin	Presidential Decree No.365	1.6	Reconstruction	In operation as a IPP owned by French Company	×
13	Suusamyr	Presidential Decree No.365	14.0	New	Far removed from Chui valley	×
14	Karakol	Presidential Decree No.365	3.0	New	Far removed from Chui valley Chui	×
15	**Ak Suu-1**	EBRD 20 promising site	1.98	Reconstruction		○
16	**Ak Suu-2**	EBRD 20 promising site	1.73	Reconstruction		○
17	**Lebedinovka**	JSC Chakan GES	7.6*2	Renovation of Existing		○

*1: ○: to be surveyed, ×: excluded from candidate sites to be surveyed
*2: Designed maximum output of the existing power plant



Legend

●	: Potential Site (new)	(yellow)	: Potential Sites approved by Presidential Decree No.365
■ (red)	: Potential Site (reconstruction on abolished power plant)	(light cyan)	: 20 Promising Sites selected in EBRD's SHPP master plan
■ (black)	: Existing SHPP	(cyan)	: 4 Pilot Project Sites selected in EBRD's SHPP master plan
■ (green)	: SHPP under construction	(pink)	: SHPP Potential Sites based on KSTC Information
○	: Pilot Project selected in EBRD's SHPP master plan	(orange)	: Sites suggested by the Survey Team
		Bold	: Sites surveyed by the Survey Team

Note: Sites located in Suusamyr Valley are excluded

Figure 6-1-1 Existing SHPPs and Potential Sites in Chui Oblast

6-2 Site Survey of Potential Sites

6-2-1 Kegeti Site

Kegeti site is located in the middle part of Kegeti River flowing down from the north slope of Kyrgyz Range to the west end of Kegeti Village, which is located about 18 km south-southwest of the Tokmok City, about 60 km east of Bishkek.

Major technical features on Kegeti Site according to the application form for grant aid from Japan are as follows.

Installed Capacity: 2.4 MW (2 x 1.2 MW)
Annual possible power generation: 18 Mil. kWh
Discharge: 1.5 m^3/s
Head: 180 m
Length of Headrace: 2,500 m
Available hydrological data: Discharge data for 50 years observation
at Hydropost "Lesnoi Kordon"
Catchment area: 256 km^2, Average discharge: 2.40 m^3/s

Any design documents including location data and waterway route map, which make it possible to identify intake point and powerhouse location, was not provided.

(1) Conditions on Access to the Site

- From Bishkek, 1) traveling on the trunk road towards the eastern direction, 2) at Tokmok city, about 65 km far from Bishkek, taking the local road which goes to the direction of Kyrgyzstan Range, 3) the Kegeti village is 21 km far from Tokmok.
- The intake site (N42 ° 33'53 .3 ", E75 ° 07'13 .9" / EL1, 748m), which is located 17 km upstream of Kegeti Village, is easily accessible by car. The intake site is a place, where a water fall can been seen on the slope of left bank, and the stream from the water fall flows into Kegeti River. From this point, the local road runs up on the left bank of the river for a while, crosses the river to the right bank, climbs up on the steep slope, crosses the river, and then arrives at a place 2,000 m above sea level where the road is closed. Upstream of this point is no accessible by car.
- The route map from Bishkek to the Kegeti site is shown in Figure 6-2-1.

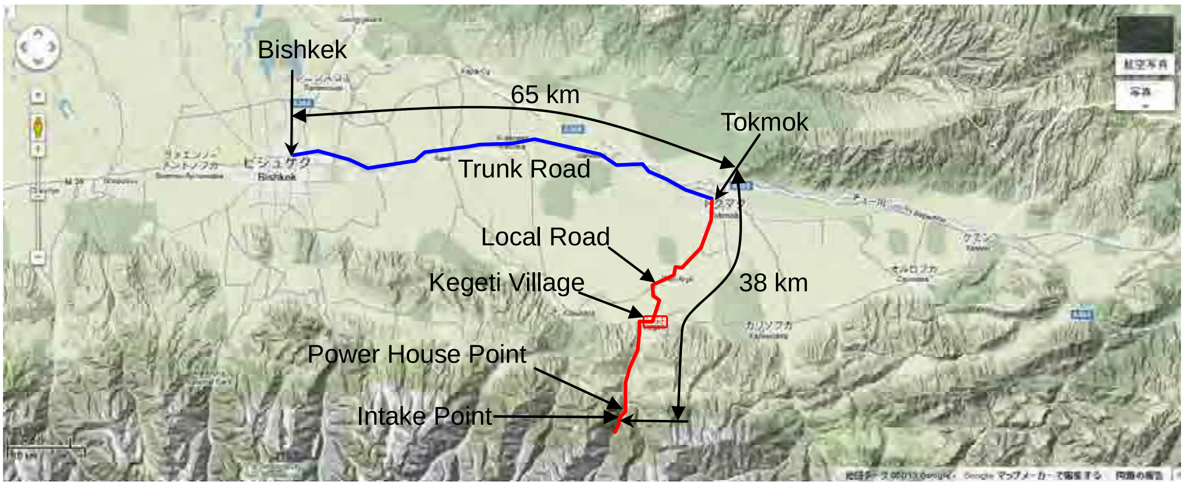


Figure 6-2-1 Route Map to Kegeti Site

(2) Findings from Site Survey

In addition to the site for the application form for grant aid from Japan, a potential site which was identified as an alternative by the Survey Team was also surveyed. Of these two sites, the former is referred as to Kegeti-1, and the latter Kegeti-2.

1) Potential site for the application form: Kegeti-1

- The detailed information on location, plant layout, etc. was not furnished from MEI. The Survey Team had no choice but to identify the intake site based on the topographical conditions. The identified intake site (N42°33'53.3 ", E75 ° 07'13 .9" / EL1, 748m) is about 17 km upstream of Kegeti Village. At this site, a water fall can be seen on the left bank slope, and a stream from the waterfall flows into the Kegeti River. The powerhouse site indentified by the Survey Team (N42°33'45.1", E75°07'06.6") is on the left bank about 1.9 km downstream of the intake site.
- The river flow discharge was estimated at 0.3 - 0.4 m^3/s. (observed in February and April 2013). River gradient between the intake and powerhouse is about 1/20.
- The riverbed around the intake site is covered with sediments of gravel, boulder, etc. without any rock outcrops. Any remarkable inhibition of water flow in the river by ice and snow was not found around the site, although some part at the edge of the river water was frozen. (observed in February 2013)
- The valley between the intake and powerhouse is V-shaped with steep slops with a gradient of 30 ° or more. Many scree slopes are distributed on the left bank slope, while a few scree slopes on the right bank slope, and then the left bank slope seems a dip slope. However, on the right bank slope, some talus is also found, and there are some landslide areas near the river. Rather large landslide slope of talus is found about 500 m downstream of the intake site on the right bank Judging from these conditions, it is difficult to construct open-channel headrace on both the left and right bank slopes.
- The riverbed width is gradually wider as going downstream. (Riverbed sediment is deposited more widely more downstream)
- There are no houses along the road around the site, and any river water usage for irrigation also is not found. The vegetation on the slopes around the site is sparse, and used for grazing horses, cows, etc.

