Preliminary Asset Management and Operation and Maintenance Plan of Chubek Irrigation System

September 2016

TAJ: Water Resources Management in Pyanj River Basin Project

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I. INTRODUCTION

1. Chubek Irrigation System (CIS) is located in Khatlon Oblast on the right bank of Pyanj River. Water from the Pyanj River is diverted by gravity without any regulator across the river. The Chubek Main Canal with original capacity of about 150 cubic meter per second (cumec) was constructed in 1950 while the distribution system was constructed during 1950-1987 to supply water to command areas located in Hamadoni, Farkhor, Vose, and Kulob districts. The water is supplied by a combination of gravity system and 20 sets of pumping units. Some areas require multistage pumping. The total pumping required for various irrigation areas varies from 8.5 to 177.5 m. General layout of CIS is shown in Figure 1.

2. This paper is to describe CIS service area, water supply, irrigation asset (main, gravity, and pump systems) at both present condition and expected status after the completion of Water Resources Management in Pyanj River Basin Project (the Project) and other relevant information. The paper also presents current operation and maintenance (O&M) practice to identify gaps. Based on the identified gap, O&M plan is proposed to ensure full cost recovery and CIS sustainability. The O&M plan proposed in this paper is, however, required to be updated after the completion of modernization and rehabilitation (M&R) of CIS by the Agency of Land Reclamation and Irrigation (ALRI), the executing agency to implement Outputs 2 and 3 of the Project with help of the project implementation consultant by reflecting actual works to be done and detailed O&M requirement.[1] Then, updated O&M plan including the plan to increases of irrigation service fee (ISF) and the government budget allocation will be reviewed and confirmed by Asian Development Bank at least one year before project completion. Finally, the government has to approve the O&M plan before project completion by issuance of government resolution. The procedure of the development and approval of the O&M plan described above is stipulated in the covenant of the loan agreement of the Project.

II. CIS SERVICE AREA

A. Original CIS Service Area

3. CIS has a total design command area of 50,163 hectare (ha); 35,819 ha (71%) is fed by gravity and 14,344 ha (29%) by pumps. Vose District has the highest proportion (57%) of irrigated area served by pumps while Kulob has only 2% of the command area served by pumps. Data on district-wise irrigated area is given in Table 1.

Table 1: Area Served by Pump and Gravity Irrigation – Design Conditions

District	Land Irrigated by Chubek Canal – Design Conditions			
	Irrigated Land Total, ha	Irrigated by Pumps, ha	Irrigated by Gravity, ha	Irrigated by Pumps, %
Hamadoni	16,508	0	16,508	0%
Farkhor	24,548	5,837	18,711	24%
Vose	8,740	8,140	600	93%
Kulob	367	367	0	100%
Total	**50,163**	**14,344**	**35,819**	**29%**

Source: ALRI.

4. The gravity irrigation distribution system consists of about 1 kilometer (km) lead channel with a capacity of about 400 cumec, a complex of head regulator and sediment

[1] Output 1 (Water resources in Pyanj River basin better managed) of the Project will be implemented by the MEWR, the another executing agency.

escape structure at the end of lead channel, about 17.2 km long Chubek Main Canal, about 390 km of interfarm canals including main canal, and about 621 structure.

5. The CIS was designed to serve primarily the areas by gravity. Pumps were installed wherever required to irrigate the adjoining high areas. This is evident from the profile of the existing canal which is very close to the natural ground level to minimize cost by keeping the cut and fill at minimum. The canals have a number of falls to keep the profile close to natural ground level instead of keeping the head to minimize pumping for high lands.

B. Current CIS Service Area

6. Because of inadequate maintenance of the system since its commissioning, the existing irrigated area is estimated at 43,210 ha, about 86% of the design conditions. The district-wise existing irrigated area is: Hamadoni 13,984 ha (85%), Farkhor 22,500 ha (92%), Vose 6,397 (73%), and Kulob 376 ha (100%). Details are in Table 2.

Table 2: Area Served by Pump and Gravity Irrigation – Existing Situation

District	Total Irrigated Land of the District, ha	Land Irrigated by Chubek Canal – Existing Situation			
		Irrigated Land Total, ha	Irrigated by Pumps, ha	Irrigated by Gravity, ha	Irrigated by pumps %
Hamadoni	16,508	13,984	0	13,984	0%
Farkhor	24,548	22,500	5,837	16,663	26%
Vose	19,337	6,397	5,797	600	91%
Kulob	8,350	329	329	0	100%
Total	**68,743**	43,210	**11,963**	**31,247**	**28%**

Source: Remote Sensing data given in RESTEC Study.

7. The Project is aiming at full operation of CIS covering original service area of 50,163 ha with M&R so that CIS will be operated with less O&M requirement, more available O&M fund, and with maximizing agricultural benefit.

III. CLIMATE

8. The area has a moderately long growing season for crops. Day time temperatures in mid-summer are very hot, rising to about 40°C on average maximum daily) in July. Annual rainfall is approximately 340 mm, with 88% of this rainfall occurring in the six months December to May. Very little rain falls in the vegetative season, meaning there is a very heavy reliance on irrigation water. Average wind speed is moderate throughout the year. Potential evaporation rates vary from just over a millimeter a day in December and January to 6 mm a day in July. Mean monthly climate data of the project area is given in Table 3.

Table 3: Climatic Data of Chubek Irrigation System

Month	Min Temp °C	Max Temp °C	Humidity %	Wind km/day	Sunshine hours	Rainfall mm
January	-8.6	7.4	81.0	162.0	3.8	39.7
February	-5.2	12.4	77.0	207.0	4.7	39.2
March	-1.3	16.7	72.0	228.0	5.0	63.6
April	4.4	23.6	68.0	208.0	6.8	42.2
May	9.9	30.1	52.0	200.0	8.7	20.1
June	13.3	35.6	41.0	183.0	10.2	1.8
July	15.7	38.4	43.0	156.0	12.8	0.0

August	13.1	37.1	33.0	158.0	11.5	0.1
September	7.6	31.2	44.0	123.0	10.0	0.0
October	2.0	24.3	66.0	132.0	7.6	9.0
November	-4.3	16.0	70.0	142.0	5.6	26.2
December	-6.1	9.0	82.0	154.0	4.0	39.4
Average	3.4	23.5	61.0	171.0	7.6	281.3

Source: Meteorological data of Hamadoni/Vose, Farkhor, and Kulob from 1980 to 2000.

IV. WATER RESOURCES

A. Source of Water

9. The source of irrigation water is the Pyanj river, which has large and reliable flows. The Pyanj River rises in the Pamir Mountains to the east. About 160 km downstream of the project area, it is joined by two major tributaries – the Vakhsh and the Surk'ab Darya – after which it is called Amudarya, the largest river of Central Asia. The highest flow are due to snow melt, and, therefore, the flow peak is in summer. The Pyanj River is morphologically active and keep on changing its course. The river has a high sediment load, particularly in the spring and early summer, and the sediment is particularly abrasive. Average turbidity in the river water is 1.10 kilogram per cubic meter (kg/m^3).

10. Discharge data of Pyanj River at No 27 Khirmanjo Monitoring Station, located about 120 km upstream the CIS intake point, for the period 1970-90 is given in Table 4 below.

Table 4: Pyanj River Discharge

Month	Maximum Values		Minimum Values		Mean Discharge (m^3/s)	Standard deviation (m^3/s)	Coefficient of Variation	% of Annual Discharge
	Discharge (m^3/s)	Year of Occurrence	Discharge (m^3/s)	Year of Occurrence				
Oct	836	1978	314	1980	453	86	0.19	4.6
Nov	515	1969	252	1980	333	48	0.14	3.3
Dec	372	1991	217	1990	275	30	0.11	2.8
Jan	299	1970	194	1981	239	23	0.10	2.5
Feb	264	1970	191	1984	226	17	0.08	2.1
Mar	591	1985	194	1986	247	43	0.17	2.5
Apr	1,090	1985	194	1986	463	191	0.41	4.6
May	4,230	1978	606	1979	927	352	0.38	9.5
Jun	4,370	1969	1,090	1982	1,764	656	0.37	17.5
Jul	3,560	1969	835	1981	2,210	634	0.29	22.7
Aug	1,850	1984	448	1982	1,824	520	0.29	18.7
Sep	836	1978	314	1980	914	294	0.32	9.1
ANNUAL					**823**	**205**	**0.24**	**100.0**

Source: No 27 Khirmanjo Monitoring Station: Pyanj River, Stream flow statistics.

11. Mean annual discharge of the Pyanj River is 823 cumec, with 24% co-efficient of variance. Minimum mean monthly discharge of 226 occurs in February while maximum mean monthly discharge of 2,210 cumec is observed in July. There is very high seasonality in the flow pattern; about 18% of the annual flows occur during the low-flow months (October to March) and about 82% during the high-flow months (April to September).

B. Quality of Water Records

12. The operation of the Chubek Canal Head Regulator is the responsibility of Ministry of Energy and Water Resources (MEWR) which gives instructions to the gates operator on how much water to divert for each 10-day period. The decision of how much water to divert is based on the long-term irrigation water requirements, quarterly agreement with the central Asian states sharing the water of trans-boundary rivers, and consolidated 10-day indents received from the district ALRI offices. Beyond the Chubek Head Regulator, the responsibility of gauging and maintenance of records lies with the respective ALRI office. Although water flow records are available for various locations along the CIS, the gauging stations are not being maintained, and currently, there is no arrangement for measuring flows and updating the rating curves.

13. The automatic water recorder well in the approach channel upstream of the Chubek Main Canal Head Regulator has been abandoned. The gauges are recorded from the painting on the upstream wall of the pond area and discharge is estimated using this level with consideration to gate opening. In the field offices, there are no current meters in working order to measures flows and ultrasound recorders to measure water depths. Water depths are measures crudely using a rod. The water measuring structures along the canals are in a state of disrepair.

14. Spot discharge measurement conducted by the consultant together with ALRI staff in September 2015 revealed over-registering of water discharge of the Chubek Main Canal by 58% (i.e., actual water supply was 63% of the recorded). While discharge estimation from water stage, with periodic calibration of the rating curve, could give reasonably accurate results, loss of channel cross-section area due to sediment accretion, which goes unrecorded, leads to over-estimation of discharge.

15. Similar is the case with sediment data. There are no records of sediment intake into the project areas. For estimation of sediment inflow, which formed the basis of design of sediment excluding basin, sediment data of Pyanj River at No 27 Khirmanjo Monitoring Station was used which is located about 120 km upstream of the CIS intake point. In addition, sediment samples were collected from the sediments excavated from the canals to get grain size distribution for use in the design of the sediment excluding basin.

16. The poor state of flow and sediment records have strong implication on the current studies and due consideration needs to be given to this factor while drawing conclusions. First, the inadequate irrigation supplies is evident from the overall situation of agricultural production indicated by less cropped area, poor yields and lower overall agricultural production. The crop water requirements for future cropping patterns and intensities should, thus, be based on agro-climatic factors rather than the historic records.

17. Second, the irrigation efficiency[2] is an important parameter in estimation of future irrigation requirements. Attempts were made during the current studies to estimate irrigation efficiency using remote sensing data. While this technique gives fairly reliable estimates of consumptive use, the actual flow data is requires to calculate the irrigation efficiency and reliability of estimated efficiency will be no better than reliability of the flow records. The project' overall estimated irrigation efficiency of 20%–30% should better be adjusted to 30%–40% considering the over-registering of flow records.[3] It is generally observed that lower supplies lead to lower losses and thus higher efficiency.

[2] Irrigation efficiency is the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation (surface, sprinkler or drip irrigation).

[3] By multiplying with the over-registering factor of 50/31.6=1.58, the range of 20-30 comes to 31.6–47.4. The range of 30–40 has been adopted for the base case.

18. Third, the current state of flows and sediment records underscore the need for strong and properly equipped institutional arrangement with trained staff for regular observations, analysis, and recording of the observed data. Adequate resources need to be allocated for purchase of the proper field equipment for discharge observation and sediment sampling, establishment of a laboratory to analyze the sediment samples, and training of the staff.

C. Water Diverted to Chubek Irrigation System

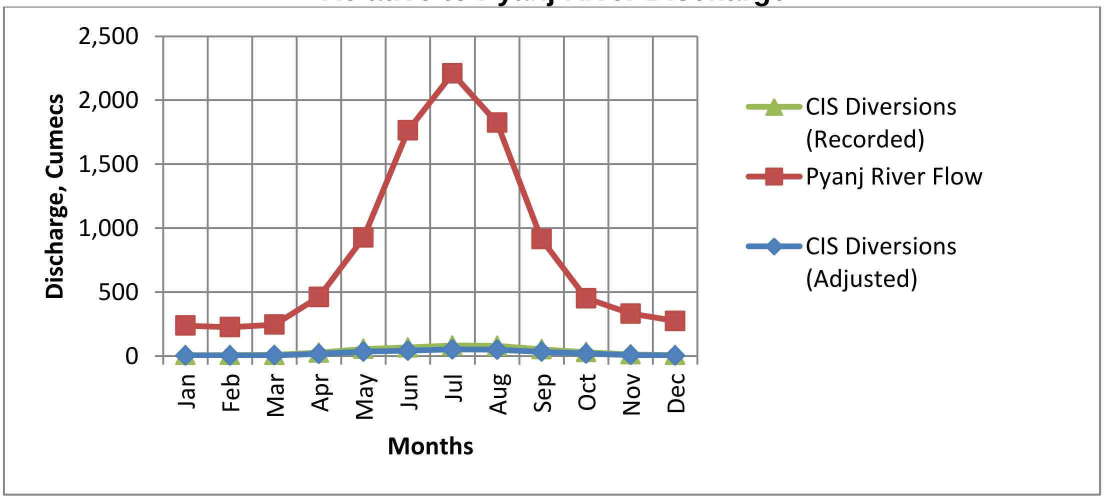
19. The mean monthly discharge of the Chubek Canal (as recorded) relative to Pyanj River discharge is given in Table 5 below. It is obvious that, overall, the CIS uses 3.3%–6.9% of Pyanj River water. However, during the peak water demand months (June, July, and August) Chubek Canal diverts 3.7%–4.4% of Pyanj River water. The average annual diversion is 4.5%. The shows mean monthly discharge of the Chubek Canal (as recorded as well adjusted follow discussion in para. 14) relative to Pyanj River discharge.

Table 5: Mean Monthly Diversions to Chubek Canal Relative to Pyanj River Discharge

Month	Pyanj River	CMC, mean Q		CIS Diversion as % of Pyanj River flows	
	Mean Q Cumec	Recorded Cumec	Adjusted Cumec	As recored %	Adjusted %
Jan	239	9	5.69	4%	2%
Feb	226	9	5.69	4%	3%
Mar	247	10	6.32	4%	3%
Apr	463	27.16	17.17	6%	4%
May	927	56.52	35.72	6%	4%
Jun	1,764	67.32	42.55	4%	2%
Jul	2,210	82.82	52.34	4%	2%
Aug	1,824	79.68	50.36	4%	3%
Sep	914	53.83	34.02	6%	4%
Oct	453	31.42	19.86	7%	4%
Nov	333	13.5	8.53	4%	3%
Dec	275	9	5.69	3%	2%
Average	822.92	37.44	23.66	5%	3%

Source: ALRI.

Figure 2: Mean Monthly Diversions to Chubek Canal (Recorded as well as Adjusted) Relative to Pyanj River Discharge



20. The monthly recorded diversions to the CIS for the period 2009–2014 are given in Table 6.

Table 6: History of Diversion to Chubek Irrigation System, '000 m3

Month	2009	2010	2011	2012	2013	2014	Average	% of Total

Jan	15,120	0	0	0	0	24,373	6,582	**0.6**
Feb	0	0	0	0	0	7,862	1,572	**0.1**
Mar	0	0	0	0	2,4182	0	4,836	**0.4**
Apr	13,694	72,539	79,972	89418	8,4735	25,384	60,957	**5.4**
May	45,649	89,188	187,622	152,153	15,9345	143,327	129,547	**11.4**
Jun	139,802	160,164	181,570	179,297	17,3334	176,412	168,430	**14.8**
Jul	194,072	211,144	187,622	208,086	21,0678	232,762	207,394	**18.3**
Aug	190,328	761,398	187,622	199,571	20,8345	217,482	294,124	**25.9**
Sep	86,569	148,107	158,423	145,567	13,5318	143,778	136,294	**12.0**
Oct	73,608	108,942	74,451	87,372	8,8932	81,557	85,810	**7.6**
Nov	45,922	13,198	25,920	49,998	3,5718	0	28,459	**2.5**
Dec	14,561	0	864	25920	2,4373	0	10,953	**1.0**
All	**819,325**	1564**,680**	**1,**084**,065**	**1,137,381**	**114,4958**	**1,**052**,937**	**1,134,**959	**100.0**

Source: ALRI

21. Table 6 Above shows that annual water intake in CIS varies from 0.8 billion cubic meter (2009) to 1.5 billion cubic meter (2014) with an annual average water intake of 1.13 billion cubic meter. And, more than 80% of water is used during May to September which are high consumptive use summer months.

V. CHUBEK IRRIGATION SYSTEM ASSET (MAIN AND GRAVITY IRRIGATION)

A. Present Asset and Condition

22. In CIS, there are total 67 main and inter-farm canals with the total length of about 390 km of which 102 km are concrete lined. There are total of 621 structures of which about 200 previously included devices for measuring water in open channel systems. All canals and structures were built during 1950s-1980s when the country was a part of the Soviet Union. Most structures are in very poor condition and require rehabilitation and modernization. A summary of inventory of the inter-farm canals is given in Table 7 below.

Table 7: Inventory of Inter-farm Canals

S. №	Name of ALRI District Dept	Number of Canals	Date of Start of Operation	Command Area (ha)	Canals length (km)	Number of structures
1	Chubek Canal Dept (main canal)	1	1950	0	17.2	7
2	Hamadoni District Dept	27	1956-1971	16,508	113.0	97
3	Farkhor District Dept	35	1950-1987	24,548	226.8	461
4	Vose District Dept	3	1963-1975	8,740	27.3	52
5	Kulob District Dept	1	1973	367	5.4	4
	Total	**67**		**50,163**	**389.7**	**621**

Source: ALRI.

1. Main Canal

23. As stated in para. 4, the water from Pyanj River is conveyed to the Chubek Main Canal Head Regulator (CMCHR) through a 1 km long and about 50 m wide leading channel. A sediment flushing channel located just upstream of the CMCHR with sill level 50 cm below that of CMCHR reduces silt entry in the main canal by diverting to the Pyanj River lower 50 cm layer with high concentration of sediments in the bed load. The Chubek Main Canal is trapezoidal in section with top width of 35 m and average depth of flow of 2.5 m. The CMCHR has five bays controlled by radial gates, two on the left are 4.0 m each and the remaining three are 3.5 m each.

24. The 17.2 km long Chubek Main Canal conveys water from the Chubek Head Regulator to the point where it feeds various interfarm branch canals. It is trapezoidal in section with top width of 35 m and average depth of flow of 2.5 m and its original discharge capacity was 150 cumec.

2. Interfarm Canals

a. Inter-farm Canals in Hamadoni District

25. Inventory of 35 inter-farm canals, which are under the overall responsibility of the Hamadoni District Department of ALR[4] is given in Table 8 below.

Table 8: Inventory of Inter-farm Canals of the Hamadoni District

S. No.	Name of the Canal	Date of Start of Operation	Irrigated Area (ha)	Length (km)	Water Measuring Structures	Number of Outlets	Other Structures
1	Canal R-1	1951	887	7.4	2	4	1
2	Canal R-3	1971	225	2.5	1	0	1
3	Canal R-4	1956	572	3.5	1	2	1
4	Canal R-5	1958	1,028	9.0	2	5	1
5	Canal R5-1	1958	274	4.7	1	1	1
6	Canal Buz-5	1957	36	2.0	1	1	1
7	Canal Buz-3	1958	206	5.8	1	1	1
8	Canal R-7	1952	3,747	4.4	4	4	1
9	Canal R7-1	1955	334	0.9	1	0	1
10	Canal R7-2	1955	283	5.6	1	1	0
11	Canal R7-3	1966	411	3.2	1	1	1
12	Canal R8-2	1956	170	2.8	1	1	1
13	Canal R-9	1958	252	4.4	1	1	2
14	Canal R-10	1957	414	4.5	1	1	1
15	Canal Shokhai Rost	1956	1,070	9.6	2	3	2
16	Canal PR-5	1957	1,062	5.3	3	3	1
17	Canal PR-5	1958	189	0.7	1	1	1
18	Canal PR-10	1957	1,030	8.3	2	1	2
19	Canal R-12	1957	245	3.6	1	1	1
20	Canal LRX1	1957	336	2.5	1	1	1
21	Trough LRX	1957	63	1.0	1	0	1
22	Trough LR-1	1957	450	5.0	1	3	1
23	Trough LR-1-2	1957	120	1.9	1	0	1
24	Trough LR-1-3	1957	343	3.5	1	1	1
25	Trough LR-1-4	1957	642	2.6	1	0	1
26	Trough LR-5	1957	109	1.0	1	0	1
27	Arpa Tuguldi	1956	2,010	7.3	0	1	2
	Totals		**16,508**	**113**	**35**	**37**	**25**

Source: ALRI.

26. Other structures include head regulators, cross-regulators, bridges, aqueducts, pipe culvert, and box culverts.

[4] In some command areas where WUAs are fully developed and operational, WUAs are responsible for operation and maintenance (O&M) of the interfarm canals lying within the boundaries of their areas. In other areas, the respective district ALRI offices are responsible of O&M of their interfarm canals.

b. Inter-farm Canals in Farkhor District

27. Details of 39 inter-farm canals, which are under the responsibility of the Farkhor District Department of ALRI are given in Table 9 below.

Table 9: Inventory of Inter-farm Canals of the Farkhor District

Sr. No	Name of the Canal	Irrigated Area ha	Length Km	Design Discharge m^3/sec	Climate Proofed Discharge m^3/sec	Canal Capacity Sufficient (Y/N)
1	Canal leading to PS Urtaboz 3	424	0.65	1.00	0.85	Yes
2	Canal P-4	282	1.14	1.40	0.56	Yes
3	Canal leading to PS Urtaboz 2	215	0.45	0.60	0.43	Yes
4	Canal 1-X-17	95	1.7	0.60	0.19	Yes
5	Canal P-2 (Urtabuz)	1,724	8.4	4.00	3.45	Yes
6	Canal 7-X-2	143	1.17	1.00	0.29	Yes
7	Canal 7-X-2-1	82	1.93	0.35	0.16	Yes
8	Canal 3-X-3	247	2.96	1.20	0.49	Yes
9	Canal 6-X-1	573	4.11	0.80	0.87	Yes
10	Canal P-1 Chairali	3,849	15.86	10.00	7.70	Yes
11	Canal Puchkak	2,182	7.1	10.00	4.36	Yes
12	Canal KarangiPata	759	8.7	3.70	1.52	Yes
13	Canal KarangiPata (side outlet)	600	0.87	3.70	1.20	Yes
14	Canal P-2 (Leskhoz)	250	3.5	0.50	0.50	Yes
15	Feeding Canal Maida-Patta	1,286	7.2	7.20	2.57	Yes
16	Main Canal Maida-Patta	1,200	15	7.20	2.40	Yes
17	Canal X-1	196	1	0.50	0.39	Yes
18	Canal X-3	503	1.5	1.50	1.01	Yes
19	Trough (ЛР-10)	1,086	7.6	1.90	1.65	Yes
20	Trough (RD-14)	1099	5.3	2.30	2.20	Yes
21	Trough (RD-17)	353	4	0.60	0.54	Yes
22	Trough (RD-18)	917	6.53	1.60	1.39	Yes
23	Trough (RD-20)	1,297	5	2.20	1.97	Yes
24	Trough (RD-20-4)	343	4.3	0.86	0.69	Yes
25	Trough (RD-28)	762	4.1	1.10	1.16	Yes
26	Trough (RD-28,1)	277	1.6	0.40	0.55	Yes
27	Trough (RD-32-1)	192	4.2	0.60	0.38	Yes
28	Trough (RD-35)	112	2.5	0.75	0.22	Yes
29	Trough (RD-36)	379	2.4	0.86	0.76	Yes
30	Canal 7-X-2-2	40	2	0.15	0.08	Yes
31	Canal 5-X-2	274	2.2	0.50	0.55	Yes
32	Surkhob Canal	1576	9.5	1.50	2.40	No
33	Canal Kok-Kul 1	421	12.5	1.50	0.84	Yes
34	Canal Kok-Kul 2	347	9.4	5.00	0.69	Yes
35	Canal Kul -2-1	1,063	8	2.50	2.13	Yes
	Total	**24,548**	**226.88**			

Source: ALRI.

c. Inter-farm Canals in Vose District

28. Detail inventory of 3 inter-farm canals, which are under the responsibility of the Vose District Department of ALRI are given in Table 10 below.

Table 10: Inventory of Inter-farm Canals of Vose District

S. No.	Name of the Canal	Date of Start of Operation	Irrigated Area (ha)	Length (km)	Number of Water Measuring Devices	Number of Outlets	Other structures
1	Canal Agra Tuguldi RD 158	1963	2,603	5.5	9	6	1
2	Canal Agra Tuguldi RD 131	1963	3,022	6.4	8	7	1
3	Canal Kulob Dare Navbati 2	1975	3,115	15.4	10	9	1
	Total		**8,740**	**27.3**	**27**	**22**	**3**

Source: ALRI.

d. Inter-farm Canals in Kulob District

29. There is only one inter-farm canal under the CIS in Kulob District, managed by the Kulob District Department of ALRI. It is called Dare 3, was constructed in 1973, is 5.41 km long, has 4 outlets and serves a command area of 367 ha.

3. On-farm System

30. Maintenance of on-farm facilities has always suffered because of lack of resources. Even during the Soviet time, the maintenance of on-farm facilities was poor as its responsibility was delegated to farm brigades in addition to their normal task of farm operations unlike maintenance of interfarm and other major facilities which were funded directly by the Government.

31. Presently, the maintenance and cleaning of the farm watercourses is the responsibility of farmer. In some command areas where WUAs are fully developed and operational, WUAs, assisted by farmers, are responsible for O&M of the interfarm canals as well as dredging of main drains and collector drains lying within the boundaries of their areas. WUAs hire machinery from the market for cleaning and maintenance of water ways in their hydrological units. In other areas, the respective district ALRI offices are responsible of O&M of their interfarm canals and drains.

32. The technical and financial issues faced by the WUAs are primarily the issues regarding O&M of the on-farm irrigation and drainage (I&D) facilities. WUAs need to collect TJS30 per ha annually to cover their charges. However, their collection efficiency is low. Poor maintenance results in poor controls and ultimate would need major investments to defray deferred maintenance. The main modernization activities in the on-farm systems include modernization of various hydraulic structures, lining of selected water channels, and cleaning of interfarm and on-farm drains.

B. Expected Improved Asset After Project

33. **Climate Proofing.** Canal capacities have been checked to ascertain whether their capacities comply with the climate proofing requirement. Out of the 66 inter-farm canals, 55 (83%) have been found to have capacity sufficient to meet the increased irrigation requirements under likely changed climate conditions during the next 50 years.

Thus, the head regulators and possibly the capacities of only 11 (17%) inter-farm canals require remodeling to meet the climate-proofed discharge requirements. The total cost of climate proofing of irrigation distribution network is estimated at $385,200. Details are given in Table 11 below.

Table 11: Estimated Cost of Climate Proofing of Irrigation Distribution Network Asset

District	Total number of interfarm canals, No	Canals with sufficient capacity, No	Canals with insufficient capacity, No	Estimated cost of climate proofing, $
Hamadoni	27	19	8	288,900
Farkhor	35	34	1	48,150
Vose	3	1	2	48,150
Kulob	1	1	0	0
TOTAL	**66**	**55**	**11**	**385,200**

Sources: Consultant Team Estimates.

34. Aside from climate proofing, a detailed walk-through survey to assess of all canal works was undertaken by the consultants in March 2015 and also to determine the status of works and the repair or improvement requirements of the Chubek I&D system. Main observation about the system are given in the next paragraphs.

1. Intake Section and Main Canal

35. Intake Section and Chubek Main Canal is found in good condition as compared to inter-farm and on-farm canals except for the following issues: (i) Deposition of heavy sediments in upper reaches; (ii) Erosion adjoining outlets of the main canal; (iii) Degradation of off taking structures; (iv) Poor condition of water regulating structures of the main canal; (v) Sharp curve on main canal; (vi) Radial gates on the head regulator of main canal are in bad condition with damaged gate seals causing excessive leakage from bottom and sides; (vii) Steel stop log require sand blasting and painting; and (vii) The operation of the head regulator and cross regulator gates was electrified but all electric equipment was missing.

a. Modernized Asset of Main Canal Cross-Section

36. Modernization of Chubek Main Canal aims at providing assured water supplies for irrigation of 50,163 ha command area with a climate-proofed peak flow requirement of 93.26 cumec. The works included in modernization of canal cross sections may be grouped as follows: (i) earthworks on canal banks; (ii) removal of sediment; and (iii) canal lining repairs.

37. **Earth Work on Canal Banks:** Main canal side inspection roads facilitate O&M and access to water monitoring installations. They are essential for delivering agricultural inputs to fields and speedy removal of harvested products from the area. Rehabilitation of canal banks comprises preparatory scarifying of existing earthwork, hauling in of material from sites not more than 2.0 km away from work sites, proper mixing of scarified with newly brought-in material prior to compaction, and well controlled water applications to achieve good quality compaction. The total volume of work is 19,500 cubic meter. Summary of earth work volume and cost estimate is given in Table 12.

38. **Sediment Removal:** Sediment deposits in the main canal is the result of deferred maintenance and must be removed to facilitate passage of climate-proofed peak. The total volume of sediment to be removed has been assessed as 65,000 cubic meter. Summary of sediment removal and cost estimate is given in Table 12.

Table 12: Earth Work and Sediment Removal for Modernization of Main Canal

Volume of Earth Work m^3	Cost of Earth Work, $	Volume of Compaction m^3	Cost of Compaction $	Total Cost of Earth Work $
65,000	130,000	19,500	29,250	159,250

Sources: Consultant Team Estimates.

39. **Canal Lining Repairs:** Lining repairs will be undertaken where it has deteriorated. Implementation of works involves the removal of dilapidated works, all preparatory tasks such as slope and base preparation for in-situ casting of concrete, any formwork, and incidental joint filler. The work items include making good of lining cracks which should be properly opened up to a width of about 5 cm to allow for proper filling with a suitable concrete mix and to achieve bonding between different materials. Canal lining repair work is only required on Kulob Dayra Canal A total of some 3,752 cubic meter concrete lining work will have to be executed under the main canal to repair defective concrete lining panels. Details of lining repair volumes and cost estimate are given in Table 13.

b. Modernized Asset of Main Canal Structures

40. Work grouped under main canal structures includes rehabilitation of existing works, and repairs to some existing and installation of new gates. Volume of work and cost estimate for modernization works in Chubek Main Canal are given in Table 13. The works are summarized as including but not limited to the following: (i) Modernization of main head regulator and escape structure; (ii) Rehabilitation and modernization of cross regulators; (iii) Rehabilitation and modernization of offtake structures to inter-farm canals; (iv) Replacement of the gates; and (v) Automatic water level measuring structures.

41. **Head Regulator and Escape Structure:** The works comprise the installation of new radial gates on head regulator including any preparatory tasks, delivery and installation of gate, and frame and all fixtures required. All gates will be provided with electric drives to facilitate easy, timely, and more accurate gate setting. Plan and cross-section of the main canal head regulator including radial gates are shown in Figs. 2–4. In addition, cleaning of right side bay and restoration of concrete wall of escape structure has been included. Existing automatic water recorder will be replace and connect to Supervisory Control And Data Acquisition (SCADA) system. Summary of volume of works and cost estimate are given Table 13.

42. **Cross Regulators:** The nine existing cross regulators, will be rehabilitated according to their original design specifications as this exceeds the climate-proofed peak discharge. This involves demolition and removal of degraded concrete works including foundation work, and casting of wing walls and deck. Provisions include delivery and installation of new gate frames, gates, motorized lifting devices and all miscellaneous items and incidental works. Existing gate hoisting motors also need to be replaced. An Automatic water level recorder has been proposed on each cross regulators which will be connect to SCADA system. Summary of volume of works and cost estimate is given Table 13.

43. As a result of operation of the proposed sediment excluding basin in head reach of Chubek Main Canal which will remove about 85% of sediments, the existing loose-boundary (unlined canal) system will undergo changes. Due to much less sediment concentration in the canal and with existing steep slopes it will tend to scour the channel bed. This would have serious consequence on channel geometry and stability of the associated structures.

44. The fundament remedial measure is to reduce the velocity in the Chunek Main Canal to match the one corresponding to the regime velocity according to the new sediment load so that it would not scour its bed and banks. Remodeling of existing fall structures/cross regulators is proposed reduce the channel slope which will reduce the main canal velocity. Summary of volume of remodeling works of fall structures and cost estimate are given Table 13.

45. **Offtake Structures to Feed Inter-Farm Canals:** The 13 existing offtaking structures feeding the inter-farm canals, will be rehabilitated and modernized to meet climate-proofed peak water requirements. This involves demolition and removal of degraded concrete works including foundation works, and casting of wing walls and deck. Provisions include delivery and installation of new gate frames, gates, motorized lifting devices and all miscellaneous items and incidental works. Existing electrification instruments of the gates will also be replaced. Details are given in Table 14. An Automatic water level recorder has been proposed on head regulators which will be connect to SCADA system. Summary of volume of works and cost estimate are given Table 13.

46. **Replacement of Gates:** All gates installed at head regulators and cross regulators are in deteriorated condition due to aging and inadequate maintenance, and thus need to be replaced. All gate seals are in poor condition and excessive water leakage is observed from bottom and sides seals. Most of the hoisting equipment installed are badly damaged and some are missing and will be replaced with new hoisting equipment. New Vertical fixed wheel type gates will be provided at all inter-farm canals head and cross regulators. The fixed wheel type gate equipment will comprise gate leaf, stem rod type hoisting mechanism, embedded parts and hoisting deck. Typical Foxed-wheeled type gates are shown in PPTA consultant report. A summary of cost estimates for gates replacement is given Table 13.

47. **Automatic Water Level Measuring Structures:** It is proposed to install new automatic water level recorders on each diversion structures to ensure that the gate is set accurately to deliver the flow required at that offtake and these will be connected to SCADA system. New gauging wells of the international standard will be installed upstream of all off taking and cross regulator structures Summary of volume of works and cost estimate is given in Table 13.

