Initial Environmental Examination

November 2019

Cambodia: Irrigated Agriculture Improvement Project Kamping Pouy, Prek Po, and Canal 15 Subprojects

Prepared by the Ministry of Water Resources and Meteorology for the Asian Development Bank.

CURRENCY EQUIVALENTS

(as of 2 October 2019)

Currency unit	–	riel (KR)
KR 1.00	=	$0.00024
$1.00	=	KR 4,081

ABBREVIATIONS

ADB	–	Asian Development Bank
DED	–	detailed engineering design
FWUC	–	farmer water user community
GHG	–	greenhouse gas
ha	–	hectare
MOWRAM	–	Ministry of Water Resources and Meteorology
O&M	–	operation and maintenance
PAM	–	project administration manual
PDWRAM	–	Provincial Department of Water Resources and Meteorology
PMIC	–	project management and implementation consultant
PMU	–	project management unit
SPS	–	Safeguard Policy Statement
SRP	–	Sustainable Rice Platform
WRIS	–	water resources information system

NOTES

In this report, "$" refers to United States dollars.

EXECUTIVE SUMMARY

A. Background

1. This initial environmental examination (IEE) has been prepared as part of the feasibility studies for the Asian Development Bank (ADB) project, Irrigated Agriculture Improvement Project. The IEE covers three irrigation subprojects. An EIA will cover a further a fourth subproject which has been categorized as Category A for environment.

2. The project will assist the government to (i) rehabilitate, modernize, and climate proof four irrigation systems in Battambang, Kampong Cham, Kampong Thom, and Takeo provinces; (ii) ensure sustainability of irrigation schemes; (iii) improve farming practices for increased agriculture productivity and crop diversification; and (iv) improve water resources information system, and irrigation asset management system for better water resources planning and investment. The project will focus on efficiency and climate resilience of irrigation systems enhanced and water resources management improved.

3. This IEE and the environmental management plan (EMP) is for subprojects in **Kamping Pouy** in Battambang province, **Prek Po** in Kampong Cham province and **Canal 15** in Takeo province. Investments in the three subprojects will combine civil works to rehabilitate and modernize main and secondary canals and drainage channels with support for FWUC activities and capacity building for farmers on water resource management. This will provide robust infrastructure for the irrigation of both wet and dry season crops. Works at the water source points at two of the schemes (new pumping station on the Mekong at Prek Po and repair/consolidation of the reservoir wall and refurbishment of the link canal at Kamping Pouy) will safeguard water availability. The planned increases in irrigated cropping are shown in Table 1.

Table 1: Planned Increases in Irrigation for the Subprojects

No.	Name Sub-Project	Province	Existing Command Area (Ha)			New Command Area (Ha)		
			Wet Season	Dry Season	Cumulative Total Irrigated	Wet Season	Dry Season	Cumulative Total Irrigated
1	Kamping Pouy	Battambang	12,000	8,000	20,000	12,000	12,000	24,000
2	Prek Po	Kampong Cham	380	1,200	1,580	8,000	8,000	16,000
3	Canal 15	Takeo	5,000	1,000	6,000	5,000	2,500	7,500
Total			**17,380**	**10,200**	**27,580**	**25,000**	**22,500**	**47,500**

Source: TRTA consultants estimates from Kamping Pouy, Prek Po and Canal 15 Feasibility Study Reports.

4. The three subprojects have been subject to full due diligence examination of all aspects of feasibility, including technical, economic, environment and social safeguards, climate change adaptation and mitigation, irrigation efficiency and water productivity. ADB projects are assigned to an environment category depending on the significance of the potential environmental impacts and risks. These three subprojects have been classified as Category B for environment. The subprojects are judged to have minimal, site-specific environmental impacts that can be readily addressed through effective implementation of mitigation measures as documented in the IEE and EMP.

B. Baseline Environment

5. **Geology and soils.** The proposed Kamping Pouy subproject area is on Quaternary alluvium formations, with the western half underlain by lake bed deposits and the eastern half on deltaic deposits. These both weather in situ to a soil with a surface accumulation of humus overlying an extensively leached and saturated subsoil at a depth of about 50cm. The Prek Po subproject is also on Quaternary alluvium formations, with the main part on alluvial plain deposits,

with organic deposits (swamps) around the boundaries. These both weather *in situ* to a soil which is clay-rich, and is associated with humid, tropical climates. The majority of the Canal 15 subproject area is on a combination of recent and quaternary floodplain deposits which have weathered *in situ* to a dystic plinthosol under the FAO[1] soil classification. This is a clayey soil, dark in color owing to the accumulation of organic matter. It is very plastic when wet and difficult to puddle. Because of long period of submergence, the soil undergoes chemical changes to its mineral constituents giving it poor nutrient-holding property. The more elevated southern extension of the subproject area is on alluvial plain deposits weathering to a gleyic acrisol, a clay-rich soil associated with humid, tropical climates.

6. **Land use**. The Kamping Pouy command area is fully sown to rice in the wet season and partially in the dry. There are village gardens in the eastern part and along the primary canal which runs parallel to the road linking the reservoir with Road 57. These gardens commonly comprise mango trees, banana, coconut, papaya and kapok. Along the primary canal and secondary canals are occasional large trees (*Albizia lebbeck, Acacia melanoxylon* and *Samanea saman*), but the majority are low trees/tall shrubs of *Zizyphus jujube, Cassia siamensis, Albizia myriophylla, Barringtonia* sp. and *Lanatus* sp. The canals themselves are significantly silted and support thick growths of *Mimosa pudica, Ipomea* sp. and rush grasses. No canal fisheries have been noted. Along paddy dykes, away from the canals, are occasional *Bombax ceiba* and *Dipterocarpus elatus*.

7. The Prek Po command area comprises paddy over most of its area but is currently only partially sown to rice in both the wet and dry season. There are small village gardens along the road network. These gardens commonly comprise mango trees, banana, coconut, and papaya. The first 2 km of the primary canal passes through the built-up area of Prek Po and are encroached upon by houses and outbuildings, vegetation and rubbish. In the section of the main canal running south from the town of Prek Po formal plantings of non-native mahogany trees (possibly Senegal mahogany (*Khaya senegalensis*)) line the canal banks. Further into the command area the primary canal and secondary canals are lined with occasional trees of *Acacia melanoxylon* and *Combetrum quadrangulare* and low trees/tall shrubs of *Zizyphus jujube* and *Albizia myriophylla*. The canals themselves are free of vegetation but no canal fisheries have been noted. Along paddy dykes, away from the canals, are occasional *Zizyphus jujube, Cassia siamensis* and clumps of *Bombax ceiba*.

8. Before the construction of Canal 15 in 1980, farmers in the area grew low yielding floating rice using the annual flood pulse from the Mekong and Bassac basin. The construction of the major secondary canals in the mid 1990s completed the change from one floating rice crop per year to recession rice cropping[2] and the possibility of two crops per year. Currently 100% of farmers grow the recession crop while only about 30% to 40% grow a second dry season crop due to unreliable water supply and risk of early flooding.

9. The low-lying areas along Canal 15 are fully flooded for five months of the year and there are no villages or village gardens in this area. Vegetation along the main canal comprises *Eucalyptus camaldulensis* and *Acacia acutangula* trees with *Mimosa* scrub. Occasional trees along the paddy dykes are *Nauclea orientalis* (Yellow cheesewood) and *Barringtonia acutanula* (Freshwater mangrove). All these species can stand long periods of inundation. In the southern (Samput) extension of the command area, the elevation is higher and inundation only occasional – so vegetation along the canals and paddy dykes is distinctly different and comprises *Bombax ceiba* (Sugar palm), *Eucalyptus tereticornis* (Forest red gum) and *Acacia obliquefolia* (Madras thorn).

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[1] Food and Agriculture Organization of the United Nations 1974, *World Soil Classification*. A supra-national classification which groups soils for their pedogenesis and main soil-forming factors.

[2] Rice growing in residual water from receding flood waters.

10. No protected areas, rare or endangered species have been recorded for either of the subproject sites.

11. **Rainfall and hydrology**. The monthly rainfall for the Kamping Pouy subproject is shown in Table 2. This data shows that through the wet season (May to October), the crop water requirement could be largely met from rainfall in an average year. In dry years (80% exceedance is shown as a dry year) irrigation is necessary, particularly in view of the uncertainty of commencement of the wet season.

Table 2: Dry, minimum and maximum rainfalls (mm)

1985–2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	4	24	49	97	141	131	157	189	227	239	66	6	1,329
Dry 80%	0	0	25	41	78	79	111	127	163	163	17	0	1,164
Dry 50%	0	13	48	76	135	123	155	181	218	232	34	1	1,340
Wet 20%	9	39	74	158	213	172	203	234	288	318	110	14	1,469
Max year	24	100	100	291	302	248	233	378	397	441	381	20	1,707
Min year	0	0	11	20	24	42	27	77	86	105	0	0	1,062

Source: PDWRAM Battambang.

12. Irrigation water is drawn from the Kamping Pouy reservoir. The estimated inflow from the local catchment into the reservoir is low, and is shown in m^3/s in Table 3.

Table 3: Local inflow to Kamping Pouy for dry, minimum and maximum years
(million cubic meters)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	1.05	0.32	0.20	0.15	0.12	0.29	1.08	4.48	11.77	14.81	9.13	3.59
Maximum	3.47	1.07	0.33	0.24	0.19	5.41	6.82	14.69	22.84	22.04	19.10	9.66
Minimum	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.04	0.06	0.08	2.21	0.58
20% Exceedance	1.33	0.38	0.25	0.19	0.15	0.13	1.43	9.89	15.91	19.25	11.51	4.28
50% Exceedance	1.06	0.32	0.22	0.17	0.14	0.12	0.11	2.01	12.87	15.88	9.82	3.70
80% Exceedance	0.43	0.19	0.14	0.11	0.09	0.08	0.07	0.19	7.55	12.52	6.39	2.15

Source: TRTA Consultants estimates. TRTA Technical Report - Hydrology.

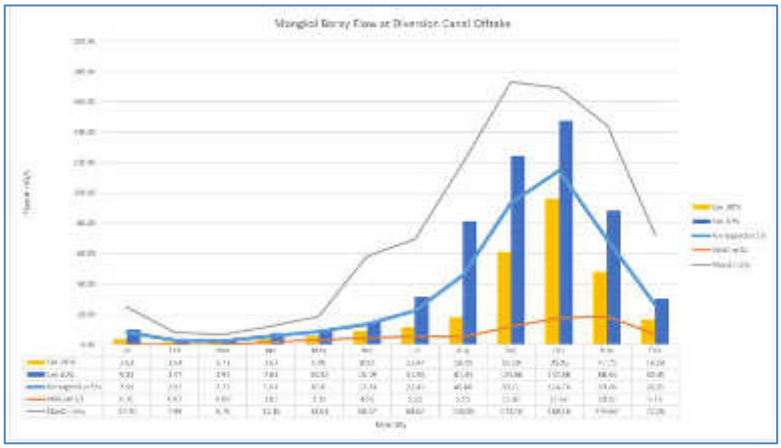
13. The hydrology of the subproject area also includes the Mongkol Borey – a river which is linked to the Kamping Pouy Reservoir by a canal (the Ou Dounpov) which has a designed flow capacity of $37m^3/s$, but through deterioration currently operates at a much lower flow.

Figure 1: Layout of the Hydrology of the Existing Kamping Pouy Scheme

Source: Kampong Pouy Feasibility Study Report, TRTA 2018.

14. The hydrograph for the Mongkol Borey at Figure 2 describes river flow at the diversion point, and also shows the average cumulative river flows (Q values) from previous wet seasons.

Figure 2: Hydrograph of the Mongkol Borey River Flow, at the diversion point



Source: Kampong Pouy Feasibility Study Report, TRTA 2018.

15. The monthly rainfall for the Prek Po subproject area is shown in Table 4. This data shows that through the wet season (May to October), the crop water requirement could be largely met from rainfall in an average year. In dry years (80% exceedance[3]) however, irrigation is necessary.

Table 4: Averages for dry, minimum and maximum rainfalls

(mm)

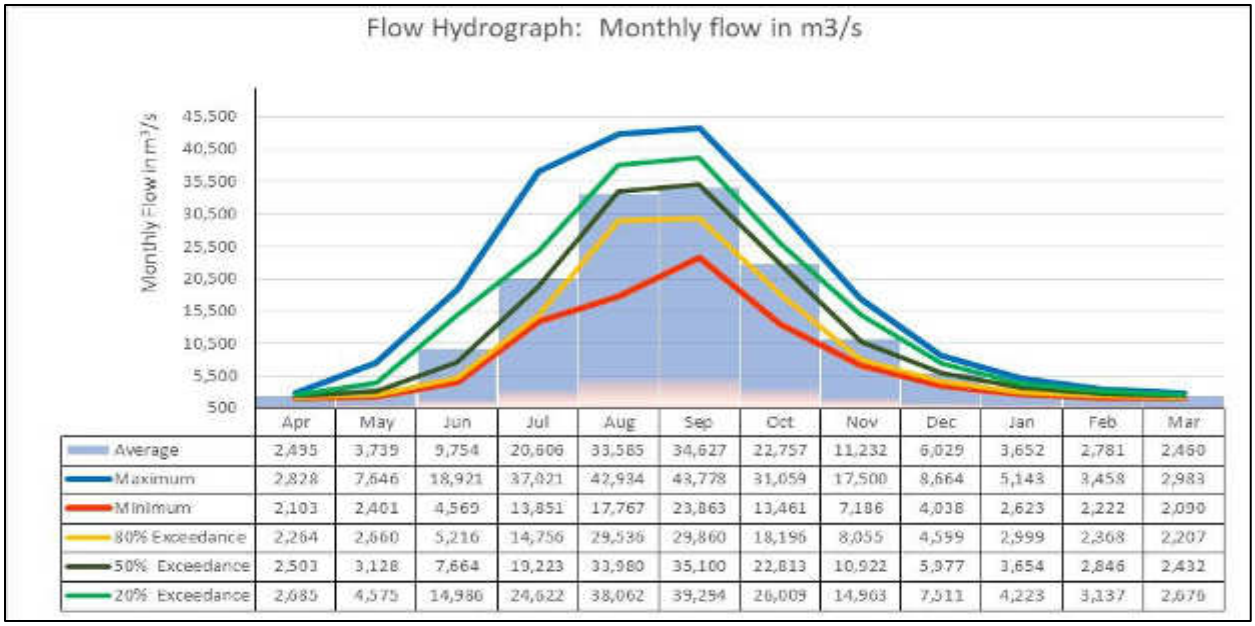
1985 – 2011	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Average	99	185	189	181	198	270	204	61	13	11	17	55	1,485
Dry 80%	36	122	124	111	125	169	104	6	0	0	0	1	1,219
50%	75	179	165	163	207	259	212	48	2	1	0	38	1,466
Wet 20%	155	249	278	279	264	350	263	103	25	21	7	104	1,617
Max year	335	375	424	376	319	532	484	225	64	63	247	200	2,164
Min year	11	44	66	51	54	100	0	0	0	0	0	0	1,024

Source: Prek Po Feasibility Study Report, TRTA 2018

16. The major water source in the area is the Mekong River. The flow records selected to represent the water availability for the Prek Po system in the hydrographic survey was the Mekong River flow at Kampong Cham, just upstream of the subproject area. A hydrograph based upon the monthly flows at this station for different years and flow exceedance probabilities is given in Figure 3.