2) Potential site upstream of the site for the application form: Kegeti-2

- River condition upstream of the site for the application form (Kegeti-1) was also surveyed.
- The river gradient upstream of the Kegeti-2 intake site is getting steeper as attitude increases. Since the 2 km long section from the Kegeti-1 intake site has a steep river gradient with a slope of approximately 1/10, an alternative potential site (Kegeti-2) can be considered around this section.
- The slopes around the river are steeper and the valley becomes narrower as altitude increases, and on the slopes of valley, outcrops of fractured rock mass are widely seen. The vegetation around Kegeti-1 site is mainly grass, but upstream of the intake of Kegeti-1, there are more tall conifers.

3) Conditions on Distribution and Transmission Line

- About 12km down the stream of Kegeti River from the candidate power station location, 220kV Ala-Archa - Bystrovka transmission line passes east and west. Several hundred meters on the north of the 220kV line, 35kV Koroi-Kegeti line lies parallel to the transmission line. A 10kV distribution line reaches the end of a settlement at which a ground-base 10/0.4kV transformer is located. Distance between the transformer and the candidate power station location is about 5km. From the transformer, a 0.4kV low voltage distribution line supplies power to the residents in the settlement. It is necessary to construct an access distribution line from the candidate power station location to the terminal of the 10kV distribution line in the settlement if there is no restriction on the existing facilities. On the other hand, construction of a long (20km) 10kV access distribution line to the existing 35/10kV Kegeti distribution substation will be required if the conditions of the existing facilities do not allow direct connection of the access distribution line due to the risk of exceeding the capacities of them and/or other technical restrictions. The access to the candidate power station location is the gravel road; however, inclination of the road is gentle. Therefore, there is virtually no obstacle to transport equipment to the construction site.

(3) Longitudinal Profile of River and HPP Layout Plan

Locations of the HPP potential sites identified through the site surveys, their location data, and longitudinal profile including HPP layout plan are shown in Figure 6-2-2, Table 6-2-1, and Figure 6-2-3.

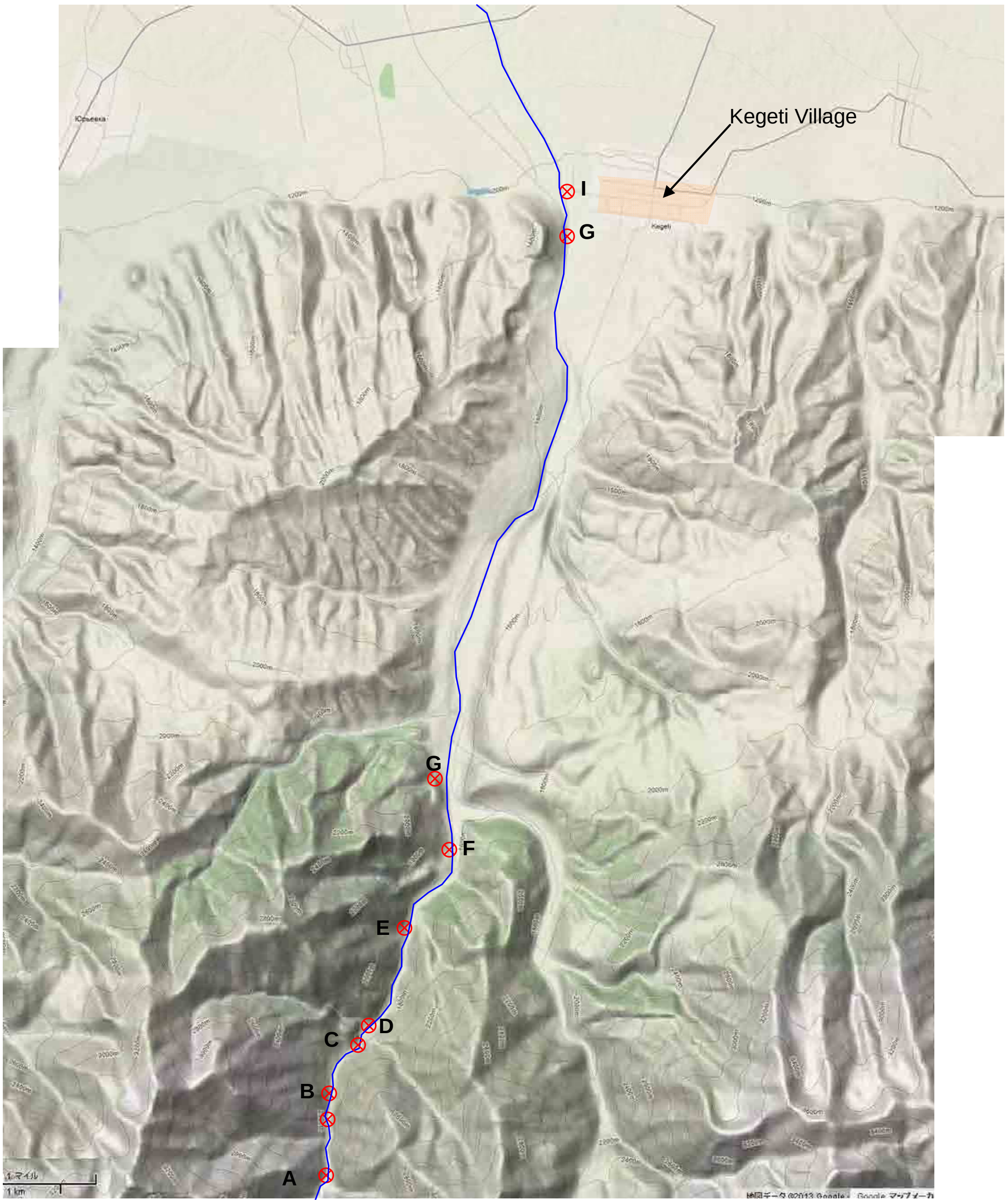


Figure 6-2-2 Measure Points along Kegeti River

Table 6-2-1 Location Data for Measure Points along Kegeti River

Measure Points		Latitude	Longitude	Altitude (EL.m)	Height difference (m)	Cumulative Distance (m)	Interval Distance (m)	Gradient (L/H)	Estimated Discharge (m^3/s)
A	Road Closed	N42°32'25.7"	E75°06'38.2"	2,028	—	—	—	—	0.2～0.3
B	No.2 Intake	N42°33'01.2"	E75°06'42.4"	1,927	-101	980	980	10	0.3
C	No.2 Powerhouse	N42°33'45.1"	E75°07'06.6"	1,767	-160	2,600	1,620	10	0.3
D	No.1Intake	N42°33'53.3"	E75°07'13.9"	1,748	-19	2,950	350	18	0.3～0.4
E	No.1Powerhouse	N42°34'47.5"	E75°07'42.4"	1,663	-85	4,790	1,840	22	
F	Upstream of Settlement	N42°35'30.4"	E75°08'16.1"	1,585	-78	6,350	1,560	20	
G	End of 10kV Distribution Line	N42°32'25.13"	E75°06'38.8"			7,590	1,240		
H	Intake for Irrigation	N42°41'11.1"	E75°09'46.1"	1,240		17,510	9,920		
I	35kV Transmission Line	N42°41'35.3"	E75°09'45.9"			18,190	680		