Table 13: Details of Quantities of Materials and Cost of Main Chubek Canal Structures Modernization and Associated Works

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
			Canal Struct	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	Nos	L (m)	Cost ($)	Nos	L (m)	Cost ($)	Nos	Cost ($)
1	Headwork	Replacement head intake gates	0		0		400x250 cm	2	12,086								
		Replacement head intake gates	0		0		350x250 cm	3	15,750								
		Replacement of gear with lifting screws	0		0		Weight	808	2,424								
		Hydropost								1	5	30	1	24	4,800	1	2,000
2	Head spillway	Cleaning rightspillway bay from the sediment	750	3,750	0	0	0		0								
		Restoration of the right concrete wall (from the river side)	0		20	3,200	0		0								
		Concreting of the apron of the right gate, width 6 m, length 25 m	0		75	12,000	W (Kg)	3,300	9,900								
3	Assembly structures on the PC 24	Cross regulators	25	125	50	8,000	280x400 cm	5	13,000								
		Raising of Crest	50	250	300	72,000											
		Replacement of bridge slab and railings			74	22,200											
		Outlet					280x400 cm	3	7,800								
		Hydropost														1	2,000
4	Assembly structures on the PC 38	Cross regulators	5	25	10	1,600	480x200 cm	3	17,370								
		Outlet to Canal Dekhonobodi Nav	5	25	10	1,600	300x200 cm	3	10,500								
		Raising of Crest	50	250	300	72,000											

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
			Canal Struct	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	Nos	L (m)	Cost ($)	Nos	L (m)	Cost ($)	Nos	Cost ($)
		Hydropost											1	20	4,000	1	2,000
5	Assembly structures on the PC 51	Cross regulators	31	155	30	4,800	550x400 cm	1	13,658								
		Outlet to Canals LR-1,LR-2, LR-3					150x200 cm	5	8,450								
		Raising of Crest	50	250	300	72,000											
		Hydropost	10	50	6	960				1	4	30	1	25	5,000	1	2,000
6	Assembly structures on the PC 61	Outlet to Left Branch					140x400 cm	3	10,515								
		Outlet to Left Branch					177x400 cm	1	4,190								
		Outlet to Left feed					395x110 cm	6	14,724								
		Raising of Crest	50	250	300	72,000											
		Discharge	189	945	140	22,400	575x230 cm	4	32,356								
		Hydropost	10	50	6	960				1	4	30	1	20	4,000	1	2,000
			10	50	6	960				1	4	30	1	25	5,000	1	2,000
			10	50	6	960				1	4	30	1	30	6,000	1	2,000
7	Assembly structures on the PC 85 and PC 95	Cross regulators	50	250	10	1,600	463x510 cm	2	29,364								
							W (Kg)	210	630								
8	Assembly structures on the PC 114	Cross regulators	120	600	120	19,200	450x500 cm	4	55,900								
		Raising of Crest	50	250	300	72,000											
		Hydropost	10	50	6	960				1	4	30	1	24	4,800	1	2,000
9	Assembly structures on the PC 144	Outlets	24	120	25	4,000	150x200 cm	4	6,760								
10	Assembly structures on	Cross regulators					550x400 cm	2	27,316								

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
			Canal Struct	**Cost ($)**	**Canal Struct**	**Cost ($)**	**Gate Type**	**No. of Gates**	**Cost ($)**	**Nos**	**L (m)**	**Cost ($)**	**Nos**	**L (m)**	**Cost ($)**	**Nos**	**Cost ($)**
	the PC 172	Raising of Crest	50	250	300	72,000											
		Outlets	106	530	105	16,800	150x200 cm	3	5,070								
		Hydropost	10	50	6	960				1	4	30	1	15	3,000	1	2,000
11	Canal Kulob Darya	Cross regulators on the pc 91	0		0		200x300 cm	3	10,515								
		Aqueduct of 4x2x66m, of St4 sheet steel 7 mm thick			45	7,200	W (Kg)	72,600	217,800								
		Cross regulators and discharge	0		0		150x200 cm	5	8,450								
		Renovation of 40% lining concrete between the PC-91 PC 158, thickness 20 cm, width 7m, length of 6700 m, the total volume 9380 m3)	1,000	5,000	3,752	600,320											
	TOTAL		2,490	**13,325**	5,252	**1,162,680**			**534,528**	7	29	**210**	8	183	**36,600**	9	**18,000**

Source: Consultant Team Estimates.

Table 14: Detail of Quantities of Material and Cost of Electrification for Modernization of the Chubek Main Canal

№	Name of Structures	Type of work	Measuring unit	Quantity	Unit cost ($)	Total Cost, ($)
1	Head water intake structure	Electric motors for gates	pcs	10	200	2,000
		Replacement of 4 conductor cable	m	30	10	300
		Control box	Pcs	2	500	1,000
		Replacement of wire	m	200	3	600
		Replacement of motor starter for hoists	Pcs	9	20	180
2	Assembly structures on the PC 38	Electric drives for gates	Pcs	6	200	1,200
		replacement of reinforced concrete pole;	Pcs	3	150	450
		Replacement of electrical wire	m	200	3	600
		Replacement of 4 conductor cable	m	40	10	400
		Control box	Pcs	1	500	500
3	Assembly structures on the PC 51	Electric motors for gates	Pcs	6	200	1,200
		replacement of reinforced concrete pole;	Pcs	3	150	450
		Replacement of wire	m	200	3	600
		Control box	Pcs	1	500	500
		Replacement of 4 conductor cable	m	50	10	500
4	Assembly structures on the PC 61	Electric drives for gates	Pcs	14	200	2,800
		Replacement of 4 conductor cable	m	100	10	1,000
		Replacement of wire	m	200	3	600
		Control box	Pcs	2	500	1,000
5	Assembly structures on the PC 114	Electric drives for gates	Pcs	4	200	800
		Replacement of 4 conductor cable	m	50	10	500
		Replacement of wire	m	100	3	300
		Control box	Pcs	1	500	500
6	Assembly structures on the PC 172	Electric drives for gates	Pcs	5	200	1,000
		Replacement of 4 conductor cable	m	100	10	1,000
		Replacement of wire	m	200	3	600
		Control box	Pcs	1	500	500
	Total Cost ($)					**19,080**

Source: Consultant Team estimates.

c. Construction of Sediment Excluding Basin (New Asset)

48. **Issue of Sediment Handling.** Pyanj River carries huge sediments and it is estimated that about 700,000 ton of suspended sediments enter the CIS every year, which is a huge burden on O&M budget for cleaning the irrigation network, an environmental hazard, and a cause of accelerated deterioration of pumps. The bed load is excluded and diverted back to the Pyanj River at the Chubek Main Canal Head Regulator (CMCHR) through the escape channel with sill level 60 centimeter lower than the sill level of the CMCHR. As sediment concentration is highly associated with discharge, about 84% of the sediments enter the CIS during the three summer months of June–August. There is a pressing need for minimizing sediments entry to CIS to alleviate the situation.

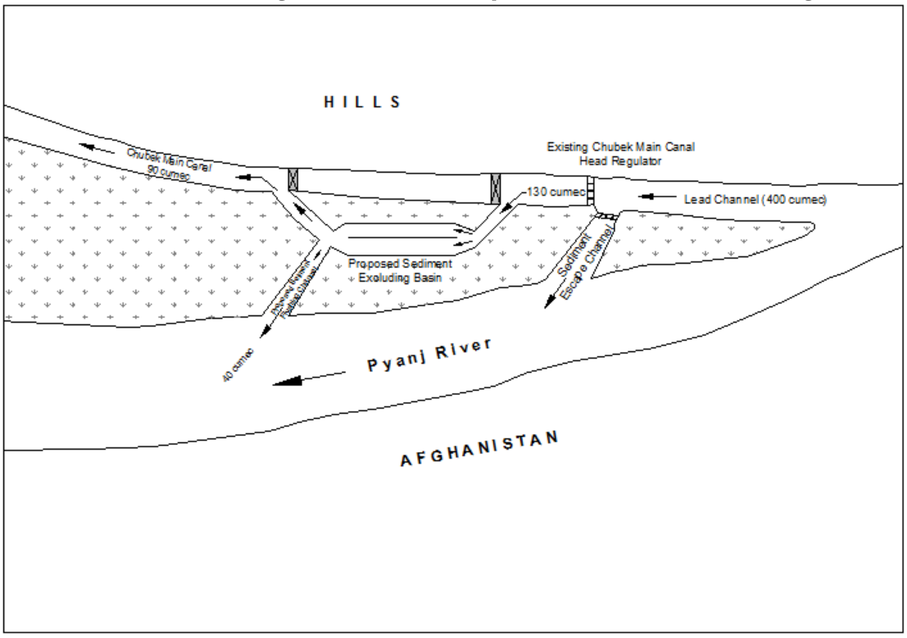
49. **Conditions Favorable for an Efficient Sediment Excluding Mechanism.** Luckily, the hydrologic and existing facilities favor the construction of an effective and efficient silt excluding basin that could be located in the head reach of the Chubek Main Canal.

50. The magnitude of Pyanj River flows much higher than the CIS diversions throughout the year and availability of a minimum of about 3 m head difference from the proposed sediment excluding basin to Pyanj River during high flow months create conditions favorable for effective hydraulic flushing of a large proportion of sediments thus significantly reducing the cost of dredging. The capacity of the lead channel is 400 cumec and capacity of the Chubek Main Canal is 150 cumec compared to CIS peak discharge requirement with climate proofing of 93.26 cumec. Thus at CMCHR about 270 cumec could bus used for flushing the bed load thus releasing 130 cumec in the Chubek Main Canal. Out of 130 cumec, 93.26 cumec could be released to meet the peak irrigation water requirement with climate proofing while the remaining, a little less than 40 cumec, could be used for hydraulic flushing at the

proposed sediment excluding basin. Thus the existing system provides enough capacity for continued flushing of the base load sediments at existing sediment escape channel at the CMCHR and about 40 cumec flow required for hydraulic flushing at the sediment excluding basin proposed along the left bank of the Chubek Main Canal.

51. **Sediment Management Plan.** It is proposed to continue making use of the existing arrangements for hydraulic flushing of the base load at the CMCHR and a sediment excluding basin to remove about 85% of the coarser portion of the suspended sediments, 70% through hydraulic flushing and 15%, that would settle in the bed of the basin, by mechanical equipment. The remaining 15% of the suspended sediment which would consist mainly of silt and clay will be passed on to the CIS about half of which would settle in the irrigation canal system and the remaining half would be deposited in the fields. Figure 3 shows the proposed sediment management plan through a schematic diagram.

Figure 3: Schematic Diagram of the Proposed Sediment Management Plan

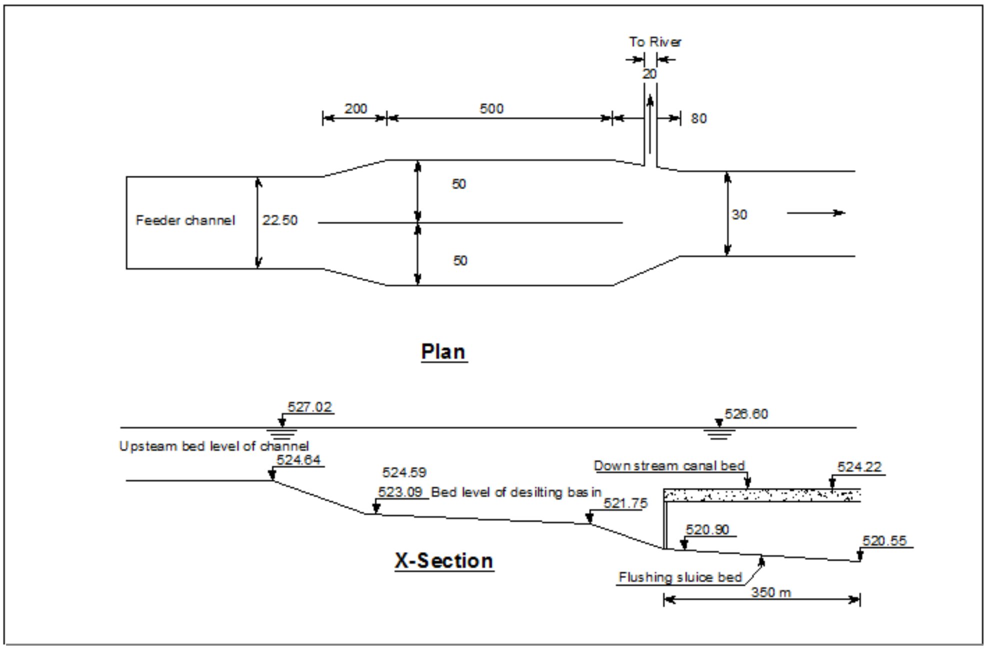


52. **Location/Layout of Sediment Excluding Basin.** The sediment excluding basin is proposed about 250 m downstream of the Chubek Main Canal Head Regulator on left side of the Chubek Main Canal on government-owned land.

53. **Design of Sediment Excluding Basin and Associated Works.** The sediment excluding basin has been designed using simplified Engelund and Hansen equation and various related design manuals. Main components of the sediment excluding basin are: (i) 100 m long feeder channel from existing Chubek Main Canal to the sediment excluding basin; (ii) Intake of sediment excluding basin with gates; (iii) Sediment excluding basin (500 m x100 m) in two compartments which can be operated independently; (iv) Gated flushing sluice with 160 m long channel leading to Pyanj River; (v) 650 m channel from sediment excluding basin to the existing main canal; (vi) Fall structure at the junction of channel from the sediment excluding basin and the main canal; and (vii) Strengthening of the flood embankment between the sediment excluding basin and Pyanj River.

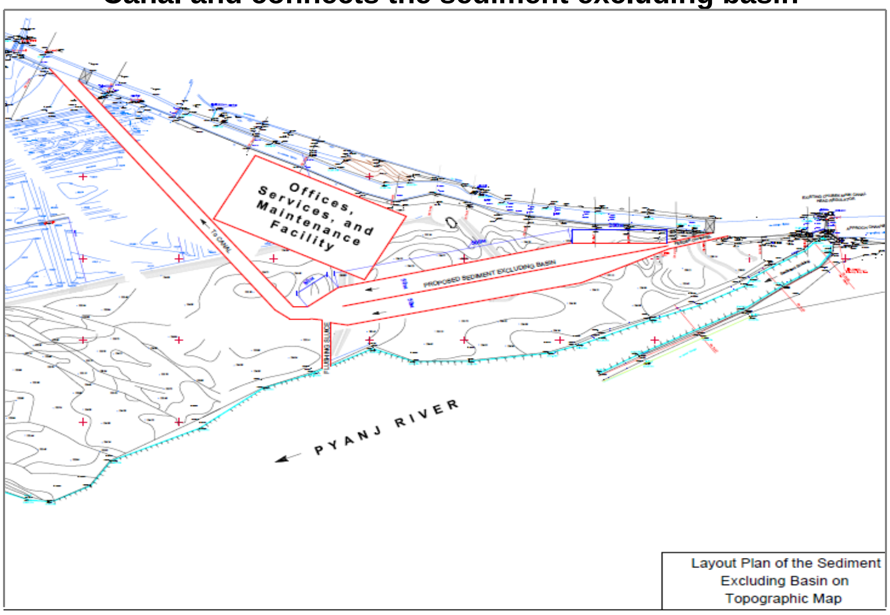
54. The schematic diagram of the proposed sediment excluding basin is given in Figure 4. It has been designed to remove 85% of the sediments entering the canal about 70% by hydraulic flushing and 15% by physical removal using the equipment.

Figure 4: Schematic Diagram of the Proposed Sediment Excluding Basin



55. As shown in Figure 5, a concrete-lined trapezoidal feeder channel offtakes from the Chubek Main Canal and connects the sediment excluding basin. Gates have been provided at the entrance of the basin to regulator the flow through the sediment excluding basin. Sediment excluding basin have two compartments which would be operated alternately to facilitate removal by machinery of heavier sediments that settle at the bottom. Each compartment is 50 m wide and has the maximum depth of 6 m at the upstream of flushing sluice. Bed slope at upstream of flushing sluice is 1 in 100 to facilitate rapid flushing of the sediments. A 20 m wide concrete-lined trapezoidal channel is proposed to facilitate hydraulic flushing of the sediments from sediment excluding basin to Pyanj River. Detail plan of sediment excluding basin, a bridge which will be provided on the feeder channel at the patrol bank of Main Chubek Canal, plan of fall structure, general plan of the proposed head regulators, are shown in PPTA consultant report.

Figure 5: Concrete-lined trapezoidal feeder channel offtakes from the Chubek Main Canal and connects the sediment excluding basin



56. There is a need to construct a service and maintenance facility for equipment and staff working on the sediment excluding basin. A 300m x 150m piece of government land has been identified very close to the proposed location of the sediment excluding basin. The facility would include office space, shed for equipment, a small facility for maintenance of the equipment, and bachelor accommodation for operational staff.

57. **Equipment Required for Cleaning Sediment Excluding Basin.** With its varied-slop bottom (Figure 4) and high velocity at the entry into sediment sluicing channel, the sediment excluding basin has been designed to hydraulically flush most of the heavier sediments. However, it is expected that about 105,000 m^3 (15%) of the sediments entering into the canal could settle annually in the basin which will need to be removed mechanically.

58. Therefore heavy sediment removing equipment that could work from outside of the basin would be required to remove these sediments. The same equipment could also be used to clean the feeder channel upstream of the head regulator and the escape channel. The estimated cost of the proposed equipment is given in Table 15 below.

Table 16: Equipment for Removing Sediments from the Basin

№	Machine	Technical Secification	Number	Unit cost, $	Total cost, $
1	Excavators	weight 25,2 to 32,2 tons, Capacity-165-178 lit, dipper capacity -1-1,5 m^3, excavation depth7,33м, boom length 13m	2	250,000	500,000
2	Bulldozer	wight 17,7 t, capacity-180 lit, width 4 m	1	70,000	70,000
3	Dumptruck	Listing capacity from 10 to 40t	2	70,000	140,000
4	Loader truck	dipper capacity 2-3m^3	1	65,000	65,000
5	Light duty vehicle	5-door 4-drive wheels ,5-sits	1	25,000	25,000
6	Diesel tanker	Capacity -20 Tonn	1	20,000	20,000
7	Mobile repair truck		1	20,000	20,000
8	Toolbox sets		5	1,000	5,000
		TOTAL			**845,000**

2. Interfarm Canals

59. Following is the result of the inter-farm canals condition survey: (i) Heavy sedimentation of upper reaches of inter-farm canals (IFC) with Pebbles; (ii) Heavy sedimentation of middle reaches of the inter-farm canals with sand; (iii) Double loop sedimentation of IFCs and IFCs without Hydropost (water measuring structures; (iv) Poor maintenance of IFCs resulting in dumping of excavated sediment on the canal banks; (v) Poor maintenance of IFC water regulating structures; (vi) Water discharge without water measurement; (vii) Vulnerable water Infrastructure over/along canal including foot bridges and service roads; (viii) Poor condition of lined IFCs particularly in tail reaches; and (ix) The pump feeding canals suffering with double loop sedimentation (i.e., sedimentation in the IFCs from the main canal as well as from high heaps of sand along canal banks).

a. Earthwork for Modernized Asset

60. Inter-farm canals rehabilitation aims at ensuring continued operation of the canal system with high conveyance efficiency and minimum losses of water, thus contributing to assured delivery of water to the on-farm canals network. The work included in rehabilitation of canal cross sections may be grouped as follows: (i) earthworks on inter-farm canal embankments; and (ii) removal of sediment.

61. **Earthwork on Inter-farm Canal Embankments:** Canal embankments have

degraded, particularly where there is no inspection or service road. Loss of soil from an embankment commonly varies from a shallow 20 cm to as much as 1.0 m depth. This leaves the upper edge of the canal side lining panels unsupported causing it to break up and disintegrate. While erosion of embankments is not evenly spread throughout the project area, rebuilding canal banks is necessary to maintain an appropriate canal flow section. Rebuilding embankment tops will require scarifying operations before placement of additional earth material. Essential are selection of material suitable for embankment formation, and proper mixing of scarified with newly brought-in fill material. Strict control of moisture for compaction of material is essential for achieving well compacted layers. Summary of earth work cost estimate is given in Table 17.

62. **Sediment Removal:** Sediment deposits must be removed from canal cross sections to facilitate passage of the climate-proofed peak water requirements. Sediment in canals is primarily of the silt fraction. Removing sediment from concrete lined canals often results in secondary damages due to use of inappropriate excavation equipment (draglines), old excavators which cannot be accurately controlled, inexperienced or poorly skilled machine operators, or deployment of machinery at locations unsuitable for mechanical excavation. Summary of earth work cost given is given in Table 17.

Table 17: Earth Work and Sediment Removal for Modernization of Inter-Farm Canals

District	Volume of Earth Work m^3	Cost of Earth Work $	Volume of Compaction m^3	Cost of Compaction $	Total Cost of Earth Work $
Hamadoni	288,001	576,001	86,400	129,600	705,601
Farkhor	261,000	522,001	78,300	117,450	63,9451
Vose	78,000	156,000	23,400	35,100	191,100
Kulob	6,001	12,001	1,800	2,700	14,701
Total	**633,002**	**1,266,003**	**189,900**	**284,850**	**1,550,853**

Source: Consultant Team estimates.

b. Typical Interventions on Inter-farm Canal Asset

63. **Inter-Farm Canal Structures Rehabilitation and Modernization:** Work grouped under inter-farm canal structures includes rehabilitation of existing works, repairs to some and the installation of gates and may be summarized as follows: (i) Rehabilitation of existing head regulators along inter-farm canals; (ii) Rehabilitation of existing cross regulators along inter-farm canals; (iii) Measuring structures (hydropost); (iv) Cross drainage structures; (v) Reconstruction/rehabilitation of aqueducts; (vi) Rehabilitation of road bridges and pedestrian crossings; (vii) Repair/replacement of gates; and (viii) Rehabilitation of off-takes to on-farm canals.

64. **Inter-farm Canal Headwork Structures Feeding Inter-farm Canals:** The structures will be checked for the capacity to pass climate-proofed peak water requirements. The existing head regulator structures with enough capacity and with good condition will be retained with minor repair works. Works foreseen are limited to replacement of concrete superstructure and mechanical parts. Minor concrete works repair is required for stilling basins, walls, friction blocks, Gates will also be replaced. Provisions include the delivery and installation of new gate frames, gates, lifting devices, and all miscellaneous items and incidental works.

65. Eleven head regulators, which do not have sufficient capacity to pass the climate-proofing discharge, have been proposed for remodeling. Cost of these head regulators has been included in its respective canal rehabilitation cost. A typical inter-farm canal head regulator is provided in PPTA consultant report.

66. **Cross Regulators on Inter-Farm Canals:** The cross regulator structures will be

rehabilitated to pass climate-proofed peak water requirements. The modernization works would include concrete works and replacement of gates. This involves demolition and removal of degraded concrete works including existing foundation work before laying new foundations, and casting of structure wing walls and structure deck. Transitional works will be removed to the extent necessary, only, not creating additional or secondary level damage to the existing works. Provisions include the delivery and installation of new gate frames, gates, lifting devices and all miscellaneous items and incidental works. Summary of volume of works and cost estimates for Hamadoni, Farkhor, and Vose are given in Table 18, Table 19, and Table 20 respectively. Typical cross regulator with fall on inter-farm canal is provided in PPTA consultant report.

67. **Measuring Structures:** New gauging section of the International Standard type will be installed downstream of head-regulators and canals where sufficient head is available to install a gauge in inter-farm canals. Only engineering survey of the canals will reveal the actual locations at which gauging section can be erected. Gauging sections are also proposed to be installed downstream of all off-takes feeding on-farm canals. Hydro bridge will be provided on canals for measuring the velocity. Summary of volume of works and cost estimates for Hamadoni, Farkhor, Vose. and Kulob are given in Table 18, Table 19, and Table 21 respectively. A typical hydro-post with bridge is in PPTA consultant report.

68. **Cross-Drainage Structures:** The pipe culverts and cross drainage structures on inter-farm canals convey water across drainage channels and below and above canals. Commonly, they are single or double barrel culverts. For all cross-drainage structures, adequate attention must be paid to rebuilding of structure transitions as original transitions were undercut by drainage flows, thus losing stability. In a number of cases, drainage flow has eroded the channel bed on the downstream side of the structure which will be repaired. Summary of volume of works and cost estimates for Hamadoni, Farkhor, and Vose are given in Table 18, Table 19, and Table 20, respectively.

69. **Road Bridges and Pedestrian Crossings:** Bridges and pedestrian crossings are generally in good condition. Road bridges require limited repairs but pedestrian crossings are generally in a good state. Work comprises of parapet walls and other minor repairs. Summary of volume of works and cost estimates for Hamadoni, Farkhor, and Vose are given in Table 18, Table 19, and Table 20, respectively.

70. **Reconstruction/Rehabilitation of Aqueducts:** Steel aqueducts on the inter-farm canals which are in bad condition will be completely replaced. Sub-structures of these crossings are in good condition and only minor repair works are required. Typical steel aqueduct plan and cross sections are shown on Figs 13 and 14. Size of these aqueducts and specification of steel will be finalized at detail design stage. Some steel aqueducts required minor repair consisting of one or two panels replacement. Concrete trough crossing are in generally good condition and required minor repairs. Summary of volume of works and cost estimates for Hamadoni, Farkhor, and Vose are given in Table 18, Table 19, and Table 20, respectively. Plan and section a typical concrete aqueduct is in PPTA consultant report.

71. **Repair/Replacement of Gates:** All gates installed at different structures on inter-farm canals are in deteriorated condition due to aging and inadequate maintenance All gate seals are in poor condition and excessive water leakage is observed from bottom and sides seals. Most of the hoisting equipment installed are badly damaged and will be replaced. New gates will be installed at the inter-farm head and cross regulators Vertical slide type gates shall be installed at all such structures The slide type vertical gate equipment will comprise gate leaf, stem rod type hoisting mechanism, embedded parts, and hoisting deck. Summary of volume of works and cost estimates for Hamadoni, Farkhor, and Vose are given in Table 18, Table 19, and Table 20, respectively. Typical vertical slide gates are in PPTA consultant report.

72. **Offtake Structure for On-Farm Canals:** The existing off-take structures for on-farm canals will be rehabilitated to pass the climate-proofed peak water requirements. This includes a new gate, frame and drive but no electrification, miscellaneous works, and structure transition to the regular canal cross section. Rehabilitation includes replacement of headwalls at both ends of the pipe conduits, delivery and installation of new gates, frames, gates and lifting devices, and construction of downstream outfall basins. Summary of volume of works and cost estimates for Hamadoni, Farkhor, and Vose are given in Table 18, Table 19, and Table 20, respectively. Typical pipe outlets are provided in PPTA consultant report.

c. Inter-farm Canals in Hamadoni District

73. The twenty-seven (27) inter-farm canals, which are under the responsibility of the Hamadoni District Department of ALRI. were constructed during 1957-1971. They have a total length of 113.5 km and about 95 different type of structures. During walk through survey and detail discussion with field staffs the required renovation/modernization of structures and inter-farm canals were identified and the associated volumes of modernization work are estimated and given in Table 18 below. The volume of earth works and cost estimate for rehabilitation of inter-farm canals in Hamadoni District is given in Table 17.

d. Inter-farm Canals in Farkhor District

74. The 39 Inter-farm canals, which are under the responsibility of the Farkhor District Department of ALRI were constructed during 1950-1987. They have a total length of 226.8 km and about 377 different type of structures. During walk through survey and detail discussion with field staffs, the required renovation/modernization were identified and the associated volumes of modernization work are estimated and given in Table 19 below. The volume of earth works and cost estimate for rehabilitation of inter-farm canals in Farkhor District is given in Table 17.

e. Inter-farm Canals in Vose District

75. The 22 Inter-farm canals, which are under the responsibility of the Farkhor District Department of ALRI were constructed during 1963-1975. They have a total length of 27.3 km and about 52 different type of structures. During walk through survey and detail discussion with field staffs the required renovation/modernization were identified and the associated volumes of modernization work are estimated. Cost estimate for modernization of the inter-farm canals structures is given in **Table 20** below. The volume of earth works and cost estimate for rehabilitation of inter-farm canals in Vose District is given in Table 17.

f. Inter-farm Canals in Kulob District

76. There is only one inter-farm canal under the CIS in Kulob District, managed by the Kulob District Dept of ALRI. It is called Dare 3, was constructed in 1973, is 5.41 km long, and has 4 outlets. During walk through survey and detail discussion with field staffs the required renovation/modernization were identified and the associated volumes of modernization work are estimated and cost of works given in Table 21 below. The volume of earth works and cost estimate for rehabilitation of inter-farm canals in Kulob District is given in Table 17.

Table 18: Details of Quantities of Materials and Cost of Structures Modernization and Associated Works in Hamadoni District

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			ACWM	
			Canal Struct	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	NOs	L (m)	Cost ($)	NOs	L (m)	Cost ($)	Nos	Cost ($)
1	Canal R-1	Inlet	21	103	24	3,840	150x150 cm	1	1,300								
		Outlet (3)	71	353	59	9,504	80x80 cm	3	1,755								
		Outlet	27	133	18	2,816	100x80 cm	1	730								
		Hydropost (2)								2	3	60	2	13	2,600	2	3200
2	Canal R-3	Inlet (1)	19	93	20	3,160	80x80 cm	1	585								
		Head regulator	30	150	200	48,000											
		Hydropost								1	1.5	30	1	9	1,800	1	1600
3	Canal R- 4	Inlet (1)	22	112	18	2,816	80x80 cm	1	585								
		Outlet (2)	53	263	45	7,152	80x80 cm	2	1,170								
		Head regulator	30	150	200	48,000											
		Hydropost								1	3	30	1	14	2,800	1	1600
4	Canal R-5	Inlet (1)	55	276	39	6,246	80x80 cm	1	585								
		Outlet (3)	228	1,142	142	22,725	100x100 cm	3	2,340								
		Outlet (1)	71	356	41	6,613	80x80 cm	1	585								
		Outlet (1)	90	452	62	9,984	100x80 cm	1	730								
		Hydropost (2)								2	2.5	60	2	12	2,400	2	3200
5	Canal R5-1	Inlet (1)	97	483	41	6,611	200x150 cm	1	1,690								

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			ACWM	
			Canal Struct	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	NOs	L (m)	Cost ($)	NOs	L (m)	Cost ($)	Nos	Cost ($)
		Outlet (1)	74	371	87	13,848	150x100 cm	1	1,040	1							
		Hydropost						1		1	2.5	30	1	11	2,200	1	1600
6	Canal Buz-3	Inlet (1)	25	124	22	3,472	100x80 cm	1	730								
		Outlet (1)	22	110	21	3,328	100x80 cm	1	730								
		Hydropost								1	2.5	30	1	11	2,200	1	1600
7	Canal Buz-5	Inlet (1)	28	142	23	3,648	100x80 cm	1	730								
		Outlet (1)	24	119	27	4,346	100x100 cm	1	780								
		Hydropost								1	2.5	30	1	13	2,600	1	1600
8	Canal R-7	Inlet (1)	58	290	45	7,168	100x100 cm	1	780								
		Outlet (4)	163	815	120	19,203	100x100 cm	4	3,120								
		Head regulator	30	150	200	48,000											
		Hydropost (4)								5	4.5	150	4	12	2,400	4	6400
9	Canal R7-1	Inlet (1)	15	75	12	1,840	100x80 cm	1	730								
		Hydropost								1	3	30	1	12	2,400	1	1600
10	Canal R7-2	Inlet (1)	20	99	13	2,016	100x80 cm	1	730								
11	Canal R8-1	Inlet (1)	15	76	12	1,840	80x80 cm	1	585								
		Outlet (1)	13	65	12	1,920	80x80 cm	1	585								
		Hydropost								1	2.5	30	1	11	2,200	1	1600

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			ACWM	
			Canal Struct	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	NOs	L (m)	Cost ($)	NOs	L (m)	Cost ($)	Nos	Cost ($)
12	Canal R8-2	Inlet (1)	13	67	11	1,680	150x100 cm	1	1,040								
		Outlet (1)	16	82	12	1,840	100x80 cm	1	730								
		Hydropost								1	2.5	30	1	11	2,200	1	1600
13	Canal R-9	Inlet (1)	22	111	18	2,816	100x80 cm	1	730								
		Outlet (1)	19	94	13	2,000	100x80 cm	1	730								
		Aqueduct Outlet	33	166	33	5,200	80x80 cm	1	585								
		Aqueduct					4,563	1	15,971								
		Hydropost								1	2.5	30	1	11	2,200	1	1600
14	Canal 10	Inlet (1)	16	82	12	1,840	100x80 cm	1	730								
		Outlet (1)	13	63	16	2,598	60x60 cm	1	550								
		Hydropost								1	3	30	1	15	3,000	1	1600
15	Canal Right Branch	Inlet (1)	66	328	49	7,760	100x100 cm	1	780								
		Outlet(3)	393	1,963	317	50,640	100x100 cm	3	2,340								
		Aqueduct	31	154	34	5,440	5,930		20,755								
		Hydropost (2)								2	4.5	60	2	20	4,000	2	3200
16	Canal PR 5	Inlet (1)	17	84	12	1,936	80x80 cm	1	585								
		Outlet (2)	36	179	32	5,066	60x60 cm	2									
		Hydropost (3)								3	3	90	3	13	2,600	3	4800

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			ACWM	
			Canal Struct	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	NOs	L (m)	Cost ($)	NOs	L (m)	Cost ($)	Nos	Cost ($)
17	Canal PR 9	Inlet (1)	29	145	16	2,502	100x80 cm	1	730								
		Outlet (1)	60	298	28	4,550	100x100 cm	1	780								
		Hydropost								1	2.5	30	1	11	2,200	1	1600
18	Canal PR-10	Inlet (1)	49	247	39	6,232	100x100 cm	1	780								
		Outlet (1)	42	211	30	4,770	60x60 cm	1	550								
		Aqueduct	36	180	40	6,432	5,750		20,125								
		Hydropost (2)								2	2.5	60	2	14	2,800	2	3200
19	Canal R-12	Inlet (1)	18	91	24	3,840	80x80 cm	1	585								
		Hydropost								1	2.5	30	1	11	2,200	1	1600
20	Flume channel LRX	Inlet (1)	59	296	28	4,518	60x60 cm	1	550								
		Head regulator	30	150	200	48,000											
		Hydropost								1	2.5	30	1	11	2,200	1	1600
21	Flume channel LRX-1	Inlet (1)	96	481	79	12,656	60x60 cm	1	550								
		outlet (1)	29	144	55	8,830	60x60 cm	1	550								
		Hydropost								1	2.5	30	1	11	2,200	1	1600
22	Flume channel LR-1	Inlet (1)	31	153	16	2,480	100x80 cm	1	730								
		outlet (3)	88	439	54	8,608	100x80 cm	3	2,190								
		Hydropost								1	1.5	30	1	8	1,600	1	1600
23	Flume channel	Inlet (1)	18	92	6	960	100x80 cm	1	730								

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			ACWM	
			Canal Struct	**Cost ($)**	**Canal Struct**	**Cost ($)**	**Gate Type**	**No. of Gates**	**Cost ($)**	**NOs**	**L (m)**	**Cost ($)**	**NOs**	**L (m)**	**Cost ($)**	**Nos**	**Cost ($)**
	LR1-2	Hydropost								1	1.5	30	1	8	1,600	1	1600
24	Flume channel LR1-3	Inlet (1)	26	132	12	1,920	80x80 cm	1	585								
		Outlet (1)	36	180	11	1,680	80x80 cm	1	585								
		Head regulator	30	150	200	48,000											
		Hydropost								1	1.5	30	1	8	1,600	1	1600
25	Flume channel LR1-4	Inlet (1)	36	180	15	2,400	80x80 cm	1	585								
		Head regulator	30	150	200	48,000											
		Hydropost								1	1.5	30	1	8	1,600	1	1600
26	Flume channel LR1-5	Inlet (1)	30	150	12	1,920	80x80 cm	1	585								
		Hydropost								1	1.5	30	1	8	1,600	1	1600
27	Canal Arpa Tuguldi (AT)	Inlet (1)	120	600	250	40,000	100x80 cm	1	730								
		Head regulator	30	150	200	48,000											
		Aqueduct	48	240	56	8,960	63,631	1	222,709								
	Total		2,876	**14,731**	2,826	**692,171**	79,874	65	**322,749**	36	63	**1,050**	34	286	**57,200**	34	**54,400**

Consultant Team Estimates.