[3] When 80% of rainfall readings for a normal year would exceed the readings for the subject (dry) year.

Figure 3: Average, minimum and maximum flows in Mekong River at Kampong Cham

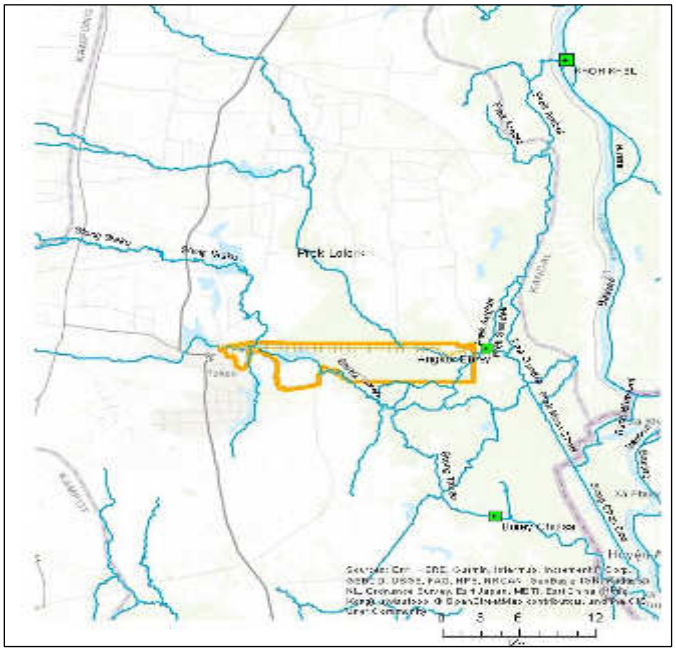


	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Average	2,495	3,739	9,754	20,606	33,585	34,627	22,757	11,232	6,029	3,652	2,781	2,460
Maximum	2,828	7,646	18,921	37,021	42,934	43,778	31,059	17,500	8,664	5,143	3,458	2,983
Minimum	2,103	2,401	4,569	13,851	17,767	23,863	13,461	7,186	4,038	2,623	2,222	2,090
80% Exceedance	2,264	2,660	5,216	14,756	29,536	29,860	18,196	8,055	4,599	2,999	2,368	2,207
50% Exceedance	2,503	3,128	7,664	19,223	33,980	35,100	22,813	10,922	5,977	3,654	2,846	2,432
20% Exceedance	2,685	4,575	14,980	24,622	38,062	39,294	26,009	14,963	7,511	4,223	3,137	2,676

Source: Kampong Pouy Feasibility Study Report, TRTA 2018.

17. Water flowing into Canal 15 and the rest of the flooded areas in Takeo comes from upwelling of the Bassac river complex in the east together with the run-off water from the surrounding areas in the western side. The wet season is from May to October while the short dry season is from late November to April. The flood season generally occurs from July to early November. The average annual rainfall observed at Takeo is estimated at 1280 mm (1982-2011 average).

Figure 4: Canal 15 Water Resource and Catchment Area



Source: Canal 15 Feasibility Study Report, TRTA Consultants 2018.

18. The significant annual contribution of water to the Canal 15 command area is from the upwelling of the Bassac River system via the Angkor Borey River at the eastern end of the main canal. Peak flows are between September and November, but flows hardly occur during the driest part of the year, between March and April. The biggest contributor to runoff from the surrounding areas is the Slakou River which originates from the slopes of the western mountains. The next major tributary emptying into the catchment basin is the Takeo River, also originating from the western mountains and on the north is the Prek Thu Lo Lork River. Although Slakou and Takeo rivers are partially diverted for irrigation use, there is still significant runoff from these rivers during the wet season.

19. The command area of Canal 15 is subject to annual flooding in the wet season, mainly from overland flow from the Bassac River. The extent and size of the flooded area differs yearly. The annual depth of water and duration of inundation varies depending on the Bassac and Mekong river flood levels. The floods of 2011 were among the highest annual floods recorded.

20. **Water Quality**. The surface water quality in the Kamping Pouy reservoir at takeoff point 4 and in a secondary canal in the north of the subproject area and from the primary canal at its end, near the village of Paoy Suay was sampled and analysed. All showed acceptable levels of total nitrogen, heavy metals and arsenic, but water in the reservoir and canals had positive *E. coli* counts (with the highest levels in the reservoir sample) indicating human and animal waste in runoff. In Prek Po, the surface water quality was sampled at two points along the primary canal, which runs north-south through the command area. The sample furthest from Prek Po, in the south of the area, showed the poorest water quality, with selenium levels higher than Cambodian raw water standard and elevated levels of *E. coli*. Total nitrogen was elevated in both samples, indicating a degree of wastewater contamination. At Canal 15, surface water quality was sampled at two points in August 2018: one along the main canal at the junction with Canal 87 (the north-flowing secondary canal); and one in the canal though the southern extension of the command area, south of the Samput pump house. The sample taken in the middle of the flooded command area at Canal 15 (SW2) had detectable pesticide residues – a significant reading given the massive dilution by flood waters.

21. Groundwater in the Kamping Pouy command area is shallow, with most domestic wells at 2-5 m depth. These wells tap into the same water table which maintains the level of water in the primary and secondary canals and shares their water quality. Deeper wells only occur around the edges of the command area and two were sampled. The more shallow sample (7m) showed *E.coli* contamination as well as levels of total nitrogen and arsenic which were detectable but within standard. The single deep well sample (30m) had good water quality for all parameters measured. Groundwater in the Prek Po command area is deep, with most domestic wells at 30-40 m in depth. Two wells were sampled at points along the primary canal. Both showed acceptable levels of heavy metals, arsenic and total nitrogen. However, one well, at 40m depth, showed elevated *E. coli* levels, which suggests direct contamination. Additionally, elevated levels of 4,4 DDT[4] were found in the sample from a deep well in the center of the command area, which was 20 times higher than the local standard. It is possible that this has originated from recent, local misting for mosquitos in the residential area and is unrelated to agricultural activity. The sale of DDT is banned in Cambodia. At Canal 15, low level pesticide residues were found in deep wells (GW1 and GW3) but no herbicide residues. High coliform levels were also found in a deep well beside the Samput pumping station (GW1). Arsenic levels were slightly elevated, but within standard for non-drinking water at a deep well in a primary school at Angkor Borey (GW3).

[4] 4,4'-Dichlorodiphenyltrichloroethane (DDT), a pesticide and derivative of DDT. Studies show a range of human health effects linked to DDT and its breakdown products.

22. **Acoustic environment**. Site ambient noise levels in Kamping Pouy are characteristic of rural settings in Cambodia. The use of numerous small pumps on paddy dykes and along canals and frequent motorcycles along canal levee banks elevate the daytime noise levels. Typical daytime noise levels along primary and secondary canals are 1 hour averages of 33-38 dB, with maximum peaks of 60-70 dB due to vehicles. In Prek Po, site ambient noise levels are higher, due to the number of settlements within the command area and proximity to main roads. The use of numerous small pumps on paddy dykes and along canals and frequent traffic also elevate the daytime noise levels. Typical daytime noise levels along primary and secondary canals in Prek Po are 1 hour averages of 50-52 dB, with maximum peaks of 70-80 dB due to vehicles. At the pump station channel on the Mekong at Prek Po, without pumps operating, the noise levels were: 1 hr average 50.4 dB; max 78.9 dB; min 39.1 dB. At Canal 15, site ambient noise levels are typical for an isolated rural setting in Cambodia. Recorded daytime noise levels on the periphery of the command area are 1 hour averages of 32.6, 37.0, 32.4 and 42.2 decibels (dB), with maximum peaks of 56 to 63.4 dB due to vehicles.

C. Assessment Findings

23. **Benefits.** The result of the project improvements to irrigation and drainage facilities will be (i) an increase in certainty and control of existing irrigation areas; (ii) expansion of reliable irrigation into new areas; and (iii) longer cropping periods on areas previously unavailable for parts of the year due to flooding.

24. Tables 5, 6 and 7 show the beneficial impacts of the project investments in the three subprojects with respect to increases in areas sown and yields which can be expected in the "with" project case in the year 2028 (6 years after commissioning of the civil works). The project investments include the design and management measures for climate change adaptation.

Table 5: Project Benefits through Civil Works, Agro-Inputs and Practices of the Kamping Pouy Subproject to 2028

		Without project		With project		
		Wet season traditional variety	Dry season Early variety	Wet season traditional variety	Wet season IRRI variety	Dry season Early (HYV) variety
Area	ha	12000	8000	8400	3600	12000*
Irrigated		no	yes	yes	yes	yes
Planted		May	Jan-Mar	May	May	Jan-Mar
Harvested		Nov	Apr-Jun	Nov	Sep	Apr-Jun
Yield	kg/ha	2500	2565	4500	5000	5000

ha = hectare, kg/ha = kilogram per hectare; IRRI = Irrigated Rice Research Institute; HYV = heavy yielding variety.
Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

Table 6: Project Benefits through Civil Works, Agro-Inputs and Practices of the Prek Po Subproject to 2028

		Without project		With project	
		Wet season traditional variety	Dry season Early variety	Wet season traditional variety	Dry season Early (HYV) variety
Area	ha	380-5600[a]	1200	8000	8000[b]
Irrigated		no	yes	yes	yes
Planted		May	Jan-Mar	Aug	Dec
Harvested		Nov	Apr-Jun	Nov	Mar
Yield	kg/ha	3000	3500	4500	5000

[a] Variable due to severity of wet season floods. Currently at 380 ha. [b] These totals may include non-rice crops.
Source: Prek Po Feasibility Study Report, TRTA 2018.

25. Unlike the other two subprojects, farmers at Canal 15 cannot grow wet season rice because the command area (except the Samput area) is fully inundated. Here, the benefits will accrue from enabling two dry season crops, using residual water retained in the deepened canals from the wet season. These benefits are reported in Table 7.

Table 7: Project Benefits through Civil Works, Agro-Inputs and Practices of the Canal 15 Subproject to 2028

		Without project		With project	
		Dry season early Recession rice	**Late Dry Season**	**Dry season early Recession rice**	**Late Dry season**
Area	ha	1000	5,000	2500	5,000
Irrigated		no	yes	no	yes
Planted		Dec	April	Dec	April
Harvested		March	July	March	July
Yield	kg/ ha	3500	3500	6000	6000

Source: Canal 15 Feasibility Study Report, TRTA 2018.

26. In terms of sustainable areas sown as a result of increased irrigation, the project will increase potential growing areas by 4,000 ha in the dry season in Kamping Pouy, by up to 7,620 ha in the wet season and 6,800 ha in the dry season at Prek Po and by 1,500 ha in the dry season at Canal 15. The beneficiaries of these changes will be local farmers, with flow-on effects to local commercial enterprises. Since rural populations are the poorest sectors of the Cambodian population, poverty alleviation effects will be direct and sustainable.

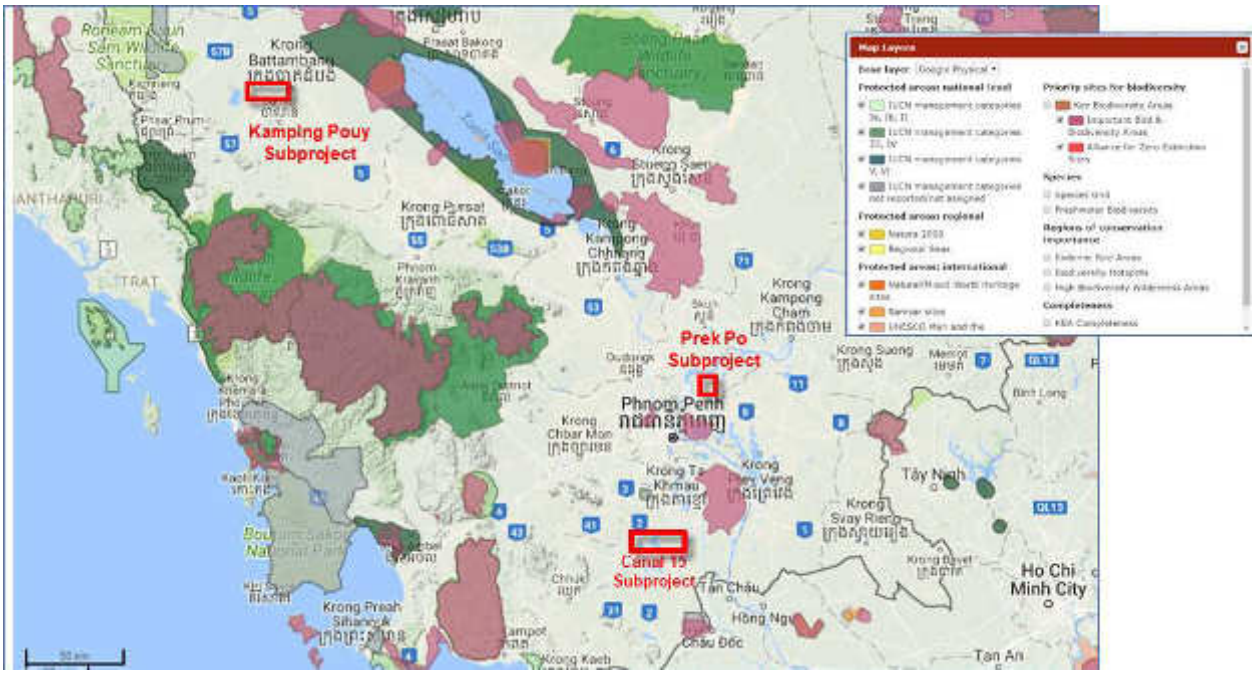
27. In addition to increases in area and yield, capacity building and training will support a decrease in the use of pesticides and support for the uptake of fertilizer tailored to local conditions.