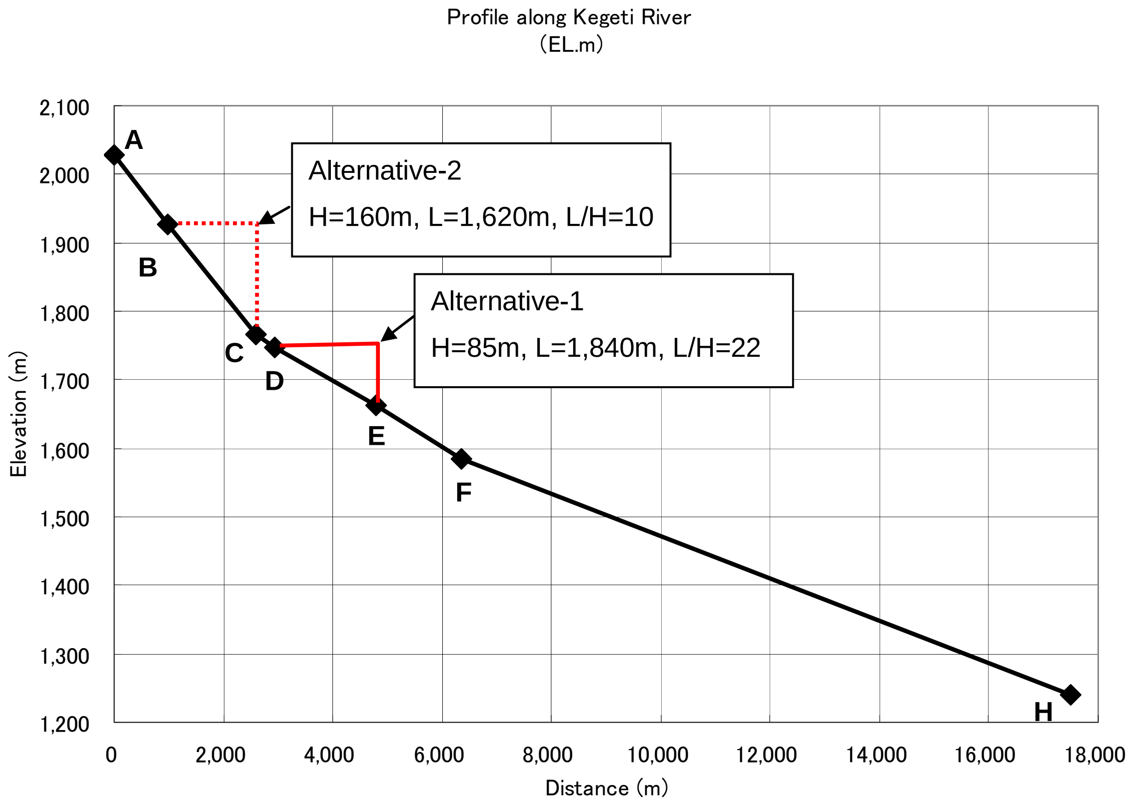


Figure 6-2-3 Longitudinal Profile of Kegeti River

(4) Photographs of Site Conditions

Photo 6-2-1: Road closed point
Estimated Q = 0.2 - 0.3 m3/s

Photo 6-2-2: Upstream from A

Photo 6-2-3: Downstream of A

Photo 6-2-4 Gulch on right bank at A

Photo 6-2-5: Slope on roadside between A&B
(dip slope)

Photo 6-2-6: Fallen Rocks on road
between A&B

Photo 6-2-7: Cut slope and Embankment Slope of Road between A and B

Photo 6-2-8: B (Kegeti-2 Intake)

Photo 6-2-9: Downstream of B
(River flowing through very steep slope)

Photo 6-2-10: Steep slope section between B and C (seen from downstream to B)

Photo 6-2-11: Downstream of B

Photo 6-2-12: Upstream of C

Photo 6-2-13: Water fall near D (Kegeti-1 Intake)

Photo 6-2-13: River at D
Estimated Q = 0.3 m3/s

Photo 6-2-14: River at D

Photo 6-2-15: River at D

Photo 6-2-16: River at F
(No house upstream of the small settlement on the right bank)