Table 19: Details of Quantities of Materials and Cost of Structures Modernization and Associated Works in Farkhor District

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			Well with ACWM	
			Canal Struc.	Cost ($)	Canal Structures	Cost ($)	Gate Type	No. of Gates	Cost ($)	NOs.	L (m)	Cost ($)	NOs.	L (m)	Cost ($)	NOs.	Cost ($)
1	Canal Left Branch	Outlet (12)	96	480	60	9,600	80x80 cm	12	7,020								
		Weir (8)	48	240	40	6,400	100x150 cm	8	8,320								
		Other Struc.(4)	61	305	22	3,520	100x150 cm	10	10,400								
		Outlet	2	10	1	160			0	1	3	30	0	0		1	1,600
2	Canal LR 18	Weir (2)	18	90	11	1,760	100x150 cm	2	2,080								
		Hydropost	10	50	5	800			0	1	2	30	0	0		1	1,600
3	Canal LR 20 - 4	Weir (2)	18	90	10	1,600	100x150 cm	2	2,080								
		Hydropost	10	50	3	480				1	2	30	0	0		1	1,600
4	Canal LR 20	Weir (3)	18	90	10	1,600	100x100 cm	2	1,560								
		Outlet (1)	12	60	5	800	80x80 cm	1	585								
		Conduit (1)	24	120	6	960		0									
		Trough	10	50	2	320				1	2	30	0	0		1	1,600
		Hydropost	10	50	2	320				1	2	30	0	0		1	1,600
5	Canal LR 10	Conduit (1)	12	60	5	800		0									
		Hydropost (2)	4	20	2	320				2	3	60	0	0		2	3,200
6	Feeding Branch	Outlet (1)	6	30	5	800	100x150 cm	1	1,040								
		Other Struc.(2)	12	60	10	1,600	100x150 cm	8	8,320								
7	Canal LR 1 Chairali	Weir (2)	126	630	17	2,720	100x100 cm	5	3,900								
		Outlet (2)	12	60	10	1,600	80x80 cm	2	1,170								
8	Canal Kaloi - Puchkak	Weir (1)	6	30	5	800	100x100 cm	1	780								
		Other Struc.(3)	18	90	15	2,400	100x100 cm	3	2,340								
9	Canal Karagi Patta	Weir (3)	36	180	16	2,560	100x100 cm	3	2,340								
10	Canal LR 28	Weir (2)	18	90	11	1,760	100x100 cm	2	1,560								

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			Well with ACWM	
			Canal Struc.	Cost ($)	Canal Structures	Cost ($)	Gate Type	No. of Gates	Cost ($)	NOs.	L (m)	Cost ($)	NOs.	L (m)	Cost ($)	NOs.	Cost ($)
		Outlet (2)	18	90	10	1,600	80x80 cm	2	1,170								
		Aquaduct	240	1,200	20	3,200											
		Conduit (2)	24	120	11	1,760											
		Trough	5	25	1	160				1	1.5	30	0	0		1	1,600
11	Canal LR 32 -1	Aquaduct	24	120	6	960											
		Conduit	24	120	6	960											
		Hydropost	2	10	1	160				1	2	30	1	6	1200	1	1,600
12	Canal LR 35	Aquaduct	24	120	20	3,200											
13	Canal LR 36	Weir (1)	12	60	6	960	100x100 cm	1	780								
		Hydropost (2)	10	50	2	320				2	3	60	2	12	2400	2	3,200
14	Canal Leading to PS Urtaboz 1	Outlet	6	30	5	800	150x150 cm	1	1,300								
15	Canal Leading to PS Urtaboz 4	0	0	0	0	0	0	0		0	0		0	0			
16	Canal leading to PS Urtaboz 3	Weir and outlet	240	1,200	12	1,920	150x150 cm	2	2,600								
17	Feeding Canal Maida - Patta	Outlet (4)	24	120	12	1,920	80x80 cm	4	2,340								
		Aquaduct	60	300	8	1,280											
		Hydropost	10	50	3	480				1	2	30	0	0		1	1,600
18	Main Canal Maida -	Outlet	12	60	5	800	80x80 cm	1	585								
		Other Struc.(2)	72	360	18	2,880	100x100 cm	8	6,240								

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures (Gates)			Replacement of Water Level Meters (Rulers)			Replacement of Hydro Bridges			Well with ACWM	
			Canal Struc.	**Cost ($)**	**Canal Structures**	**Cost ($)**	**Gate Type**	**No. of Gates**	**Cost ($)**	**NOs.**	**L (m)**	**Cost ($)**	**NOs.**	**L (m)**	**Cost ($)**	**NOs.**	**Cost ($)**
	Patta	Hydropost	10	50	2	320				1	2	30	1	12	2400	1	1,600
		Canal-x-2	10	50	1	160				1	1.5	30	1	8	1600	1	1,600
		Canal-x-3	10	50	1	160				1	1.5	30	1	8	1600	1	1,600
		Canal-x-2-1	5	25	1	160				1	1.5	30	1	6	1200	1	1,600
19	Canal LR 10	Drop Structure	0	0	3	480											
20	Canal LR 10	Weir	6	30	5	800	100x100 cm	1	780								
		Head regulator	30	150	200	48,000											
		Aquaduct	3	15	5	800											
21	Canals LR 8,12,12-3, 12-4,14, 17, 21, 22, 23, 24, 25, 26, 29, 32, 32-1,35, R -2, 6-X-1, Yulduz, Ishon	Hydropost		0		0				20	1.5	600				20	32,000
22	Outflow of districts; Lenin, Lokhuti, and Kirov, LR 29, 32, 32-1, R-1, 3, 4, 5X-1, 5X-2, 1-X-00-16, R-3-1, R-3-1-1	Hydropost		0		0				13	1.5	390	13	12	2400	13	20,800
23	Canals 1-K, 2-K, 3-K, 2-K-1	Hydropost		0		**0**				0	0		0	0		4	
Total			1,458	**7,340**	527	**117,920**	0	82	**69,290**	49	32	**1,470**	20	64	**12,800**	53	**78,400**

Source: Consultant Team estimates.

Table 20: Details of Quantities of Materials and Cost of Structures Modernization and Associated Works in Vose District

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
			Canal Struct.	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	Cost ($)
1	Canal Arpa Tuguldi at PK 158	Inlet	1	5	2	320	200x200 cm	1	1950								
		Outlet	5	25	4	640	200x200 cm	5	9750								
		Hydropost	6	30	5	800				1	3	30	1	12	2,400	1	1600
2	Canal Leading to PS 2	Inlet	6	30	4	640	100x150 cm	1	1040	1	1.5	30	1	11	2,200	1	1600
		Hydropost	6	30	4	640				1	1.5	30	1	11	2,200	1	1600
3	Canal R - 7	Inlet	5	24	4	640	100x100 cm	1	780								
		Hydropost	5	24	3	480				4	6	120	2	10	2,000	2	3200
4	Canal Gashtepa	Inlet	5	24	4	640	100x150 cm	1	1040	1	1.5	30	1	7	1,400	1	1600
		Hydropost	5	24	4	640				1	1.5	30	1	7	1,400	1	1600
5	AT	Inlet	5	24			150x150 cm	1	1300								
6	AT - 1a	Inlet	5	24	4	640	100x150 cm	1	1040								
		Hydropost	5	24	4	640				1	1.5	30	1	7	1,400	1	1600
7	AT - 1	Inlet	5	24	4	640	100x150 cm	1	1040								
		Hydropost	5	24	4	640				1	1.5	30	1	7	1,400	1	1600
8	Canal Arpa Tuguldi at PK 131	Inlet	6	30	4	640	250x200 cm	1	2200								
		Head regulator	30	150	200	48,000											
		Hydropost	6	30	4	640				1	1.5	30	1	10	2,000	1	1600
9	Canal R 2	Inlet	5	24	4	640	200x150 cm	1	1690								
		Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
10	Spillway PK - 131	Inlet	5	24	4	640	200x150 cm	1	1690								
		Outlet in PK 45	300	1500	25	4,000	100x150 cm	1	1040								

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
			Canal Struct.	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	Cost ($)
		Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
11	Beshkatagan	Inlet	6	30	4	640	100x150 cm	1	1040								
		Hydropost	6	30	4	640				1	1.5	30	1	8	1,600	1	1600
		Inlet	5	24	4	640	100x150 cm	1	1040								
12	Maras	Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
		Inlet	10	48	7	1,120	100x150 cm	1	1040								
13	Canal R 2	Hydropost	10	48	7	1,120				2	1.5	60	2	8	1,600	2	3200
14		Inlet	5	24	4	640	100x150 cm	1	1040								
	Canal R 2- 3	Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
15		Inlet	5	24	4	640	100x150 cm	1	1040								
	Canal R 2- 4	Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
16	Canal Kulob Dare Second	Inlet	4	20	2	320	150x150 cm	1	1300								
		Head regulator	30	150	200	48,000											
		Outlet	12	60	9	1,440	150x150 cm	3	3900								
		Hydropost	16	78	11	1,760				3	1.5	90	3	10	2,000	3	4800
17	Canal KD - 6	Inlet	5	24	4	640	80x100 cm	1	730								
		Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
18	Canal KD 12 - 2	Inlet	5	24	4	640	80x100 cm	1	730								
		Hydropost	5	24	4	640				1	1.5	30	1	8	1,600	1	1600
19	Shobika	Inlet	10	50	8	1,280	80x100 cm	1	730								
		Outlet	4	20	3	480	80x100 cm	1	730								
		Hydropost	5	25	5	800				1	1.5	30	1	8	1,600	1	1600
20	Canal SH 1 - 1, PK 1-1	Inlet	5	24	4	640	80x100 cm	1	730								
		Hydropost	5	25	3	480				1	1.5	30	1	8	1,600	1	1600

Sr. No.	Name of Canal and Structures	Type of Structure (No.)	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
			Canal Struct.	Cost ($)	Canal Struct	Cost ($)	Gate Type	No. of Gates	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	Cost ($)
21	Canal SH 1 - 1, PK 1-3	Inlet	5	24	4	640	80x100 cm	1	730								
		Hydropost	4	22	3	480				1	1.5	30	1	8	1,600	1	1600
22	Poitug	Inlet	14	72	11	1,760	80x100 cm	1	730								
		Outlet	29	144	22	3,456	80x100 cm	3	2190								
		Hydropost	19	96	15	2,400				3	1.5	90	3	8	1,600	3	4800
Total			650	**3,348**	461	**137,696**		35	**42,260**	31	41	**930**	29	196	**39,200**	29	**46,400**

Source: Consultant Team estimates.

Table 21: Details of Quantities of Materials and Cost of Structures Modernization and Associated Works in Kulob District

Sr. No.	Name of Canal and Structures	Volume of Earth Work (m^3)		Volume of Concrete Work (m^3)		Replacement of Metal Structures			Replacement of Water Level Meters (Rulers)			Replacement of Hydrobridges			ACWM	
		Canal Struc. (No.)	Cost ($)	Canal Struc. (No.)	Cost ($)	Gate Type	No. of Gates	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	L (m)	Cost ($)	Nos.	Cost ($)
1	Canal Kulob Dare 3	25	125	8	1280	200x200 cm	4	7800	1	2	60	1	3	600	1	1600
Total		25	125	8	1280		4	7800	1	2	60	1	3	600	1	1600

Source: Consultant Team estimates.

3. On-farm Asset

a. On-Farm Canals

77. Maintenance of on-farm facilities has always suffered because of lack of resources. Even during the Soviet time, the maintenance of on-farm facilities was poor as its responsibility was delegated to farm brigades in addition to their normal task of farm operations unlike maintenance of interfarm and other major facilities which were funded directly by the Government.

78. Farmers generally lack the financial resources and equipment for rehabilitation and maintenance of their on-farm I&D works. Thus the full potential benefits from investment in rehabilitation and upgradation of inter-farm I&D infrastructure will not be realized, unless there is an associated improvement in the on-farm I&D system. However, without some form of investment support from the Government for WUAs and farmer groups, the on-farm I&D infrastructure is likely to continue to deteriorate with negative impact on land use and soil productivity, crop yields, and agricultural production. Therefore, creating opportunities for farmers to increase their income so that they can invest in on-farm I&D and so that WUAs can charge realistic ISFs is very important.

79. Equitable water distribution is necessary before farmers can practice field irrigation techniques which result in water savings, higher water use efficiencies at field level, and the corresponding reduced groundwater level fluctuation, reduced drainage flows and lower risks of soil salinity. Only if the on-farm I&D infrastructure is adequately developed and maintained will it be possible to achieve equitable water distribution to all irrigators within a scheme's service area, leading to improved crop yields and productivity.

80. Practical measures to improve on-farm I&D infrastructure to facilitate more timely water deliveries in appropriate volumes include: (i) appropriately dimensioned on-farm canals so that their capacity is adequate for their command area (no extra capacity to convey larger than required flows); (ii) installation of simple, accurately dimensioned, calibrated and operated canal off-take structures on the inter-farm canal system together with installation of an appropriate flow measuring structure; and (iii) accurate installation of simple flow dividing and/or distribution boxes releasing water onto agricultural fields.

81. However, besides rehabilitation and improvement of the I&D infrastructure, proper operation of structures and monitoring of flows in canals and drains by system operators and system users will be required to achieve and maintain high operational standards. Procedures for regular meetings and consultation of farmers, WUAs and District's representatives to plan, monitor and to address grievances need to be established with the local administration taking the role of decision maker in cases where the parties involved cannot achieve agreement themselves.

82. Eventually the cost of water delivery and marginal analysis of costs and returns to water use needs to be factored into the water distribution and management framework to maximize the returns to water use across the range of locations and schemes in the country.

83. The proposed modernization of on-farm canal includes the concrete lining of on-farm canal and installation flow measurement (hydro-post) at the intake. Detailed cost of installation of flow measurement structures and installation of new gates are given in cost tables of inter-farm canal modernization. Proposed cost estimate of concrete lining in four districts are given below in

84.

85. Table **22**.

Table 22: Cost of Concrete Lining of On-Farm Canals

Jamoats	Type of Canal	Length of Canal, m	Volume of work per 1 м Canal, m^3	Cost of Construction of 1 м canal, $	Total Cost,$
Farkhor District					
Vatan	Concrete	4,600	0.18	18	82,800
Gulshan	Concrete	5,760	0.18	18	103,680
Gairat	FlumeLR-60	10,000	0.095	20	199,500
	covered conduit	10,000	d 300 мм	20	200,000
Galaba	Concrete	10,380	0.18	18	186,840
Zafar	Concrete	10,280	0.18	18	185,040
Dekhkonarik	Concrete	6,400	0.18	18	115,200
	Concrete	3,800	0.18	18	68,400
Darkad	FlumeLR-60	5,000	0.095	20	99,750
	covered conduit	2,800	d 300 мм	20	56,000
Komsomol	Concrete	5,760	0.18	18	103,680
Farkhor	Concrete	1,360	1.18	18	24,480
Total		76,140			1,425,370
Hamadoni District					
	FlumeLR-100-FlumeLR-60 (LR-80)	6,000	0.127	27	160,020
Chubek	FlumeLR-60	2,700	0.095	20	53,865
	concrete канал Р-1	1,300	0.8	80	104,000
	concrete канал ПР-10	800	1.2	120	96,000
Dashti-gulo	FlumeLR-100- LR-40 (LR-60)	3,700	0.095	20	73,815
Mekhnatobod	FlumeLR-60	2,000	0.095	20	39,900
Kakhramon	Concrete	630	0.18	18	11,340
Kalinin	Concrete	1,421	1.18	18	25,578
A. Turdiev	Concrete	4,665	2.18	18	83,970
Total		23,216			648,488
Vose Disrict					
Tugarak	Concrete	282	0.18	18	5,076
Guliston	Concrete	567	0.18	18	10,206
	FlumeLR-80	5,000	0.127	27	133,350
Avazov	Concrete	1,510	0.18	18	27,180
Total		7,359	0.667		175,812
Kulob District					
Total	Concrete	70	0.18	0.18	13
Total in CIS		**106,785**			**2,249,683**

Source: Consultant Team estimates.

b. Drainage

86. The combined on-farm channel efficiency and field efficiency of the irrigated areas is estimated at around 50%. Thus, around half of the diverted water is lost at on-farm canal and farm level. The area where on-farm drainage is not in good condition, most of the water percolates and adds to the ground water. Consequently, ground water level is high in the areas where on-farm drainage conditions poor. Such drainage has been identified for priority cleaning under the project in order to bring down the ground water level.

87. The O&M cost of drainage is so high that farmers are not in position to bear the cost. Therefore, the condition of the on-farm drainage is deteriorating day by day along with the danger of soil salinity. WB funded project for on-farm canal and drainage for cleaning and easing O&M is under implemented. To supplement the WB funding and improve the on-farm condition in the high ground water table area (GWL is less than two meters), the team has

assessed the extent of such area, quantify the drainage length, and cost estimate for cleaning.

88. The 544.82 km long primary and collector drains in four project districts which suffer from neglect and deferred maintenance need to be cleaned and reshaped to function appropriately. The total cost estimate is given Table 23.

Table 23: Earth Work for Cleaning of Drains

Jamoats	Suspended area, (ha)	Total length of drains, (m)	Length of drains planned for cleaning under PAMP project	Length of drains to be cleaned under Proposed Project, (m)	Volume of cleaning and leveling work, m^3	Unit cost, \$/ m^3	Total Cost (\$USD)
Farkhor District							
Vatan	2,777	23,600	0	23,600	58,507	3.50	204,773
Gulshan	2,263	16,000	0	16,000	18,703	3.50	65,459
Gairat	1,075	13,400	0	13,400	26,043	3.50	91,150
Galaba	1,184	32,200	0	32,200	69,825	3.50	244,388
Zafar	1,274	16,150	0	16,150	43,341	3.50	151,692
Dehkonarik	2,353	20,919	0	20,919	44,615	3.50	156,153
Darkad	801	7,450	0	7,450	18,886	3.50	66,100
Komsomol	436	21,800	0	21,800	65,497	3.50	229,239
Farkhor	1,560	5,200	0	5,200	13,988	3.50	48,956
Total	13,723	156,719	0	156,719	359,403		1,257,911
Hamadoni District							
Chubek	276	8,800	0	8,800	13,200	3.50	46,200
Dashi Gulo	5,542	45,200	13,450	31,750	98,410	3.50	344,435
Mehnarobod	2,314	53,750	24,100	29,650	68,340	3.50	239,190
Kakhramon	1,979	43,420	33,440	9,980	24,405	3.50	85,418
Kalinin	1,126	17,500	11,850	5,650	6,300	3.50	22,050
A. Turdiev	2,713	53,980	7,860	9,230	11,930	3.50	41,755
Total	13,950	222,650	90,700	95,060	222,585		779,048
Vose District							
Tugarak	980	44,040	15,880	28,160	22,968	3.50	80,388
Guliston	617	39,910	17,560	22,350	62,050	3.50	217,175
A. Avazov	1,379	71,500	24,150	47,350	130,675	3.50	457,363
Total	2,976	155,450	57,590	97,860	215,693		754,926
Kulob District							
Total	350	7,000	0	7,000	27,300	3.50	95,550
Total Cost	**30,999**	**544,819**	**148,290**	**356,639**	**824,981**		**2,887,434**

Source: Consultant Team estimates.

VI. CHUBEK IRRIGATION SYSTEM ASSET (PUMP IRRIGATION)

A. Present Asset and Condition

89. Of the total design command area of 50,163 ha of the CIS, about 14,344 ha (29%) is served by 22 group of pumping units comprising 102 pumps ranging in head from 8.5 to 177.5 m. Some areas involve 2–3 stage pumping. The pumps are located in four clusters. Kulobdarya Pumping System serves 3,482 ha, Janubi Pumping System serves 2,503 ha, and Lenin-Gulistan Pumping System serves 2,522 ha. About 367 ha of the irrigated area served by these pumps lies in Kulob District while the remaining area is in Vose Districts. The Urtaboz Pumping System serves 5,837 ha in Farkhor District.

90. The combined design pumping capacity of the 102 pumps was 84.7 cubic meter per second (cumec). Currently, many pumps are totally out of operation and, the remaining are in poor shape. The total pumping capacity of currently operating pumps is about 29 cumec (about 34% of the design capacity). The pumps presently in working condition, suffer from accelerated deterioration because high concentration of sediments in water and lack of

repair facilities. The overall efficiency of the current pumping units is not more than 50% whereas the new pumping unit with efficiency exceeding 75% are available.

91. The design areas served by various PSs and their pumping heads are given in Table 24.

Table 24: Pumping Stations in the Project Area

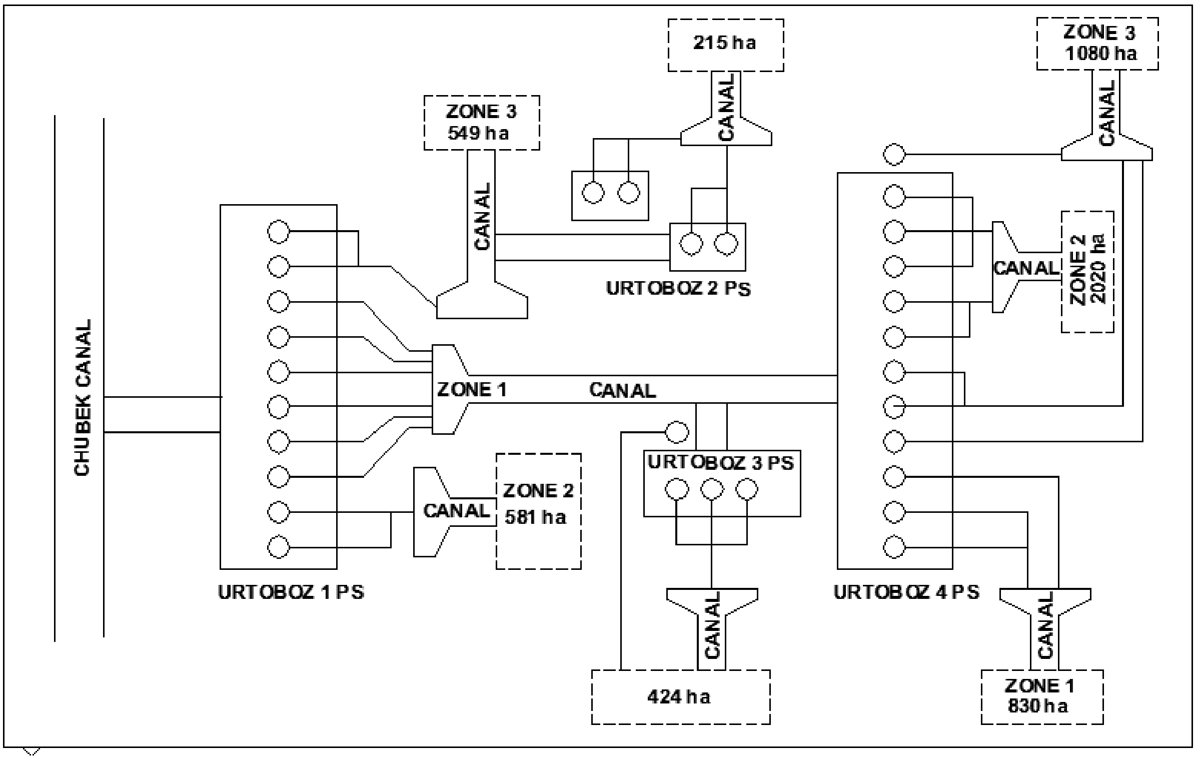
Pumping Station	Pump Units	Area Served (ha)	Other Pumps in Multistage Pumping	Total Pumping Head, (m)
FARKHOR DISTRICT				
Urtaboz 1	9,10.1,2	1,130		14.5
Urtaboz 2	1-4	215	Urtaboz 1	85.0
Urtaboz 3	1-4	424	Urtaboz 1	38.5
Urtaboz 4	1-3	830	Urtaboz 1	34.5
Urtaboz 4	7-11	2,020	Urtaboz 1	78.5
Urtaboz 4	4-6, 12	1080	Urtaboz 1	88.5
Ordzonikidze		138		13
District subtotal		**5,837**		
VOSE DISTRICT				
Kulobdarya 0	1	100		8.5
Kulobdarya 0A	1	70		8.5
Kulobdarya 1	1-3	2,945	Kulobdarya 0,0A	103.5
Janubi 1	1-2	1,120		15.0
Janubi 2	All (1-5)	400		15.0
Perikachka	All (1-2)	725	Janubi 1, 2	23.0
Moskva 1	All (1-3)	180	Janubi 1, 2	27.0
Moskva 2	All (1-3)	178	Janubi 1, 2	65.0
Gulistan	All (1-2)	40		20.0
Lenin 1	1-3	1,210		70.0
Lenin 2	1-7	967	Lenin 1 (4,5)	130.0
Lenin 6	1-3	205	Lenin 1 (6)	150.0
District subtotal		**8,140**		
KULOB DISTRICT				
Beshtegirmon		100	Kulobdarya 0,1	177.5
Jdanov 1		267	Kulobdarya 0,1	170.5
District subtotal		367		
Total Pumps-Served Area		**14,344**		

Source: ALRI.

92. There are two main cascade pumping systems in CIS. One is the Vose cascade pumping system supplying water through fourteen PSs to agricultural lands of Vose District and Kulob District and the other one is Urtaboz cascade PS supplying water to agricultural land in Farkhor District through six PSs (Figure 6).

93. Figure 6: Schematic Drawing for Urtoboz Group of Pumping Stations
94. Figure 7: Schematic Drawing for Urtoboz Group of Pumping Stations
95. Figure 8: Schematic Drawing for Urtoboz Group of Pumping Stations

Figure 6: Schematic Drawing for Urtoboz Group of Pumping Stations

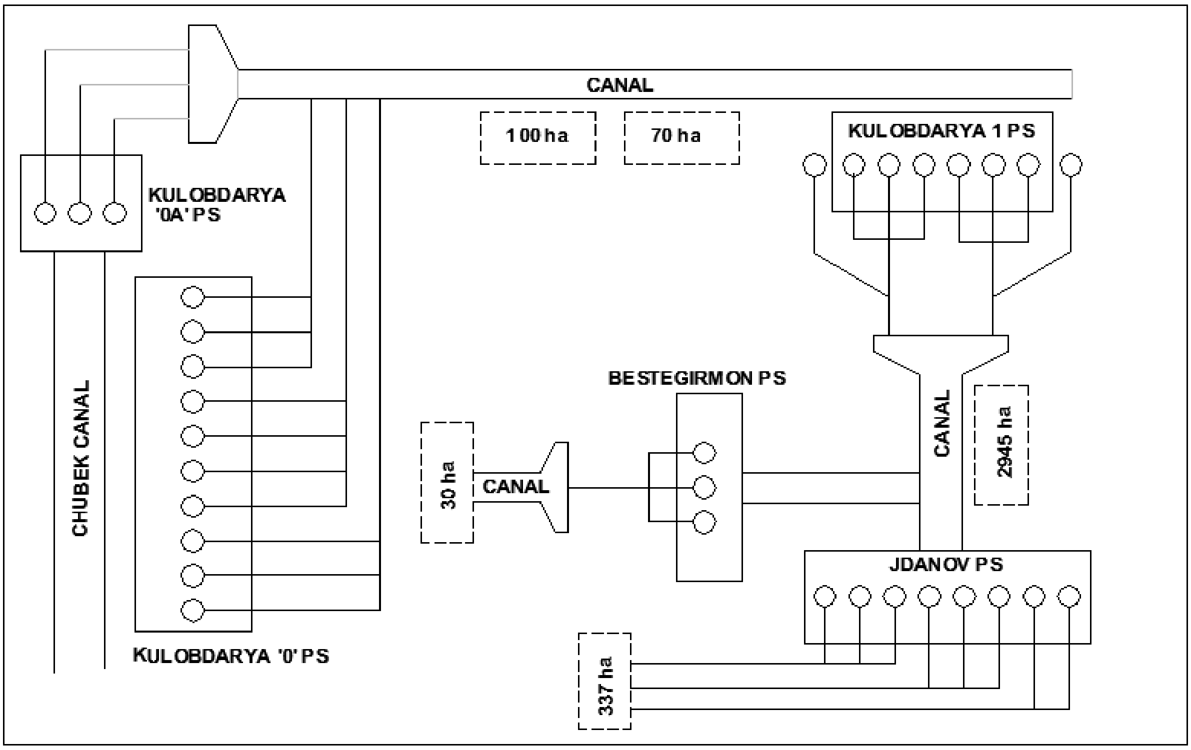


96. The Urtoboz cascade pumping system is schematically presented in Figure 6 above. Urtoboz1 PS is a the base PS of this cascade. It supplies water to 1,130 ha of farm area as well as pumps water required for next level PSs Urtoboz 2, Urtoboz 3, Utoboz 4 and 4A which serve 215 ha, 424 ha and 3,930 ha respectively. The remaining PS of Farkhor district Ordzonikidze PS is not shown in the schematic drawings because it operates independently.

97. The Vose cascade system consists of three different cascade pumping systems i. e. Kulobdarya, Janubi and Lenin. In addition, there is also one isolated single stage PS at Guliston which takes water from the canal and supplies water to 40 ha of farm area.

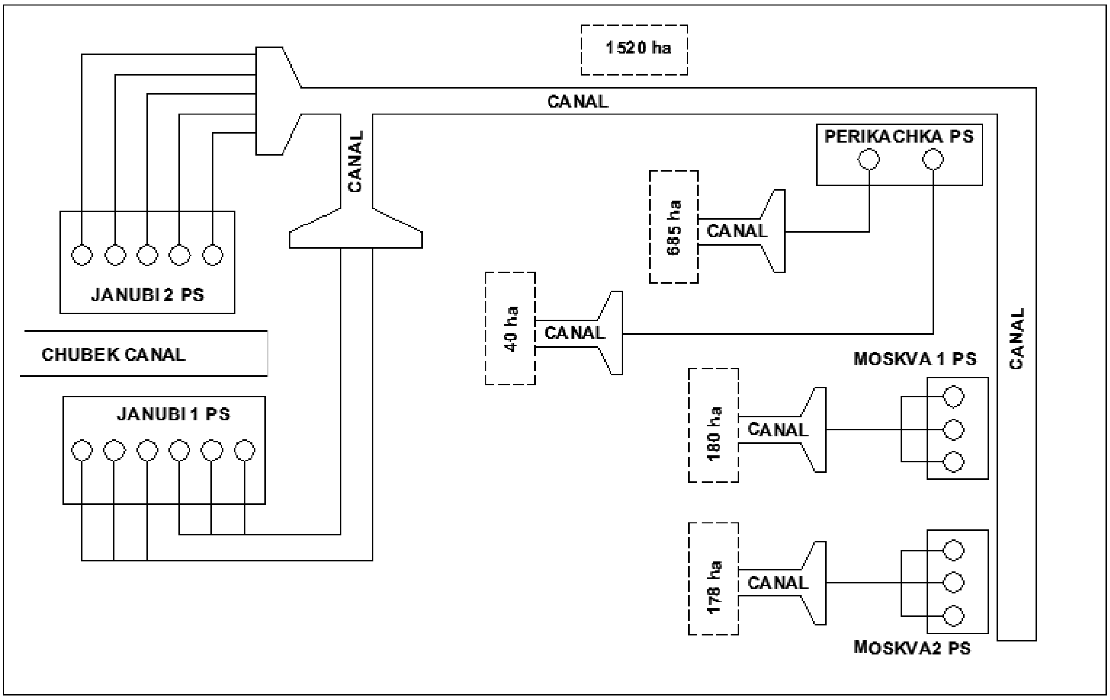
98. In the Kulobdaryo cascade (first one) the base pump stations (PSs) are Kulobdarya '0' and Kulobdarya '0A' with ten pumps and three pumps respectively, feeding two command area of 100 ha and 70 ha and also supplying water to the next level PS at Kulobdarya 1. The Kulobdarya 1 PS has eight pumps which feed water to a command area of 2,945 ha and also supply water to the next second level PSs at Beshtegirmon and Jdanov. The Bestegirmon PS and Jdanov PS have three and eight pumps respectively feeding to their total command area of 367 ha. The cascade pumping system is schematically presented in below.

Figure 7: Schematic Drawing for Kulobdarya Group of Pumping Stations



99. In the Janubi cascade, the base PSs are Janubi 1 and Janubi 2 with total of six pumps and five pumps respectively feeding command area of 1,520 ha. The Janubi cascade pumping system is presented schematically in below.

Figure 8: Schematic Drawing for Janubi Group of Pumping Stations

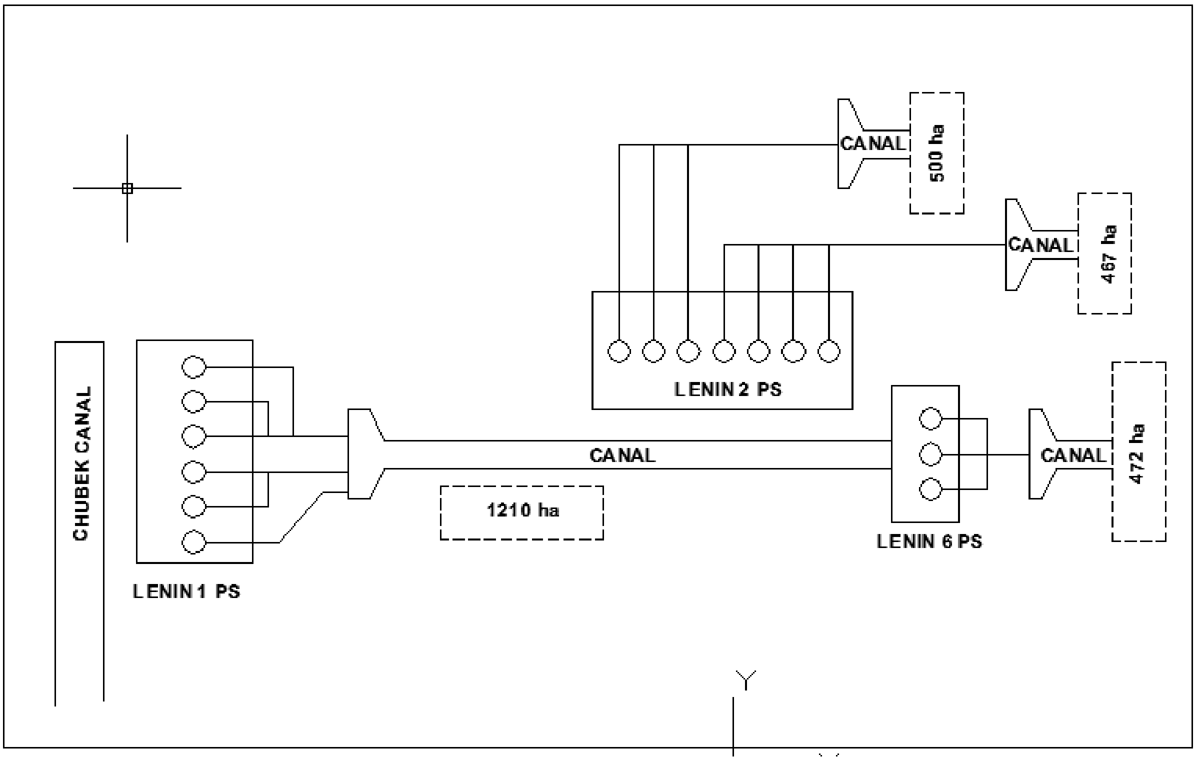


100. Both these base PSs also supply water to the next level PSs at Perikachka and Moskava 1 and 2 which serve 725 ha, 180 ha and 178 ha area, respectively.