28. **Pre-construction – Design and Location**. Environmental design issues for the irrigation subprojects have focussed on: (i) no encroachment on protected areas and no impact on critical habitats; and (ii) matching the total irrigation area for a new dry season crop to the availability of water.

29. Protected areas and critical habitats. The locations of the Kamping Pouy, Prek Po and Canal 15 subprojects have been checked against maps of MOE protected lands and the data in the International Biodiversity Assessment Tool (IBAT)[5]. These checks showed that the subprojects do not encroach upon, nor border any legally protected areas, international conservation areas, key biodiversity areas (KBAs) or important bird and biodiversity areas.

[5] International Biodiversity Assessment Tool. IBAT is a multi-institutional programme of work involving BirdLife International, Conservation International, IUCN and UNEP-WCMC which provides a geographical- and data-based decision support tool.

Figure 5: IBAT Identified Areas and Subproject Locations



Source: www.ibat-alliance.org/ibat-conservation.

30. Water availability. The irrigation schemes must be sustainable and responsibly managed, to ensure that agreed irrigation flows are maintained and other water users are not disadvantaged. In Kamping Pouy, irrigation resources will be drawn from the reservoir which is fed from its immediate catchment and will be augmented by water from the existing Ou Dounpov canal which links with the Mongkol Borey river. The hydrological analysis of these sources undertaken by the TRTA team indicates that by using shorter season rice varieties, maximising the storage off tail-end wet season rains at the beginning of the dry season, and proper management of the reservoir, diversion channel and command area, irrigation for a dry season crop over an additional 4,000 ha is possible.

31. Importantly, the intensive management of the Kamping Pouy Reservoir[6] based upon the movement of 10-day water releases from the reservoir and into the command area as required will ensure that the diversions drawn from the Mongkol Borey will be sustainable. Under the planned reservoir management regime, the majority of water will be drawn from the Mongkol Borey during June-December when flows are high in order to maintain the reservoir at a high level entering the dry season. The appropriate use of this "water bank" will ensure that minimal water will be required from inflow to the reservoir (catchment and Mongkol Borey diversion) in the dry season. This in turn will ensure that the Mongkol Borey will not be dewatered in any season and that minimal water will be drawn from it in the lowest part of the dry season to protect environmental functions. Other schemes drawing water from the Mongkol Borey downstream of the diversion to Kamping Pouy have been examined and their water demands confirmed.

32. In Prek Po, more than sufficient water is available from the Mekong River to meet the irrigation demand at Prek Po command area in all months of the year. The additional irrigation areas at Prek Po as a result of the project will be 14,420 ha (an extra 7,620 ha irrigated in wet season and an extra 6,800 ha irrigated in the dry season). A guide to the size of the irrigated water demand, by assuming a water demand of 1.2 l/s/ha in the growing season, gives an indicative monthly water demand of 31.104 million m^3 (MCM) for each growing month. This

[6] Through the project-supported establishment and capacity building of a local JOROP (Joint Reservoir Operations) unit of MOWRAM and PDWRAM.

amount is only 0.0077 of the lowest monthly flow in the driest year (80% exceedance) in the Mekong flow at the extraction point.

33. In the Canal 15 subproject, the question of water availability relates equally to the amount of the water resource and the delivery of that water. The hydrological survey undertaken for the feasibility of the Canal 15 subproject concluded that there is sufficient water available at Canal 15 all year round from a combination of inflow from the upstream catchment and overflow from Bassac and Mekong Rivers. However, the delivery of water to the paddy field is by overland flow from overtopping of the Canal 15 and its lateral canals during periods of high flow and by pumping in the dry months. In this latter period the water in the main canal is only about 0.5 – 0.8 m deep and the smaller lateral canals and ponds annually dry up. Delivery is therefore constrained and this will be addressed by the project works.

34. Dredge spoil reuse planning**.** A program of systematic sampling of sediment in all main and secondary canals for dredging as part of design revision. From this data the implementation team will prepare a dredge spoil management plan based upon the sampling program and contamination "triggers" in West Australian *Assessment levels for Soil, Sediment and Water (2010).* The reuse categories defined in the plan will be incorporated into modified detailed design and works specifications.

35. **Construction**. During construction of the subprojects, the main potential impacts will be air and water pollution and soil erosion, all of which can be managed by strict control of construction contractors and effective implementation of EMP mitigation and monitoring measures. The preparation and approval of works schedules and method statements for key construction activities is required as part of each Site Environmental Management Plan (SEMP). The work plan and scheduling will be approved by the commune councils, taking into account the need for access during harvesting and planting periods.

36. Traffic management will include (i) sequential work scheduling (to ensure that only short stretches are worked on at a time), and (ii) provision of access to existing residences and services is maintained and any damage is repaired to pre-project condition. This will be most significant where canal improvements are being undertaken along the 1,500 m stretch of canal running through the built-up area of Prek Po. Special measures to minimize impacts on residents, including agreed working hours and access will be developed in consultation with residents. The situation is different in the Canal 15 subproject where there is a lack of roads within the main command area (due to its role as a permanent floodway). This means that the roads servicing the docking points for boats will experience a high concentration of construction traffic which will need to be identified in the SEMP and managed by the contractors.

37. For construction impacts of noise and dust, sensitive receptor sites have been identified for all subprojects. In these areas, special safeguards, including consultation before the commencement of works in each locality, have been developed. At Canal 15, the absence of villages within the flood-prone command area means that there are few sensitive receptors who will be impacted by noise and dust from works along the main canal and secondary canals. However, the small southern extension of the command area, supplied by the Samput pumping station, is more closely settled and sensitive receptors will require adequate protection from construction impacts in this area.

38. Dredged spoil will only be used as directed by the dredge spoil management plan.. At Canal 15, dredged spoil from canal deepening and widening cannot be easily removed from site due to lack of access, but also cannot be piled high on embankments because it will be eroded by floodwaters and cause siltation in the canal, and overtopping and overland flow should not be significantly impeded, causing unintended flood afflux in other areas. The embankments here will be widened, rather than increased in height.

39. Mitigation of construction-phase impacts relies heavily on responsibility of works

contractors to follow environmental specification clauses designed to minimize pollution of air and water and soil erosion.

40. **Operation**. One result of irrigation subprojects is the potential for local increases in the levels of agricultural fertilizer and pesticide residues and their effects on water quality and people. Impact mitigation during operation will be aided by capacity building and training under the project on IPM and to use fertilizers and pesticides efficiently and responsibly.

41. At the Prek Po pumping station, electric pumps will operate within 50 m of residential areas. However, these are submersible pumps with noise levels below ambient noise levels in the locality. Noise mitigation measures will be part of the design of the pump outlet tank and restricted daytime-only operating hours will further reduce received noise levels. At Prek Po the main canal becomes clogged with domestic garbage due to the deficiencies of solid waste management services. A solid waste management component for Prek Po commune, comprising support for existing disposal site improvements and development of a community based waste management and action plan, has been designed and will be included in the project implementation phase. Also at Prek Po, the project will intercept domestic greywater (which currently flows into the main canal) and treat it to national standards before discharge.

42. At the Samput pumping station in the Canal 15 subproject, it is proposed to install three pumps and operate two in concert to achieve a discharge capacity of 1.2 m^3/s. When the specifications of the pumps are confirmed noise modelling will be undertaken to determine the level of noise impact on nearby residences (the nearest is 40m). Previous work on other larger pump stations indicate that noise attenuation from a properly sound-insulated pump house is in the order of 35% noise reduction at a distance of 20m. These levels of noise mitigation will be targeted by the pump house design and, since the nearest houses are double this distance away, no noise impacts are anticipated. Operational guidelines will also include limitations on the maximum pump running hours per day in daytime.

43. Greenhouse gas (GHG) emissions from the increased areas of cropping comes from paddy gas production and the additional use of pumps for water movement (electric-powered pumping station at Prek Po and Canal 15 (Samput) and small, mainly diesel pumps used by farmers in the subprojects for local water lifting tasks). The total CO_{2e} emissions generated by the three subprojects will be approximately 40,072 tons/annum. The reconfiguration and modernization of canals in the subprojects to maximize water delivery to farm fields through gravity will reduce the use of small pumps (which accounts for just under 50% of the total GHG generation) and will further reduce the GHG generation from this source. Additionally, in the case of the Canal 15 subproject, the replacement of inefficient diesel pumps at the Samput pumping station with higher capacity electric pumps will result in significant savings in GHG emissions.

44. A Climate Change and Disaster Risk Assessment (CDRA) Report has been prepared by the TRTA team. The CDRA[7] found that for Kamping Pouy, projected climate change is expected to: (i) increase the frequency, intensity, and peak flood height; (ii) increased occurrence and length of drought conditions that could damage irrigation infrastructure and disrupt access to water; and (iii) reduced agricultural productivity. For Prek Po, rainfall is projected to decrease by 0.9% in the normal dry period and to increase by 11.1% during the wet period by 2050. Projected temperature increases are 2.5ºC and 2.9ºC in the wet season and dry season respectively. The projected change in flow in the Mekong River with climate change is an increase in the dry season flow and increased variability in the wet season flow. For Canal 15, the average maximum temperature during the dry season will increase and the wet season average maximum temperature will have a larger increase. Dry season rainfall will slightly (- 3.9 %) while the wet season will see an increase of 9.6%. Overall, the average annual rainfall will increase by 7.0% from 1,246 mm to 1,333 mm. Future flood projections (2050) do not differ markedly from the baseline flood (2011).

[7] Using the IPCC AR4 SRES A1B scenarios in Cambodia Climate Change Toolbox, http://icem.com.au/CambodiaCC/.

45. Adaptations to predicted future changes and disaster risk reduction measures are included in the detailed design of subprojects and operational measures. For Kamping Pouy, to safeguard against increased flooding, the drainage canals will be widened to increase their capacity for higher discharge and two additional drainage canals are proposed for modernization to accommodate flood discharges by enlarging culverts and check structures. Measures to reduce the impacts of drought on agricultural production include irrigation scheduling, installation of water flow measurement equipment in the canals and irrigation management in command area blocks. Reinforcement of the reservoir wall will insure against future failure.

46. Prek Po pump station will be designed for the lowest level of the Mekong River during the dry season, thereby ensuring that farmers will get irrigation water throughout the year and in drought periods. The main and all secondary canals will be lined with concrete, thus reducing seepage losses, and irrigation scheduling will be done for better water management. Existing drainage canals, which have been serving both for irrigation and drainage, will function only for drainage, as separate irrigation canals will be constructed.

47. Excavation to deepen Canal 15, the lateral Canal 87 and Samput Intake Canal will provide more water holding capacity, and continued water conveyance capability of the canals during dry season. From standard engineering design, the planned excavation depth of Canal 15 was about 1.5m. However, an additional depth of 0.5m (30% deeper excavation than standard) to store more water for use is proposed to adapt to projected higher temperatures and lower rainfall in the dry season. This adaptation will also allow navigation and mobility of farmers and communities, to transport their products to market and haul equipment and materials necessary for agricultural production in lower flow and drought periods. Deeper canals will also retain more water from flooding season ensuring higher water availability for dry season cropping. The increased depth of major canals will also act to delay the onset of flood and marginally reduce extreme flood peaks.

48. Capacity building at the subprojects will also address climate change and disaster risk. FWUC establishment and capacity building will address the increased need for coordinated and managed water allocations and the practice of water conservancy in future higher water demand situations. To reduce the impacts of seasonal low water availability on agricultural production and increase the adaptive capacity of farmers, the project's training component will include FWUC and farmer training and awareness raising on climate change and its impacts. Farmers field schools will also include a component on climate change and effects on productivity. In the subproject areas training of commune councils and village leaders in disaster risk reduction and disaster management will be contracted by the project.

49. Climate change adaptation and disaster risk reduction measures have been integrated in the detailed design of the Kamping Pouy, Prek Po and Canal 15 Irrigation Systems. The combined incremental cost has been estimated at approximately $5.2 million for climate adaptation measures and $1.0 million for disaster risk reduction.

D. Public Consultation

50. Public consultations were undertaken in the Kamping Pouy and Prek Po communes on 6 and 9 April 2018, respectively, and at Canal 15 on 24/25 September 2018. The topics covered included present experience and perceptions of environmental problems and anticipated environmental issues in subproject construction and operation. The readiness of community members to complain if things go wrong and the avenues of complaint/redress were also examined.

51. The main existing environmental issue was garbage (discarded pesticide packaging, no garbage management service or disposal site; and garbage accumulating in canals) and this will be addressed by the project during implementation. Other concerns expressed included the provision of sufficient bridges on main and secondary canals to allow convenient access of

farmers to their land and that canal bank roads should be constructed to withstand erosion and gullying. These issues were considered during detailed design, with design options referred back to the community before finalization.

52. Concerns were expressed for scheduling of construction and its potential to interfere with farming activities – particularly harvest. Construction scheduling is an important part of impact mitigation. Agreement on construction schedules with community and continued consultation during construction is included.

53. Usual methods of complaint about environmental issues affecting livelihood, safety and amenity were discussed, and the currently accepted country system for complaints has been integrated in the project grievance redress mechanism (GRM).

E. Grievance Redress Mechanism

54. A project-specific GRM has been designed to receive and manage any public environmental issues that may arise due to the subproject. The implementing agency will coordinate the GRM. All stakeholder project agencies and staff will be initiated into the GRM procedures by the implementation team and will take an active role in supporting the GRM when necessary. Records of complaints received and how they are addressed will be maintained and reported in the quarterly project progress report and semi-annual environmental monitoring report.

F. Environmental Management Plan

55. The IEE will include an EMP where the identified environmental impacts and mitigation measures are presented as an action plan for their implementation. The plan will include institutional arrangements and responsibilities for EMP implementation, potential impacts and mitigation measures, indicators of progress, and frequency and nature of monitoring activities with cost estimates and reporting requirements, capacity building and training, grievance redress mechanism, public consultation and information disclosure and any specific contractor specifications.

56. The EMP will be a critical document for the subprojects. The provisions of the EMP will be incorporated into tender documents and construction contracts.

G. Conclusion

57. The majority of identified environmental impacts are assessed as not significant. The main risks that have been identified in the assessment (uncoordinated management of diversion and reservoir release at Kamping Pouy; potentially contaminated sediments released by canal dredging; surface and groundwater contamination by agricultural chemicals; careless spoil disposal; and, clogging of canal infrastructure by discarded solid waste) have been addressed by mitigation and management measures.