Photo 6-2-17 220kV Ala-Archa – Bystrovka Line

Photo 6-2-18 35kV Koroi - Kegeti Line

Photo 6-2-19 10/0.4kV Transformer closest to Candidate Power Station Location

(5) Bird view for Waterway Route

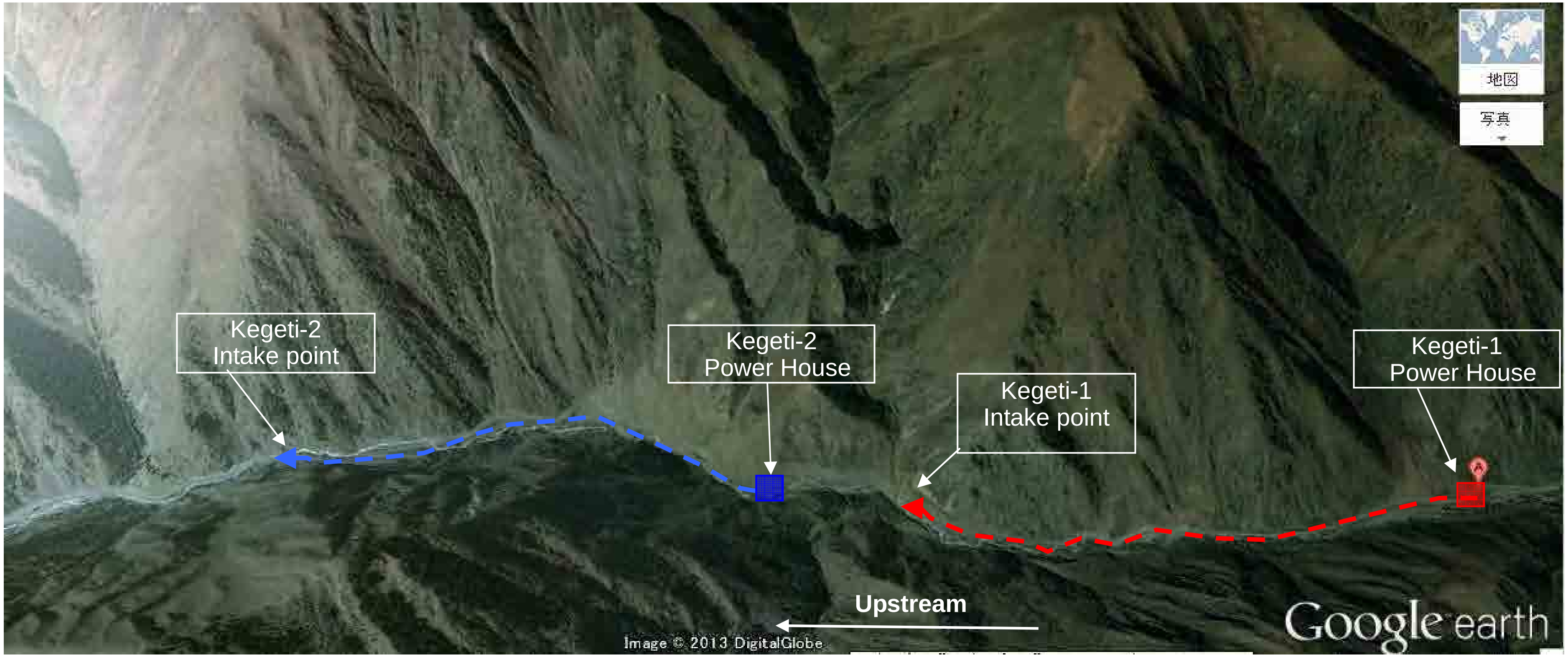


Figure 6-2-4 Bird View for Waterway Route of Kegeti Site

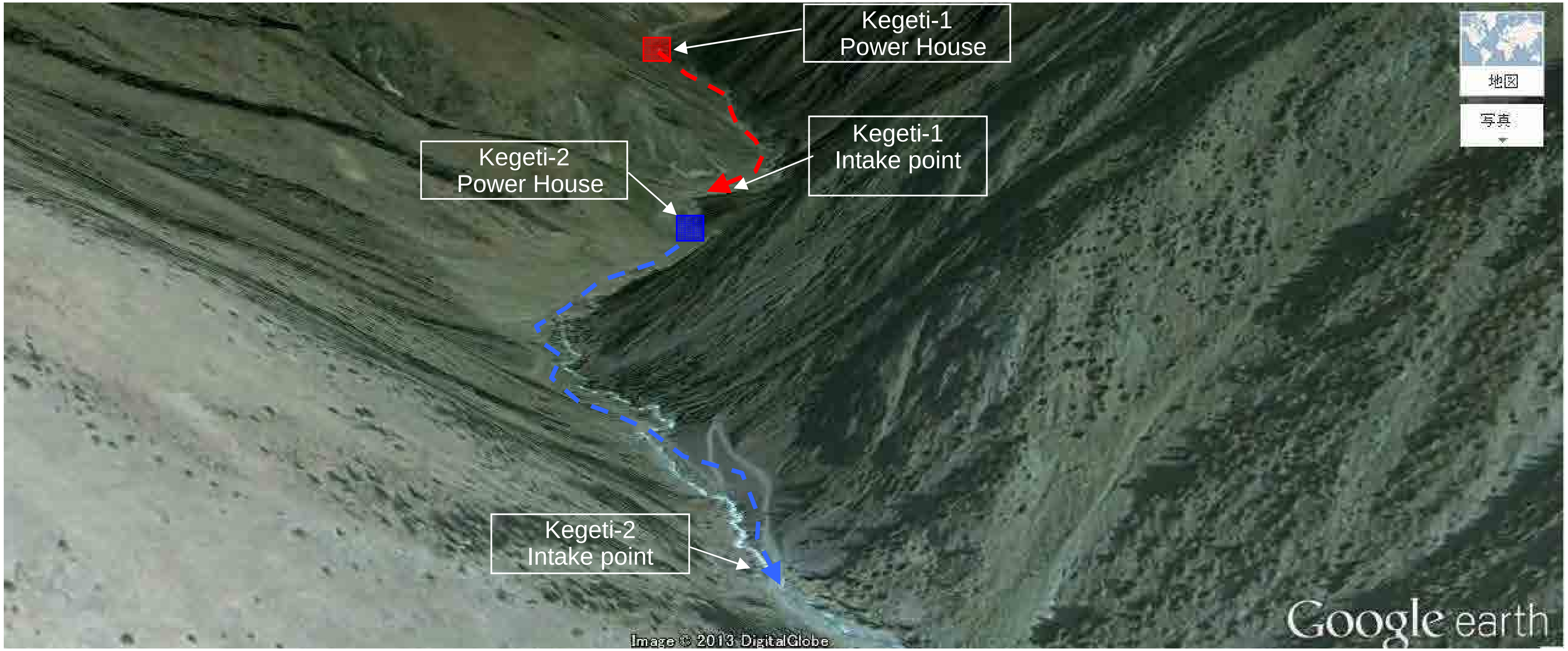


Figure 6-2-5 Bird View for Waterway Route of Kegeti Site (seen from upstream)

(6) Findings and Evaluation

In addition to the site for the application form for grant aid from Japan, a potential site which was identified as an alternative by the Survey Team was also surveyed.

In both the two sites, it is difficult to construct open-channel headrace on both the left and right bank slopes, due to the fact that the slopes of the valley between the intake and powerhouse are very steep with landslide areas and outcrops of fractured rock mass. Therefore, it is recommended that the headrace is not conventional open channel constructed on the slopes of valley but pressure pipe to be embedded for all the stretches from the intake to the powerhouse along the road.

The estimated river flow discharge was at 0.3 – 0.4 m^3/s (in February and April 2013), which is about one-fifth of design maximum discharge of 1.50 m^3/s for the application form.

There are no houses along the road around both the sites, and any river water usage for irrigation also is not found. No major environmental and social issues have been found. In addition, according to the Project Coordinator for small hydropower development at the Bishkek UNDP office, since there is a low possibility that a private company will develop a SHPP at this site, there will be no problem if JICA constructs a SHPP.

Since any big issues have not been identified until this stage as mentioned above, both the sites (Kegeti-1 and Kegeti-2) are evaluated as promising candidates and subsequently calculations on power generation features and estimation of their construction costs will be carried out in the next stage.

6-2-2 Djardy-Kainda Site

Djardy-Kainda site is located in Djardy-Kainda River, flowing down from the north slope of Kyrgyz Range to Panfilovskoye, which is a town about 80 km west of Bishkek. The site is a site for the old Djardy-Kainda SHPP which was constructed in the 1960s and abolished after starting operation of large-scale hydropower plants including Toktogul hydropower plant in the 1970s. This site was surveyed as one of promising SHPP potential sites to be reconstructed at the places of abolished SHPPs in Chui Oblast..

The features of Djardy-Kainda site for the abolished power plant, and reconstruction plan according to KSTC, are shown below.

	Abolished Plant		New Plan	
Name	Installed Capacity	Commission Year	Installed Capacity	Resource
Djardy-Kainda	0.24 MW	1956	1.20 MW	KSTC “Energy”

(1) Conditions on Access to the Site

- There is a trunk road in a good condition between Bishkek and Panfilovskoye Town, about 78 km west of Bishkek. From Panfilovskoye to the site, 12 km upstream of Panfilovskoye, there is a local road, which is unpaved but in not so bad condition for travelling of vehicles. The site is totally 2 hours and a half ride from Bishkek.
- The intake site is about 1 km upstream (or south) of the powerhouse. All the facilities of the abolished SHPP are located on the right bank of the river, but there is no road upstream of the powerhouse site on the left bank. However, the intake site is accessible by car though a road running on the left bank.
- The route map from Bishkek to the Djardy-Kainda site is shown in Figure 6-2-6.