101. In the Lenin cascade the base PS is Lenin 1 with six pumps feeding command area of 1,210 ha and also supplying water up to the next level Lenin 2 and Lenin 6 PS. This PS Lenin 2 has seven pumps which feed water to a command area of 967 ha with two separate group of pumps.

102. The Lenin Cascade pumping system is presented schematically in the below.

Figure 9: Schematic Drawing for Lenin Group of Pumping Stations



103. The Lenin 6 PS is located at the end of canal which has 3 pumps and serves area of 205 ha (may be higher area of 472 ha).

104. The PS at Guliston takes water directly from the Chubek canal branch and serves 40 ha area with set of two pumps.

105. The present condition of the pumps in different PSs is summarized in the following Table 25.

Table 25: Present condition of Pumps in the Pumping Stations

Sr. No.	Pumping Station	Nos. of Pumps installed	Nos. of Pumps in working condition	Nos. of Non – functional Pumps
1	Urtoboz 1, Zone 1	6	2	4
	Urtoboz 1, Zone 2	2	1	1
	Urtoboz 1, Zone 3	2	1	1
2	Utoboz 2,	4	2	2
3	Urtoboz 3	4	2	2
4	Urtoboz 4, Zone 1	3	2	1
	Urtoboz 4, Zone 2	4	2	2
5	Urtoboz 4A, Zone 3	5	1	4

Sr. No.	Pumping Station	Nos. of Pumps installed	Nos. of Pumps in working condition	Nos. of Non – functional Pumps
6	Ordzonikidze	3	2	1
7	Kulobdarya 0	10	4	6
8	Kulobdarya 0A	3	0	3
9	KulobDarya 1	8	3	5
10	Janubi 1	6	2	4
11	Janubi 2	5	2	3
12	Perikachka	2	1	1
13	Moskva 1	3	0	3
14	Moskva 2	3	0	3
15	Guliston	2	1	1
16	Lenin 1	6	1	5
17	Lenin 2	7	2	5
18	Lenin 6	3	1	2
19	Beshtegirmon	3	2	1
20	Djanov	8	3	5
	TOTAL	102	37	65

106. Summary of present condition of pumping systems in the PSs of different districts is presented in Table 26 below.

Table 27: District wise Summary of Pumping Systems

Pump Houses in District	AS PER DESIGN		CURRENT SITUATION		ASSESSMENT (%)	
	Pumps (Nos.)	Total Capacity m^3 / sec	Pump Working(Nos.)	Total Capacity m^3 / sec	Nos. of working Pumps (%)	Capacity (%)
Farkhor	33	28.95	15	12.85	45.5	44.4
Vose	58	53.09	17	14.77	29.3	27.8
Kulob	11	2.67	5	1.13	45.5	42.5
ALL	**102**	**84.7**	**37**	**28.75**	**36.3**	**33.9**

B. Expected Asset and Condition After Project

a. Potential Benefits of Modernized Asset

107. **Improved, Timely and Reliable Water Supply to End Users.** With the modernization of pumping units, the end users can get required water supply for their crops at the required time and with assured reliability particularly during peak period. In addition, the improved and reliable water supply can build confidence in the end users to go for cash crops of their choice.

108. **Improved Efficiency of Pumping and Reduced Running Cost.** The new pumps proposed as part of modernization are energy efficient low speed pumps. These pumps will improve overall efficiency of the pumping system by more than 25% over that of the existing pumps.

109. As part of modernization, field instrument for measurement of pressure, flow, motor current, energy consumption are proposed to be added. These instruments will provide required data to regulate and monitor the water supply matching with the actual requirement.

110. The energy efficient pumps along with properly regulated pumping operation matching the actual requirement will substantially reduce the overall operating or running cost.

111. **Improved Relationship of Operators with End Users and Improved Cost Recovery.** With the provision of appropriate field instruments and local SCADA system control and data acquisition) system, field data such as pressures, flows, energy consumption etc. can be periodically received from all PSs and processed at central location. This will help the operators to properly interact with the end users with reliable water supply and energy consumption data. It will improve relations of operators with the end users and help in cost recovery.

b. Selection of Target Pump Stations

112. **Selection of Target PSs.** Since the PSs are effectively operating in groups, it is important to decide priority for the group of PSs. The priority for the groups of PSs is recommended in Table 28 considering the following factors: (i) Strategic Location of the PS; (ii) Present Condition of the PS; (iii) Irrigation Area and the Total Pumping Head; (iv) The Irrigated Area and the Modernization Cost.

113. Under the Project, Urtaboz pumping system with weighted average head of 59 m and Janubi pumping system with weighted average head of 21 m will be modernized. Lenin and Kulobdarya pumping systems have more than 90 m weighted average head. A World Bank report has shown that with lifts higher than 60 m and using an energy price of 0.02 $/Kwh and its developed cropping patterns, more than 60% of the lands would produce a negative margin in pump-fed irrigation systems.[5] Therefore, a feasibility study will be conducted under the Project to explore alternative cost efficient water-supply method for the irrigated area under these two non-targeted pump systems.

Table 28: Priority Order for the Groups of Pumping Stations

Priority Order	Group of Pumping Stations	Irrigation Area Served (ha)	Factors Deciding the Priority
Priority-1	Janubi	2,603	Low pumping heads, low cost of modernization
Priority-2	Urtoboz	5,837	High irrigation area coverage, moderate cost of modernization
Priority-3	Lenin	2,382	High pumping head but worst present condition, moderate cost of modernization.
Priority-4	Kulobdarya	3,115	High irrigation area coverage, moderate pumping head but very high cost of modernization

c. Summary of Modernized Asset

114. **Pumps And Motors Sets.** A list of the recommended new pumps and motor sets is in

115.

[5] World Bank. 2003. Irrigation in Central Asia (Page 30, Page 12 of Annex, and others). Washington, D.C.

116. Table **29**.

Table 29: List of Recommended New Pumps and Motor sets

S. No.	Name of the PS	Nos. of Pumps	Pump Flow M^3/Hr	Pump Head (m)	Pump speed rpm	Motor Rating Kw	Operating Voltage Kv	Type of Pump
1	Urtoboz 1 Zone 1	4	5,400	20	750	450	6.0	HSC
	Urtoboz 1 Zone 2	1	2,160	35	980	300	6.0	HSC
	Urtoboz 1 Zone 3	1	2,484	69	980	700	6.0	HSC
2	Urtoboz 2	1	648	30.1	980	100	0.4	HSC
3	Urtoboz 3	1	1,080	32	980	150	0.4	HSC
4	Urtoboz 4 Zone 2	2	3,420	69	980	950	6.0	HSC
5	Urtoboz 4 Zone 3	2	3,060	88	980	1100	6.0	HSC
6	Janubi 1 - 2	2	2,700	11.5	980	150	0.4	Submersible
		2	5,400	11.5	980	250	0.4	Submersible
7	Perikachka	2	900	5	980	25	0.4	Submersible
		1	2,700	5	980	60	0.4	Submersible
8	Moskva 1	2	540	12	980	30	0.4	HSC
9	Moskva 2	2	540	54	980	160	0.4	HSC
	TOTAL	23						

'HSC' denotes the conventional Horizontal Split case Pumps and 'Submersible' denotes Fully submersible axial flow type pumps in tube or otherwise.

117. **Pump Suction and Discharge Piping and Valves.** The set of suction and Discharge piping described in Table 30 below means set of suction and discharge piping for each new pumps with required eccentric and concentric reducers, dismantling joints, gate valves, butterfly valves manually operated or motorized as mentioned.

118. The pipe sizes of suction and discharge piping and sizes of valves wherever not mentioned in the Table 30 below shall be the sizes as calculated for the design flow and maximum flow velocities as mentioned in the section IV of PPTA consultant report (Appendix 13) under guiding principles for modernization and rounded off to next higher size of standard available pipe sizes.

Table 30: List of Modernization of Suction and Discharge Piping and Valves

Sr. No.	Name of the Pumping Station	Nos. of Sets of Suction and Disch. Piping	Description
1	Urtoboz 1 Zone 1	4	Suction Piping with Isolation Valve and Discharge Piping with Non – return (Check) valve and Motorized butterfly valve
	Urtoboz 1 Zone 2	1	Same as above
	Urtoboz 1 Zone 3	1	Same as above
2	Urtoboz 2	1	Suction Piping without Isolation Valve and Discharge Piping with Check valve and manual butterfly valve
3	Urtoboz 3	1	Same as above
4	Urtoboz 4 Zone 2	2	Suction Piping with Isolation Valve and Discharge Piping with Check valve and Motorized butterfly valve
5	Urtoboz 4 Zone 3	2	Suction Piping with Isolation Valve and Discharge Piping with Check valve and Motorized butterfly valve plus 3 Nos. 1200 mm dia motorized butterfly for interconnection of headers.
6	Janubi 1 - 2	2	Discharge Piping 800 mm dia. up to canal head with check valve.
		2	Discharge Piping 600 mm dia. up to canal head with check valve.
7	Perikachka	1	Discharge Piping 800 mm dia. up to canal head with check valve.
8	Moskva 1	2	Suction Piping without Isolation Valve and Discharge Piping with

Sr. No.	Name of the Pumping Station	Nos. of Sets of Suction and Disch. Piping	Description
			Check valve and manual butterfly valve
9	Moskva 2	2	Same as above

119. **Over Head Cranes and Material Handling Devices.** The recommended capacity of Over Head cranes is mentioned in the Table 31 below. The span of the crane, Longitudinal Travel, Lifting heights etc. shall be suitable for the dimensions of the existing pump house buildings where the old cranes are to be replaced by new one. Supply of suitably designed gantry girders for the crane shall also be part of the crane mentioned below

Table 31: List of Recommended Over Head Cranes and Material Handling Devices

Sr. No.	Name of the Pumping Station	Nos. of Cranes	Description
1	Urtoboz 1	1	Over Head Crane Capacity : 10 Ton with Gantry Girders
2	Urtoboz 2	1	Monorail Crane Capacity : 3 Ton with Gantry Girders and supporting structure
3	Urtoboz 3	1	Monorail Crane Capacity : 3 Ton with Gantry Girders and supporting structure
4	Urtoboz 4	1	Over Head Crane Capacity : 10 Ton with Gantry Girders
5	Janubi 1 - 2	1	Over Head Crane Capacity : 5 Ton with Gantry Girders and Required supporting steel structure at the new location.
6	Perikachka	1	Over Head Crane Capacity : 3 Ton with Gantry Girders and Required supporting steel structure at the new location.
7	Moskva 1	1	Over Head Crane Capacity : 3 Ton with Gantry Girders
8	Moskva 2	1	Over Head Crane Capacity : 3 Ton with Gantry Girders

120. **Ventilation System And Air Conditioning for SCADA.** The set of ventilation system for each of the PS shall include set of wall mounted exhaust fans and accessories specifically designed for the heat load of of each PS and one window air conditioner for the SCADA room in each PS. A list of recommended modernized ventilation systems is in Table 32.

Table 32: List of Recommended Modernization of Ventilation System

Sr. No.	Name of the Pumping Station	No. of Sets	Description
1	Urtoboz 1	1	Set of exhaust fans and Window Air Conditioner for SCADA Room
2	Urtoboz 2	1	Set of exhaust fans and Window Air Conditioner for SCADA Room
3	Urtoboz 3	1	Set of exhaust fans and Window Air Conditioner for SCADA Room
4	Urtoboz 4	1	Set of exhaust fans and Window Air Conditioner for SCADA Room
5	Janubi 1 - 2	1	Air Conditioner for SCADA room Capacity Minimum 1.5Ton
6	Perikachka	1	Air Conditioner for SCADA room Capacity Minimum 1.5Ton
7	Moskva 1	1	Set of exhaust fans and Window Air Conditioner for SCADA Room
8	Moskva 2	1	Set of exhaust fans and Window Air Conditioner for SCADA Room

121. **Modernization Of Instrumentation.** The set of instruments for each of the PS shall include set pressure gauges and compound gauges, pressure switches, pressure transmitters, flow meters in each PS as listed in Table 33 below.

Table 33: List of Recommended Modernization of Instrumentation

S. No.	Name of the Pumping Station	Set of Instruments	Pressure Gauges		Pressure Switch	Pressure Transmitter	Flow Meters
		Nos.	Pressure Gauges	Compound Gauges	Nos.	Nos.	Nos.

S. No.	Name of the Pumping Station	Set of Instruments	Pressure Gauges		Pressure Switch	Pressure Transmitter	Flow Meters
1	Urtoboz 1	1	12	10	2	8	2
2	Urtoboz 2	1	6	4	2	2	2
3	Urtoboz 3	1	6	4	2	2	2
4	Urtoboz 4	1	17	10	7	7	7
5	Janubi 1 - 2	1	8	4	-	4	8
6	Perikachka	1	1	1	1	1	2
7	Moskva 1	1	3	2	1	1	1
8	Moskva 2	1	3	2	1	1	1

122. **Provision of SCADA System.** Local SCADA panels with GSM module at 8 Nos. of PSs with computer will be provided as listed below (i) Urtoboz 1 (ii) Urtoboz 2 (iii) Urtoboz 3 (iv) Urtoboz 4 (v) Janubi 1 – 2 (vi) Perikachka (vii) Moskva 1 (viii) Moskva 2. Central SCADA Panel at VOSE office will be provided with computer of sufficient capacity to receive the data from all the 8 Nos. Local SCADA panels through wireless GSM network.

123. **Modernization of Electrical System.** The recommended components of modernization of Electrical system at each PS are summarized in Table 34 below.

Table 34: List of Recommended Modernization of Electrical System

Sr. No.	Name of the Pumping Station	No. of Sets	Description of Electrical Items
1	Urtoboz 1	1	MV PMCC, FCMA Type MV Motor Starters, MV Capacitors, Vacuum Circuit Breakers, Vacuum Contactors, Capacitor Control Panel, LV Auxiliary Switchgear, Set of MV/LV and Control cables, Battery Backup etc.
2	Urtoboz 2	1	LV PMCC, LV Motor Starters, LV Capacitors, MCCBs, MCBs, LV Power and control cables etc.
3	Urtoboz 3	1	LV PMCC, LV Motor Starters, LV Capacitors, MCCBs, MCBs, LV Power and control cables etc.
4	Urtoboz 4	1	MV PMCC, FCMA Type MV Motor Starters, MV Capacitors, Vacuum Circuit Breakers, Vacuum Contactors, Capacitor Control Panel, LV Auxiliary Switchgear, Set of MV/LV and Control cables, Battery Backup etc. **plus** MV panel, MV Starter and Cables for existing 1600 KW pump motor
5	Janubi 1 - 2	1	LV PMCC, LV Motor Starters, LV Capacitors, MCCBs, MCBs, LV Power and control cables etc.
6	Perikachka	1	LV PMCC, LV Motor Starters, LV Capacitors, MCCBs, MCBs, LV Power and control cables etc.
7	Moskva 1	1	LV PMCC, LV Motor Starters, LV Capacitors, MCCBs, MCBs, LV Power and control cables etc.
8	Moskva 2	1	LV PMCC, LV Motor Starters, LV Capacitors, MCCBs, MCBs, LV Power and control cables etc.

MV PMCC mentioned below denotes Medium Voltage (6.0 Kv) Power and Motor Control Center and LV PMCC denotes Low Voltage (0.4 Kv) Power and Motor Control Center. MCCB denotes Molded Case Circuit Breakers and MCB denotes Miniature Circuit Breakers.

124. **Modernization of Pump House Buildings and Provision of Associated Facilities.** Recommended Modernization of existing Pump House Buildings and Provision of associated facilities are summarized in Table 35.

Table 35: List of Recommended Modernization of Pump House Buildings and Provision of Associated Facilities

Sr. No.	Name of the Pumping Station	Description of Pump House Building Modernization, Modifications of Pump Foundations and Provision of Associated Facilities
1	Urtoboz 1	• Modification of existing foundations / construction of Foundations for 6 Nos. new pumps. • Repairs of Roof, Side Walls / Enclosures, Windows, Flooring, painting etc. of Pump House Building.
2	Urtoboz 2	• Modification of existing foundations / construction of Foundations for the new pump.

Sr. No.	Name of the Pumping Station	Description of Pump House Building Modernization, Modifications of Pump Foundations and Provision of Associated Facilities
3	Urtoboz 3	• Modification of existing foundations / construction of Foundations for the new pump.
4	Urtoboz 4	• Modification of existing foundations / construction of Foundations for 5 Nos. new pumps. • Repairs of Roof, Side Walls / Enclosures, Windows, Flooring, painting etc. of Pump House Building
5	Janubi 1 - 2	• Construction of RCC structure including intake structure for 4 Nos. new submersible pumps with a steel structure shed above it. • Branch canal leading to the intake structure of the new submersible pumps. • Repairs of Roof, Side Walls / Enclosures, Windows, Flooring, painting etc. of Janubi 1 and 2 Pump House Buildings.
6	Perikachka	• Construction of RCC structure including intake structure for 4 Nos. new submersible pumps with a steel structure shed above it. • Modification of existing foundations / construction of Foundations for shifting of existing working pump.
7	Moskva 1	• Modification of existing foundations / construction of Foundations for new pumps. • Repairs of Roof, Side Walls / Enclosures, Windows, Flooring, painting etc. of Pump House Building
8	Moskva 2	• Same as above
9	Vose Office	• Repairs and Modification of Stores room

125. The diagrams and sketches for each PS enclosed at the end of this document are listed in Table 36.

Table 36: List of Sketches and Diagrams

Sr. No.	Sketch / Diagram No.	Description of Sketch / Diagram
1	Diagram 01	Schematic Diagram of Pumping System at Urtoboz 1 PS
2	Diagram 02	Schematic Diagram of Pumping System at Urtoboz 2 PS
3	Diagram 03	Schematic Diagram of Pumping System at Urtoboz 3 PS
4	Diagram 04	Schematic Diagram of Pumping System at Urtoboz 4 PS
5	Diagram 05	Schematic Diagram of Pumping System at Kulobdarya ‘0’ and ‘0A’ PS
6	Diagram 06	Schematic Diagram of Pumping System at Kulobdarya 1 PS
7	Diagram 07	Schematic Diagram for Pumping System at Janubi 1 and Janubi 2 PS
8	Diagram 08	Schematic Diagram for Pumping System at Perikachka PS
9	Diagram 09	Schematic Diagram for Pumping System at Moskva 1 PS
10	Diagram 10	Schematic Diagram for Pumping System at Moskva 2 PS
11	Diagram 11	Schematic Diagram for Pumping System at Guliston PS
12	Diagram 12	Schematic Diagram for Pumping System at Lenin 1 PS
13	Diagram 13	Schematic Diagram for Pumping System at Lenin 2 PS
14	Diagram 14	Schematic Diagram for Pumping System at Lenin 6 PS
15	Sketch 01	General Arrangement Plan and Section of Proposed Structure for Submersible Pumps at Kulobdarya ‘0’ – ‘0A’ PS
16	Sketch 02	General Arrangement Plan and Section of Proposed Structure for Submersible Pumps at Janubi 1 – 2 PS
17	Sketch 03	General Arrangement Plan and Section of Proposed Structure for Submersible Pumps at Perikachka PS

Note: Diagrams with modernization option of un-targeted PSs are also provided for reference.

VII. PRESENT CIS O&M STRUCTURE

A. Role and Functions of Central Government Agencies

126. MEWR, responsible for national-level water resources management (WRM), controls the operation of Chubek Main Canal diversion structure on Pyanj River. Beyond the diversion structure, management of the canals, various structure on the canals, and the pumps is the responsibility of ALRI. The role of ALRI in O&M is discussed in the following sections. The organization structures of MEWR and ALRI, ALRI's structure for CIS O&M, and the structure of local ALRI's office in each target district are given in Attachment 2.

B. Role and Functions of Local Government Agencies

127. Khatlon oblast-based office of ALRI has important coordinating and supervisory functions for O&M of I&D schemes, and executing responsibilities for inter-raion water infrastructure works.

128. In particular, ALRI's six entities are functional in CIS area for O&M of canals and water infrastructures. These are i) State institution "Chubek Channel" (SI "Chubek Channel"); ii) Land Reclamation and Irrigation Department of Farkhor district; iii) Land Reclamation and Irrigation Department of Hamadoni district; iv) Land Reclamation and Irrigation Department of Vose district; v) Land Reclamation and Irrigation Department of Kulob district; and vi) Vose Pumped Irrigation Department. These entities report directly to Kulob Regional Land Reclamation and Irrigation Amalgamation, except for SI "Chubek Channel", which is subordinated to ALRI, RT.

129. As per a hierarchical structure Kulob Regional Land Reclamation and Irrigation Amalgamation is subject to Khatlon Regional Land Reclamation and Irrigation Department. The structure of each of these sub divisions is almost similar and commonly includes administrative staff employed by accounting unit, planning and economic unit, water unit, production & technical unit, human resource unit and support services (guards, drivers), as well as maintenance /operational sections or hydro sections. O&M of off farm canals and drainage system are carried out by the district level ALRI unit.

130. At the field level, district and inter-district water management organizations (primarily raivodkhozes / district level ALRI) are responsible for timely inspection of off-farm I&D infrastructure and execution of maintenance within their geographic area of jurisdiction. The organization structure is listed in Attachment 1. District level offices are primarily engaged in monitoring system performance, assessing seasonal water requirements and short duration water deliveries, in determining system maintenance requirements and to plan seasonal execution of maintenance activities.

131. District-level management offices of ALRI (i.e. Raivodkhozes) have planning, supervisory and monitoring functions with regard to irrigation system performance, O&M of off-farm infrastructure. They are generally not charged with executing system maintenance and are neither furnished with plant and machinery necessary to execute works such as canal and drainage desilting or structure repair works. ALRI district level offices engage local PMK[6] enterprises to execute system maintenance, i.e. primarily in force account. As yet there is no information that raivodkhozes ever prepare bills of quantities to conduct open or restricted tendering procedures for maintenance work to be executed. When maintenance or capital repair work is funded from centrally allocated budgets, oblast or raion tender

[6] PMKs were public entities during the Soviet era but have now been privatized. So, now they are private entities. However, there are still few government-owned PMKs too.

committees may, at times, be called upon to conduct a restricted tendering process for SOE's (i.e. PMKs or the like).

132. The organizations mentioned above and the district based PMKs own and operate some equipment units suitable for construction and to a lesser extent to execution of maintenance. Data collected on staff and equipment for the offices in charge of system O&M within project area are in poor condition.

133. It was confirmed that ALRI and its line offices are poorly equipped to execute such maintenance tasks as canal and drainage desilting at regular times and to the extent necessary. Since all of the equipment owned by the ALRI and its line offices in the districts originates from the time before dissolution of the Soviet Union, and has been in service for long periods, its reliability and performance are more than doubtful. The number of excavation units owned by each O&M organization within the project area would be adequate to deal with the annual sediment inflow, provided the equipment is operational and deployable throughout the annual cycle.

C. Role of Farms in System Maintenance

134. All farming entities are collectively responsible for O&M of on-farm I&D infrastructure and the assets listed at former kolkhozes, sovkhozes and state farms. Presently the country seeks ways to transfer such infrastructure to newly created farming entities and to evolving WUAs. Debt issues related to former kolkhozes and sovkhozes, inadequate legal provisions and land rights issues all affect the formation of new bodies capable of assuming authority over part or all of the former on-farm I&D infrastructure. Donor funded projects, such as the World Bank's "Farm Privatization Project" and the "Rural Infrastructure Rehabilitation Project", the IFC's "Farmer Ownership Model/Technical Assistance Project in Sughd or the SDC funded "Regional Water Management Project in Fergana Valley" as well as its Caritas implemented "Regional Development Project Muminobod", DFID's "Privatisation/Transfer of Irrigation Management in Central Asia"[7] or the ADB's "Agricultural Rehabilitation Project" as well as its funded TA for "Support for Facilitating Sustainable Project Benefits", all provide information and support to the government of Tajikistan and the ALRI for creating more enabling frame for formation and establishment of user based organizations, improvements in water management and water users assuming responsibilities for O&M of I&D infrastructure.

135. Farming entities responsibilities for system O&M are limited to the on-farm I&D infrastructure within the boundaries of the former state farms, kolkhozes and sovkhozes, and are complementary to raivodkhozes responsibilities for off-farm works. Farming entities responsibilities for on-farm I&D works include timely inspection, planning and execution of maintenance within the boundaries of the farm. However, system maintenance of on-farm infrastructure is undergoing important changes. Earlier, off-farm and on-farm infrastructure maintenance was carried out in force-account by *raivodkhozes* and other ALRI organizations. Changes are brought about by the fact that the present land reform process creates a lot of smaller land holdings which conceptually make earlier on-farm works to off-farm infrastructure. A vacuum of responsibilities develops for on-farm infrastructure serving a number of land reform created farming entities. To illustrate the situation Attachment 3 has been included showing principle components of the irrigation system. The schematic layout shows I&D works located between a former farm boundary and the field irrigation level. Items numbered (1) and (7) were and remain the responsibility of a raivodkhoz or inter-raion organization and depending on the registration of the asset, items (8) and (9), too. Other works, numbered (2) to (6) were commonly on-farm works and thus be the responsibility of

[7] Final Report, Knowledge and Research Services Contract R8025, Department for International Development, December 2003; an introductory workshop was also held in the ALRI in Dushanbe on February 16, 2004

the former farm. The I&D items in question are primarily the works numbered (2), (3) and possibly (6). Item numbers (4) and (5) are commonly of seasonal nature, regularly ploughed up and subsequently levelled during land preparation exercises. Prior to commencement of the seasonal irrigation period these canals (item numbers 4 and 5) will be rebuilt to facilitate irrigation.

136. Farming entities still retain some multi-purpose equipment and agricultural machinery which can potentially be used to support execution of maintenance however all or most farms do not own the heavy earthmoving equipment necessary to maintain permanent canals and drains of the on-farm infrastructure. Therefore, farming entities need to rely on district construction organizations, primarily PMKs and those owning earthmoving and excavation equipment.

D. Role of Functions of Beneficiary Organization

137. On-farm irrigation system (municipal property) are in budget of local governments or after the land reform they got orphaned or are included in Dehkan farms land. Currently, water users' associations (WUAs) are mainly involved in O&M of on-farm irrigation system.[8]

138. Presently, there are 20 WUAs in the project area covering an area of 41,807 hectares (about 83%) of the total project area (Table 37). Eight WAU are in Hamadoni, 9 in Farkhor and 3 in Vose District. The irrigated area covered by WUA varies from 930 to 3,115 ha with an average of 2,090 ha. These WUAs are not organized strictly on hydrological boundaries.

Table 38: Water Users' Associations in the Project Area

No.	Name of jamoats	Name of WUA	Irrigated area, ha	Number of dehkan farms, WUA members	Length of irrigation canals, km	The length of the collectors and drains, km
Hamadoni						
1	Dashtigullo	Ganji Panj	2,475	720	71.10	51.10
2	Chubek	Chubek-13	2,045	300	43.00	6.50
3	Panjrud	Panjrud	1,838	301	58.10	36.00
4	Mekhnatobod	Panjob-4	1,971	326	44.50	44.60
5	Mekhnatobod	Mekhnatobod-11	930	291	25.90	16.50
6	S-Turdiyev	Sayod	1,651	345	34.20	32.80
7	Panjob	Sayrob-1	1,579	147	83.10	-
8	Kakhramon	Siyovush-1	3,073	805	75.40	6.50
	Total		**15,562**	**3,235**	**435.30**	**194.00**
Farkhor						
1	Darkad	Darkad	1,819	310	46.14	35.50
2	Komsomol	S. Safarov	2,039	410	54.15	16.45
3	Farkhor	Farkhor	1,875	435	18.70	6.06
4	Vatan	Vatan	2,913	830	45.50	21.76
5	Gayrat	K.Marks	1,471	310	19.42	18.47
6	Zafar	Sarob	1,806	700	41.65	33.35
7	Dehkanarik	Kommunizm	2,040	400	30.40	56.58
8	Gulshan	Urta Boz	3,115	545	150.69	-

[8] Law No. 387 for establishment of WUAs was approved on 8 November 2006 which regulates the basis of creation, activity, and management of WUAs as non-commercial organizations with the aim of O&M of irrigation systems for serving the interests of water users.

No.	Name of jamoats	Name of WUA	Irrigated area, ha	Number of dehkan farms, WUA members	Length of irrigation canals, km	The length of the collectors and drains, km
9	Galaba	Surkhob	1,805		101.40	85.58
	Total		**18,883**	**3,940**	**508.05**	**273.75**
Vose						
1	Guliston	Shodob	2,256	173	66.00	19.80
2	A. Avazov	Obi Manzag	2,605	253	74.55	69.60
3	Khoja Mumin	Tugarak	2,501	248	76.20	48.50
	Total		**7,362**	**674**	**216.75**	**137.90**
20	**GRAND TOTAL**		**41,807**	**7,849**	**1,160.10**	**605.65**
	Average		2,090	392	58.01	30.28

Source: ALRI.

139. A typical WUA has a Board of Directors (BOD) consisting of 5-7 members of the WUA elected by the general assembly every three years though secret ballot. The Chairman of the Board is either elected by the general assembly or by the members of the BOD. The BOD may be supported by village representatives, one from each village.

140. The collective responsibilities of BODs are: (i) Coordination between the farmers and service provider organizations (ALRI and the local offices of the Department of Agriculture); (ii) Estimate irrigation water requirement for all crops of each farmer of the WUA and give consolidated irrigation water requirements over the growing season to ALRI; (iii) Facilitate distribution of the required amount of water at appropriate times; (iv) Facilitate cleaning of the I&D facilities; and (v) Collect ISFs from the farmers on the basis of bills prepared ALRI.

141. The BOD has an advisory/oversight role for WUA activities. It hires/appoints an Executive Director who heads the Executive Body responsible for day-to-day activities. The Executive Body constitutes accountant, engineer, mirabs (water masters) and other staff as required. The Executive Director is responsible for (i) calling and coordinating meetings with community and other organizations; (ii) collecting documents for registration and registering the association at Oblast Judicial Office; (iii) preparing status report for monitoring by NGO and authorities; and (iv) keeping liaises with authorities (Government, dehkan farmers, and rural water supply organization etc). To be effective, the Executive Director should be an influential and respectable person in the area

142. The account is responsible for keeping accurate accounts of income and expenditures, regular collection of ISFs and WUA service charges, and issuing receipts for collections. The person for this position should have knowledge of accountancy. The Engineer is responsible for keeping the system in order by managing regular and timely repair and maintenance, purchasing/hiring equipment for O&M, and informing the Board about issues. The Engineer need to have basic knowledge of engineering. The Mirob is responsible for daily operation of the system, security of assets, and conveying information about system problems to engineer The village representatives assist in collection of ISF from respective villages and thus reduce the workload of Book Keeper.

143. The technical problems of WUAs include: (i) WUAs are frequently created without hydraulic boundaries in mind; (ii) The ownership issue for on-farm I&D networks -- at present State property cannot be handed over to any non-government and legal entities at no cost; (iii) Poor conditions of on-farm irrigation infrastructure- - one of the main responsibilities of WUAs is to ensure efficient use of water and land resources, yet without adequate water; (iv) Lack of measuring systems and therefore it is hard to ensure economic water use; (v) Low

knowledge levels and capacity of WUA specialists in running WUA business; and (vi) Absence of material-technical resource base in WUAs.

144. The institutional problems of WUAs include: (i) Low level of ISF collection; (ii) Financial stability/viability of WUAs remains a main issue as financial sustainability of a WUA directly depends on financial stability of its farmer-members—yet it is difficult to expect financial viability at this stage of the overall reform process; (iii) Imperfect direct agreements/contracts on water delivery between WUAs and Water management organizations, and between WUA and water users that should take into consideration the interest of all sides; (iv) Majority of WUAs don't know how to properly operate water management organizations; (v) Failure to separate of functions of governance and management inside the WUAs; (vi) Methodology for taxation of collected fees by WUAs still remains unclear: in some places VAT is requested on all fees, in other places from those fees that are transferred to State organization for water management, and vice versa; and (vii) Barter transactions make it difficult for WUAs to be financially viable.

E. Equipment Availability for O&M

145. The construction organizations of the ALRI are the principal owners and operators of construction and heavy earthmoving equipment, such as draglines, bulldozers, tipper trucks and mobile cranes. Hence they are the ones best equipped and experienced to execute maintenance works. Almost all construction and earthmoving equipment in Tajikistan is Soviet Union made and has been in service for excessive time periods. Much has been written about the status and availability of general construction and heavy earthmoving equipment in the ARP Final Report.[9] Generally the age and operational status of equipment units is such that many are beyond repair, out of order or requiring repeated intensive services and repairs. A more recent report prepared by the ALRI indicates that around one-third of excavators (i.e. draglines) and less than one third of bulldozers are operational at the end of 2012.[10]

146. Suitability of equipment for O&M of I&D appears to have been of little importance when acquiring plant and machinery in the past. Rope operated draglines, the principal machine for desilting of drains and irrigation canals, often causes secondary level defects including: (i) lining damage and increases in concrete lining repairs; (ii) lowering of canal and drainage channel bed levels, leading to unwarranted increases in dead storage volumes; (iii) loss of bed gradient; (iv) loss of cross section shape, and hence; (v) changes in hydraulic efficiency; (vi) loss of land adjacent to canals and drains and used for access to canals and drains or for crop production.

147. The practice of using draglines for desilting activities cannot be discontinued immediately by ALRI as there are very few hydraulic excavators available in the open market. District and oblast organizations executing maintenance need to improve their understanding of what constitutes suitable equipment units and focus on this issue to improve their services to agricultural water user, to minimize losses resulting for the use of inappropriate equipment and to show agricultural water users that they actively pursue measures which reduce the cost of future maintenance and improved distribution system water management.

VIII. PRESENT CIS O&M EXPENDITURES

148. Since the year 1996, the ALRI collects ISFs from farms and reports increasing collection rates. This is a reassuring development as it provides funding to ALRI line offices

[9] Final Report, Volume 3, Supplementary Appendix B: Improvement of Irrigation and Drainage Component, ADB TA 3514-TAJ, 2001.

[10] Annual Report 2012, ALRI.

to implement maintenance of the off-farm I&D infrastructure. It remains to be seen if it also transforms the ALRI from a budget spending organization to one earning income through providing services to the agricultural sector.

A. Formats, Budget Items, and Expenditure Monitoring

149. All expenditure data provided by ALRI for review and analysis has been extracted from a standard format.[11] Ministries in Tajikistan are required to use when reporting on expenditures to the Government. Budgetary and expenditure items listed on the form are generally not grouped according to any spending categories, such as operation or maintenance. In the context of Tajikistan, where pump supported lifting of water for irrigation is a major concern, separate monitoring of budget allocations and expenditures for O&M of water pumping installations is more than opportune, it should be a must. Separating items related to pump irrigation would provide the information necessary for reviewing its costs in the context of the national economy, for establishing the economic cost of agricultural production on pump irrigation schemes, and for shifting agricultural production from high volume-low income crops to either low volume-high income or high volume-higher income crops. In this context it is interesting to note that ALRI is poorly in a position to support its expenditure records with a complementary and consistent record of revenue collection, particularly ISF collection. It would, therefore, be opportune to develop a consistent set of formats covering Government budget contributions to O&M, projected seasonal or annual ISF collection, actual annual revenue collection including ISFs, and a format for expenditure recording. It is understood that the Farm Debt Resolution and Policy Reform project recommended procurement and installation of financial software package for then ALRI to establish a consistent set of financial procedures at central, provincial and district level of ALRI.