58. It is concluded that: (i) the infrastructure subprojects planned for the Kamping Pouy, Prek Po and Canal 15 subprojects have significant potential benefits for the rural populations of these areas; and that (ii) the design features, operational regimes and construction management safeguards will address the range of potential environmental impacts identified and will be actioned through the Project EMP and continuously checked in the environmental monitoring program.

59. The environmental assessment has confirmed that the subprojects are environment category B under the ADB SPS and that the design, mitigation and monitoring measures identified in the IEE and EMP, if effectively implemented, will reduce environmental impacts to an acceptable level.

I. INTRODUCTION

A. The Proposed Project

1. The Irrigated Agricultural Improvement Project (IAIP) is a project loan to support the Ministry of Water Resources and Meteorology (MOWRAM) of the Government of Cambodia to: (i) rehabilitate, modernize, and climate proof four irrigation systems in Battambang, Kampong Cham, Kampong Thom, and Takeo provinces; (ii) ensure sustainability of irrigation schemes by strengthening institutional and financial arrangements as well as capacity for government staff and farmer water user communities (FWUCs) in operations and maintenance (O&M); (iii) improve farming practices for increased agriculture productivity and crop diversification; and (iv) improve water resources information system (WRIS), and irrigation asset management system for better water resources planning and investment.

B. Impact and Outcome

2. The project is aligned with the following impact inclusive economic growth through agriculture and irrigation attained[1]. It will have the following outcome: water and agriculture productivity in the project areas enhanced. [2]

3. **Output 1: Efficiency and climate resilience of irrigation systems enhanced**. The project will modernize, and climate-proof four irrigation systems to ensure irrigation for about 43,500 ha of agricultural land.[3] It will (i) remodel and improve reservoir embankment, pumping stations, main, secondary, and tertiary canals and drains as well as appurtenant structures; (ii) design joint reservoir operation for two subprojects, and schedule irrigation to improve water sharing arrangements between linked systems and ensure equitable water distribution, particularly during droughts; (iii) strengthen existing FWUCs and forming additional FWUCs with strong women participation, and help them collect irrigation service fees and perform sustainable O&M of the distribution canals; (iv) pilot an irrigation asset management information system to improve O&M budgeting and procedures; and (v) formulate SRP in the Stung Chinit South subproject, providing farmers the opportunity to protect endangered bird species habitat, while achieving a premium price for rice by complying with sustainable production standards.[4]

4. **Output 2: Water resources management improved**. The project will: (i) install hydromet stations to support water resources management in upstream watersheds in Battambang and Kampong Cham provinces; (ii) train government staff and FWUCs on modern canal operation techniques, irrigation scheduling, water management, and O&M; (iii) establish a data center in MOWRAM including a building equipped with data management facilities (database and server system, analytical system, dissemination facilities, doppler radar, etc.); (iv) develop a WRIS using satellite-based information and ground observation to serve as a common platform for sharing water resources management data; (v) train MOWRAM and its provincial departments staff on water accounting and data management; and (vi) provide a program for scholarships, internships, training, and mentoring in water resources management.

5. Three of the sites selected for subprojects, **Kamping Pouy** in Battambang province, **Prek Po** system in Kampong Cham province and **Canal 15** system in Takeo province, are the subject of this Initial Environmental Examination (IEE) report. The IEE is based upon the feasibility studies and detailed designs of two of the subprojects (Kampong Pouy and Prek Po) and the Feasibility

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[1] Government of Cambodia. 2018. *Rectangular Strategy for Growth, Employment, Equity, and Efficiency, Phase IV.* Phnom Penh

[2] The design and monitoring framework is in Appendix 1.

[3] These systems or subprojects are Kamping Pouy in Battambang, Prek Po in Kampong Cham, Canal 15 in Takeo, and Stung Chinit South in Kampong Thom.

[4] The SRP is a multi-stakeholder platform established by the United Nations Environment Program and the International Rice Research Institute in December 2011.

Study for Canal 15 subproject. An additional subproject which has been categorized as Category A for environment due to potential impacts on critical habitat, is the subject of a separate EIA.

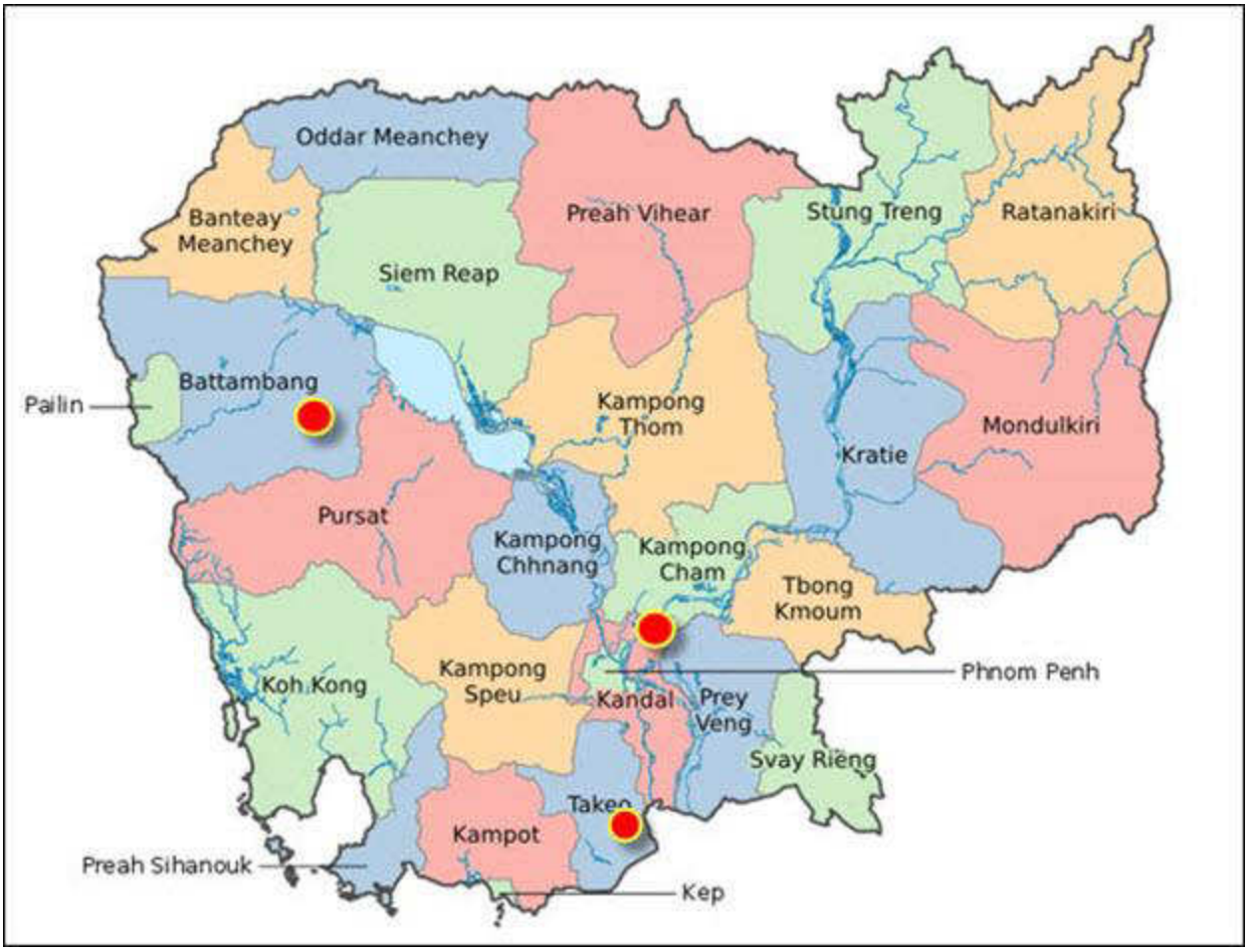
6. The planned increases in irrigated area as a result of the subproject works are summarized in Table 1 below.

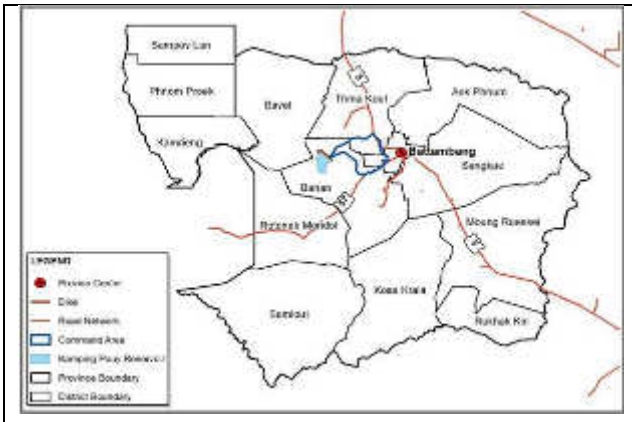
Table 1: Planned Increases in Irrigation for the Subprojects

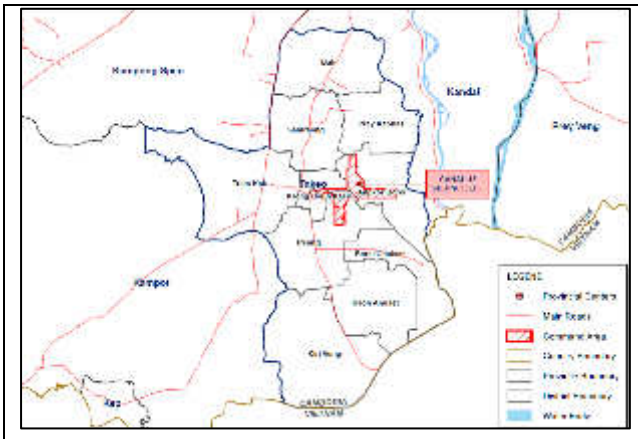
No.	Name Sub-Project	Province	Existing Command Area (Ha)			New Command Area (Ha)		
			Wet Season	Dry Season	Cumulative Total Irrigated	Wet Season	Dry Season	Cumulative Total Irrigated
1	Kamping Pouy	Battambang	12,000	8,000	20,000	12,000	12,000	24,000
2	Prek Po	Kampong Cham	380	1,200	1,580	8,000	8,000	16,000
	Canal 15	Takeo	5,000	1,000	6,000	5,000	2,500	7,500
Total			**17,380**	**10,200**	**27,580**	**25,000**	**22,500**	**47,500**

Source: TRTA Consultants estimates in Kamping Pouy, Prek Po and Canal 15 Feasibility Study Reports

Figure 1: Project Locations







Top left: Kamping Pouy subproject, Battambang province

Top right: Prek Po subproject, Kampong Cham province

Left: Canal 15 subproject, Takeo province

Source: Kamping Pouy, Canal 15 and Prek Po Feasibility Study Reports, TRTA 2018.

C. Environmental Safeguards

7. The subprojects are classified Category B for environment under the ADB Safeguard Policy Statement (SPS, 2009), requiring preparation of an IEE. The IEE has been prepared based on information in the individual feasibility study reports (FSRs), detailed designs for two of the subprojects and on-site data collection and assessments by the TRTA environment team.

8. The IEE includes an environmental management plan (EMP). This is the key guiding document for environmental-related issues in the construction and operational phases of the project. The potential impacts of project components are identified in the IEE, and the mitigation and protection measures to avoid, reduce, and/or mitigate these impacts to acceptable levels are described in the EMP. The EMP also defines the roles and responsibilities of relevant institutions, procedures and the EMP budget. The plan seeks to ensure continuously improving environmental protection activities during preconstruction, construction, and operation in order to prevent, reduce, or mitigate adverse impacts and risks.

9. During project implementation, the EMP is coordinated and implemented by the PMU and its construction contractors. The provisions of the EMP will be incorporated in construction contracts.

II. LEGAL AND ADMINISTRATIVE FRAMEWORK

A. ADB Environmental Requirements

10. On the basis of subproject screening in the feasibility stage, the subprojects have been initially classified as Category B for environment since impacts are assessed as site-specific and can be readily mitigated. This IEE has been prepared under the provisions of the ADB Safeguard Policy Statement 2009.

11. Guidelines for international best practice will also be drawn from *IFC Environmental Health and Safety Guidelines: Annual Crop Production* (World Bank Group 2016) and *IFC Environmental Health and Safety General Guidelines* (World Bank Group 2007).

B. Cambodian Government Environmental Regulations

1. Law on Environmental Protection and Natural Resource Management

12. The Law on Environmental Protection and Natural Resources Management was enacted by the National Assembly and launched by the Preah Reach Kram/NS-RKM-1296/36. It was enacted on December 24th, 1996. This law has the following objectives:

- To protect and promote environment quality and public health through prevention, reduction and control of pollution,
- To assess the environmental impacts of all proposed projects prior to the issuance of a decision by the Government,
- To ensure the rational and sustainable conservation, development, management and use of the natural resources of the Kingdom of Cambodia,
- To encourage and provide possibilities for the public to participate in the protection of environment and the management of the natural resources, and
- To suppress any acts that cause harm to the environment.

13. Under this law the developers or project owners need to prepare an Initial Environmental Impact Assessment (IEIA) or a full Environmental Impact Assessment (EIA) report for their proposed or existing development projects.

2. Environmental impact assessment process sub-decree

14. The sub-decree No 72 ANRK.BK in the Law on Environmental Impact Assessment Process dated 11 August 1999 sets out EIA procedures. The main objectives of this sub-decree are:

- To determine an Environmental Impact Assessment (EIA) for every private and public project or activity, through review by the Ministry of Environment (MOE), prior to the submission for a decision from the Government.
- To determine the type and size of the proposed project(s) and activities, including existing and ongoing activities in both private and public sector prior to undertaking the process of EIA.
- To encourage public participation in the implementation of the EIA process and take into account their input and suggestions for re-consideration prior to the implementation of any project.

15. The sub-decree includes an annex which provides a schedule of developments which require EIA. An excerpt for relevant industries is at Table 2.

Table 2: Annex of Sub-Decree No 72 ANRK. BK. Date 11, August 1999: List of the Projects Required an IEIA or EIA

Type and activities of the projects	Size / Capacity
AGRICULTURE	
Concession forest	⁻ 10,000 Hectares
Logging	⁻ 500 Hectares
Land covered by forest	⁻ 500 Hectares
Agriculture and agro-industrial land	⁻ 10,000 Hectares
Flooded and coastal forests	All sizes
Irrigation systems	⁻ 5,000 Hectares
Drainage systems	⁻ 5,000 Hectares
Fishing ports	All sizes

Source: Sub-Decree No 72 ANRK. BK.