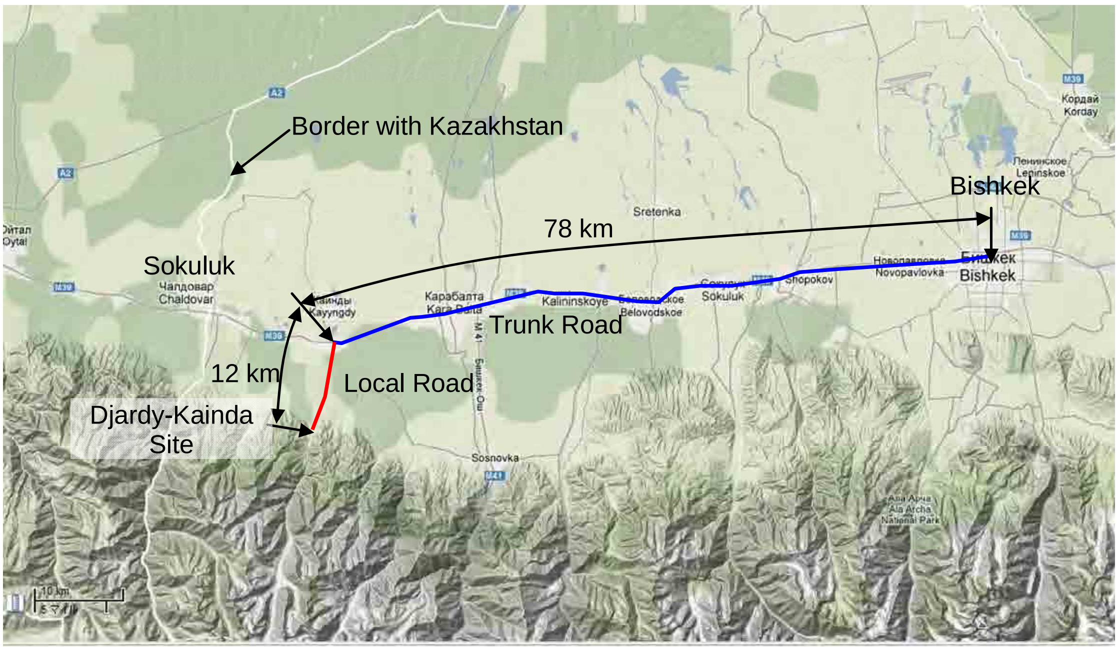


Figure 6-2-6 Route Map to Djardy-Kainda Site

(2) Findings from Site Survey

1) Power house （N42° 41’ 43.1”, E73° 39’07.6”/EL.1,234 m）

- The local road which runs along the Djardy-Kainda River ends around the irrigation water intake, but the powerhouse can be reached by tracing vehicle ruts continuing to the upstream.
- The widows of he old powerhouse have been removed, while the roof and walls still remain. Inside the powerhouse, all the equipments including the turbine and generators have been completely removed and the room seems to have been used for livestock.

2) Penstock

- The penstock is buried in the ground and fixed with concrete anchor blocks or supports at some intervals. The ground surface above the penstock is slightly low (depression) compared with others, maybe because of influence of excavation during the construction. The penstock is buried very shallowly in the ground, and some parts of it have been exposed on the ground surface. The steel pipe of most of the penstock still remains, and is 600 mm in diameter and about 220 m long. The thickness of the pipe is unknown.
- Since the penstock is buried in the slope of mud flow deposits, the foundations of concrete anchor blocks and supports are likely not to reach firm bedrock.

3) Head tank and Spillway from Head tank (Head tank: N41° 41’37.7”, E73° 39’13.7”/EL.1,309m）

- Height difference between the head tank and the powerhouse is 75 m.
- Most of the concrete structures for the head tank still remain, but their quality is very poor.
- 4 mm thick steel plates are used as liner plate for placing concrete in the curved section of inside wall of the head tank. The capacity of the head tank is estimated to be at 0.5 m^3/s or less of discharge.
- The spillway from the head tank is extended to the direction orthogonal to the penstock, and ends in the air above a small valley south of the head tank. The spillway is concrete open channel with a width of 60 cm. The slope around the spillway outlet has been widely eroded and collapsed, maybe due to water discharged from the spillway outlet. .

4) Headrace

- The headrace between the head tank and the intake is about 1.3 km in total length, and constructed with a 100 cm wide and 150 cm deep cross section which is located near the slope on a about 5 m wide platform created by cutting a hillside slope. (see Figure 6-2-7)

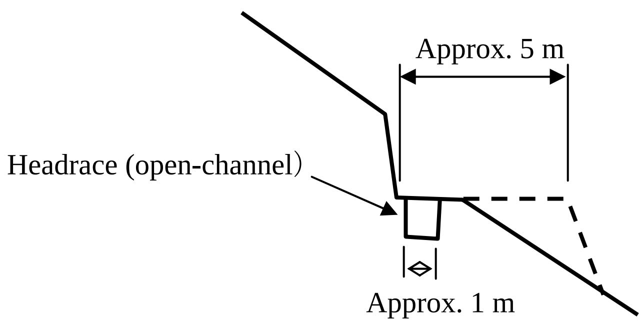


Figure 6-2-7 Cross Section of Headrace for Djardy-Kainda Site

- Inside walls of the open-channel along most of the sections are supported by 4 mm thick steel plate.
- The headrace is constructed on slopes of mud flow sediments containing sand and gravel, which is soft, but the cut slopes have no protection from erosion and/or land slide. Several parts of the slopes are collapsed and a number of sections of the open channel are buried by collapsed soil and gravel. However, the 5 m wide platform itself is still stable in most of the

sections.

- Two places where a platform has been largely collapsed are found. A collapse part (N42° 41' 20.5", E73° 39'02.4"/EL.1,310m) is 20 m wide, but the headrace at the place is not damaged. The collapse seems not circular arc slip, but just caused by gully erosion. The second one is more upstream, and its collapse width is about 10 m. The headrace channel at this place was also collapsed.
- About 300 m upstream of the head tank, a slightly larger stream cross the headrace. The part of the headrace at that section is a culvert, above which the stream water flows down across the headrace.
- The headrace section from the intake to several hundred meters downstream of the intake is located on a steep rock slope. At this section, the headrace channel is constructed with a concrete wall.

5) Intake and Intake Weir

- Due to the difficult approach from the headrace to the intake, the site (N42° 40'54.1", E73° 38'47.9"/EL.1,324m) was observed from the road located on the opposite side of the headrace.
- The intake site is several meters far from the road available for vehicle traffic.
- The river at the site is observed at 5 m wide, 0.4 m^3/s in discharge and 1/15 – 1/20 in gradient.
- Any river water usage for irrigation is not found between the intake and the powerhouse, although irrigation intake facility is found about 1 km downstream of the powerhouse.

6) Conditions around powerhouse

- No houses are found on the right bank where the power plant facilities were constructed. The places around the intake, headrace and powerhouse are used for grazing. A several houses are observed on the opposite side of the plant.
- The area around the power plant seems to belong to a national park, according to the signboard near the powerhouse.

7) Conditions on Distribution and Transmission Line

- A 10kV existing distribution line reaches the point from which the old SHPP is located with the direct distance of approximately 60m. The terminal of the distribution line does not have any connection either to a transformer or loads. Connection at the point to the candidate power station location is possible on the condition that there is no constraint in the capacity of the conductor and the transformer at the receiving end and no significant degradation of the equipment due to aging. If the condition doesn't allow, it is necessary to construct the access distribution line to the nearest 35/6-10kV substation. Although a 35kV existing distribution line passes east and west about 10km on the north of the old power station location, no distribution substation was identified during the site investigation. As for transmission lines, 220kV Karabalta - Frunzenskaya line (1 circuit) and 220kV Ala-Archa - Frunzenskaya line (2 circuits) pass east and west about 2.6km on the north of the old power station location. Besides, another circuit of the 220kV Karabalta - Frunzenskaya line passes east and west about 5.6km on the north of the other transmission lines. It is not realistic to connect to the transmission system at either of the terminal substations since the distance to both of these is several tens of kilometers.