150. Year 2013 annual expenditure data for the project area were collated by *raivodkhozes* and obtained from ALRI. Summary data are given in Tables 39 and 40 and detailed expenditures by line items in Attachment 1. Unit area expenditures for O&M related activities of *raivodkhozes* amount to TJS 15-43/ ha in 2003 that reach to TJS 81-106/ ha with weighted average of TJS 96.4/ha ($14.2/ha) in last three years. These values are largely in line with the national variations observed by the Farm Debt Resolution and Policy Reform Project. Not included, however, are the expenditures for O&M of pumping facilities.

Table 41: Unit Area O&M Expenditure in 2003

ALRI cost item	expenditure category	Kurgan Tube zone	Kulob zone
		Pyanj	Farkhor
		TJS	TJS
Total Annual Expenditures		**891,317**	**498,644**
gravity irrigation area	Ha	16,812	23,524
operation – gravity (TJS /ha)	O	0	1
maintenance – gravity (TJS/ ha)	M	27	20
pump irrigation area	Ha	4,173	9,595
operation – PS (TJS/ ha)	OP	44	0
maintenance – PS (TJS/ ha)	MP	60	0
Total annual O&M Expenditure TJS/ha	O,M,OP,MP	42.5	15.1

Source: ALRI and IRP TA consultant, July 2004.

[11] The format is coded in Russian language as "2-BX."

Table 42: Latest Unit Area O&M Expenditure in the Key District of CIS

Item	District	2012	2013	2014	Avg
O&M Expenditure TJS	Farkhor	1,905,567	3,068,905	2,168,442	2,380,971
	Hamadoni	1,013,989	1,169,272	1,212,320	1,131,860
	Vose	1,338,677	1,484,860	1,545,601	1,456,379
O&M Expenditure TJS/ha	Farkhor	85	136	96	106
	Hamadoni	73	84	87	81
	Vose	69	77	80	75

Source: ALRI 2015, PPTA Consultant 2015
Note: O&M expenditure (TJS/ha) for Vose was calculated using total irrigated land of 19,337ha, and not using CIS irrigated land of 6,397ha.

151. The ALRI reporting format "2-BX" does not distinguish between O&M related expenditures and neither between expenditures related to the gravity operated I&D works and those for the works facilitating pump irrigation. There is also a need to distinguish between O&M expenditures on flood embankments including flood risk management and O&M of irrigation water supply. For practical purposes expenditures have been categorized into four groups. Overall system operation expenditures, category "O" in Table 43 above and Attachment 1, excludes the cost of electricity for pump operation and thus comprises the following expenditure items, only:

line item(s) 7 and 9:	installation and maintenance of hydro-posts and other water measuring devices;
line item(s) 13:	telephone and radio communication;
line item(s) 24:	transportation costs,
line item(s) 35:	inspection of I&D infrastructure and PSs;
line item(s) 36:	guard services.

152. Similarly to the above, and with reference to ALRI reporting format "2-BX", maintenance cost items have been defined as category "M" in Table 44 and Attachment 1. Category "M" items exclude the cost of maintenance for pumping facilities including pump sets, penstocks, pump building and auxiliary works. Expenditure items categorized "M" include:

line item(s) 11:	Civil and production buildings;
line item(s) 15, 29, 31:	Canals and dikes without desilting/ sediment removal, and removal of sediment from canals and drains;
line item(s) 17:	Access roads;
line item(s) 22:	Wells (for I&D);
line item(s) 33, 34:	Hydro-structure protection and diversion works, and flood-control and bank protection works (banks).

153. Separating gravity from pump irrigation infrastructure allows to define two pump irrigation related expenditure items. With reference to ALRI reporting format "2-BX", all electricity expenditures are categorized "OP" (line item 21: electricity) and all maintenance expenditures for pump and transformer sub-stations are categorized "MP" (line item 19).

154. It is also suggested that the reporting format be recorded (i) in each irrigation system in each district (it seems that at present the current-style format has been recorded without distinguishing irrigation systems in each district that has to manage several irrigation

systems, which makes it difficult to see O&M status in each system); and (ii) separately from other O&M (for example, at present, State Institution “Chubek Channel” seems conducting O&M activities and recording O&M expenditures for both CIS main canal and Hamadoni flood protection embankment without distinguishing these two separated activities).

B. Salary Expenditures

155. A brief evaluation of annual salary expenditures (see Table 45 below) reveals that salary expenditure as percentage of total O&M expenditure is quite high – 21% to 26%.

Table 46: Salary Expenditure in CIS Districts (% of O&M Expenditure)

Districts	2012	2013	2014	Average
Hamadoni	25.57	25.21	26.14	25.64
Farkhor	20.56	16.15	27.35	21.35
Vose	23.32	23.51	30.26	25.70

C. Payments for Electricity Consumption

156. Unfortunately expenditure information on the operation of PSs in Farkhor district had not become available. Moreover, for Vose district, the electricity expanses available was used and find out that per ha electricity expenses are to the extent of TJS 32/ha as given in Table 47 below.

Table 48: Electricity Consumption in Vose District of CIS

Particulars	2012	2013	2014	Average
Electricity Expenditure TJS	568,914	331,141	317,666	405,907
Electricity Expenditure TJS/ha	44.3	25.8	24.7	32

Source: District ALRI, 2015.

D. Irrigation Service Fees and Operation and Maintenance Expenditure

157. The ISF for the project area has been fixed at TJS 0.0177/m.[3] However, as, currently, there is no arrangement for volumetric delivery of irrigation supplies, ISF has been calculated for each crop using the standard volume of water consumption. The ISF for various crops thus calculated, and WUA charges are given in Table 49 below.

Table 50: Irrigation Service Fees and WUA Service Charges

Crops	Irrigation Service Fees, TJS/ha	Service Charges of WUA, TJS/ha
Cotton	177	30
Wheat	38.94	30
Rice	654.9	30
Alfalfa	221.25	30
Melons	68.5	30
Maize Grain	159.3	30

Source: ALRI.

158. Data on ISF for the period 2012-2014 for three project districts covering more than 99% of the project area is given in Table 41 below.

Table 51: Irrigation Service Fee Collection in the Project Area
(for three project districts covering more than 99% of the project area)

District / Parameter	2012	2013	2014	Average
Hamadoni District				
Water delivered, 1000 m^3	53,995	65,922	77,538	65,818
Fee for water delivered @TJS0.0177/m3	955,712	1,166,819	1,372,423	1,164,985
ISF Collected	865,800	999,004	1,024,414	963,073
Collection efficiency	**91%**	**86%**	**75%**	**83%**
Farkhor District				
Water delivered, 1000 m^3	155,100	154,067	135,310	148,159
Fee for water delivered @TJS0.0177/m3	2,745,270	2,726,986	2,394,987	2,622,414
ISF Collected	844,952	749,862	1,368,375	987,730
Collection efficiency	**31%**	**27%**	**57%**	**38%**
Vose District				
Water delivered, 1000 m^3	65,596	82,439	84,238	77,424
Fee for water delivered @TJS0.0177/m3	1,161,049	1,459,170	1,491,013	1,370,411
ISF Collected	345,857	553,213	420,779	439,950
Collection efficiency	**30%**	**38%**	**28%**	**32%**
Total of three districts				
Water delivered, 1000 m^3	274,691	302,428	297,086	291,402
Fee for water delivered @TJS0.0177/m3	4,862,031	5,352,976	5,258,422	5,157,810
ISF Collected	2,056,609	2,302,079	2,813,568	2,390,752
Collection efficiency	**42%**	**43%**	**54%**	**46%**

Source: ALRI Head Office.

159. O&M data for the same area for 2014 is given in Table 42**.** It clearly indicates that the available O&M fund, both from government allocation as well as ISF, fall 61% short of O&M requirements. Such shortfall leads to deferred maintenance resulting in gradual decrease in productivity and thus requiring huge funds for periodic rehabilitation of the system. Thus there is a need to arrange adequate resources for O&M to sustain project benefits.

Table 52: Operation and Maintenance Expenses for 2014
(for three project districts covering more than 99% of the project area)

Item	Amount, $	Percent
Annual O&M Requirement	1,575,000	
Annual O&M Spending	608,486	39%
Sources of O&M financing		
Government Allocation	194,726	32%
ISF Collection	413,760	68%
Total	608,486	
Gap in O&M Financing	966,514	61%

Source: ALRI, 2015.

IX. Rational Strategy for Execution of System Maintenance

160. Present planning and execution of maintenance appears at best subjective but often erratic and unstructured. ALRI and its provincial and district level line offices need to apply agreed and structured approaches in determining maintenance requirements, execution and monitoring of works. It is noted that projects undertaken with funding from donor agencies or

NGOs consistently addressed the issue of inadequate maintenance in the context of sustainability, including proposals for improving maintenance execution and system monitoring.

A. Causes Leading to Maintenance and Defining Severity Categories

161. The natural environment and utilization of the I&D infrastructure are the major causes for system defects and hence the need for execution of maintenance. Whereas environmental processes, rainfall, wind, humidity, mudflows and landslides cannot be completely controlled, system operation greatly affects the rate of structure degradation, development of system deficiencies and system maintenance requirements. Appropriate design and operation procedures can reduce recurring maintenance requirements. Secondary damage to works results from use of poorly suited equipment but deployed in execution of maintenance and refers to the use of rope operated draglines for removal of sediment from drains, lined and unlined irrigation canals. The damage caused by draglines to the cross section of canals and drains, and the loss of agricultural land associated with such damage will have lost the national economy millions of Somoni and is now impossible to reverse. In many cases the damage is such that there is no excavation equipment at all which could now be used to execute removal of sediment without causing further damage.

162. The use of land for agricultural purposes is known to increase soil erosion. Removal of natural growth and soil cultivation together with naturally occurring rainfall and wind patterns creates the condition for increased soil erodibility and accelerated soil loss. Good agricultural and soil cultivation practices are major factors in limiting the unavoidable loss of soil from agricultural lands. Mono-cropping and poor soil aeration are factors contributing to increased soil erosion. Hence farmers throughout the country's irrigation area should be encouraged to regularly practice crop rotations including the use of nitrogen fixing legumes, which have a beneficial effect on soil structure in the upper horizon. Similarly, deep plowing (sub-soiling > 60 centimeter [cm]) would greatly improve the drainage status of the upper soil horizon, enhance leaching, permit the soil to dry out more rapidly, thus allowing for more timely seeding of cotton, and facilitating more vigorous and deeper root growth of the planted crop.

163. Maintenance has been defined and sub-divided in a rational manner by many, but categorizing maintenance is a matter of experience and choice and hence requires consensus amongst those involved in system monitoring, inspection and categorizing of works, planning and quantifying of maintenance. In this report and with due consideration to agricultural and fiscal calendar, the following division of I&D system maintenance has been adopted:

164. *Preventive maintenance and seasonal care taking* are carried out on a continuous basis and essential for maintaining smooth functioning of all system components. It is the lowest maintenance severity class and comprises of manually executed activities requiring minimal material cost but necessary to ensure that the system provides best services during the irrigation season. Tasks primarily include regular visits to all key system components for inspection of mechanical and electrical parts on structures, greasing mechanical parts, testing electrical installations, removing trash from dirt racks at PSs, canal and drainage structures, and removing plant growth from drains prior to commencement and during the irrigation season if necessary. Highest attention is to be paid water monitoring stations, identification and repair of defect metering devices including recalibration. The work requires little funding and commonly no equipment for earthmoving or lifting of heavy items. Execution of tasks requires highly disciplined and diligent staff which appreciates the need for providing best possible services to agricultural water users. The costs of preventive maintenance is largely hidden in establishment charges, because the work is undertaken by staff of the organization as part of normal duties. Commonly all tasks are accomplished by

water user organization members and staff of the *raivodkhozes*. Generally no contracting out of work is expected.

165. *Routine maintenance and regular services* are basic to sustainable system performance and operation, and commonly executed during non-irrigation periods. This intermittent severity class in maintenance refers to execution of planned works based on observations and inspections. Routine maintenance includes execution of activities at predetermined intervals such as manufacturer recommended machine and equipment services, recurring painting of mechanical works to protect against corrosion, scheduled removal of sediment from structures, canals and drains to prevent reductions in supply capacity, sealing leaks on structures and through embankments and earthwork on embankments to maintain freeboard and to avoid further deterioration. Most activities and works would be budgeted for on the basis of a regular carried out structure condition survey. If work would not be executed it will result in accelerated system deterioration, reductions in supply capacity during the next irrigation season, and gradual loss of command over land. Preventive maintenance and care taking activities, if deferred, are to be included under this category, too. Defective water measuring stations and metering devices shall be repaired and recalibrated annually. Work execution requires plant and equipment, particularly for work on embankments and in conjunction with pre-cast flume canals (latok). Work which does not require special skills may primarily be executed by members of a WUA or the farming community for on-farm I&D works. Work on the on-farm infrastructure requiring plant and equipment will be contracted out. Maintenance work on the off-farm infrastructure will primarily be done by agencies contracted to execute the work – preferably through a tendering process or a form of seasonal/ annual service agreement.

166. *Periodic maintenance and major repair work* execution are essential to ensure system serviceability of structures and equipment for the planned economic period of system components. Execution of maintenance will correct loss of component performance including regaining command over irrigable area. It is the highest severity class in maintenance and executed during non-irrigation periods. It includes all works which cannot be executed at an annual cycle and which occurs as a result of non-disastrous ad-hoc damage, manufacturer recommended major services of machinery and equipment and manufacturer recommended replacement schedules of wearing parts on pumps and engines, replacement of damaged mechanical parts on flow regulating structures, repair of concrete works on structures and canal lining, masonry, pitched rubble and gabion works on structure transitions, bank protections are included. The occurrence of such works is often the result of deferred routine maintenance, material weaknesses, poor manufacturing or construction quality and operation mishaps. Execution commonly requires considerable but foreseeable expenditures and hence can be budgeted for. Work to be executed requires skilled labor and heavy plant and equipment and will therefore be tendered out for both, the on-farm and the off-farm infrastructure or executed under a service agreement with a competent construction organization. WUA's may provide manual labor to contractors executing maintenance under a service agreement.

167. *Emergency repairs* are a special form of maintenance which, under normal conditions, is completely unforeseeable and involves the breakdown of equipment and structural collapse of works. Emergency situations may arise from extreme weather events, extensive flooding, earthquakes and similar events. Emergency works must be undertaken immediately to avoid partial or complete system shutdown and subsequent loss of agricultural production. Resource requirements are highly variable and may involve temporary measures and structures to maintain seasonal operationability of works. Depending severity and location of damage requiring emergency actions, works will either be the responsibility of the ALRI, the local Hukumat or the Ministry of Emergency Situations. Response to emergency situations is often affected by a low level of local disaster

preparedness and lack of immediately available funding. Emergency repairs are not considered further.

B. Agricultural Calendar and Execution of Maintenance

168. Maintenance must be carried out with due regard to the agricultural calendar. Agreement needs to be reached between the maintenance executing agency and farmers or WUAs representing agricultural water users about time, location and intensity of work to be executed. The aim must be to avoid or at least minimize constraining farmers' access to crop land for cultivation, crop husbandry and harvesting activities as it otherwise results in yield reductions if not yield losses and subsequently loss of seasonal income for farmers. Table 53 indicates principal periods for planning of system maintenance, inspections and execution of works. Throughout the project area, agricultural activities are minimal of not completely suspended during the period October to March and this constitutes the principle period for execution of system maintenance. Since this includes the winter months, the actual period available for work execution varies considerably and with the type of work to be done. Thus it will be necessary to complete all works within irrigation canal inverts and on pumping facilities before the onset of the irrigation season. Work on e.g. embankments and drains – provided planned properly and agreed with agricultural land users – may even be carried out during part or all of the irrigation season.

Table 54: Principal Activities and Periods for Execution of Maintenance

Maintenance Related Activity	Time indications	
	seasonal calendar	annual cycle
Monitoring performance of I&D water conveying works, VDW installations, water volume and flow measuring equipment, ancillary works	throughout leaching and irrigation season	February to October
Inspection of I&D canal works, VDW installations, water volume and flow measuring equipment, ancillary works	pre- and post-irrigation season	March, October/ November
Inspection of ancillary irrigation canal, VDW and PS related road network and appurtenance structures	Post- harvest/ drainage season	October/ November
Maintenance execution: service and care taking activities of electrical and mechanical installations	Predetermined intervals – not peak irrigation time	January to December
Maintenance execution: major irrigation canal and drainage channel related works	outside crop irrigation season	October to March/April

Source: ADB ADTA 4052-TAJ.

C. Infrastructure and Maintenance Execution Volumes

169. No detailed and readily available database about I&D infrastructure in Tajikistan exists. Neither the ALRI nor *oblevodkhozes* or *raivodkhozes* possess or maintain up to date inventories of schemes. The ALRI's institutional memory largely consists of a group of aging ALRI and line offices staff members and this group is rapidly decreasing. To collect reliable and consistent data would be a major exercise and would best be accomplished by scheme based agencies, WUAs or *raivodkhozes* in a manner required.

170. Presently available inventory date for project scheme and district areas are variable and difficult to verify. Where field information conflicts with other data sources, field information was deemed to be correct provided spot checks verified the first. If this did not remove uncertainties, reference was made to the most recent infrastructure inventory deemed comprehensive and reliable. This information dates back about twenty years to 1992. Infrastructure components and volumes for each project area were checked and if necessary determined using a pro rata approach (total irrigation area in region to project

irrigation area) to arrive at a comprehensive data set for estimating future maintenance requirements.

171. Past records of executed maintenance volumes of project districts provide poor guidance for determining expected future annual maintenance requirements. Recent and past records are at best partial collections of I&D repair requirements and consistently include volumes of deferred maintenance works. However, annual maintenance of gravity operated water distribution and evacuation networks primarily relates to two activities: (i) removal of sediment volumes from canals and drains, and (ii) repair of damage to concrete canal lining and structure repairs. For pumping facilities, maintenance is primarily related to servicing of pumps, engines, auxiliary works and pressure delivery pipelines.

D. Using Expenditures for Performance Monitoring

172. Charging agricultural water users for deliveries of water to farm boundaries requires improvement of resource management practices and calls for improvements in management of financial resources (primarily collected ISFs) and monitoring of expenditures for system operation but even more so for maintenance of I&D infrastructure.

173. The present reporting format used in ALRI (form 2-BX) to report quarterly and annually to the government of Tajikistan does not allow to easily distinguish between expenditures for irrigation system operation and those arising from maintenance of I&D works. The present terminology and use of the wording “operation” and “maintenance” is ambiguous and requires clarification, in particular when it comes to definition of requirements and allocation of expenditures in system operation and system maintenance. To further gain oversight of pump irrigation related cost and expenditures, a further sub-division should be introduced so that the use of funds and revenues, including all budget allocations, and collected ISFs as well all expenditures would be recorded under one of four categories:

- operation - denoted “O” – and relating to or the result of operating the I&D infrastructure for delivery of water to agricultural and other users but without the allocations and expenditures related to pumping water (electricity consumption and payments in particular) or operation of PSs;
- maintenance – denoted “M” – and primarily relating to execution of works on the I&D infrastructure but without the allocations and expenditures related to maintenance of PSs and delivery (pressure) pipes;
- pump operation – denoted “PO” – relates exclusively to revenues and expenditures for operation of pumps and pumping facilities when delivering of water to pump irrigation areas; and
- maintenance of pumping facilities – denoted “PM” – for revenues and expenditures related exclusively to work done on PSs, pump aggregates, delivery pipes, and auxiliary works.

174. With reference to the form 2-BX in use by the government of Tajikistan it is noticed that there are six items which would qualify as system operation expenditures and to be categorized “O”, 12 line items as system maintenance expenditure items categorized “M”, and one line item to be categorized “PO” and covering exclusively pump operation expenditure items, plus 2 line items monitoring all pump system maintenance expenditures and categorized “PM”.

E. Other Constraints Affecting Rational System Operation and Maintenance

175. Strategy development for system O&M is constrained by specialist terminology, engineering and construction standards, and original design assumptions of the existing I&D network. Irrigation canal and drainage layouts in Tajikistan are the result of design parameters which emphasized limited crop rotation, large scale mechanized field operations, and water supply driven crop production. Constructed gravity and pump I&D systems were designed to earn foreign currency at all costs as for cotton producing irrigation schemes in Central Asia or to meet the demand for agricultural produce within the internal market of the former Soviet Union. Development of irrigation schemes, therefore, did not have to meet the same stringent economic and financial criteria as schemes funded by western national banks and international funding agencies elsewhere. Developments in the recent past have invalidated the earlier valuation system. Hence, rehabilitation of I&D system needs go beyond simple structural rehabilitation of works to ensure that the invested capital supports a financially viable production system.

176. Privatization of land has created a large number of small and fewer medium sized holdings in addition to larger farms in CIS. Potentially, land permit holders are to choose the crops to be grown on the land they farm. However, the present layout of the irrigation network, the low density of farm and field level outlets together with a totally inadequate system for water measuring at all levels of the irrigation system compels farmers to jointly undertake land preparation and to adopt common field crops. Currently, this crop is cereal. In the medium to longer term the irrigation systems ability to support more flexible cropping patterns will be the key factor in determining the success of any I&D rehabilitation program. To move towards more rational management of irrigation schemes, it is necessary that a number of issues are being addressed, which may or may not require funding immediately or from within the ALRI. The following outlines some of the issues recommended for consideration.

1. Defining Gross and Net Irrigated and Drainage Area

177. Provided original and true to scale system design documents for I&D schemes would be available, these could provide a basis for determining gross and net irrigated and drainage areas. But they are not readily available and neither are land privatization records or cadastral mappings, which would offer alternative documents for determining gross and net irrigated areas. Availability of any such documents would improve the quality of total area water requirement assessments and thus help improving overall system water use efficiency.

178. Presently the term “irrigation area” is being referred to without being specific as to what land this denotes. For more transparent and rational monitoring of system performance and system O&M expenditures, the following terminology is suggested:

- Gravity irrigation area – the land continuously and exclusively under the command of the gravity operated irrigation infrastructure;
- Gravity irrigation area with supplementary or temporary supply of pumped water for irrigation during the cropping season, and
- Pump irrigation area – the land continuously or totally dependent on pumped water supply for crop production.

179. In addition to this general categorizing of irrigated land it is recommended to adopt the following terminology to define the:

- Gross irrigation area – the land which is under the command of the headworks of the water distribution system;
- Net irrigation area – the land under the command of the headworks or the water distribution system (the gross irrigation area) less all land permanently occupied by works and structures or allocated to non-agricultural uses such as settlements, and other public areas, but also the Right of Way (ROW) along canals and drains and which facilitates access during system O&M periods, or land recurrently used for construction of seasonal head ditches;
- Seasonal irrigation area – the part of the net irrigation area used for crop production during the growing season.

180. To adopt such a terminology will be instrumental in determining more realistic and accurate system performance data and in establishing actual expenditures and hence requirements for system O&M.

2. Monitoring Water Availability and Charging for Water Delivery

181. It has been mentioned in a number of cases that there is scope for improving I&D main system operation and water delivery efficiency. The general lack of consistent and verifiable water delivery monitoring data has been mentioned in various sections of the report. Concerns have been raised in the context of water delivery to farms for crop production, be it in terms of water volumes abstracted at headworks, delivered to farm boundaries, or in terms of water delivery charges levied by raivodkhozes. In this context it needs to be realized that successful introduction of ISFs hinges upon a transparent procedure for monitoring water volumes at all levels and an egalitarian practice in determining volumetric water charges. If there is no transparency about delivered water volumes, the farming population is likely not to cooperate in establishment.

182. In this context it needs to be realized that one measuring structures and hydro-posts are presently registered as assets on the off-farm and on-farm I&D systems for every 148 ha irrigation area, a very reasonable density of measuring structures. In reality however many if not most of these structures require “capital” repairs which implies that the structure has degraded so much that it has become inoperable or unuseable. Even though a detailed listing of inoperable measuring stations and dilapidated hydro-posts is not available within the ALRI or its line offices, secondary information such as requests for support to the Hydro-Geological Melioration Expedition and/or the Hydraulic and Land Reclamation Institute are ample evidence for the poor state of measuring installations in Tajikistan. Without any verifiable information accessible, it is reasonable to assume that no more than 20 per cent of initially installed measuring devices are presently operational in CIS. The density of operational measuring devices may be as low as one station for every 1,000 ha irrigation area, and this density is far too low for transparent monitoring of water deliveries to individual agricultural water users or farms.

3. Hydrologic Units

183. The existing I&D infrastructure constitutes a complex and hierarchical canal network. To create a sound basis for irrigation system management and canal operation, WUA should be re-organized/established on hydrologic boundaries so that their territorial boundaries coincide with the limits of the irrigation perimeter.

184. A more natural development would be the formation of tertiary level (on-farm) canal groups. A number of such groups would then form an organizational structure at a higher level canal such as a secondary level distributor. In this way a Water Users’ Organization (WUO) could attain a rational and internally egalitarian structure which would be in line with

the initial purpose of WUO formation, namely efficient O&M of the water distribution infrastructure for irrigated crop production including effective removal and disposal of drainage water on behalf of its members.

185. To rationalize operation of secondary (or off-farm) canals and major (off-farm) drainage works, the formation of WUAs at secondary canal level would indeed be advantageous provided such organizations will be allowed to become equal partners to raivodkhozes and other district level operating organizations of the ALRI.

186. Once WUAs have been formed at secondary canal and been operational for some time, a number of them might wish to establish a union or federation of WUAs at the level of a main canal with a water intake point on a river. Such an organization would best comprise of all water users under the command of the intake structure and including industrial and domestic water users besides the agricultural ones. The major functions of such an organization would include the collection of information with regard to main canal operation, assessment of annual and seasonal water requirements for irrigated crop production and leaching, and the monitoring of actual main canal supply volumes on behalf of the union or federation members. Such a development would promote a shift from geographic boundaries to hydraulic ones for water management and thus be in line with the intentions of the ALRI to introduce watershed basin management in Tajikistan.

4. Irrigation Scheme Inventory and National I&D Database

187. Development of electronic equipment facilitates convenient data storage and efficient database management. For ALRI and its line offices at oblast and raion level to maintain accurate information about the status of I&D infrastructure works, a comprehensive inventory should be established and recorded as an electronic database. Such a database should be compiled about each irrigation scheme and should include but not necessarily be limited to the following data:

- Division of scheme area into exclusively gravity irrigation area, gravity irrigation area with supplementary pump irrigation supply, and irrigation area exclusively receiving pumped water for irrigation in hectare;
- Net irrigation area in hectare, with a provision to monitor seasonally cropped area in hectare;
- Length of canals in kilometer by conveyance capacity and type of canal invert (earth, concrete lined, pre-cast flumes);
- Listing of hydraulic structures by location (PK) and type, with or without mechanical or electrical flow regulating device(s);
- Listing of farm or field turnouts by canal and location (PK);
- Listing of PSs by location, pumping capacity, number of aggregates, and associated pressure pipes;
- Drainage areas in hectare by type such as subsurface field drainage, open field drains, open collector drains;
- Length of drainage in kilometer by type such as subsurface field drainage, open field drains, open collector drains; and
- Listing of structures on drains by location and type, with or without mechanical flow regulating devices;

188. Ideally the scheme database will be complemented by scheme layout drawing, either a schematic one or a drawing to scale showing the location of major infrastructure items.

This drawing would be stored electronically. If possible the information stored in the database would be linked to software such as Map-Info, Arc-Info or Arc-View suitable for GIS mapping.

5. Benchmarking and Rapid Appraisal Process (RAP)

189. Benchmarking in the words of International Programme for Technology and Research in I&D (IPTRID) (UN Food and Agriculture Organization) is “a systematic process for securing continual improvement through comparison with relevant and achievable internal and external norms and standards”.[12] The aim of benchmarking is to improve the performance of an organization or irrigation project by comparing its mission and objectives with previous performance and setting of desired future targets. It is management tool used already in other countries, in industry as well as public and private sector organizations. Benchmarking thus promotes change so that an organization or project can achieve its objectives and can move from one position to a better position. It is highlighted that “those responsible within the organization (project or irrigation scheme) for the benchmarking program have the authority to bring about change; the change process is fully integrated within the organization’s management processes and procedures.”[13]

190. Benchmarking has its origin in the corporate business sector interested in gauging, and subsequently improving, its performance relative to their key competitors. Studying a key competitors’ outputs, and the processes used to achieve those outputs, other organizations have been able to adopt best management practices and enhance their own. In some cases organizations have done so well that they have, in turn, become the organization that others use as a benchmark. The scope of the benchmarking activity is determined by the objectives and scale pursued in finding “best management practices”. In any system, such as an irrigation network, there are: inputs, processes, outputs, and impacts, and these are used to measure system performance, i.e. the efficiency with which inputs will be converted to outputs, and the potential impacts that (i) the use of inputs (resources) might have and (ii) the outputs might have on the wider environment.

191. The Rapid Appraisal Process (RAP) for irrigation projects is supplementary to the benchmarking process and has been described as “a process of collection and analysis of data both in the office and in the field. The process examines external inputs such as water supplies, and outputs such as water destinations (ET, surface runoff, etc.). it provides a systematic examination of the hardware and processes used to convey and distribute water internally to all levels within the project (from the source to the fields). External indicators and internal indicators are developed to provide (i) a baseline of information for comparison against future performance after modernization, (ii) benchmarking for comparison against other irrigation projects, and (iii) a basis for making specific recommendations for modernization and improvement of water delivery service.”[14]

192. The method as presented in the reference cited in footnote 14 is a tool and guideline to practitioners evaluating irrigation schemes for the purpose of system rehabilitation, modernization and execution of maintenance.

193. The PPTA team tried to assess irrigation performance at on-farm as well as system-level using remote sensing methodology (Consultant final report Appendix 6). This could have been a very useful tool for M&E and benchmarking. However, this could not be effectively utilized due to poor ground truthing information, particularly the flow records. It is

[12] Guidelines for Benchmarking Performance in the Irrigation and Drainage Sector, IPTRID Secretariat, FAO, Rome 2001.
[13] See footnote 12, page 1.
[14] Rapid Appraisal Process (RAP) and Benchmarking – Explanations and Tools, FAO Regional Office for Asia and the Pacific, Bangkok Thailand, and World Bank Irrigation Institutions Window, October 2002.

recommended that this methodology be fully developed during the implementation stage and utilized for M&E.

X. PLAN FOR A SUSTAINABLE O&M SYSTEM

194. Sustainable O&M is clearly vital to the long-term success of the modernization project. Sustainability is built into the plans at several levels. For the major structures of the CIS, (sedimentation pond, main canals, PSs etc.) the responsibility for O&M will remain with the regional structure of ALRI. The capacity of the WUAs will be strengthened and their staff trained to undertake O&M of the local hydraulic and on-farm structures as well as facilitate collect ISFs.

A. Estimated O&M Expanses for Sediment Handling

195. O&M expanses for sediment handling are estimated for the following project scenarios.

- **Present and Future without-Project Scenario:** For calculation of sediment load in the CIS, the recorded flows have been reduced to 63.2% to adjust for over-registering as discussed in Appendix 4. It is further assume that the system will continue working without sediment excluding basin but ALRI will get it funded from other sources in future and do the silt removal through outsourced agencies at higher cost; and
- **Future with-project Scenario:** It is assume that project will fund the construction of the sediment excluding basin and heavy machinery for sedimentation removal from the sediment excluding basin as well as from the canals.

196. With the above assumptions, the O&M costs for sediment handling for the above project scenarios are estimated at $23.78/ha under the present and future without-project scenarios and will drastically reduce to $1.80/ha under the with-project scenario. Details of calculations are given in Table 55 below.

Table 55: Annual Sediment Handling Costs Under Various Project Scenarios

S. No.	Item	%	Units	Quantity	Unit Rate, $	Cost, $
PRESENT WITHOUT-PROJECT SCENARIO						
1	Total volume of sediment entering CIS		m^3	456,643		
2	Volume settling in canal system (90%)	90.0%	m^3	410,979		
3	Volume settling in the fields (10%)	10.0%	m^3	45,664		
4	Cost of sediment removal from canals (using equipment from the market)		m^3	410,979	2.50	1,027,447
5	Command area		Ha	43,210		
6	Cost of sediment handling per unit area		$/ha			23.78
FUTURE WITH-PPROJECT SCENARIO						
7	Total volume of sediments entering CIS		m^3	731,353		
8	Sediment removed by hydraulic flushing	70.0%		511,947		
9	Sediment settling in the sediment excluding basin	15.0%		109,702		
10	Sediment entering the CIS	15.0%		109,702		
11	Volume of sediments settling in canals	7.5%	m^3	54,851		
12	Volume of sediments settling in the fields	7.5%	m^3	54,851		
13	Cost of sediment removal from sediment excluding basin (using project-supplied equipment)			109,702	0.55	60,336
14	Cost of sediment removal from canals (using project-supplied equipment)		m^3	54,851	0.55	30,168

S. No.	Item	%	Units	Quantity	Unit Rate, $	Cost, $
15	Total cost of sediment handling					90,504
16	Command area		Ha	50,163		
17	Cost of sediment handling per unit area		$/ha			1.80

Notes: Sediment removal rates in the with-project, without-project, future, and present scenario cases have been based upon the actual expenditure of Hamadoni and Farkhor ALRI for O&M.

197. It is envisaged that out of present project funding for the sediment settling basin, the sediment flow in the canal will be less and hence work volume for sediment removal in canal and drainage will be reduced significantly.

B. Pumped Irrigation Systems Operations and Maintenance Costs

198. About 14,344 ha area of CIS was designed to be irrigated by water pumped by 102 pumps arranged in 20 groups in Farkhor, Vose, and Kulob districts. The pumping head varies from 8.5 m to 177.5 m. Some areas need 2-3 stages of pumping. The combined design pumping capacity of the 102 pumps was 84.7 cubic meter per second (cumec). Currently, many pumps are totally out of operation and, the remaining are in poor shape. The total pumping capacity of currently operating pumps is about 29 cumec (about 34% of the design capacity). The pumps presently in working condition, suffer from accelerated deterioration because high concentration of sediments in water and lack of repair facilities. The overall efficiency of the current pumping units is not more than 50% whereas the new pumping unit with efficiency exceeding 75% are available.

199. On the average, one hectare of pumped area requires 20,432 m^3 of water for the proposed cropping pattern for pumped areas; 87.2% during May-September and 12.8% during October-April. The electric energy consumed to irrigate one hectare of irrigated area will be directly proportional to the pumping head. For the weighted average head of 66 m, the average energy consumed per ha is estimated at 3,675 kwh. The annual average O&M cost of pumping is estimated at $49.69 at the current power tariff for the agriculture sector (**Table 56**).