16. Since the command area is substantially expanded by the refurbishment of a scheme to provide more than 5,000 ha of newly irrigated land or land previously without reliable irrigation, the provisions of the sub-decree will apply. In the case of the subprojects which are the subject of this IEE, the increase in reliably irrigated land will be more than 19,500 ha (4,000, 14,420 and 1,500 ha for Kamping Pouy, Prek Po and Canal 15 respectively). The domestic environmental impact assessment will be undertaken as agreed between MOWRAM and Ministry of Environment (MOE). Baseline data and impact assessments for this are provided by the this IEE and the Social and Poverty Impact Assessments. Khmer language translations of the IEE executive summary has been provided to MOWRAM. MOWRAM will obtain subproject approvals from MOE prior to civil works contractor mobilization.

C. Evaluation Standards

17. This section details the existing Cambodian laws and regulations for environmental standards. It also includes evaluation standards for best practice in pollution control in *IFC Environmental Health and Safety General Guidelines*. Additionally, the *2016 IFC EHS Guidelines on Annual Crop Production* recommended practices for sustainability of irrigation, crop waste, pest management and occupational health and safety.

1. Law on the Management of Pesticides and Fertilizers

18. The Law on the Management of Pesticides and Fertilizers was enacted on 14th January 2012. This law has the following objectives:

- To support a policy promoting the effective potential of agriculture sector, for the development of social and national economy,
- To ensure the safe and effective control of pesticides and fertilizers, consistent with international standards,
- To enhance public awareness on the implementation of standard requirements of pesticides and fertilizers for all relevant activities related to these products,
- To reduce risks caused by the use of pesticides and fertilizers, for beneficiary of farmers and people by ensuring food security, food safety, public health, and the sustainability of environment.

19. The scope of the law shall apply to the management and the implementation of standard requirements for:

- All type of pesticides and fertilizers, raw materials or active ingredients and other compositions of pesticides and fertilizers which are used as inputs in agricultural production.
- All activities of natural persons or legal entities who are traders, formulators, pests control services operators, advertisers, donors, and users of all types of pesticides and fertilizers.

20. The law includes a schedule of agricultural chemicals which are banned or restricted in Cambodia. Pesticides and herbicides currently used in the subproject areas are checked against these lists.

2. Law on Water Resources Management

21. The Law on Water Resources Management was adopted by the National Assembly on 22 May, 2007. This law provides procedures for the management of water resources within Cambodia. The purpose of the law is to foster the effective management of the water resources of the Kingdom of Cambodia to attain socio-economic development and the welfare of communities.

22. The Law shall determine:

- the rights and obligations of water users,
- the fundamental principles of water resources management,
- the institutions in charge of its implementation and enforcement, and
- the participation of users and their associations in the sustainable development of water resources.

23. Under this law, MOWRAM may declare any basin, sub-basin or aquifer as Water Law Implementation Area when within that basin, sub-basin, ground water or aquifer there are likely to be conflicts among water users, problems of water pollution or watershed degradation.

3. Water pollution control sub-decree

24. The sub-decree No 27 ANRK.BK on Water Pollution Control dated 13 October 2009. The purpose of this sub-decree is to regulate water pollution control in order to prevent and reduce the water pollution of public water so that the protection of human health and the conservation of bio-diversity can be ensured.

25. This sub-decree applies to all sources of pollution and all activities causing pollution of public water areas. The sub-decree also provides the pollution types, effluent standards, and water quality standards in different areas. Water quality standards are stipulated in this sub-decree for public water (Table 3).

Table 3: Water Quality Standard in public water areas for bio-diversity conservation

No	Parameter	Unit	Standard Value
A. River			
1	pH	mg/l	6.5 – 8.5
2	BOD_5	mg/l	1 – 10
3	Suspended Solid	mg/l	25 – 100
4	Dissolved Oxygen	mg/l	2.0 - 7.5

5	Coliforms	MPN/100ml	< 5000
B. Lakes and Reservoirs			
1	pH	mg/l	6.5 – 8.5
2	COD	mg/l	1 – 8
3	Suspended Solid	mg/l	1 – 15
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100ml	< 1000
6	Total Nitrogen	mg/l	0.1 – 0.6
7	Total Phosphorus	mg/l	0.005 – 0.05
C. Coastal water			
1	pH	mg/l	7.0 – 8.3
2	COD	mg/l	2 – 8
4	Dissolved Oxygen	mg/l	2 - 7.5
5	Coliform	MPN/100ml	< 1000
5	Oil content	mg/l	0
6	Total Nitrogen	mg/l	0.2– 1.0
7	Total Phosphorus	mg/l	0.02 – 0.09

Source: Annex 4 of Sub-decree on Water Pollution Control, 2009.

4. Drinking Water Quality Standards

26. For well water used for domestic purposes, including drinking, the Ministry of Industry Mines and Energy *Drinking Water Quality Standards* of January, 2004 is the evaluation standard. These are summarized in Table 4.

Table 4: Drinking Water quality standards

Parameter	Unit	Cambodian Standard for Drinking Water	Cambodian Standard for Raw Water	US EPA Drinking water
pH	mg/l	6.5 – 8.5	5.5 - 9	6.5 – 8.5
Turbidity	NTU	5	-	1
Arsenic	mg/l	0.05	<50µg/L	0
Chlorine	mg/l	0.2-0.5		
Copper	mg/l	1	<1mg/L	<1mg/L
Sulphate	mg/l	250		
Total nitrogen	mg/l	-	15	50
Lead	mg/l	0.01		
Mercury	mg/l	0.005	<1µg/L	<1µg/L
Coliform	CFU/100ml	3	$<5 \times 10^3$	<1

Source: Annex 4 of Sub-decree on Water Pollution Control, 2009.

5. Solid waste management sub-decree

27. The sub-decree No 36 ANRK.BK on Solid Waste Management is dated April 27th, 1999. The purpose of this sub-decree is to regulate solid waste management in order to ensure the protection of human health and the conservation of bio-diversity.

28. This sub-decree applies to all activities related to disposal, storage, collection, transport, recycling, dumping of garbage and hazardous waste.

6. Air pollution control sub-decree

29. The sub-decree N^0 42 ANRK.BK on Air Pollution Control and Noise Disturbance is dated July 10th, 2000. Its purpose is to protect the quality of environment and public health from air

pollutants and noise pollution (Tables 5 and 6). This sub-decree applies to all movable sources and immovable sources of air and noise pollution. It is also applied to evaluation of ambient air quality and to monitoring of air pollution status in Cambodia.

Table 5: Ambient Air Quality Standard

Parameters	Cambodian				IFC-EHS Guidelines mg/m^3
	Period 1h Average mg/m^3	Period 8h Average mg/m^3	Period 24h Average mg/m^3	Period 1year Average mg/m^3	
Carbon monoxide (CO)	40	20	-	-	
Nitrogen dioxide (NO_2)	0.3	-	0.1	-	200 (1 hr)
Sulfur dioxide (SO_2)	0.5	-	0.3	0.1	
Ozone (O_3)	0.2	-	-	-	100 (8 hr)
Lead (Pb)	-	-	0.005	-	
Particulates	-	-	0.33	0.1	50 (PM_{10} 24hr) 25 ($PM_{2.5}$ 24hr)

Source: Annex1 of Sub-Decree on Air Pollution Control and Noise Disturbance, 2000.

Table 6: Maximum permitted noise level in public and residential area (dB (A))

Location	Cambodian Standard			IFC-EHS Guidelines	
	06:00 to 18:00	18:00 to 22:00	22:00 to 06:00	Day 7.00-22.00	Night 22.00-7.00
Silence Area - Hospital - Library - School - Nursery	45	40	35	55	45
Resident Area - Hotel - Administration place - House	60	50	45		
Commercial, Services Areas and mix	70	65	50	70	70
Small Industrial factories intermingling in residential areas	75	70	50		

Source: Annex 6 of Sub-Decree on Air Pollution Control and Noise Disturbance, 2000
Note: This standard is applied to control of noise level of any source of activity that emitted noise into the public and residential areas.

7. Silt/Sediment Quality

30. For the re-use and disposal of silt from canal cleaning or dredging, there is no government standard. Standards applying to paddy field environments from the West Australian *Assessment levels for Soil, Sediment and Water (2010)*, which includes relevant potential contaminants for the subproject https://www.der.wa.gov.au/images/documents/your-environment/contaminated-sites/guidelines/2009641_-_assessment_levels_for_soil_sediment_and_water_-_web.pdf..

8. National Integrated Pest Management Programme

31. The Integrated Pest Management (IPM) Programme in Cambodia was established in 1993 after conducting national workshop on “Environment and IPM”. The overall goal of National IPM programme is to promote food security in Cambodia by enhancing the sustainability of intensified crop production system through the promotion of integrated crop management (ICM) skills at farm level. The objectives of this programme are:

(i) to reduce dependence on agricultural chemical, especially pesticides, in agricultural production and to minimize hazards to the human health, animals and environment,
(ii) to develop the capacity of farmers and agricultural technical officers in conducting training and experiments so that they are able to identify problems occurring in agricultural production and find appropriate solution to deal with the problem by themselves,
(iii) to educate farmers on agricultural technology by enhancing their knowledge on field ecology and by developing skills among farmers in monitoring and analyzing field situations that enable them to manage crops properly.

32. At the national level the position of the IPM programme was strengthened by a Prakas (Ministerial Declaration) in July 2002, recognising the National IPM Programme as coordinating body for all IPM related activities in Cambodia. The Prakas also established a Steering Committee and a Deputy Director to act as the National Coordinator.

D. Environmental, Health, and Safety Guidelines

33. ADB's SPS applies pollution prevention and control technologies and practices consistent with international good practices as reflected in internationally recognized standards such as the World Bank/IFC Group's Environmental, Health and Safety Guidelines. The Guidelines provide the context of international best practice and contribute to establishing targets for environmental performance.

34. Occupational and community health and safety, as laid out in the EHS Guidelines, will be a cross-cutting assessment for the subprojects. The two primary sources for occupational health and safety guidelines will be *IFC Environmental Health and Safety Guidelines: Annual Crop Production* (World Bank Group 2016) and *IFC Environmental Health and Safety General Guidelines* (World Bank Group 2007).

35. The EHS guidelines and targets will be used in this EIA for the assessment and mitigation of potential impacts on air and noise. Water quality standards used (for both surface water and groundwater) will be the relevant domestic Cambodian water quality standards, supported by reference to US EPA standards. Soil contamination (from dredge spoil) will be assessed against international standards (primarily the Japanese Environmental Quality Standards for soil pollution, August 1991).

III. DESCRIPTION OF THE PROJECT COMPONENTS

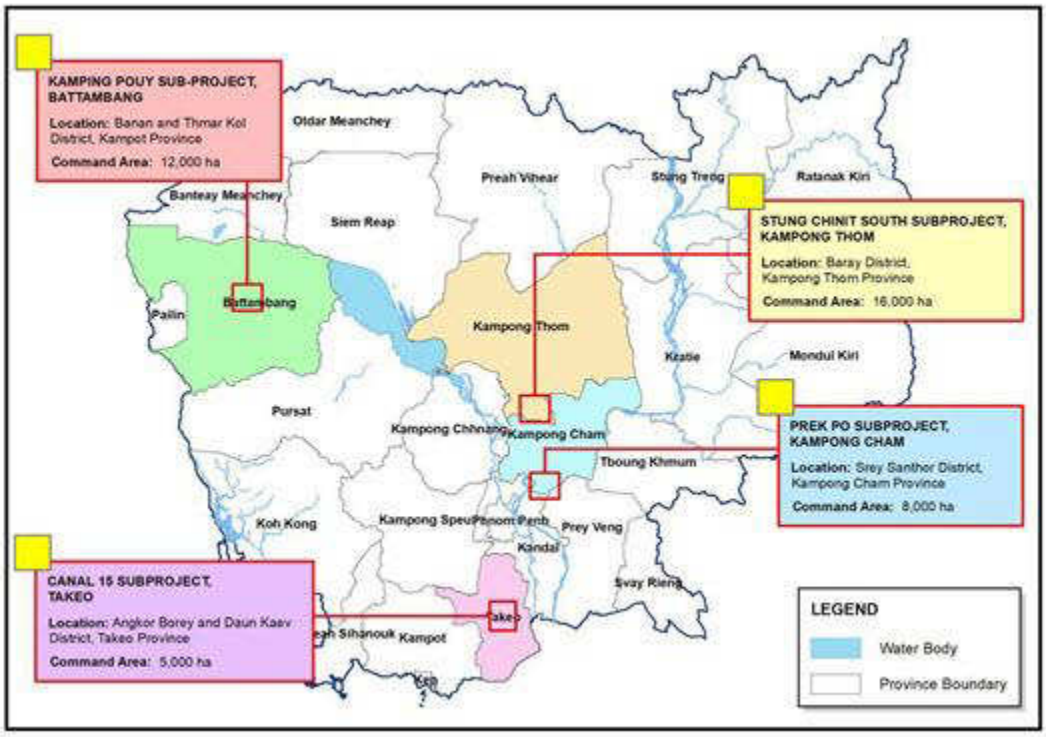
A. Overall Project

36. The Project will be implemented in Kampong Cham, Kampong Thom, Takeo and Battambang provinces. The uplands of these provinces (lands away from Tonle Sap) have potential for improved land and water productivity through improved irrigation systems and water resource management. The Project area will comprise selected irrigation systems in these provinces, which have potential for a second rice crop and the option of a third crop of either rice or another crop.

37. The Project will (i) rehabilitate, modernize and climate proof existing irrigation systems and improve their performance and management, (ii) enhance land and water productivity through watershed management and land improvement, and (iii) improve management of water resources through participatory irrigation and water resource management.

38. A long list of candidate subprojects was developed during the course of the TRTA, along with selection criteria for finalizing the preferred ones. Four subprojects have been selected using these criteria. The three which are the subject of this IEE, are the **Kamping Pouy** system in Battambang province, **Canal 15** system in Takeo province and **Prek Po** system in Kampong Cham province (Figure 2). The fourth subproject depicted in Figure 2, the Stung Chinit South subproject, is the subject of a separate EIA since it is categorized as Category A for environment under SPS 2009.

Figure 2: Location of Core Subprojects



Source: Kamping Pouy, Canal 15 and Prek Po Feasibility Study Reports, TRTA 2018.