(3) Longitudinal Profile of River and HPP Layout Plan

Locations of the HPP potential sites identified through the site surveys, their location data, and longitudinal profile including HPP layout plan are shown in Figure 6-2-8, Table 6-2-2, and Figure 6-2-9.

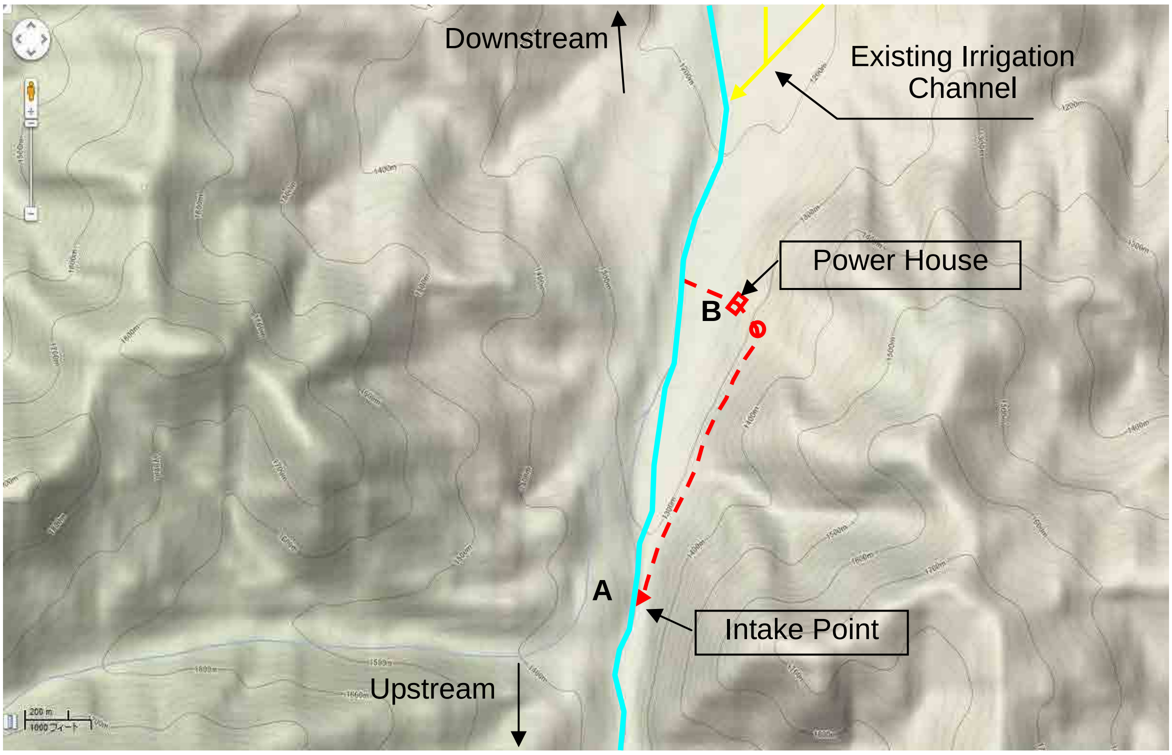


Figure 6-2-8 Location of Djardy-Kainda Site

Table 6-2-2 Location Data for Measure Points along Djardy-Kainda River

	Measure Points	Latitude	Longitude	Altitude (EL.m)	Height difference (m)	Cumulative Distance (m)	Interval Distance (m)	Gradient (L/H)	Estimated Discharge (m^3/s)
A	Intake	N42° 40' 54.1"	E73° 38'47.9"	1,324	—	—	—	—	0.4 m^3/s
B	Powerhouse	N42° 41' 43.1"	E73° 39'07.6"	1,234	-90	1,500	1,500	17	

Waterway length

Headrace : 1,500 m

Penstock : 230 m

Tailrace : 220 m

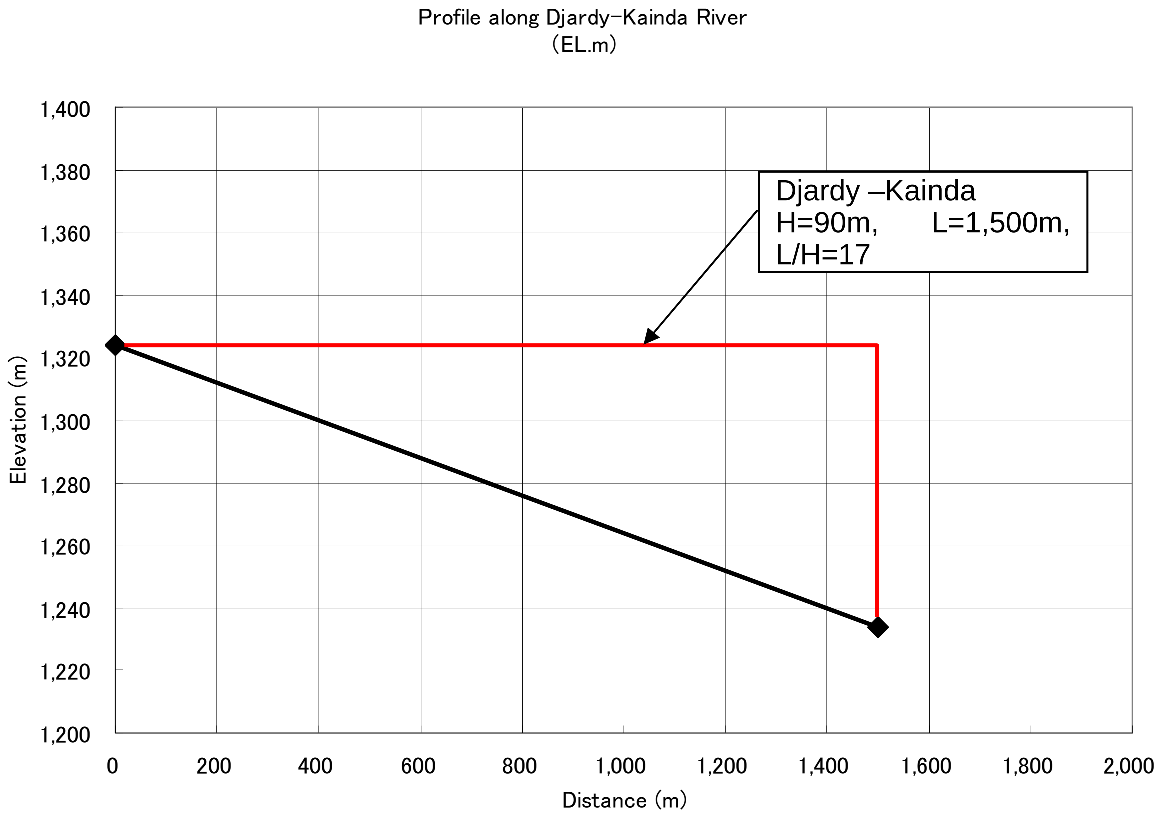


Figure 6-2-9 Longitudinal Profile of Djardy-Kainda River (Intake – Powerhouse)