Table 56: Average Cost of Pumping Under the With-Project Scenario

S. No	Item	Unit	Value
1	Annual water requirements	m^3/ha	20,432
2	Water pumped during May-Sep	%	87.2%
3	Water pumped during Oct-Apr	%	12.8%
4	Weighted average head	M	66
5	Pumping unit efficiency	%	75%
6	Annual energy requirement	Kwh	3,675
7	Current tariff (May-Sep)[a]	$/kwh	0.0044
8	Current tariff (Oct-Apr)[a]	$/kwh	0.0164
9	Average annual cost of pumping	$/ha	21.81
10	Annual O&M cost (other than energy) @2% of investment cost	$/ha	27.88
11	**Total O&M Costs**	**$/ha**	**49.69**

[a] Per Government of Tajikistan agreement with ADB in ADB-financed *Wholesale Metering and Transmission Reinforcement Project* approved in November 2014 (Schedule 4 of the Loan Agreement).

C. Total O&M Costs under the With- and Without-Project Scenarios

200. The total O&M costs under the with-project scenario are estimated at $24.89/ha for the gravity system and $74.49/ha for the pumped irrigation system. The without-project O&M

costs for gravity system are estimated at $48.78/ha of which half is for sediment handling. The calculations are given in **Table 57** below.

Table 57: Estimated Total O&M Costs

S. No.	Item	O&M Cost, $ per ha		
		Future With-Project		Future Without-Project
		Gravity-fed system	Pump-fed system	Gravity-fed system
1	Cost of sediment handling	1.80	1.80	23.78
2	Routine O&M cost	15	15	15
3	Other maintenance costs	8	8	10
4	Pumping-related costs		49.69	
5	**Total O&M costs**	**24.89**	**74.49**	**48.78**

Notes: 1. Total routine O&M costs are based on actual expenditures in Hamadoni and Farkhor districts.
2. Other maintenance costs indicate the required regular O&M costs for concrete works and hydraulic structures. The current annual expenditure on this item is $1/ha.

201. The routine O&M cost of $15.0/ha is for the gravity system under the rehabilitated infrastructure and is applicable to the entire system as the pumped systems also draw water from the gravity system. The total O&M cost for gravity-fed area of 35,819 ha is thus estimated at $891,535 and for 14,344 ha pumps-fed area is estimated at $1,069,485. The annual total O&M cost of the entire CIS for both gravity and pumped systems is thus estimated at $1,960,020 i.e., about $39.07/ha.

D. Proposed Strategy for Financing O&M Costs

1. General Approach

a. Need for Full Funding of O&M Cost

202. The foremost point is that enough funds should be made available for full financing of O&M costs to prevent the system falling back to deferred maintenance situation. The sources of funds are the government funding and ISFs.

b. Beneficiaries to be the Ultimate Financiers

203. It is fair to expect that the beneficiaries should pay at least the full O&M costs. It is, however, a social issue and depends very much on their capacity and will to pay. On the other hand, the beneficiaries are justifies in demanding the supply of adequate amount of water at proper time which, under the current situation of deteriorated water metering and management system, cannot be complied with. Also, under the dilapidated infrastructure and almost no flow measurement and reliable records, ALRI cannot claim it has supplied the right amount of water at the right time. A check on the flow by the TA revealed that ALRI is over-registering the flows by about 58%. The fact of poor delivery is evident from the poor crop yields and farmers' resistance to invest in expensive inputs considering the risk of crop failure due to poor irrigation water delivery.

204. The situation is likely to improve considerably by various project interventions. With sediment excluding basin, the annual cost of sediment handling is likely to reduce from $36.45 to $3.77 per ha. With modernization of I&D infrastructure, and strengthening capacity of local agencies, irrigation water supply is expected to improve significantly with much less requirement of funds for O&M.

205. With the implementation of Output 3, the water resources management and farming practiced are likely to improve leading to cultivation of high value crops, more intensive crop production, and high crop yield resulting in increased farmer's income and thus more capacity to pay for O&M. With an average farm size of 0.5 ha in the command areas and

average rural Tajikistan family size of five people, a farm household is expected to get an increase in his/her income by $3,362.5 per annum, whereas per capita income in the project beneficiary household will increase by about $672.5 per annum. Possible re-organization and establishment of new WUAs on hydrologic boundaries and their capacity building and training of their officials and staff will facilitate better coordination between the agencies and the beneficiaries and will increase collection efficiency of ISF from current 46% (average collection rate in three district during 2012–2014) to 80% at the project completion.

206. Under the with-project scenario, about 737.7million m^3 (78% of the average annual diversion of 945.8 million m^3) is expected to be delivered at the farm gate. At the current ISF rate of TJS0.0177/m^3, it will result in collection of annual TJS13.05 ($1.920 million) (with 100% collection efficiency) against the estimated total annual estimated O&M expenses of $1.960 million for both gravity- and pump-fed system including the cost of pumping. Thus, with current water rate (i.e., TJS0.0177/m^3 or TJS30/ha), even 100 collection efficiency will not fully meet the total O&M requirements of the project system. This clearly indicates needs of the increase of ISF rates which should be fully paid by cash[15] and for continued government support at least in the short to medium term till ISF rates are increased.

c. Differential Billing for Pumped Areas

207. According to Government Decree 125 dated February 27, 2014, ALRI has been mandated to "establishing differentiated tariffs for water supply services, taking into account the market cost of inputs for O&M of irrigation facilities." Thus, it looks fair to introduce differential billing considering that O&M cost of the pumped-fed systems is almost of the gravity-fed systems. However, it is inappropriate under the current circumstance to charge higher tariff to the pump-fed system.

208. Field evidence and report of World Food Programme (Appendix of the PPTA consultant report) suggest that the pumped-area yields and production are less than those of gravity-fed system and the prevalence of poverty is higher in pump-fed areas. This is because of inadequate and erratic irrigation water supply from the dilapidated pumping system and frequent cutoffs in power supply. Thus, it would be prudent to give special incentive to the pump-fed areas to increase their productivity through introduction of high value crops and high efficiency irrigation system, better seeds, and better water and farm management technologies which will be introduces through Output 3 under the Project. Only after it is established that they have achieved returns higher than those of gravity-fed systems (probably five years after project completion), differential ISF may be introduces.

209. It is timely to explore alternate irrigation water supply sources and delivery systems for un-targeted pump-fed systems to minimize the cost of water delivery under the Project.

2. Proposed O&M Financing Plan

a. Availability of Adequate Amount of Funds for Proper O&M

210. To realize full benefits and avoid deferred maintenance, following are required.

- WUAs should ensure O&M of the on-farm facilities by the beneficiaries either by the beneficiaries themselves or by the WUAs but to be paid for by the beneficiaries, estimated at $10/ha;
- ISF rate will need to be increased to reasonable levels with due consideration to the beneficiaries' capacity for payment. Thus, the magnitude of increase should be

[15] To date, in Tajikistan ISF payment include a significant share (66%) of payments in labor and in-kind, which are difficult to convert into real cash.

assessed carefully and implemented gradually. Under the Project, 100% increase of the ISF rate from TJS0.0177/m^3 or TJS30/ha to TJS0.0354/m^3 or TJS60/ha in CIS service area without differential ISF rates between gravity-fed and pumped-fed irrigation is proposed. Considering expected increase in farm income, the proposed level of ISF rate is considered appropriate and affordable;

- Measures should be implemented for achieving highest collection rates. This would imply better services ie supply of agreed amount of water on agreed schedule, proper system O&M, stronger WUAs with well-trained staff, and incentives for higher collection rates. Under the Project, the increase in collection efficiency of ISF from current 46% to 80% is expected with the project interventions;
- The beneficiaries should be required to pay in cash rather than in kind. Currently, a significant part of ISF is collected in kind which is a reason for low collection; and
- Considering that the current low ISF collection efficiency and low ISF rate, the Government will be required to continue providing and increase budgetary support of O&M activities at least in short to medium terms. Under the Project, 100% increase of budget allocation from $194,726 in 2014 to $389,452 is proposed. An indicator of good system performance would be gradual reduction in budgetary support.

211. With above measures, required estimated O&M cost will be fully covered by available O&M fund. The summary of the projected balance of O&M with project and with proposed increase of both ISF and government budget allocation is provided in Table 58.

Table 59: O&M Assessment of CIS (Current vs Target)

	Current (in 2014)	Target (in 2020)	Remarks
Gravity irrigation	31,247 ha	35,819 ha	
Pump irrigation	11,963 ha	14,344 ha	
Total irrigation	**43,210 ha**	**50,163 ha**	
Major crops	36% for cotton 39% for wheat	32% for cotton 32% for wheat	
Requirement			
Estimated required O&M cost	$49/ha (gravity) $99/ha (pump) **$63/ha (combined)** $2.70 million in total	$25/ha (gravity) $75/ha (pump) **$39/ha (combined)** $1.96 million in total	Required O&M reduced drastically due to proposed removal of sedimentation
Availability			
Applied ISF	$18/ha (TJS0.0177/$m^3$ in 2014)	$36/ha (TJS0.0354/$m^3$ from 2017)	100% increase as proposed in covenant
ISF collection rate	54% $0.42 million in total	80% $1.57 million in total	Expected to be achieved through project
Estimated ISF collection	$9.7/ha	$28.8/ha	
Gov budget allocation for O&M/year	$4.5/ha $194,726 (2014)	$9.0/ha $389,452 (from 2016)	100% increase as proposed in covenant
Availability (total)	**$14.2/ha**	**$37.8/ha**	
Balance	-$48.8/ha	-$1.2/ha	

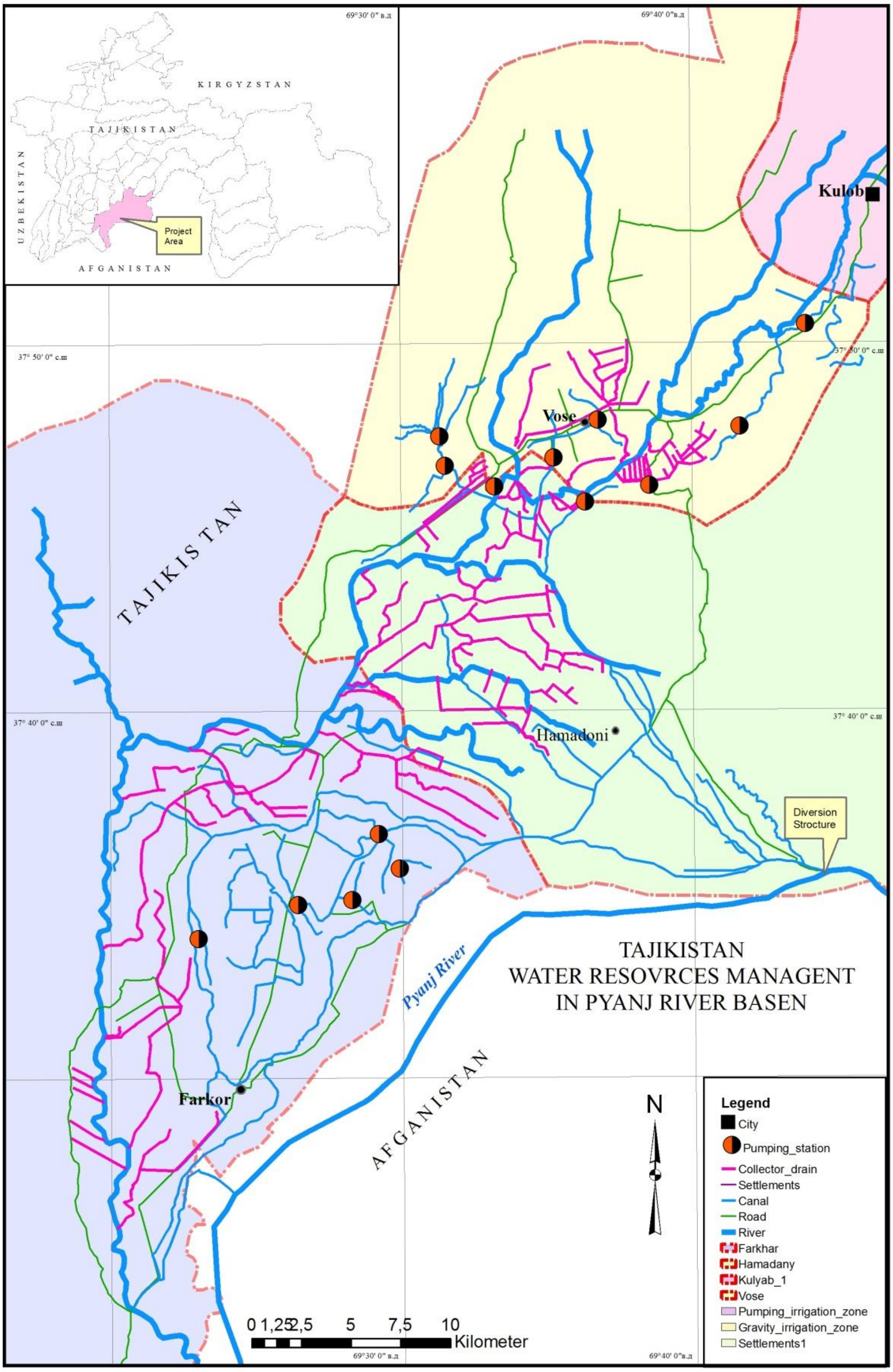
212. With above measures, required estimated O&M cost will be fully covered by available O&M fund. The summary of O&M assessment is provided in Table 48.

b. Actions Required During Project Implementation

213. The O&M balance assessment need to be updated and required O&M cost will be reassessed by ALRI at the time of completion of the modernization and rehabilitation works to develop realistic and detailed O&M plan.

214. Then, updated O&M plan including the plan to increases of ISF and the government budget allocation will be reviewed and confirmed by ADB at least one year before project completion. Finally, the government has to approve the O&M plan before project completion by issuance of government resolution.

Figure 1: General Layout of Chubek Irrigation System



Attachment 1

Table 60: Detailed O&M Expenditures in 2003 in project scheme and district areas

(TJS)

MWRLR line nos. form 2-BX	MWRLR expenditure item	expenditure category	Sughd oblast Asht-1 TJS	Kurgan Tube Panj TJS	Kulob zone Farkhor TJS	Badakh shan AO TJS	Dushanbe Inter-Rayon Vahdat TJS
1	2	3	4	5	6	7	8
I(6)	Salaries O&M staff of departments and sections	O&M	47,264	251,630	48,854	37,759	135,790
II	Operational charges and minor repairs expenditures		1,346,569	639,687	330,826	55,231	396,632
7	Hydro-structures	M	1,206	38,426	11,257	172	6,000
9	Water gauges (hydro-posts)	M	2,561	16,941	3,124	135	4,000
11	Civil and production buildings	M	2,800	453	2,906	4,800	304
13	Communication facilities	O	2,827	0	909	0	0
15	canals and dikes (without desilting/ sediment removal)	M	2,615	0	30,958	3,800	20,968
17	Access roads	M	0	0	5,226	0	0
19	PS and transformer stations	MP	207,437	250,003	0	2,950	45,220
21	electric power	OP	1,059,140	182,614	0	1,172	160,560
22	wells (I&D)	M	7,977	0	3,371	0	0
24	Transport facilities	O	23,038	0	9,007	4,104	42,000
29+31	Desilting of canals and drains	M	21,907	149,961	171,057	15,399	89,500
33	Hydro-structure protection and diversion works	M	11,743	0	88,630	22,699	27,866
34	Flood-control and bank protecting works (banks)	M	0	0	2,365	0	0
35	Inspection of dams, canals and substations	O	0	1,289	918	0	0
36	Guard services	O	3,318	0	1,097	0	214
III(42)	Other expenditures	O&M	70,130	0	118,964	6,300	118,608
	Total		1,463,963	891,317	498,644	99,290	651,030
Summary Calculation - Expenditures by category							
1	salaries (O)	O	4,799	710	1,762	2,867	24,282
2	other (O)	O	7,120	0	4,290	478	21,209
3	salaries (M)	M	42,465	250,920	47,092	34,892	111,508
4	other (M)	M	63,010	0	114,674	5,822	97,399
5	salaries O&M		47,264	251,630	48,854	37,759	135,790
6	other O&M		70,130	0	118,964	6,300	118,608
7	operation	O	29,183	1,289	11,931	4,104	42,214
8	maintenance w/out PS	M	50,809	205,781	318,894	47,005	148,638
9	electricity for PS	OP	1,059,140	182,614	0	1,172	160,560
10	maintenance of PS	MP	207,437	250,003	0	2,950	45,220
11	Total annual expenditures		1,463,963	891,317	498,644	99,290	651,030

Source: Then MWRLR 2004.

Table 61: Farkhor District LRI (FarkhorVodKhoz)

№	Item	Unit	From the state budget 2012	2013	2014	From ISFs 2012	2013	2014
	Irrigation water volume delivered	1000 m^3				155100	154,067	136,310
	Fees for water delivery services	TJS						
						Operation and maintenance costs		
1	Wages	TJS				391,737	495,541	593,041
2	Social security funds	TJS				29,074	57,115	84,438
3	Stationery	TJS				4,273	5,400	7,200
4	Office keeping costs	TJS				5,181	4,000	5,100
5	Travel per diems	TJS				4,062	4,348	4,410
6	Petrol/diesel	TJS				398,036	1,076,120	454,329
7	Contracts	TJS						
8	Training	TJS						
9	Meetings	TJS						
10	Other costs	TJS				6,200	6,800	4,000
11	Taxes	TJS				640,205	1,027,115	724,293
12	Electricity	TJS				4,800	6,500	6,200
13	Buildings maintenance	TJS						
14	Vehicle maintenance	TJS						
15	Telecommunications	TJS				800	900	800
16	Equipment purchase	TJS				411,199	373,066	274,631
17	Machinery purchase	TJS						
18	Support to the central authorities	TJS				10,000	12,000	10,000
19	Maintenance of founding assets	TJS						
	TOTAL COST	TJS				1,905,567	3,068,905	2,168,442

Source: District ALRI.

Table 62: Hamadoni District LRI (Hamadoni VodKhoz)

№	Item	Unit	From the state budget 2012	2013	2014	From ISFs 2012	2013	2014
	Irrigation water volume delivered	1000. m^3				53,995	65,922	77,538
	Fees for water delivery services	TJS				715,535	832,289	1,037,906
Operation and maintenance costs								
1	Wages	TJS	106,338	117,046	137,764	152,912	177,689	179,166
2	Social security funds	TJS	24,751	33,222	34,440	38,228	44,422	54,791
3	Stationery	TJS	1,230	1,300	1,000	1,200	1,520	4,326
4	Office keeping costs	TJS	1,000	1,000	500	800	2,440	
5	Travel perdiems	TJS	530	530	366	5,835	4,661	4,690
6	Petrol/diesel	TJS		1,000	2,904	138,256	298,036	448,236
7	Contracts	TJS	-	100		535		
8	Training	TJS	100			510	1,250	
9	Meetings	TJS	200				1,100	
10	Other costs	TJS	10,000	10,000	634	4,168	5,140	15,730
11	Taxes	TJS				388,420	392,324	297,367
12	Electricity	TJS	10,000	10,000	7,299	4,076	3,900	2,300
13	Buildings maintenance	TJS				30,100	19,953	500
14	Vehicle maintenance	TJS	40	70		27,200		
15	Telecommunications	TJS	3,000	5,000	2,999	3,816	4,000	
16	Equipment purchase	TJS						
17	Machinery purchase	TJS				28,300		15,000
18	Support to the central authorities	TJS				41,450	28,969	15,808
19	Maintenance of founding assets	TJS						
	TOTAL COST	TJS	**148,189**	**170,268**	**187,906**	**865,800**	**999,004**	**1,024,414**

Source: District ALRI.

Table 63: Chubek Canal (responsible for the head regulator and main canals)

№	Item	Unit	From the state budget			From ISFs		
			2012	2013	2014	2012	2013	2014
	Irrigation water volume delivered	1000 m^3				93,000	930,000	930,000
	Fees for water delivery services	TJS				235,400	166,551	186,022
Operation and maintenance costs								
1	Wages	TJS				100,560	116,109	132,696
2	Social security funds	TJS				25,145	29,027	33,174
3	Stationery	TJS				1,000	1,000	1,000
4	Office keeping costs	TJS				1,000	1,000	1,500
5	Travel perdiems	TJS				2,340	2,340	977
6	Petrol/diesel	TJS				70,000	70,000	70,000
7	Contracts	TJS						
8	Training	TJS				100		
9	Meetings	TJS				500		
10	Other costs	TJS						
11	Taxes	TJS						
12	Electricity	TJS				7,000	7,000	7,935
13	Buildings maintenance	TJS				935	935	
14	Vehicle maintenance	TJS				15,000	400	
15	Telecommunications	TJS				1,740	1,740	1,740
16	Equipment purchase	TJS				80		
17	Machinery purchase	TJS						
18	Support to the central authorities	TJS						
19	Maintenance of founding assets	TJS						
	TOTAL COST	TJS				**235,400**	**166,551**	**186,022**

Source: District ALRI.

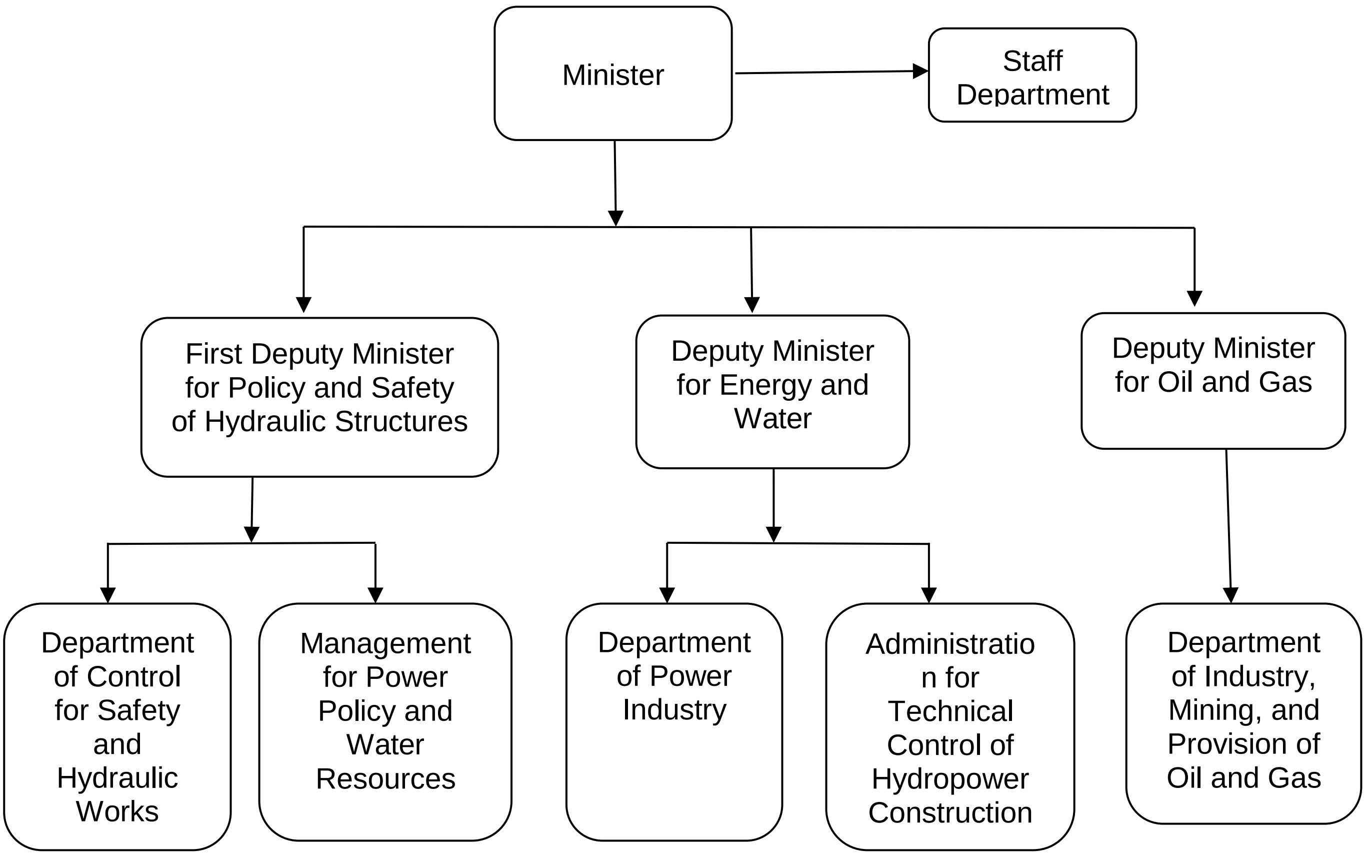
Table 64: Vose District LRI (VoseVodKhoz)

№ п/п	Item	Unit	From the state budget			From ISFs		
			2012	2013	2014	2012	2013	2014
	Irrigation water volume delivered	1000 m^3				65,596	82,439	84,239
	Fees for water delivery services	TJS				1161,049	1,310,780	1,236,585
		Operation and maintenance costs						
1	Wages	TJS	113,652	125,000	233,880	198,539	224,143	233,880
2	Social security funds	TJS	28,416	31,250	5,470	49,925	56,035	58,470
3	Stationery	TJS	1,300	1,300	1,300	1,625	1,834	1,731
4	Office keeping costs	TJS	1,000	1,000	3,000	4,644	5,242	4,943
5	Travel perdiems	TJS	360	360	200	5,805	6,553	6,182
6	Petrol/diesel	TJS	10,000	10,000		69,962	79,659	85,160
7	Contracts	TJS						
8	Training	TJS	100	100		348	392	
9	Meetings	TJS	200			58	65	
10	Other costs	TJS				12,771	14,418	
11	Taxes	TJS	1,000	1,000		754	851	
12	Electricity	TJS	10,000	10,000	7,666	284,457	321,141	310,000
13	Buildings maintenance	TJS	5,000		1,500	71,935	81,268	78,822
14	Vehicle maintenance	TJS	100	70		12,171	13,740	
15	Telecommunications	TJS	3,000	3,000	3,000	4,644	5,241	4,944
16	Equipment purchase	TJS	3,500			40,172	45,352	30,,000
17	Machinery purchase	TJS				5,805	6,553	
18	Support to the central authorities	TJS				127,715		136,021
19	Maintenance of founding assets	TJS				269,369	304,107	286,374
	TOTAL COST	TJS	**177,628**	**174,080**	**309,016**	**1,161,049**	**1,310,780**	**1,236,585**

Source: District ALRI.

Attachment 2

Figure 9: Organizational Structure of Ministry of Energy and Water Resources



Source: ALRI.

Figure 10: Organizational Structure of Agency for Land Reclamation and Irrigation

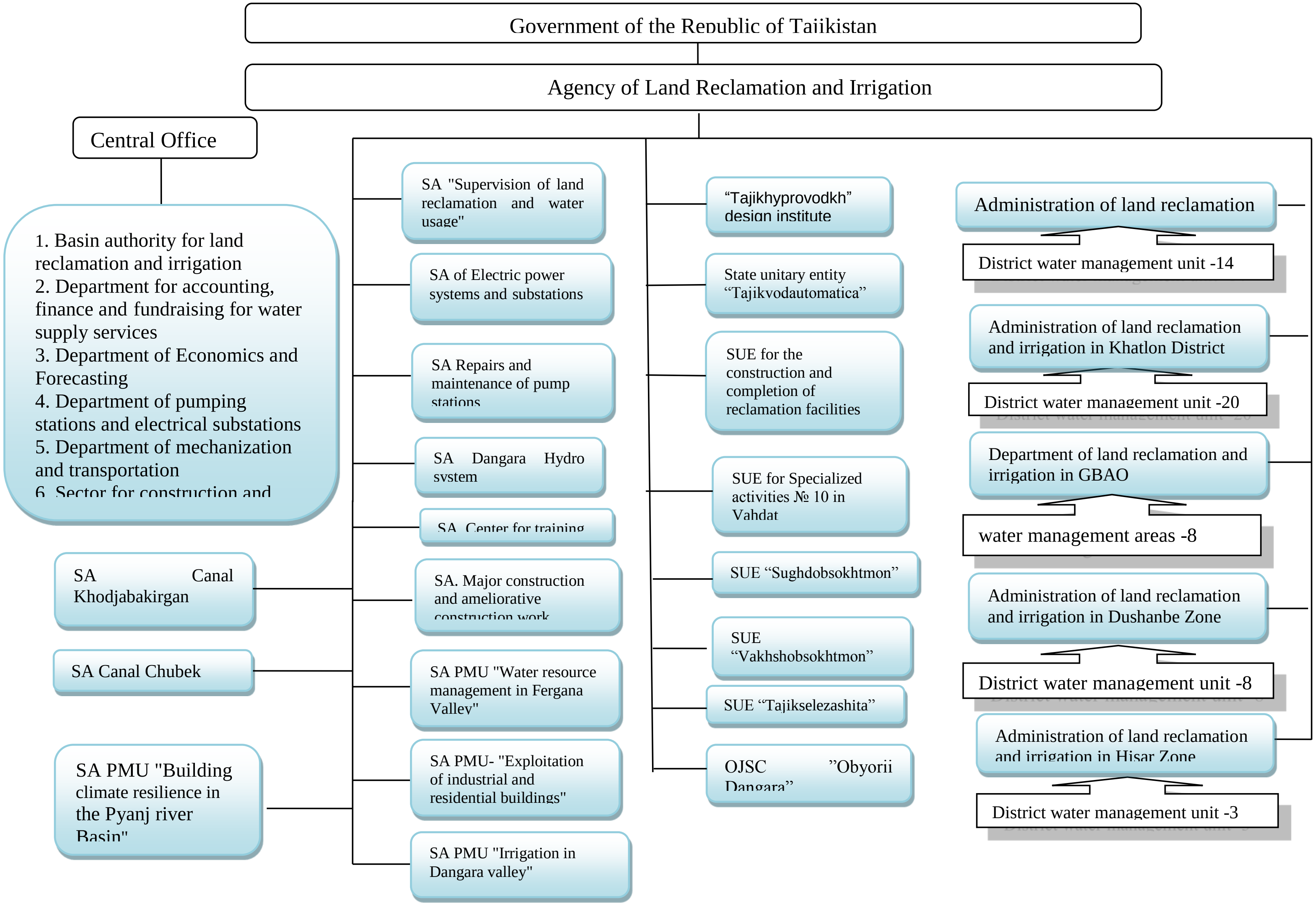


Figure 11: Organizational Structure of Agency for Land Reclamation and Irrigation in Chubek Irrigation System