39. The package of civil works, operational management and capacity building described in this chapter will contribute towards the following potential increases in irrigated areas:

Table 7: Estimate of Irrigation Areas

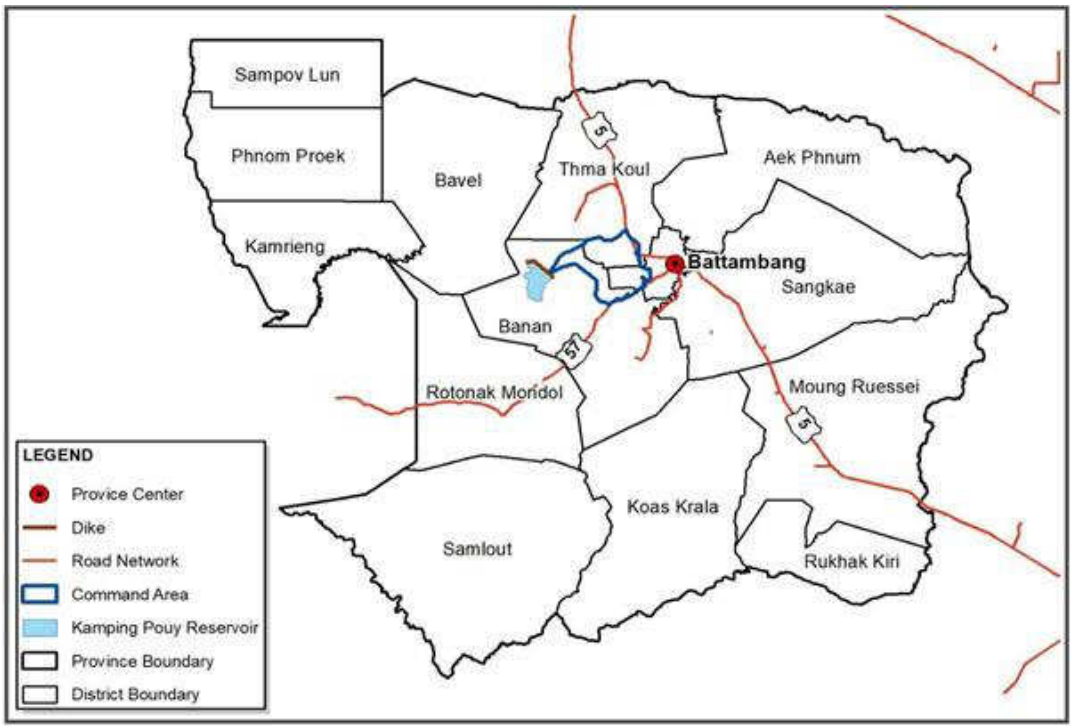
No.	Name Sub-Project	Province	Existing Command Area (Ha)			New Command Area (Ha)		
			Wet Season	Dry Season	Cumulative Total Irrigated	Wet Season	Dry Season	Cumulative Total Irrigated
1	Kamping Pouy	Battambang	12,000	8,000	20,000	12,000	12,000	24,000
2	Prek Po	Kampong Cham	380	1,200	1,580	8,000	8,000	16,000
3	Canal 15	Takeo	5,000	1,000	6,000	5,000	2,500	7,500
Total			**17,380**	**10,200**	**27,580**	**25,000**	**22,500**	**47,500**

Source: Kamping Pouy, Prek Po and Canal 15 Feasibility Study Reports, 2018.

B. Kamping Pouy Subproject

40. Kamping Pouy Irrigation System stretches from immediately west of the provincial capital of Battambang for 35 km. Irrigation water is drawn from the Kamping Pouy Reservoir.

Figure 3: Kamping Pouy Irrigation Scheme Location



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

41. Kamping Pouy Reservoir has an earthen dam of 6.5 km, equipped with four outlet structures, which deliver irrigation to different parts of the system command area. The reservoir has a maximum storage capacity of the 139 million cubic meter (mcm), from which the available storage is about 101 million cubic meters (mcm), while remaining storage is for flood control. The reservoir maximum flood extent is 48.30 km^2. The catchment area of Kamping Pouy Reservoir is 388 km^2 with an average annual rainfall of 1,299 mm and average annual inflow of 78.80 mcm. In the wet season, flood waters enter the command area through bridges and culverts across National Highway No. 57, running along the southwest boundary of the command area. In 2013, about 37% of the command area was flooded.

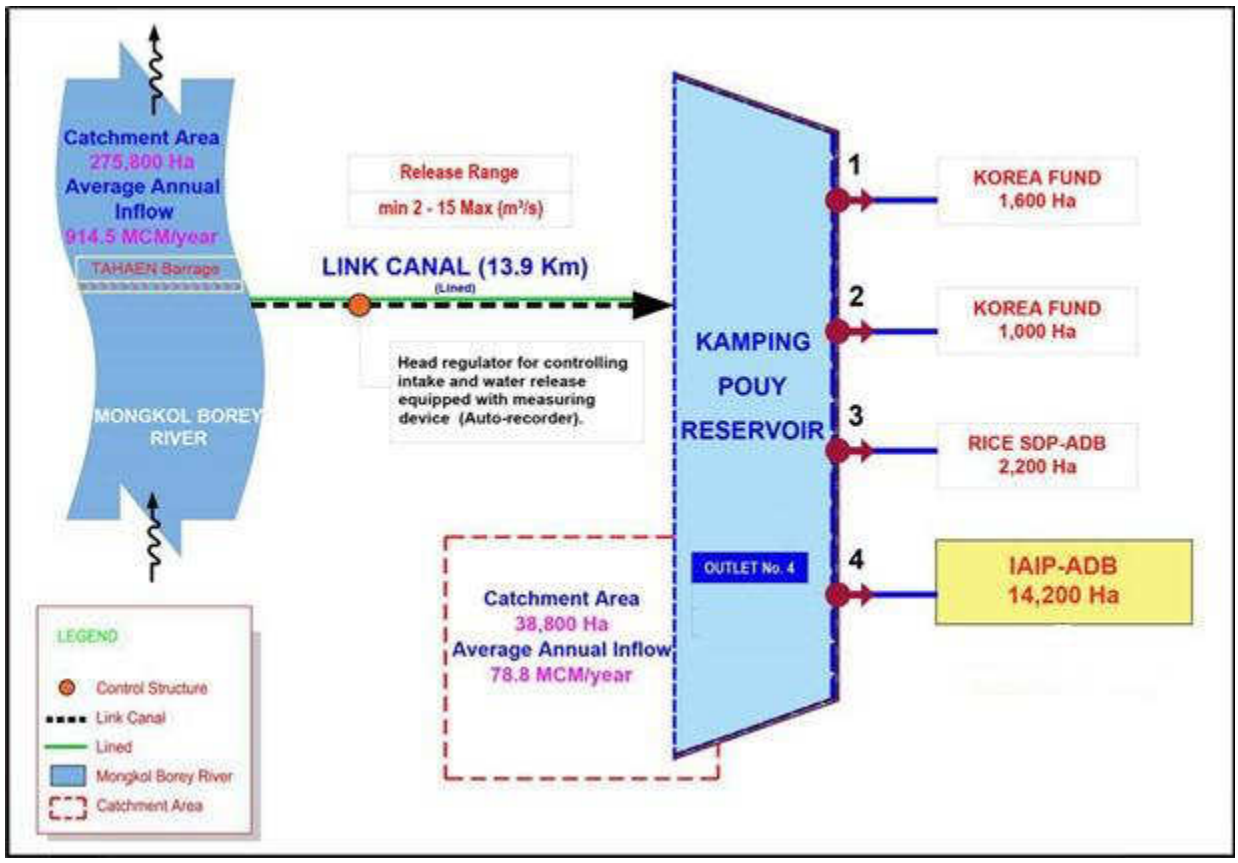
Table 8: Outlet structure on the Kamping Pouy Reservoir embankment

No.	Intake Gate	Sill Elevation (meters)	Function	Area Served (hectares)
Outlet No.1	Eight Gates	20.50	Irrigation	2,000
Outlet No.2	One Gate	20.50	Irrigation and flood spillage	1,000
Outlet No.3	Six gates	20.50	Irrigation and flood spillage	1,800
Outlet No.4	Ten Gates	20.50	Irrigation	14,200[a]
Total Command Area				**19,000**

[a] 12,000 ha is the command of this subproject and remaining 2,200 ha outside the subproject command area.
Source: TRTA Consultants estimates.

42. The reservoir is augmented by an additional supply from Mongkol Borey river flow, through a 13.9 km link canal. The catchment area of Mongkol Borey River is 2,758 km^2 which provides an average annual flow of 914 mcm. A link canal, connecting Mongkol Borey River to Kamping Pouy reservoir, plays a very important role in providing additional water supply to fill up the reservoir during the rainy season. The Link Canal is silted up to 1 m depth due to the collapse of the steep canal side slopes. Consequently, the conveyance capacity of the canal is considerably reduced compared to the original design capacity.

Figure 4: Schematic diagram of inflows of Kamping Pouy reservoir (Battambang)



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

43. Different parts of command area of the Kamping Pouy Irrigation Scheme receive irrigation water supply from different outlet structures of the reservoir. The Kamping Pouy Subproject is focusing only on 12,000 ha net command area, which gets irrigation water from Outlet No. 4. Table 9 below presents the length of existing irrigation and drainage canal networks within the target

command area of the subproject. Existing main canal and secondary canals are shown in Figure 4.

Table 9: List of existing irrigation and drainage canal with the subproject target area

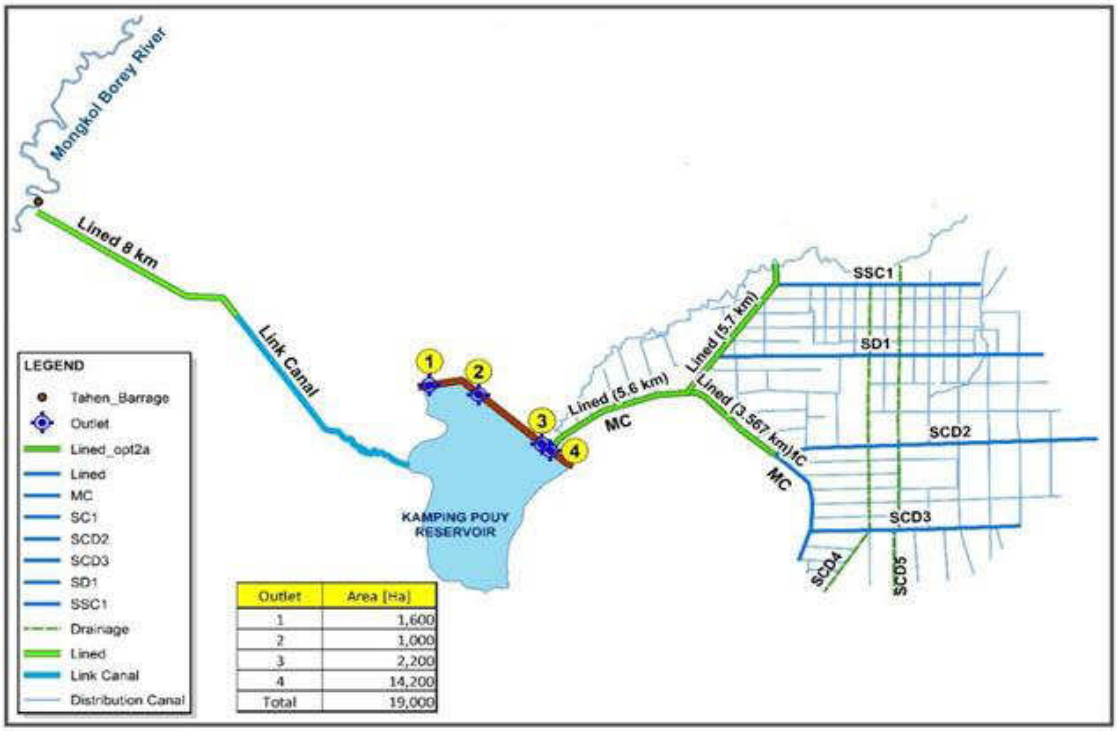
No.	Description	Number	Length (Km)	Remarks
1	Main Canal	1	9.80	Irrigation
2	Secondary Canals	3	28.5	Irrigation & Drainage
3	Distribution network	150	264	Irrigation & Drainage
Total		**154**	**301.5**	Irrigation & Drainage

Source: TRTA Consultants estimates.

44. The following are the planned civil works for the Kamping Pouy Subproject in Battambang Province:

i. Strengthening reservoir embankment of 6.5 km by providing erosion protection measure on the upstream slope;
ii. Upgrading the 13.9 km length of Link Canal with 8 km concrete lining for diverting additional water from Mongkol Borey River to Kamping Pouy Reservoir;
iii. Upgrading of 14.14 km main canal with concrete lining on the initial 9.17 km on the side canal slopes to increase canal efficiency and improve 28 distribution and control structures;
iv. Rehabilitation of secondary irrigation canals SC1 and SSC1 of 12.7 km total with concrete lining of 5.7 Km, and improvement and installation of 41 structures within the subproject target command area to ensure water delivery to 6,083 ha;
v. Rehabilitation of secondary irrigation and drainage canals SCD2, SCD3, SCD4, and SCD5 with a total length of 6.9 km and improvement and installation of 101 structures within the subproject command area to ensure water delivery to 5,517 ha and prevent the inundation of paddy lands within the command area.

Figure 5: Location of Proposed Civil Works at Kamping Pouy

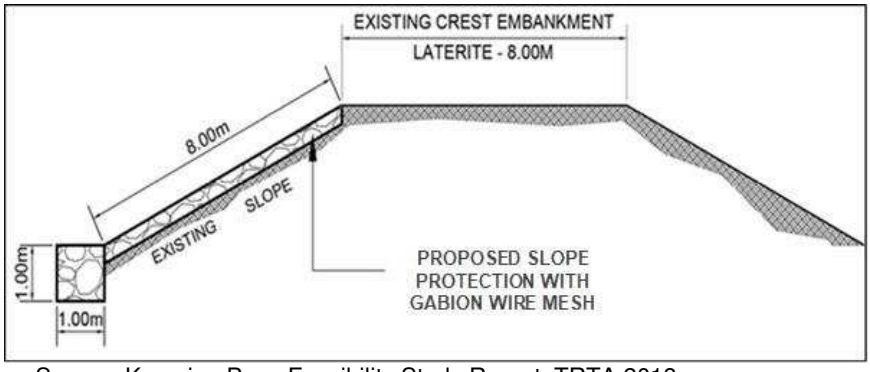


Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

1. Strengthening the Reservoir Dam

45. To control the surface erosion on the upstream face of reservoir an 8m-wide gabion mattress will be constructed along the whole length of dam (6.5 km). The planned treatment of the dam wall is shown in Figure 6 below.