(4) Photographs of Site Conditions

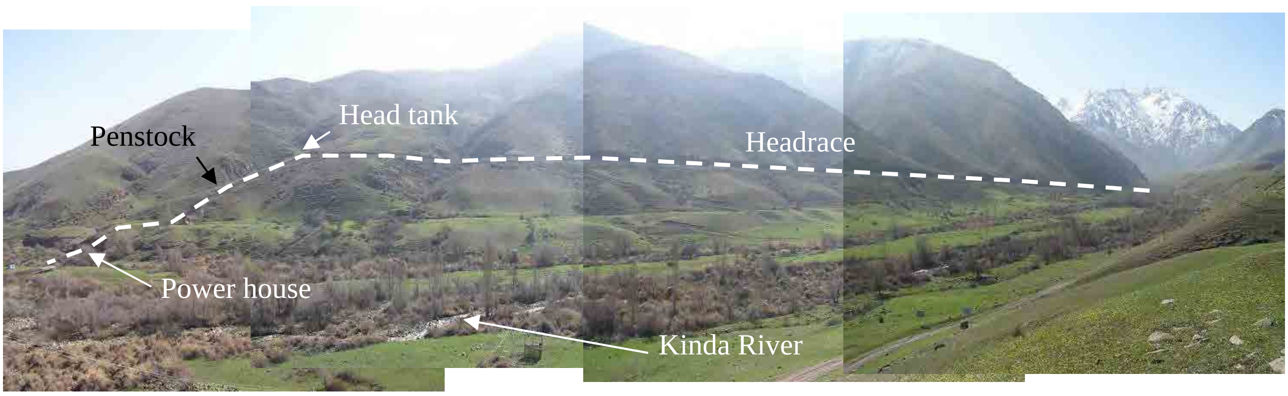


Photo 6-2-20 Djardy-Kainda Abolished SHPP (seen from opposite bank)

Photo 6-2-21: Powerhouse

Photo 6-2-22: Powerhouse

Photo 6-2-23: Inside of Powerhouse

Photo 6-2-24: Slope for Embedded Penstock

Photo 6-2-25: Anchor Block for Penstock

Photo 6-2-26: Exposed Penstock

Photo 6-2-27: Penstock (Φ600 mm)

Photo 6-2-28: Manhole & Anchor Block of Penstock

Photo 6-2-29: Slope for Embedded Penstock (seen from head tank)

Photo 6-2-30: Head Tank

Photo 6-2-31: Inlet of Penstock

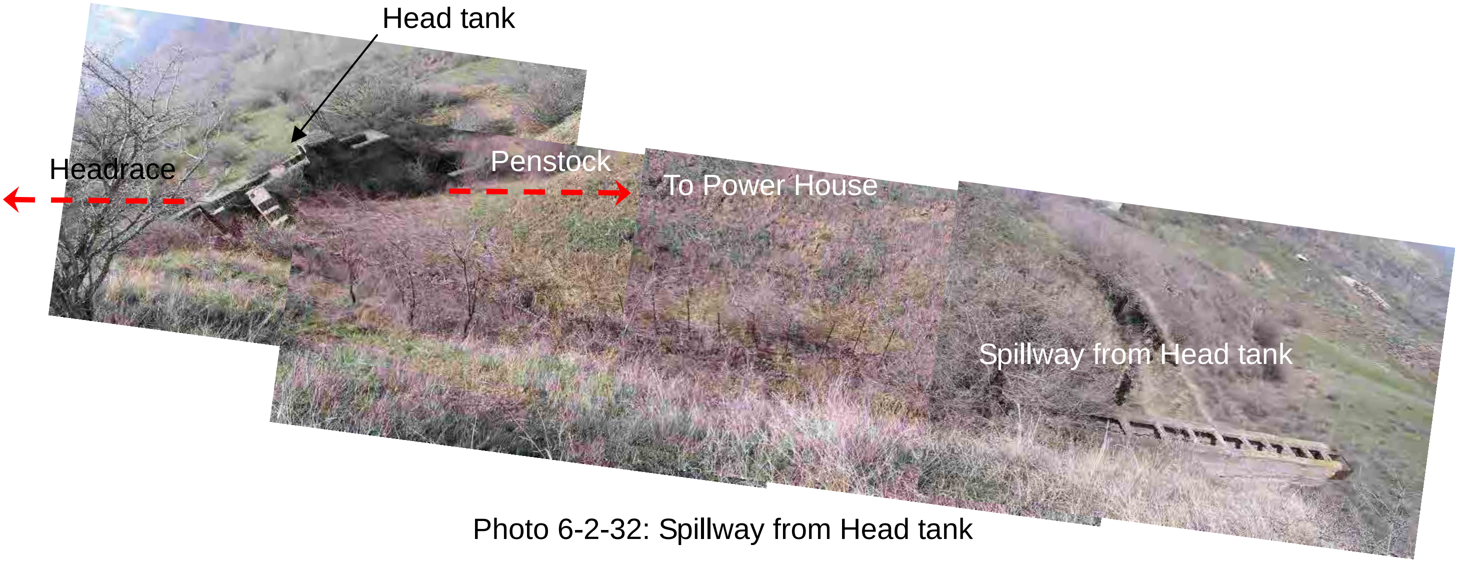


Photo 6-2-32: Spillway from Head tank

Photo 6-2-33: Platform for Headrace (5 m wide)

Photo 6-2-34: Headrace
(1 m wide, 4mm thick steel plate)

Photo 6-2-35: Headrace buried by landslide

Photo 6-2-36: Cut Slope above headrace

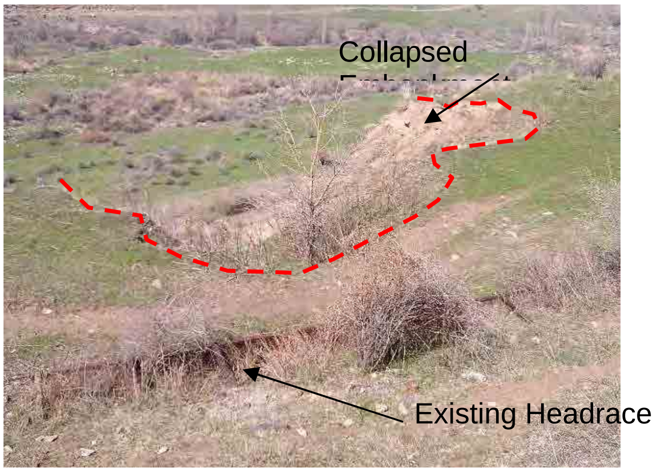


Photo 6-2-37: Collapsed Platform 1

Photo 6-2-38: Collapsed Platform
(680 m upstream of head Tank)