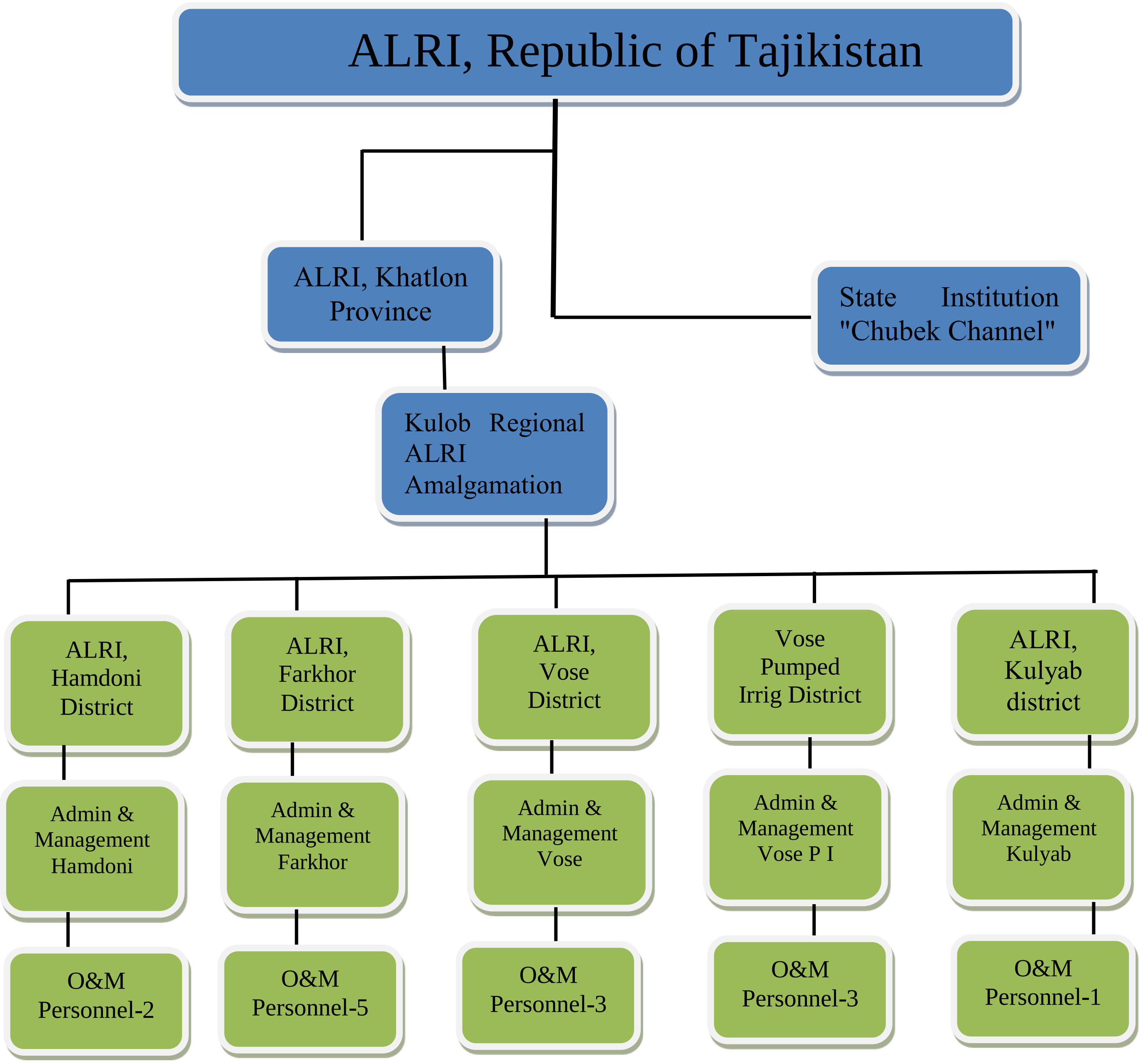


Figure 12: Organizational Structure of CIS ALRI - Hamadoni District

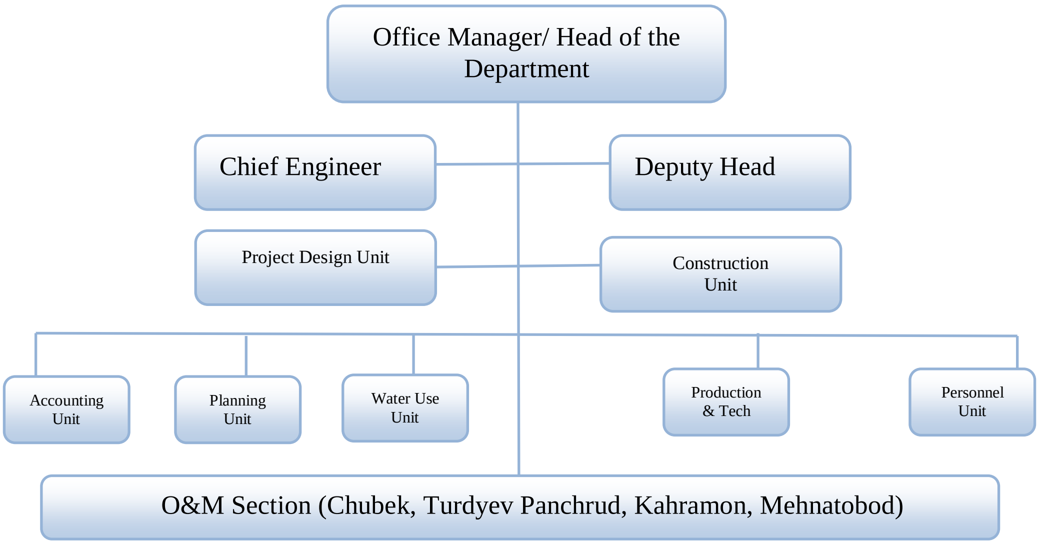


Figure 13: Organizational Structure of CIS ALRI - Farkhor District

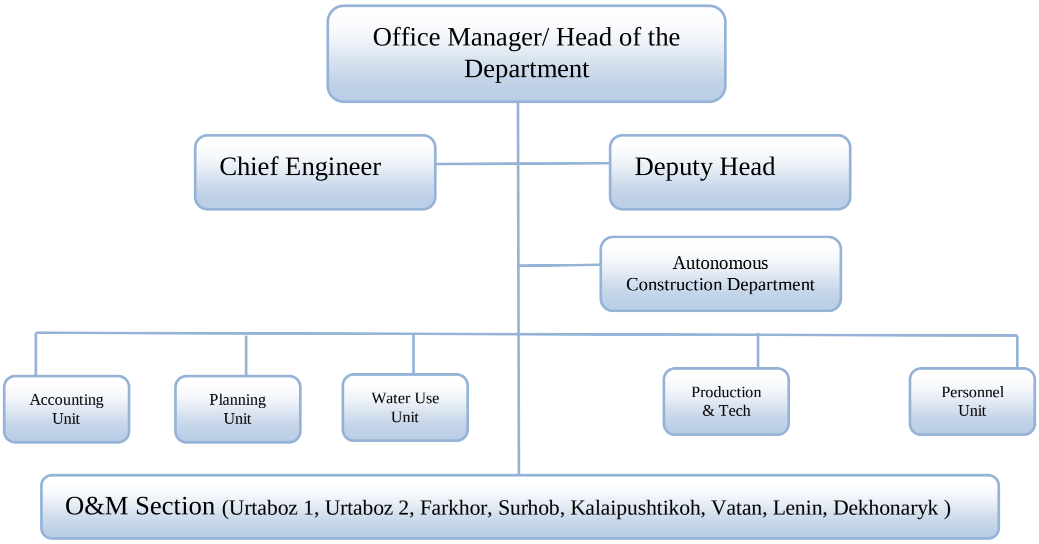


Figure 14: Organizational Structure of CIS ALRI - Vose District

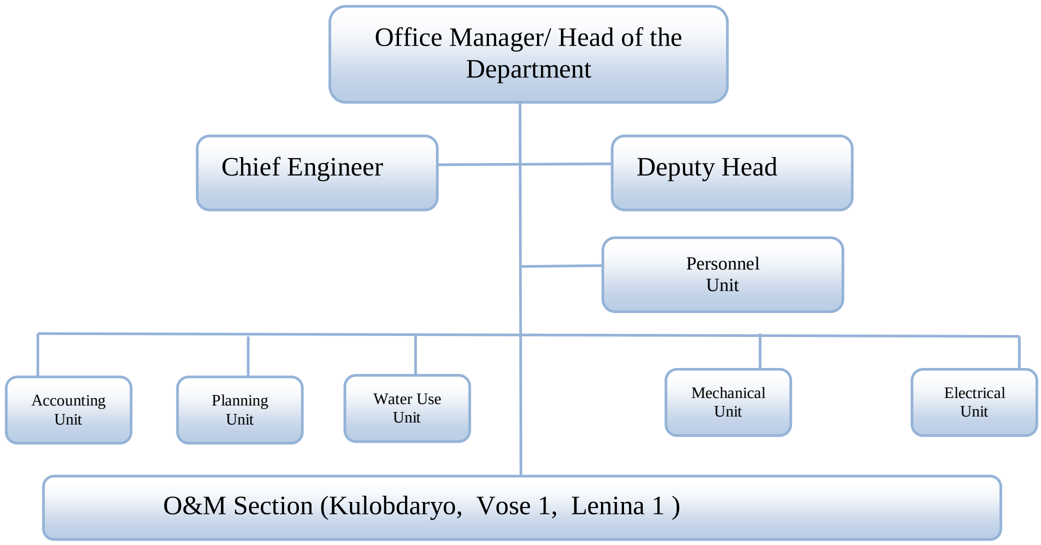
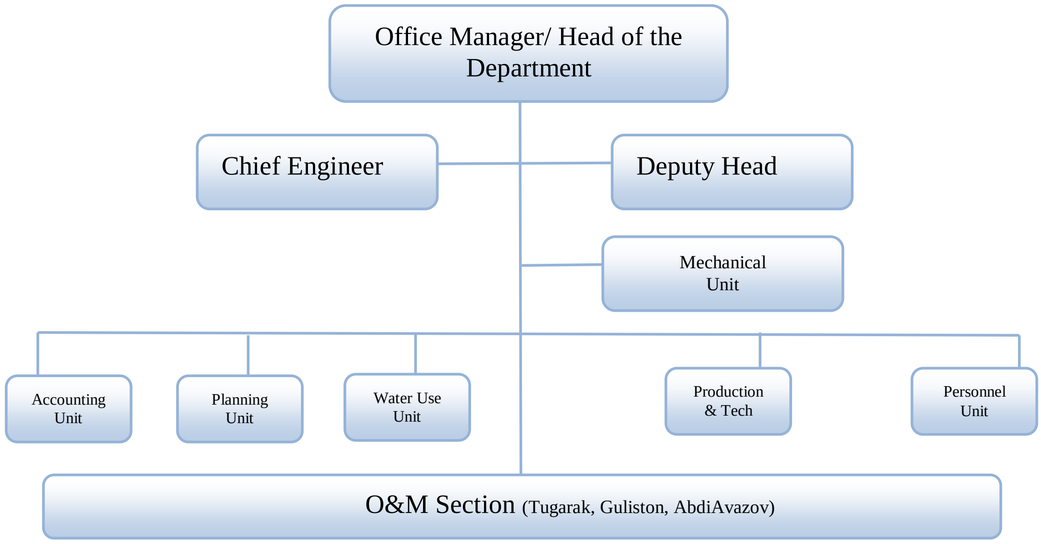