Figure 6 Typical cross section of the proposed slope erosion control work for reservoir dam



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

2. Rehabilitation of the Link Canal

46. The link canal from the Mongkol Borey has degraded and is already silted up over more than 10 km to about 1 m depth due to the erosion of the canal side slopes, with a significant reduction of its conveyance capacity. The works will include increasing conveyance capacity of the link canal by deepening the canal bed and lining it along much of its length. Lining the canal will allow higher water velocity and prevent the erosion of the canal's side slopes. It is proposed that a 9.7-km stretch of the link canal (between the Mongkol Borey intake and the entrance to the reservoir) be lined with concrete to enable more water to flow into the Kamping Pouy Reservoir from the river.

3. Rehabilitation and Modernizing of Internal Canals

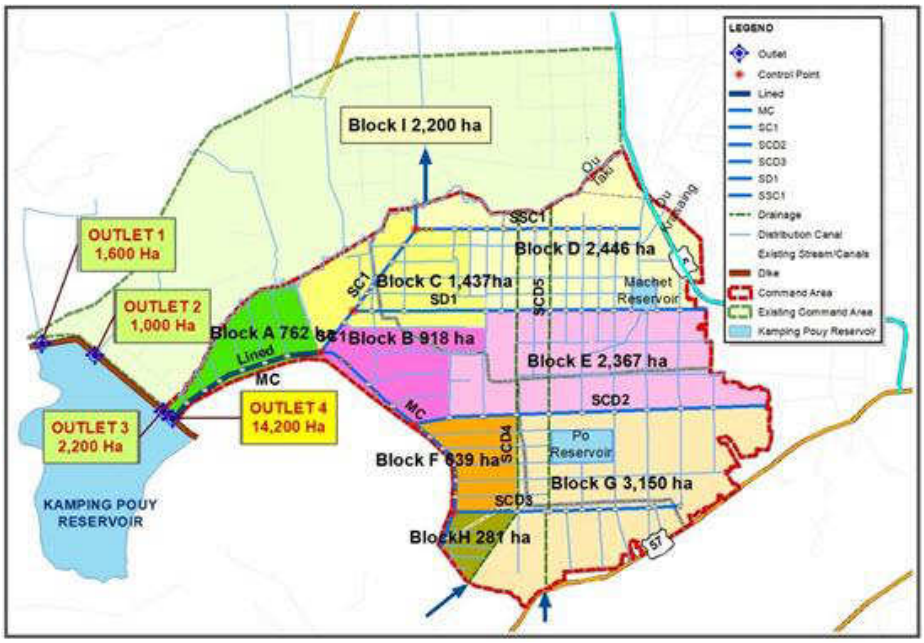
47. Works covering both irrigation canals and drainage canals are summarized in Table 10 below. The location of canals and irrigation blocks are shown on Figure 7.

Table 10: List of Proposed Civil Works for Kamping Pouy Subproject

Canal	Symbols	Command Area (ha)	Irrigation Blocks	Canal/Drain Length (km)	Canal Type	Control Structures
Main Canal	MC	14200	Blocks A to I	14.1	Lined 9.17 km	28
Secondary Irrigation Canals	SC1 and SSC1	6083	Blocks C, D, and I	12.7	Lined 5.7 Km (SC1)	41
Secondary Irrigation and Drainage Canals	SCD2, SCD3, SCD4 and SCD5	5517	Blocks E and G	39.9	Earthen	101
Drainage Canals	SD1 and TN16	Drainage			Earthen	5

Source: TRTA Consultants estimates.

Figure 7: Irrigation Blocks and Canals of Kamping Pouy Subproject

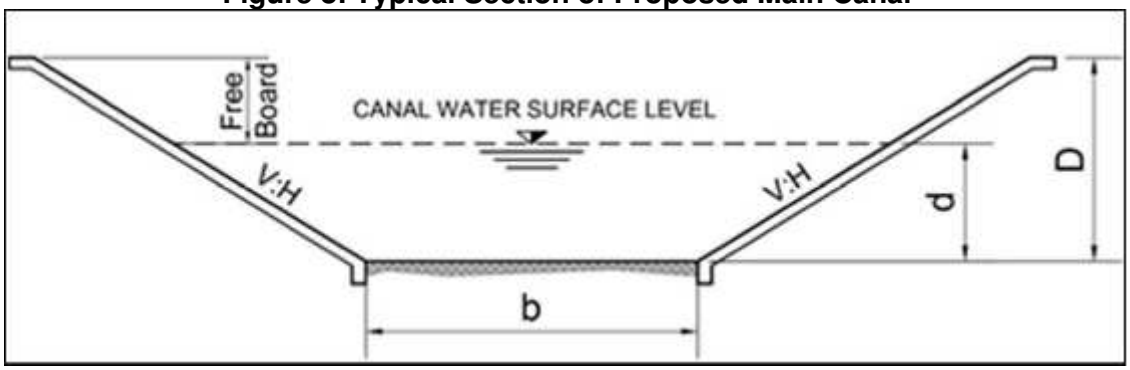


Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

48. **Main canal.** To control the erosion and destabilizing vegetation growth on the canal banks, concrete lining on the canal side slopes of an initial 5.6 km length will be undertaken along the main canal. A total of 28 different types of structures will be equipped on the main canal; most will be replacing the existing structures.

49. **Secondary and Drainage Canals**. Rehabilitation of secondary irrigation and drainage canals SCD2, SCD3, SCD4, and SCD5 of 6.9 km total, and improvement and installation of 101 structures within the subproject target command area will ensure water delivery and prevent inundation of paddy lands within the target command area.

Figure 8: Typical Section of Proposed Main Canal



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

4. Hydrometeorological Station Upgrades

50. The existing hydrometeorological monitoring gauges and data collection and analysis system at three hydromet station in the reservoir catchment, one automatic weather station in the command area and seven automatic rain gauges in the catchment and on the Mongkol Borey will

be rehabilitated with new equipment to ensure that the Kamping Pouy FWUC has reliable data upon which to plan and coordinate irrigation water distribution.

5. Joint Reservoir Operation (JOROP)

51. A Joint Reservoir Operations Unit for the Kamping Pouy Scheme (JOROP-KAPOS) will be established under the Battambang PDWRAM to operate and maintain the reservoir. The JOROP unit will include representatives of the four areas that draw water from the reservoir and discuss/approve water releases. Staff will include women and will be trained in the O&M of the reservoir in close collaboration with the FWUCs. The unit will be provided with a budget for its operations, which will be recovered in the future from FWUC contributions.

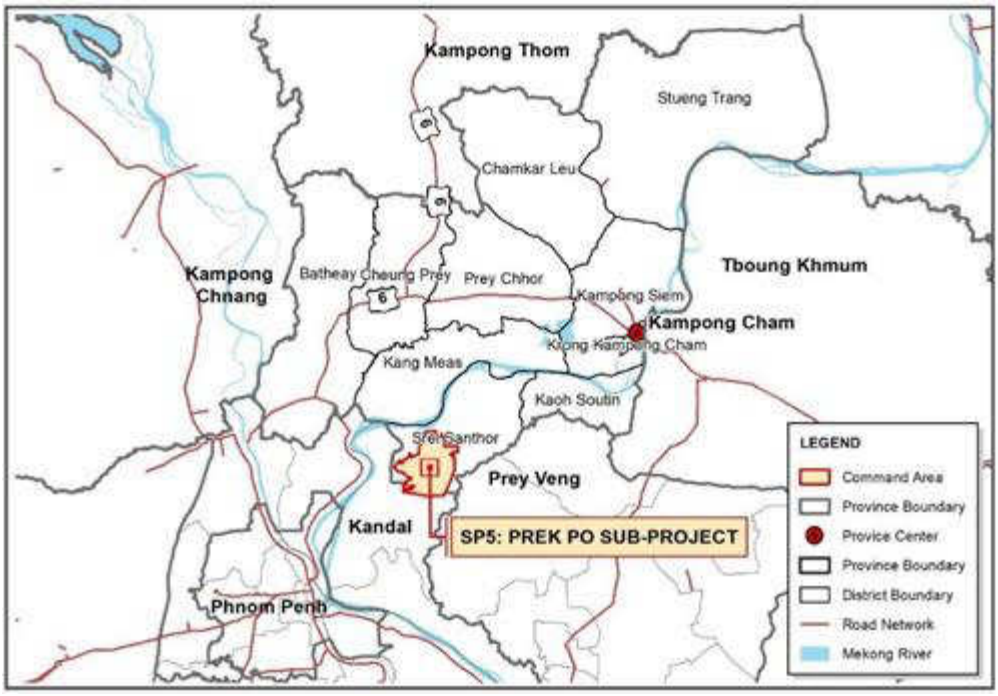
- The JOROP unit will monitor evapotranspiration and effective rainfall and incorporate these in irrigation water scheduling. This will be done for each 10-day period at the start of the season.
- It will keep track of the area planted to specific crops (rice, non-rice) in both wet and dry seasons.
- The JOROP Unit will monitor the automatic recording of water level in the reservoir.
- The JOROP Unit will be responsible for observing and recording the flow volume and discharge in the Mongkol Borey River.
- Water inlet controls with measuring devices will be installed or upgraded at the entrance of the Link Canal into the reservoir. Water will be drawn from Mongkol Borey River through the Link Canal as needed to maximise storage of late wet season rains and maintain reservoir supply

C. Prek Po Subproject

52. Most of the Prek Po subproject is located in Srey Santhor central district of Kampong Cham Province and a small southern part in Khsach Kandal district of Kandal Province. Srey Santhor district shares borders with Kang Meas and Koh Soutin districts at the north and east respectively, and at its south east lies Sithor Kandal and Pea Reang districts of Prey Veng Province. The western border of the district is shared with Khsach Kandal district of Kandal Province, see Figure 9.

53. Prek Po subproject is situated between two rivers, the Mekong and its branch, the Tonle Touch. The hydrology of the subproject area is highly dependant on the Mekong. Parts of the subproject are subject to Mekong Season flood, but the majority of the area is only affected by a 1-in-10-year flooding event. About 40% of the area never experiences flooding.

Figure 9: Prek Po Scheme Location



Source: Prek Po Feasibility Study Report, TRTA 2018.

54. The irrigation network in the command area consists of an existing 13 km long main canal, 20 secondary canals with a total length of 53km and seven tertiary canals with a total length of 58 km (Table 11). The layout of the existing canal network is shown in Figure 10.

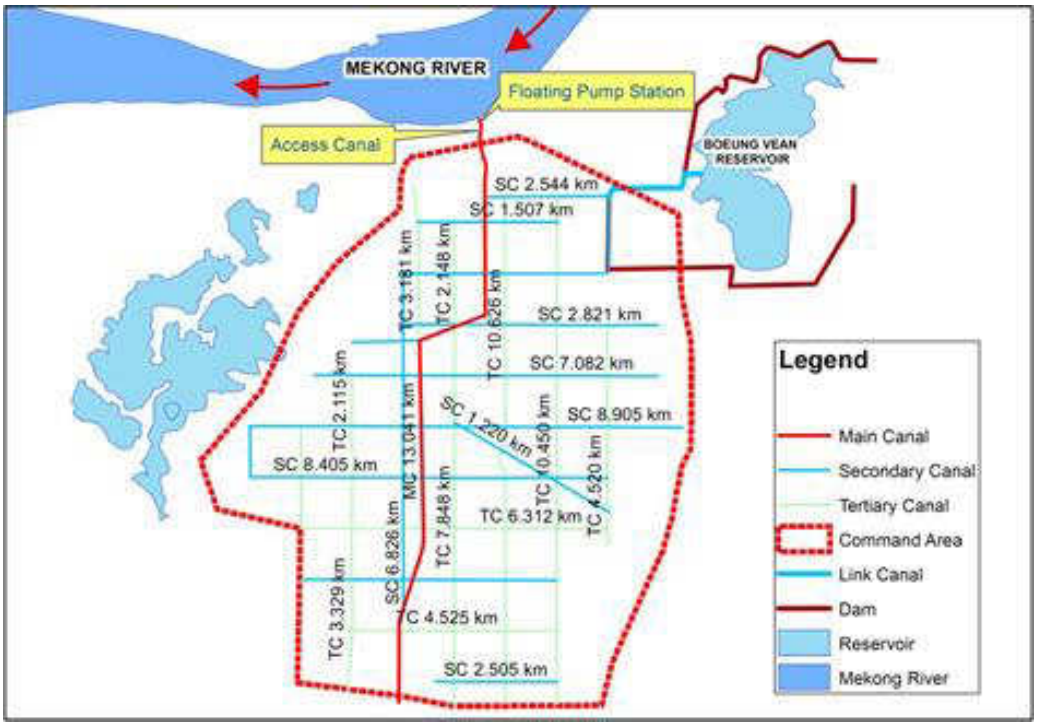
Table 11: Existing Infrastructure Facilities in the Prek Po Irrigation Scheme

Description	Unit	No.	Remarks
Floating pumping station		1	Floating station (set up by MOWRAM)
Stationary pumping station		1	Stationary/fixed station (funded by generous individuals and institutions)
Main canal	km	12.75	Used for irrigation and drainage (I&D)
Secondary canal	km	53.00	Used for I&D
Tertiary canals	km	58.00	Used for I&D

Source: TRTA Consultant estimates.

55. The command area is divided in 100ha blocks with secondary canals in east-west direction and tertiary canals in north-south directions. The quaternary canals start from the tertiary canals and are located in east west direction, and field channels are in north-south direction.