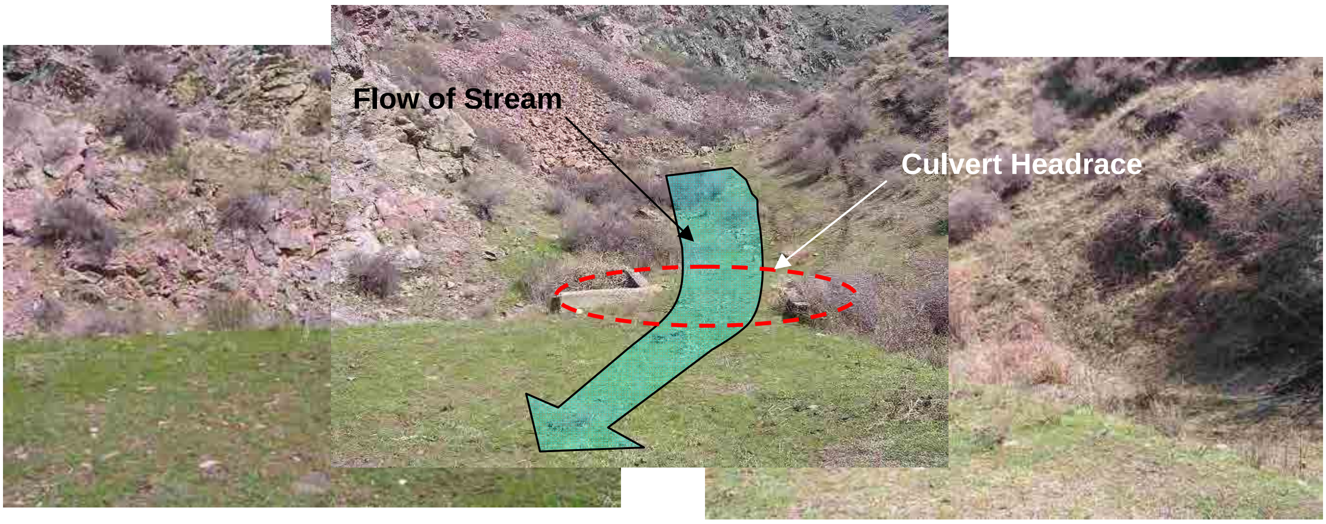


Photo 6-2-39: Stream Crossing Point (Culvert channel) (840 m upstream of head tank)

Photo 6-2-40: Collapsed Platform 2 (1,100m upstream of head tank)

Photo 6-2-41: Cut Slope above Headrace

Photo 6-2-42: Cut Slope above Headrace

Photo 6-2-43: Intake Site (seen from left bank)

Photo 6-2-44 220kV Karabalta - Frunzenskaya Line and Ala-Archa – Frunzenskaya Line

Photo 6-2-45 35kV Distribution Line (Location of the Terminal Substation is unknown)

Photo 6-2-46 Terminal Point of Existing 10kV Distribution Line

Photo 6-2-47 Positional Relation between 10kV Existing Distribution Line and Old Power Station

(5) Bird view for Waterway Route

Figure 6-2-10 Bird View for Abolished Djardy-Kainda SHPP (seen from west to east)

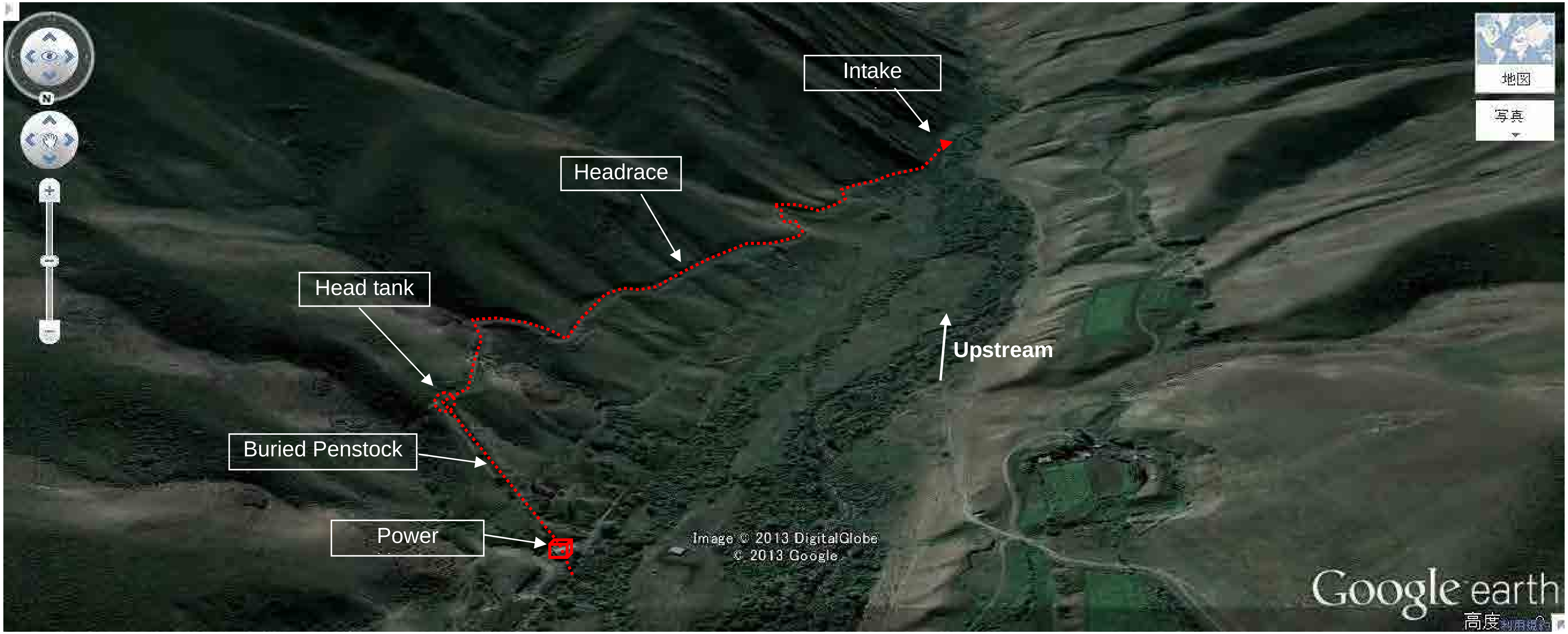


Figure 6-2-11 Bird View for Abolished Djardy-Kainda SHPP (seen from north to south)

(6) Findings and Evaluation

The abolished Djardy-Kainda SHPP has a waterway layout that consist of a intake taking water from a river flowing down from the north slope of Kyrgyz Range at around the top of a an alluvial fan and a open channel headrace lying on a platform constructed by open-cut on a slope of mud flow sediments. A new SHPP plan utilizing this abolished SHPP has a lot of features in common with existing Issyk-Ata-1 and Sokuluk-2 on-going SHPPs mentioned in the Chapter 5. River flow discharge at the Djardy-Kainda site is smaller than that at Issyk-Ata and Sokuluk Rivers. However, since L/H of 17 at this site is small, the construction costs for headrace is likely to be relatively low.

Although some parts of platform along the headrace are collapsed, the platform as a whole can be used for new headrace without a huge repair. And most of the sections of platform for headrace have accessible by construction vehicle. Therefore, there have been no issues on designing and construction works.

Only downstream of the powerhouse, the river water is taken for irrigation, and any river water usage for irrigation between the intake and powerhouse is not found. No major environmental and social issues have been found. In addition, according to the Project Coordinator for small hydropower development at the Bishkek UNDP office, since there is a low possibility that a private company will develop a SHPP at this site, there will be no problem if JICA constructs a SHPP.

Since any big issues have not been identified until this stage as mentioned above, the Djardy-Kainda site is evaluated as one of promising candidates and subsequently calculations on power generation features and estimation of their construction costs will be carried out in the next stage.