Figure 15: Organizational Structure of CIS ALRI - Kulob District



Attachment 3

Figure 16: Schematic Diagram of Pumping System at Urtoboz 1 PS

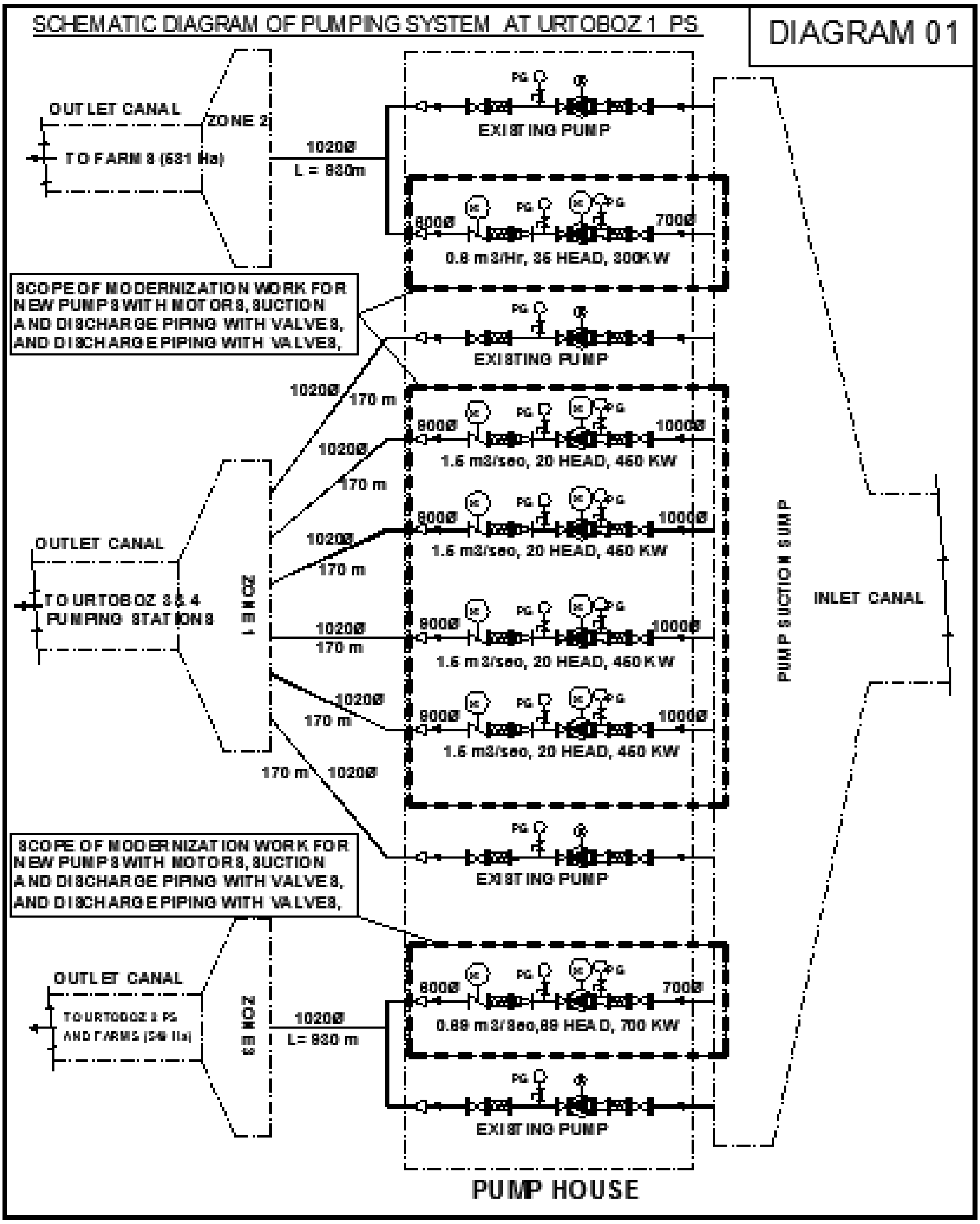


Figure 17: Schematic Diagram of Pumping System at Urtoboz 2 PS

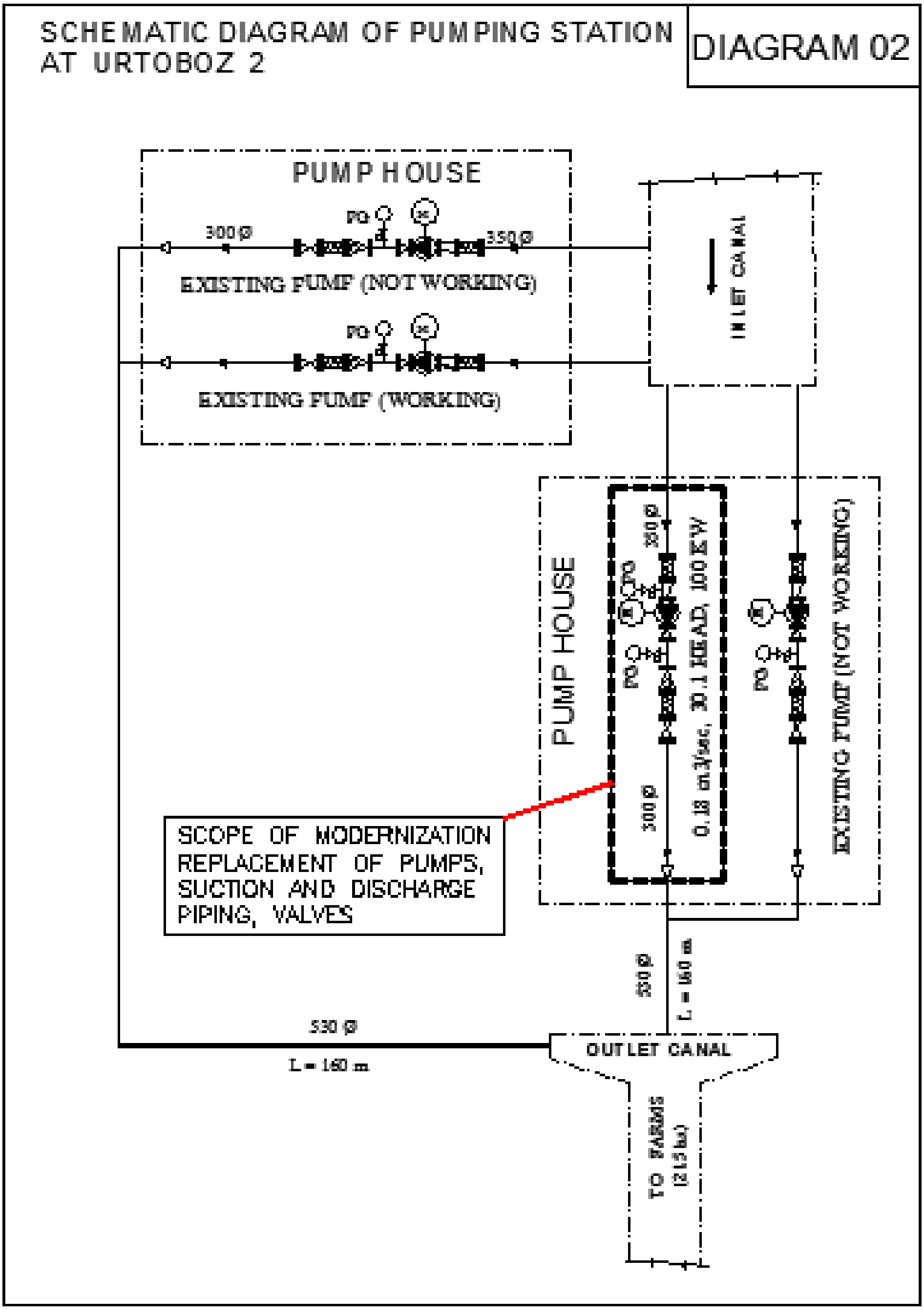


Figure 18: Schematic Diagram of Pumping System at Urtoboz 3 PS

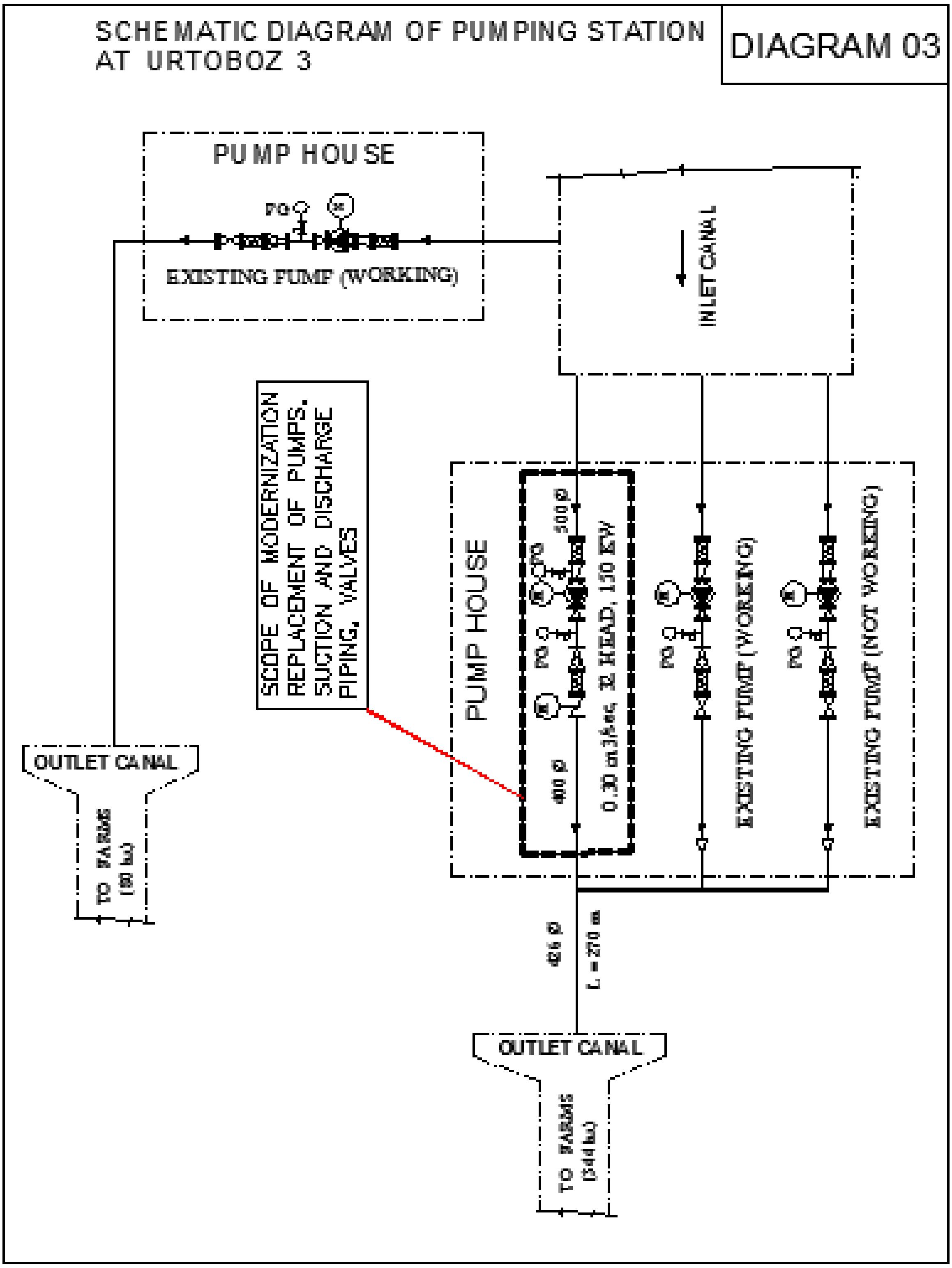


Figure 19: Schematic Diagram of Pumping System at Urtoboz 4 PS

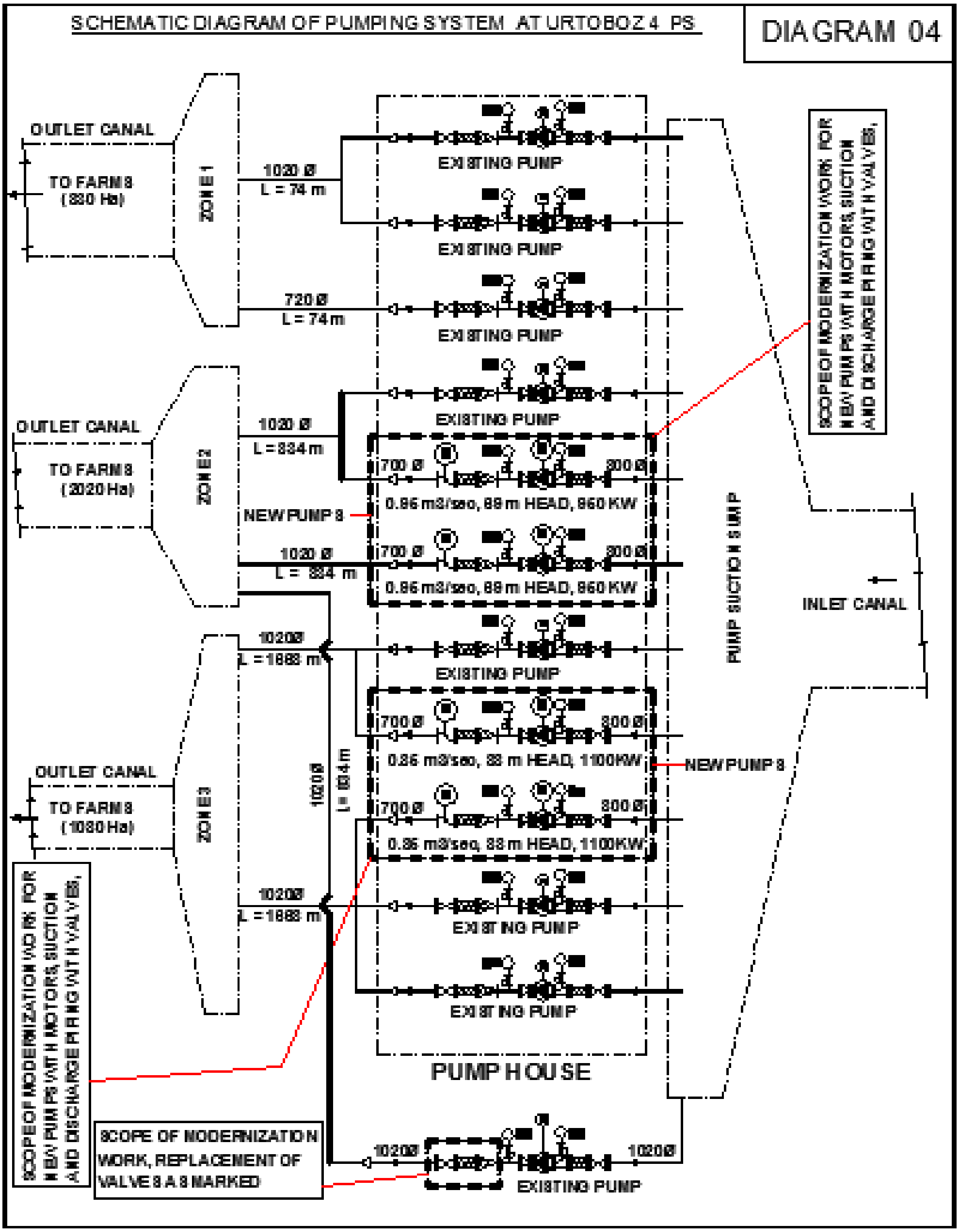


Figure 20: Schematic Diagram of Pumping System at Kulobdarya ‘0’ – ‘0A’ PS

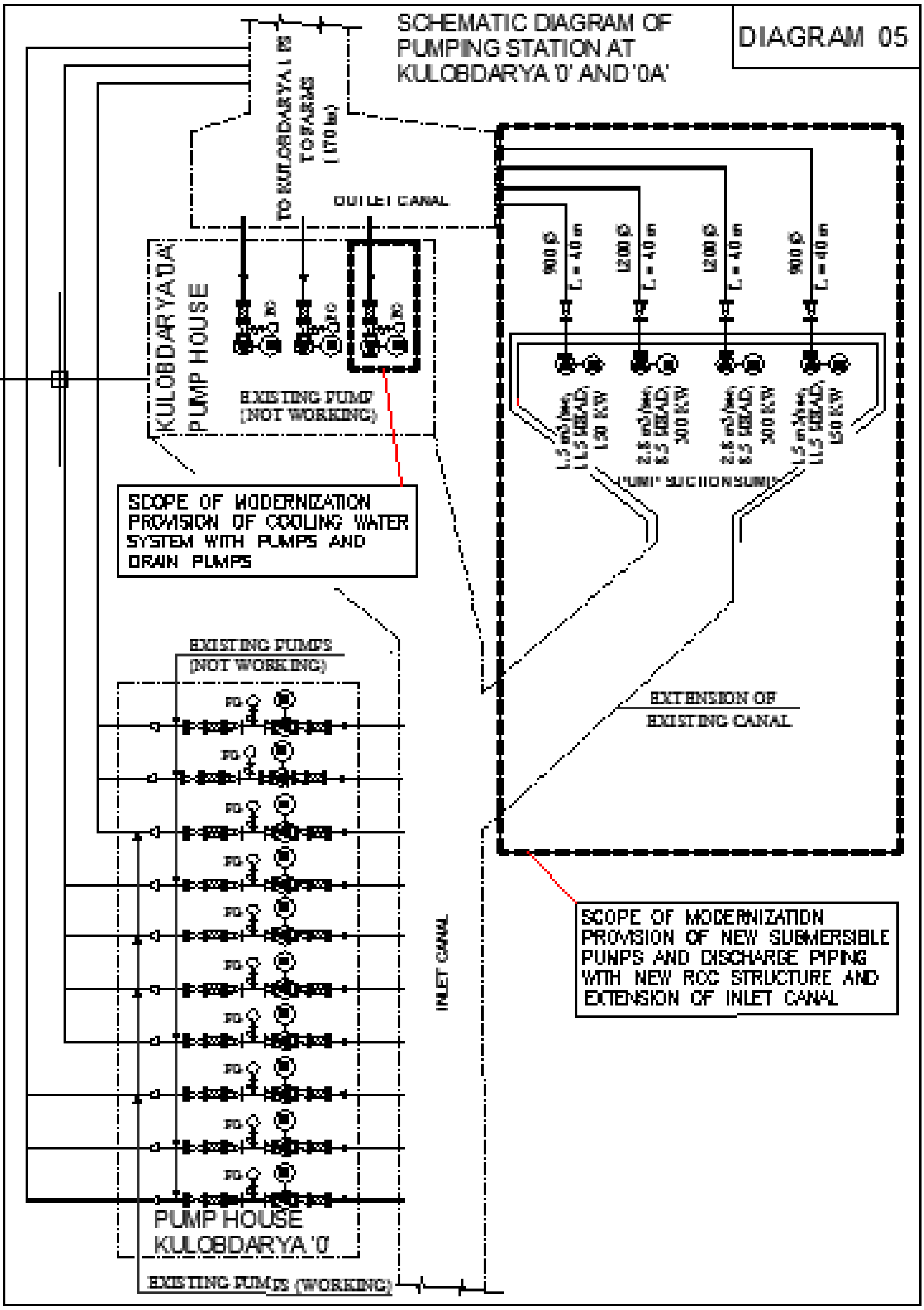


Figure 21: Schematic Diagram of Pumping System at Kulobdarya 1 PS

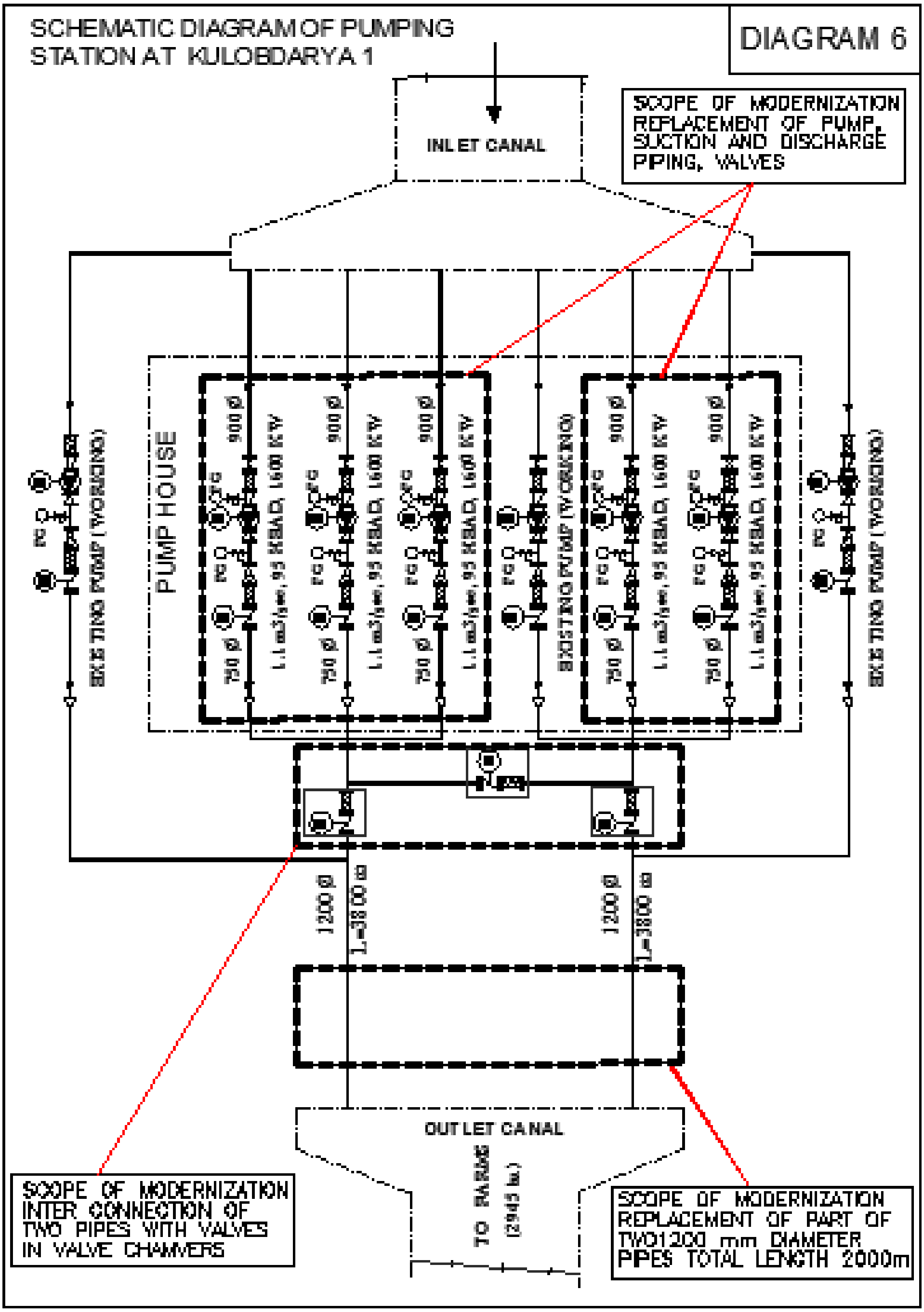


Figure 22: Schematic Diagram of Pumping System at Janubi 1 - Janubi 2 PS

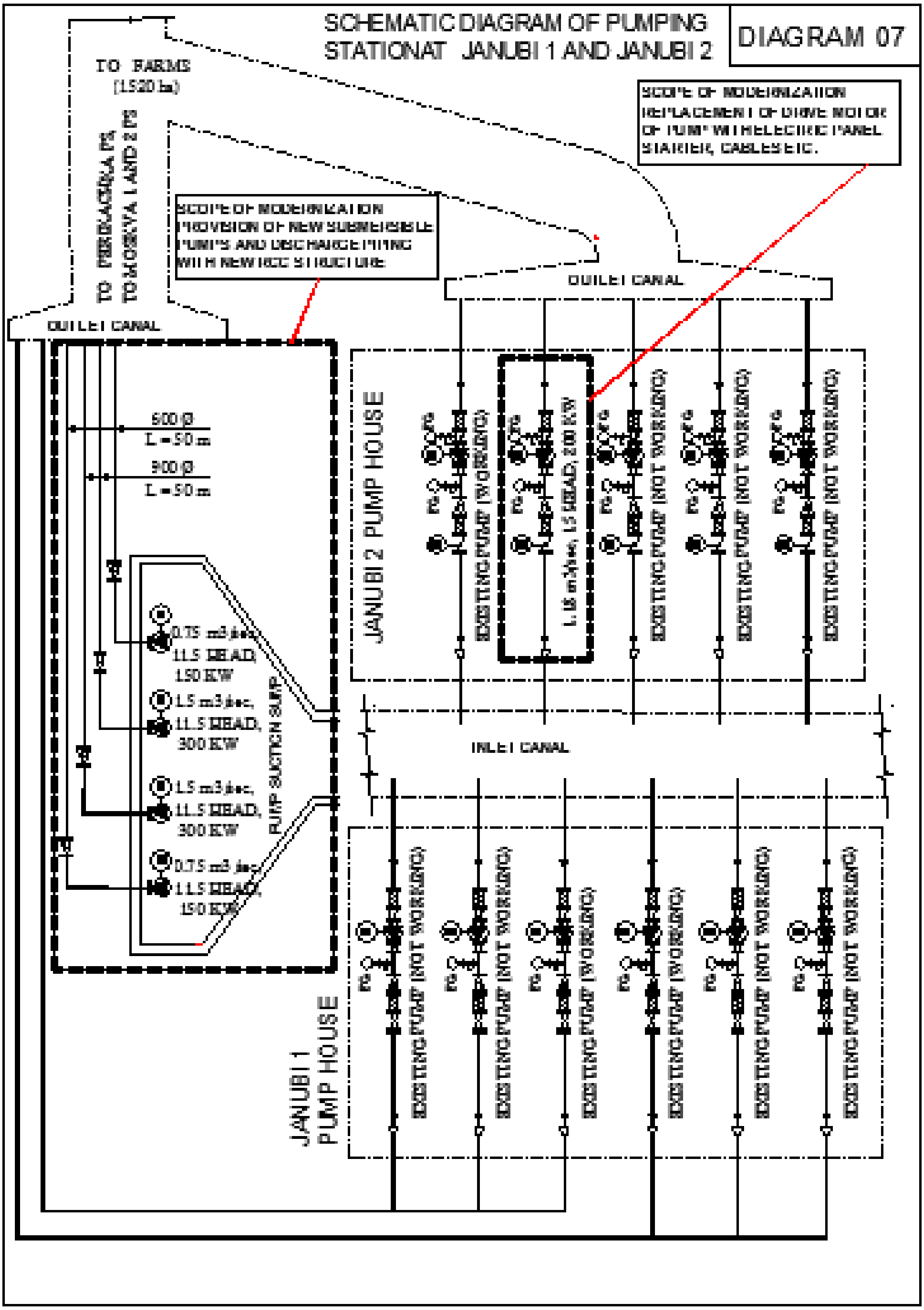


Figure 23: Schematic Diagram of Pumping System at Perikachka PS

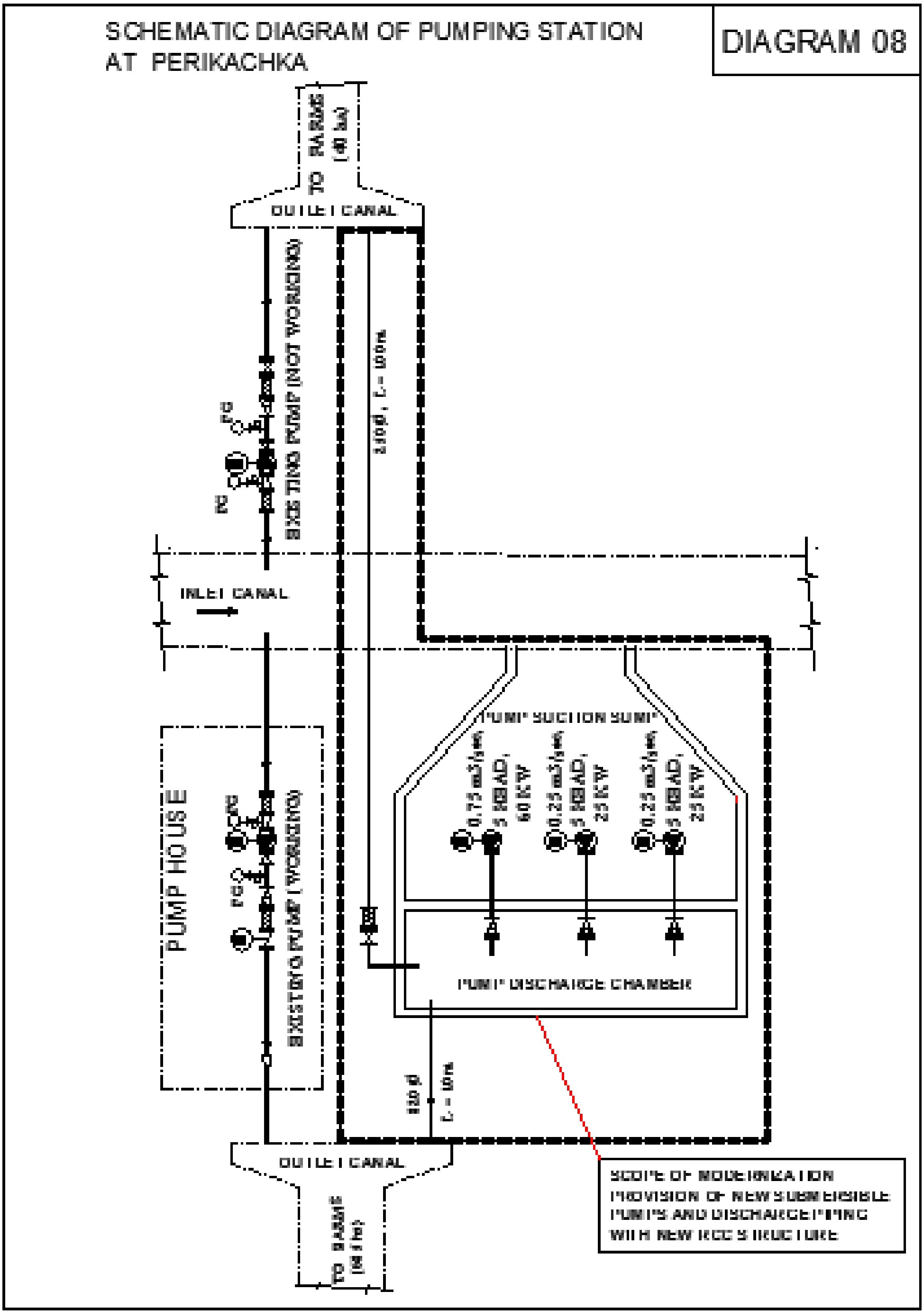


Figure 24: Schematic Diagram of Pumping System at Moskva 1 PS

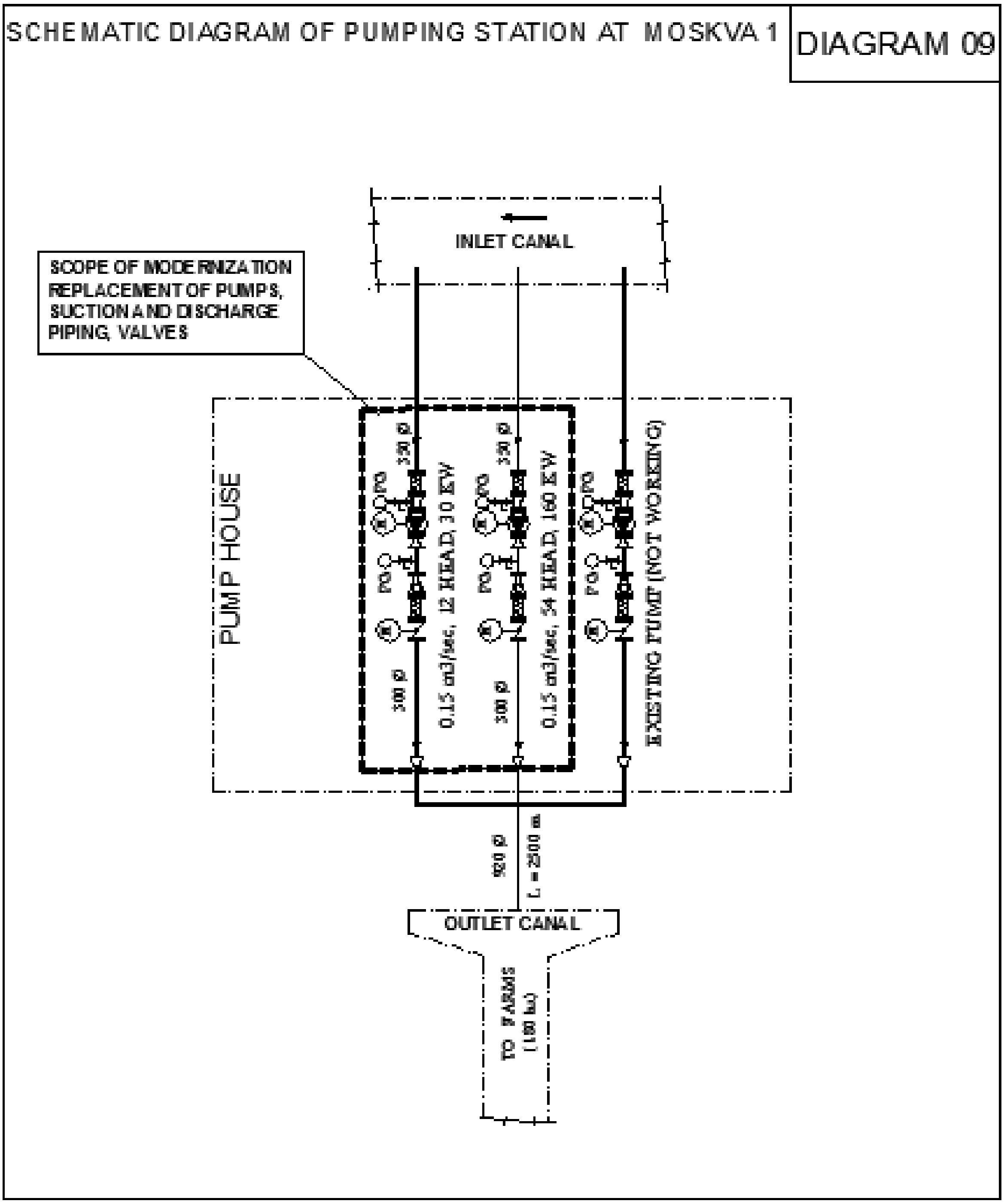


Figure 25: Schematic Diagram of Pumping System at Moskva 2 PS

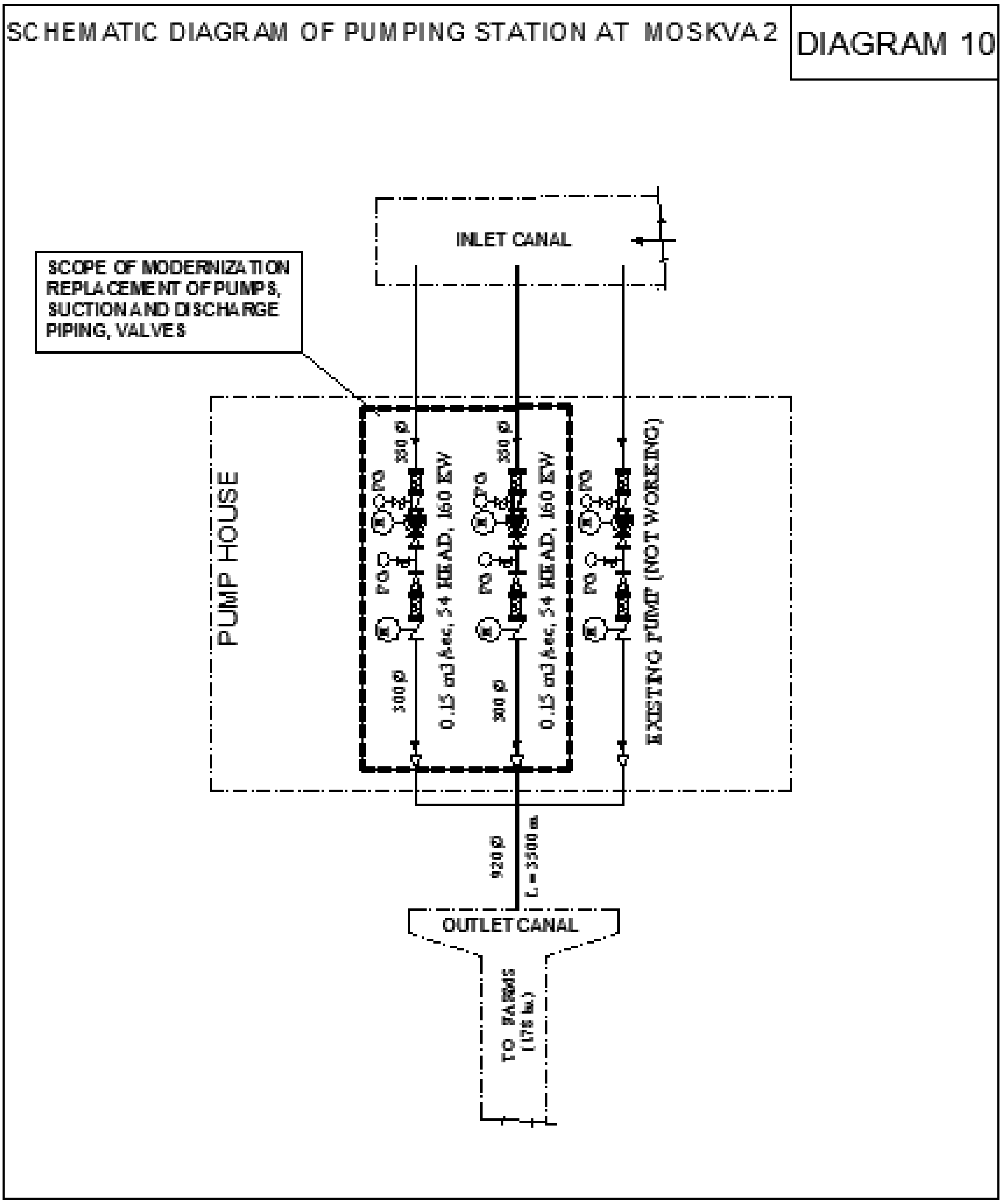


Figure 26: Schematic Diagram of Pumping System at Guliston PS

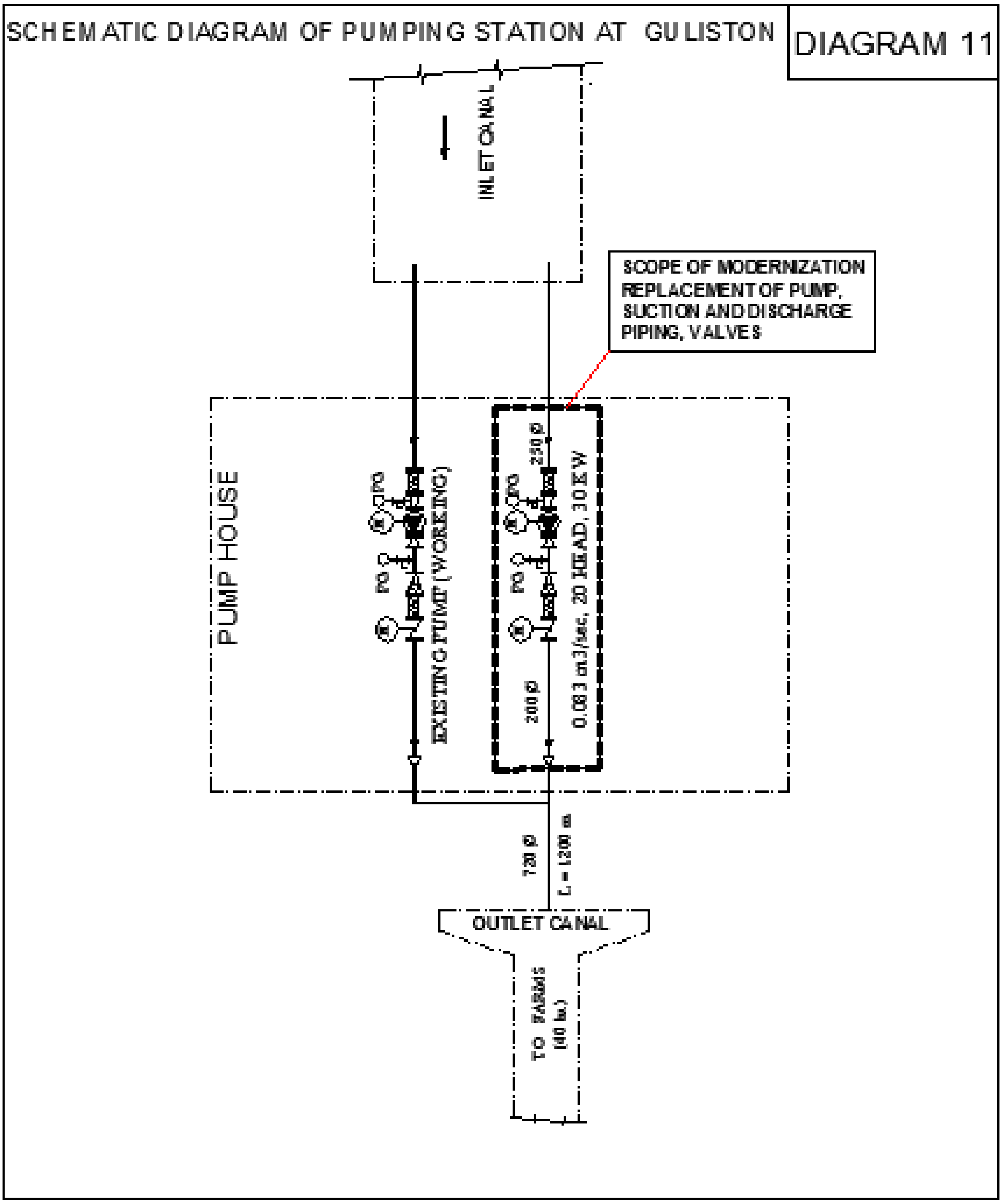


Figure 27: Schematic Diagram of Pumping System at Lenin 1 PS

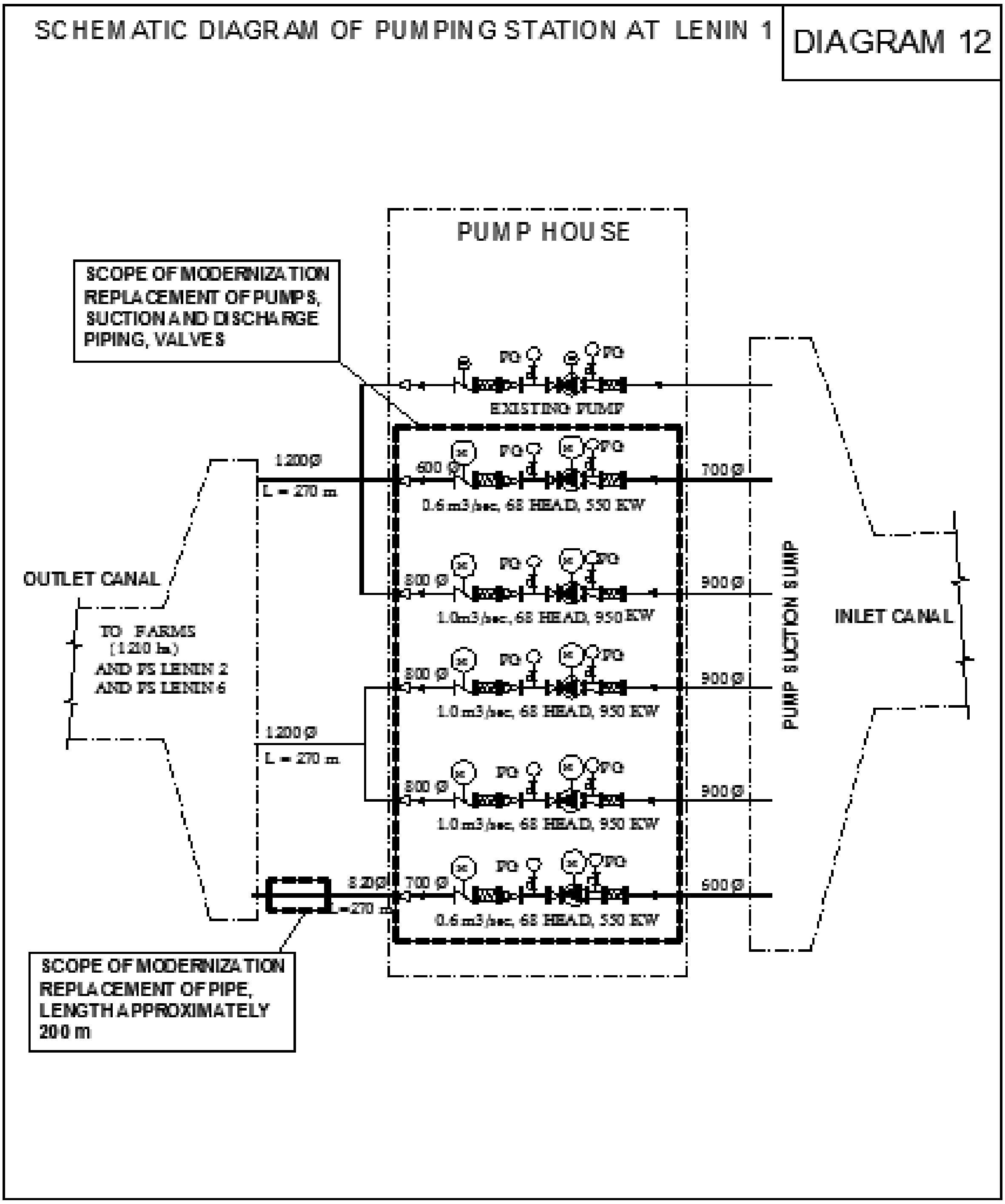


Figure 28: Schematic Diagram of Pumping System at Lenin 2 PS

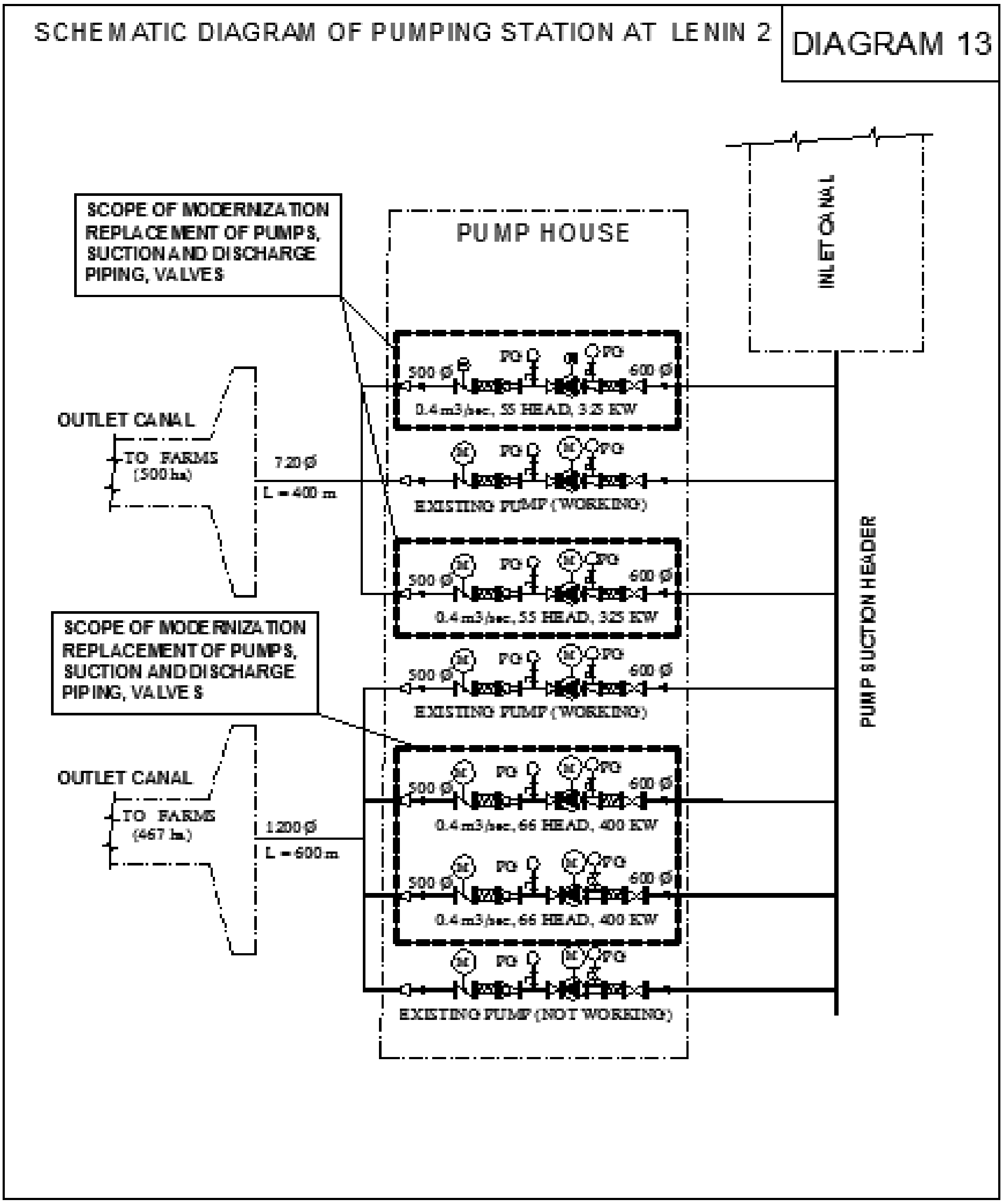


Figure 29: Schematic Diagram of Pumping System at Lenin 6 PS

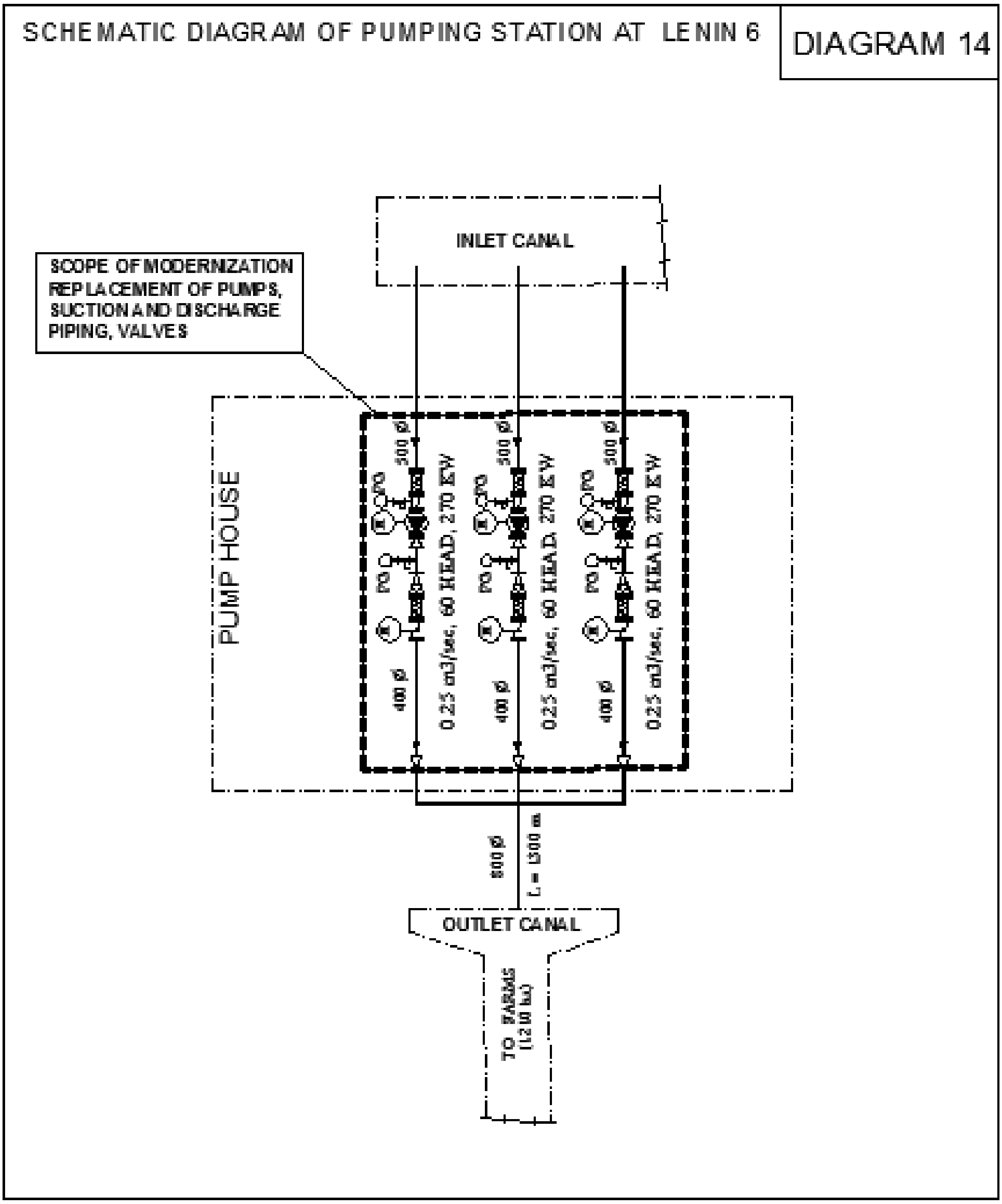


Figure 30: General Arrangement Plan and Sections of Proposed Structure for Submersible Pumps at Janubi 1 – Janubi 2 PS

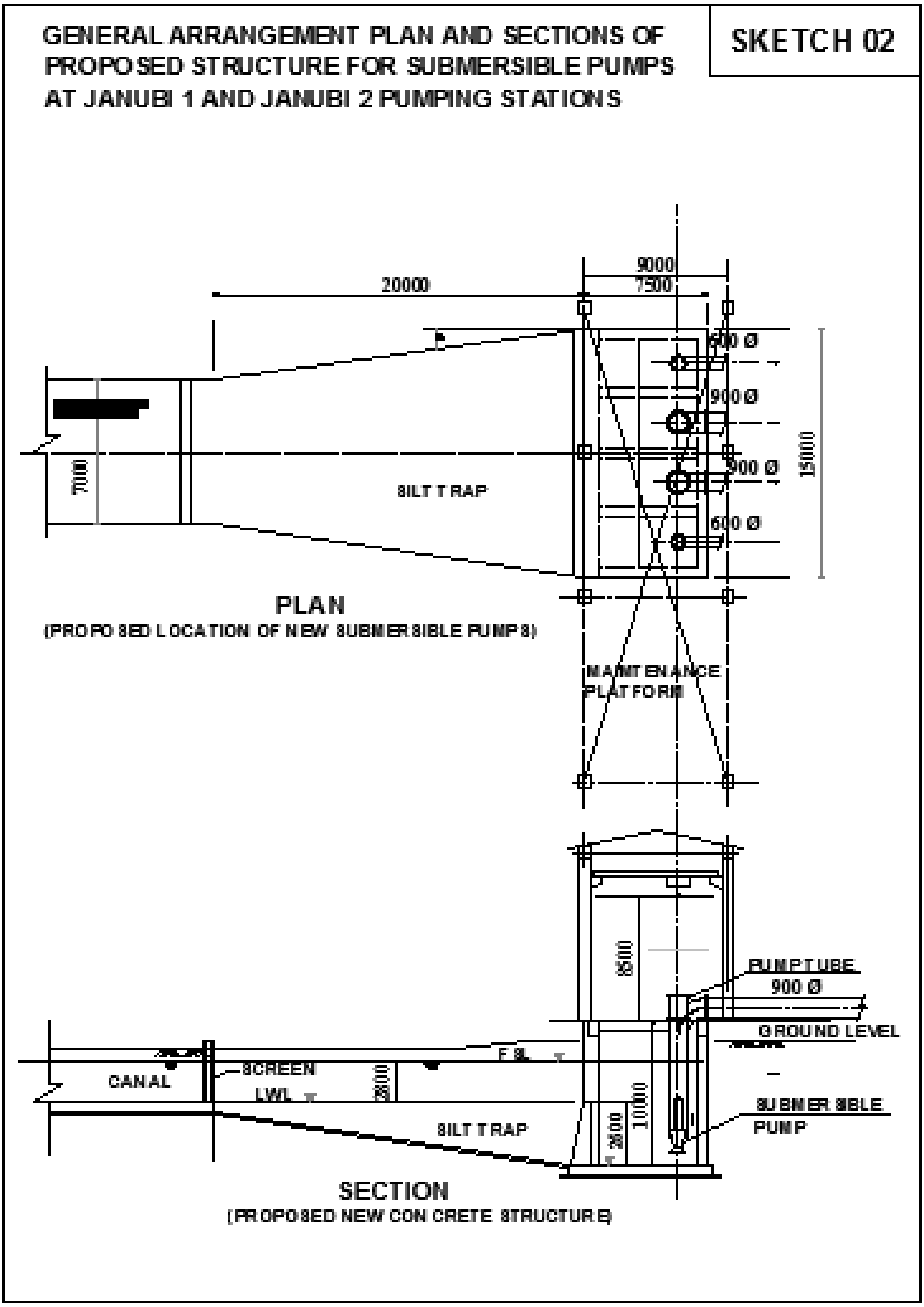


Figure 31: General Arrangement Plan and Sections of Proposed Structure for Submersible Pumps at Perikachka PS

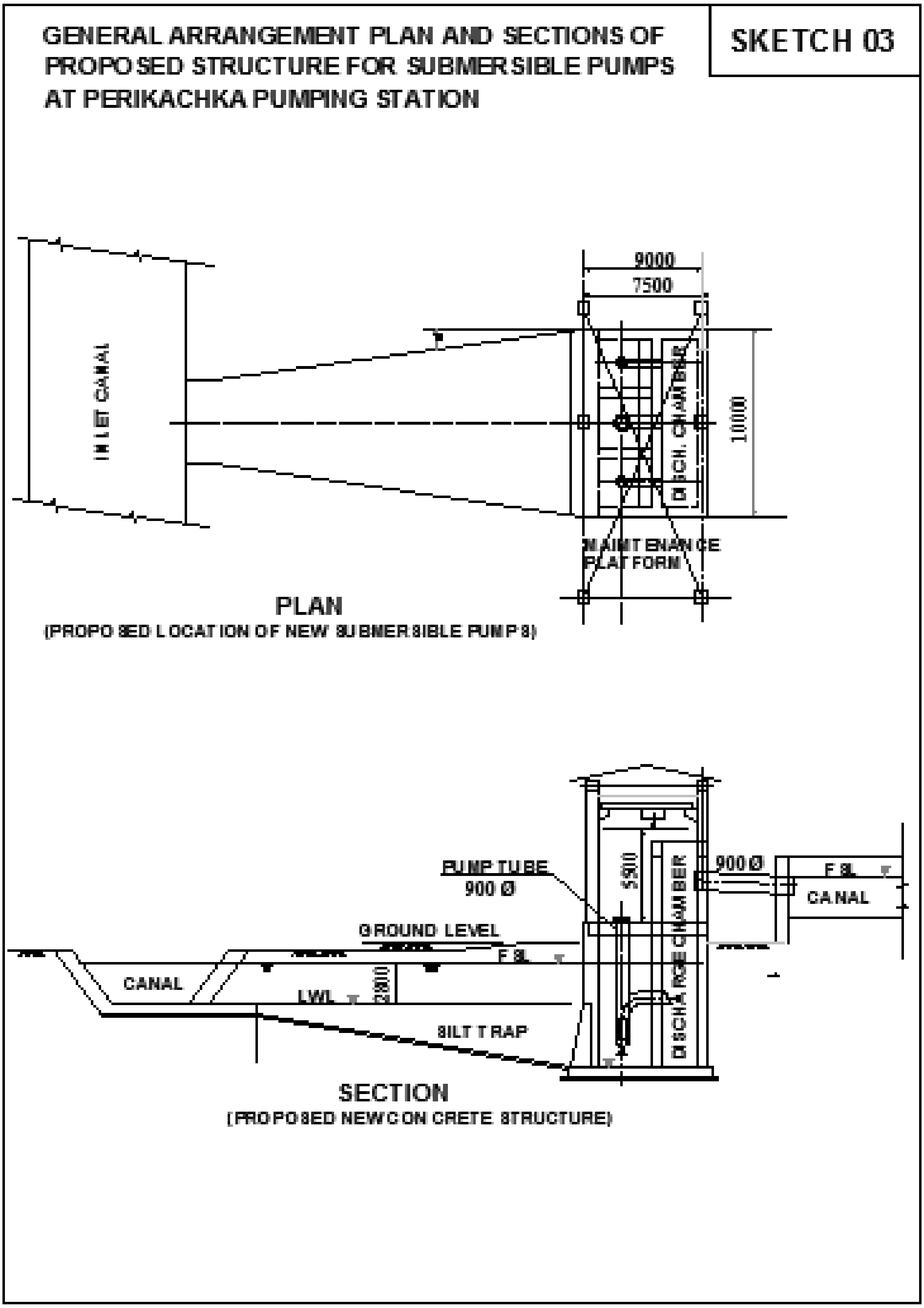
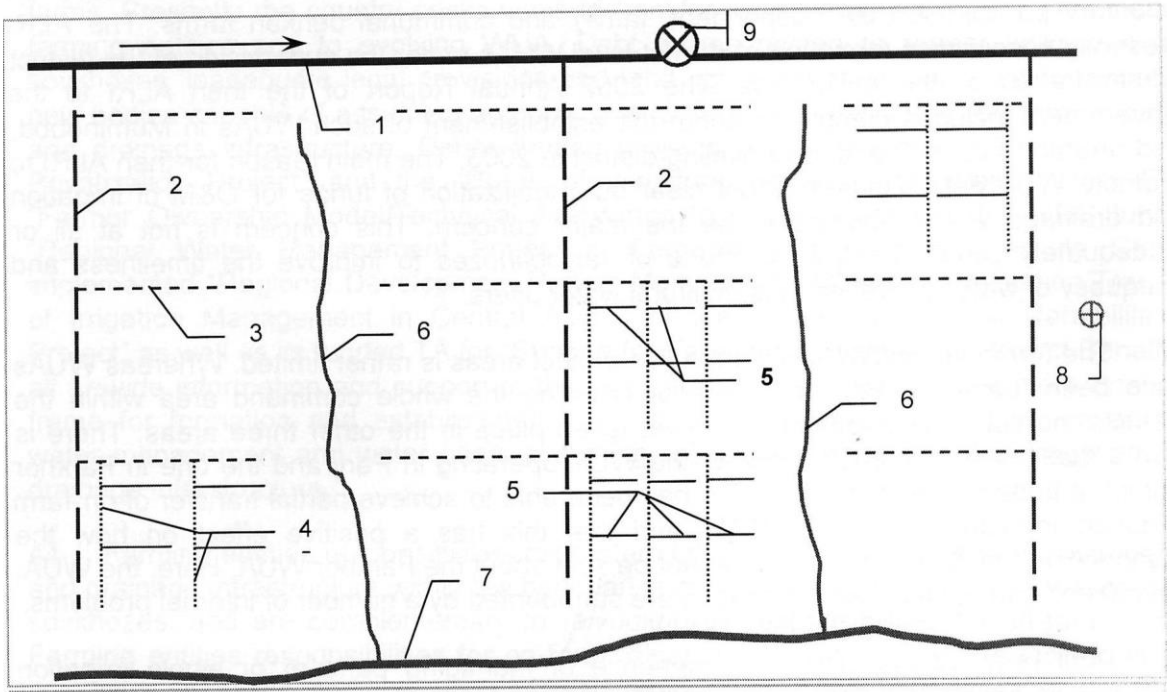


Figure 32: Typical On-Farm Irrigation and Drainage Layout in the Project Area



1 – off-farm distribution canal; 2 – on-farm distribution canal; 3 – tertiary canal (permanent and on field); 4 – seasonal/temporary field ditch; 5 – temporary cross ditch;
6 – on-farm feeder drain; 7 – off-farm collector/main drain; 8 – drainage well (VDW); 9 – pump station