Figure 10: Existing Prek Po Scheme showing Main Canal and Secondary Canals



Source: Prek Po Feasibility Study Report, TRTA 2018

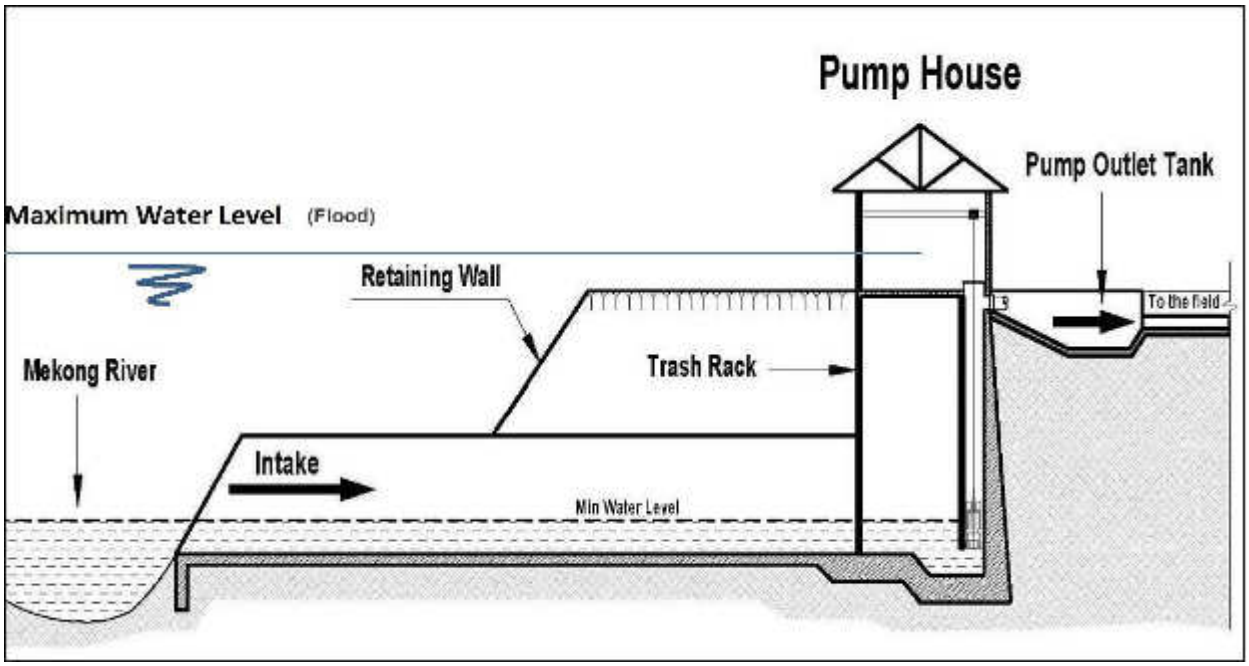
56. This subproject will have two major component areas: (i) replacement and upgrading of the pumping station extracting water from the Mekong River; and (ii) rehabilitation and modernizing of the canal system.

1. Pump Station

57. The source of water is the Mekong river, which has an abundant amount of discharge. The Mekong River water level fluctuates from minimum level of 2 m to the maximum of 12.56 m in the vicinity of the pump station. One pumping station is proposed to be installed on the Mekong River Bank to replace the existing non-functional pumping station. The pumping station is proposed to be equipped with 5 units of submergible pumps which are driven by electricity power for which the high voltage power grid is available in the area.

58. The new station will be constructed on the bank of the Mekong river. The pump station will be designed to deliver a maximum discharge capacity of 5.5m3/s with a maximum lift of 12.10 m to irrigate 8,000ha of total command area of Prek Po subproject for at least two crops per year, even when the Mekong River reaches its lowest in water level. The station will be designed for single lifting, and water will be delivered to farmers lands by gravity. Only 4 pumps of the 5 will be operated to provide the maximum required discharge; and one remaining unit will be used as a spare pump. The submersible pump will be unaffected by floods and the electrical switch gear and monitoring equipment will be installed in the pump house above the maximum projected flood level. A sketch of the pump station is shown in Figure 11 below.

Figure 11: Proposed Design Pump Station

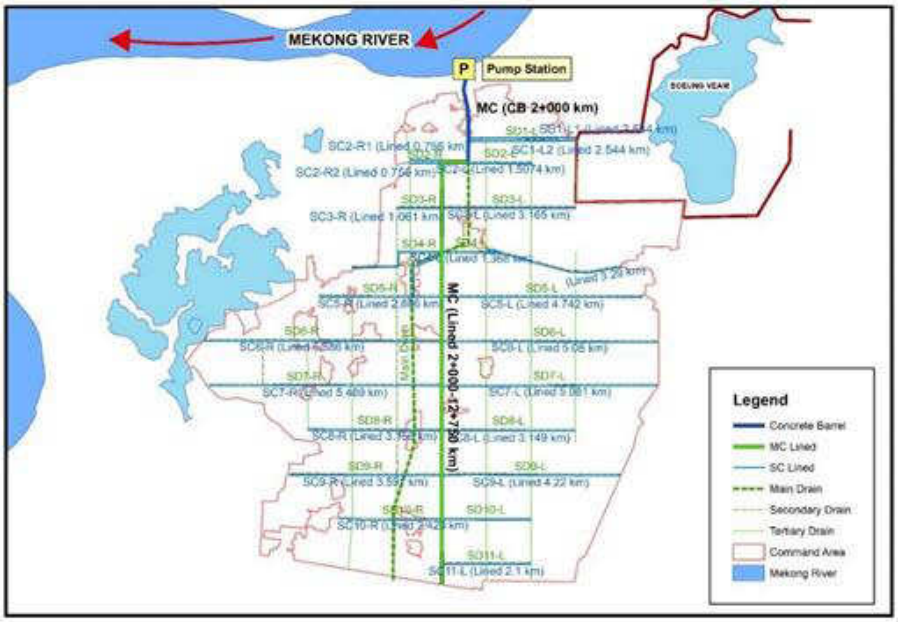


Source: Prek Po Feasibility Study Report, TRTA 2018.

2. Canal Rehabilitation and Modernizing

59. **Canal Layout.** The proposed irrigation canal layout of Prek Po is shown in Figure 12 and summarized in Table 12. The canal network consists of a main canal with total length of 12.75 km, 22 secondary canals with a total length of 70 kms. The secondary canals are proposed near the existing secondary drains to avoid land acquisition. The currently existing canal system will be re-purposed as drainage canals.

Figure 12: Proposed Layout of Prek Po system



Source: **Prek Po Feasibility Study Report, TRTA 2018**.

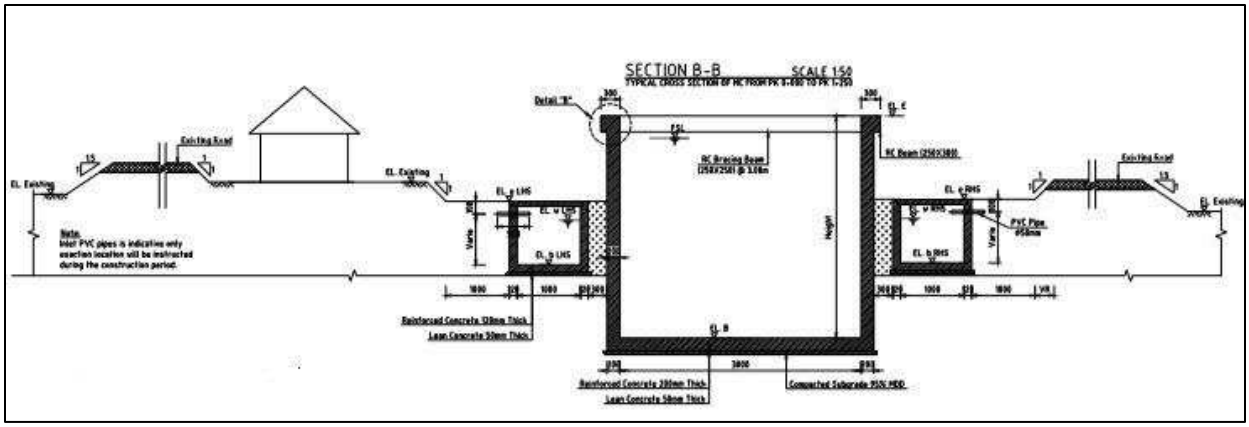
Table 12: Proposed Civil works for Prek Po

Canals	Command Area (ha)	Irrigation Blocks	Canal Length (km)	Pump	Pump Outlet Tank	Total No. of Structures
Main canal (MC)	8,000		12.75	1	1	45
Secondary canals (SCs)						
SC1L1	198	Block A 1,150 ha	2.54			4
SC1L2	133		2.54			3
SD1						4
SC2R1	215		0.76			8
SC2R2	120		0.75			8
SC2L	334		1.51			8
SC3R	150		1.06			9
SC3L	674	Block B 1,077 ha	3.16			22
SC4L	403		4.19			14
SC4R	183	Block C 1213 ha	2.47			12
Tertiary canal (TC4R)	50		1.43			1
SC5R	410		2.89			17
SC6R	570		5.59			21
SC5L	536	Block D 1,055 ha	4.74			18
SC6L	519		5.08			19
SC7R	461	Block E 1,213 ha	5.49			19
SC8R	333		3.16			11
SC9R	419		3.59			20
SC7L	502	Block F 963 ha	5.08			19
SC8L	461		3.15			18
SC9L	430	Block G 1,351 ha	4.22			12
SC10R	398		2.42			16
SC10L	344		2.11			13
SC11L	157		2.10			9
Total	**8,000**		**82.78**			**305**

Source: TRTA Consultant estimates.

60. **Main Canal.** The existing main canal also functions as a drainage canal, as it is currently deep and large in its section. Along the first 0.75 km of the head of the main canal, there are houses and others permanent infrastructures, so it is not possible to build embankments along this section. Instead, along this section the main canal will be enclosed in a covered culvert. The main canal will be an open structure after this first 0.75 km covered section. Also along this section will be two 1000 mm pipes (one either side of the main canal culvert) which will receive domestic greywater and yard drainage which currently flows directly into the open main canal. A typical cross section of the arrangement of main canal and greywater pipes in this part of the main canal is at Figure 13.

Figure 13: Typical Cross Section along First 750m Section of Main Canal through Urban Area of Prek Po

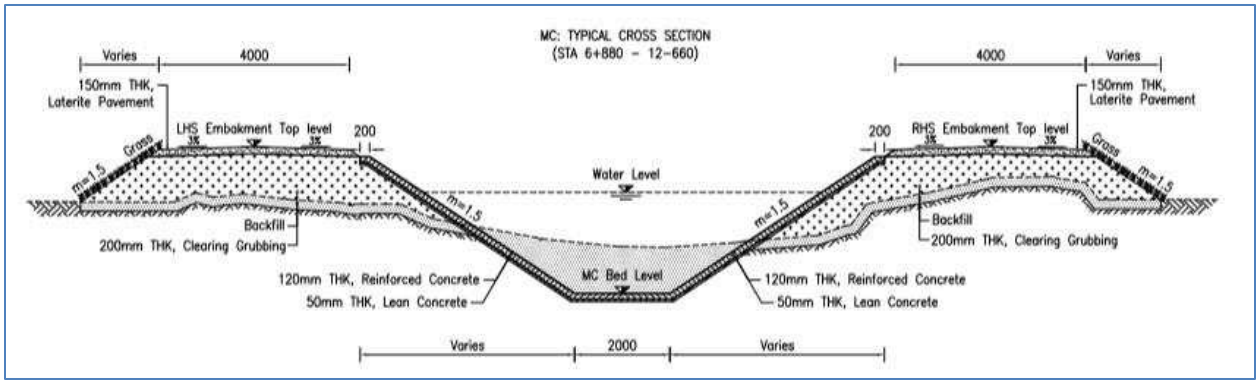


Source: Prek Po Design Drawings PPO-CW04, TRTA 2018

61. The alignment of the main canal through the remainder of the command area is proposed to shift from the original alignment to a new alignment which allows much of the old main canal alignment to be used for drainage only.

62. The main canal will be lined using reinforced concrete to reduce the water loss or to increase the water delivering efficiency along the canal. Controls and offtake structures will be installed on the canal for flow management and distribution. In addition, one side of the canal embankment is proposed to be used as an access road. Laterite pavement will be provided to increase operational longevity. Crossing bridges have been located to facilitate and maintain local access and circulation.

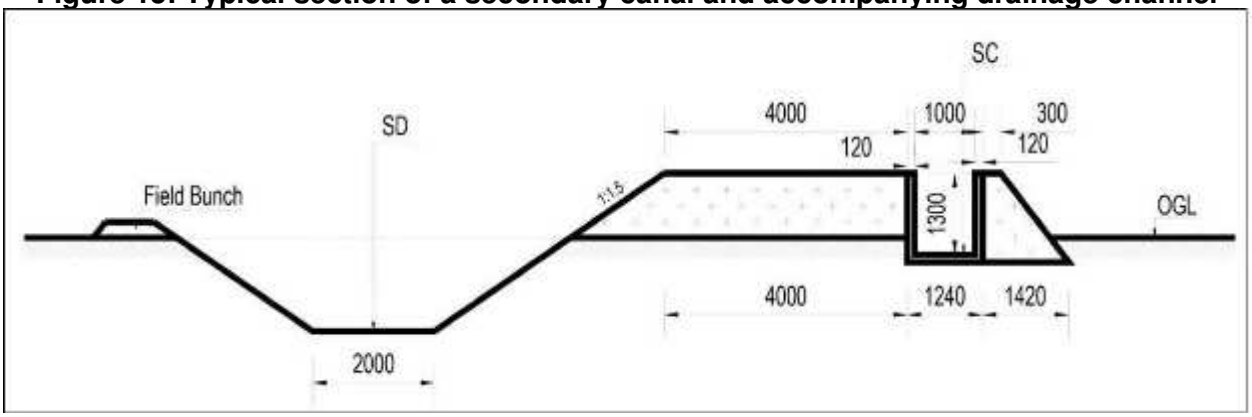
Figure 14: Section of the Main canal



Source: Prek Po Design Drawings, PPO-CW04, TRTA 2018.

63. **Secondary canals.** Twenty-two new secondary irrigation canals are proposed parallel to the existing secondary drains along the right embankment to supply irrigation water by gravity. The command area of a secondary canal varies from 120 ha to 570 ha. So, three types of concrete lining secondary canals in a U shape are proposed for different discharges (Figure 15). Laterite access roads are provided along the secondary canals for easy operation and maintenance. Outlets to the tertiary canals are proposed at 1km intervals. Altogether 305 structures are proposed in these secondary canals including 158 tertiary outlets. The main structures in the secondary canals are outlets, syphons and culverts.

Figure 15: Typical section of a secondary canal and accompanying drainage channel



Source: Prek Po Feasibility Study Report, TRTA 2018.

64. **Tertiary canals.** Existing tertiary canals are big and deep, so cannot function as irrigation canal by gravity. At present, farmers must pump water from the existing tertiary canals into their fields. Separate new tertiary canals are proposed in parallel with existing tertiary drains to irrigate lands by gravity. Existing tertiary canals will then function solely as flood removal drains. These canals will be built by FWUC and farmers and supported by the project. For improving O&M of tertiary canals, ad hoc water users committees (ad-hoc WUC) will be established for each block from among the active commune members of a representative area (30% of the command area is recommended by the feasibility study). The ad-hoc WUC will be supervised by an elected representative of the concerned communes, and they will continue working until a FWUC is established. The ad-hoc WUC will be involved throughout plan preparation and implementation processes for improving O&M of tertiary canals. It is believed that after the improvement of tertiary level O&M within each block, concerned farmers representatives and ad-hoc WUC will be capable of improving O&M of the remaining tertiary canals on their own in other blocks.

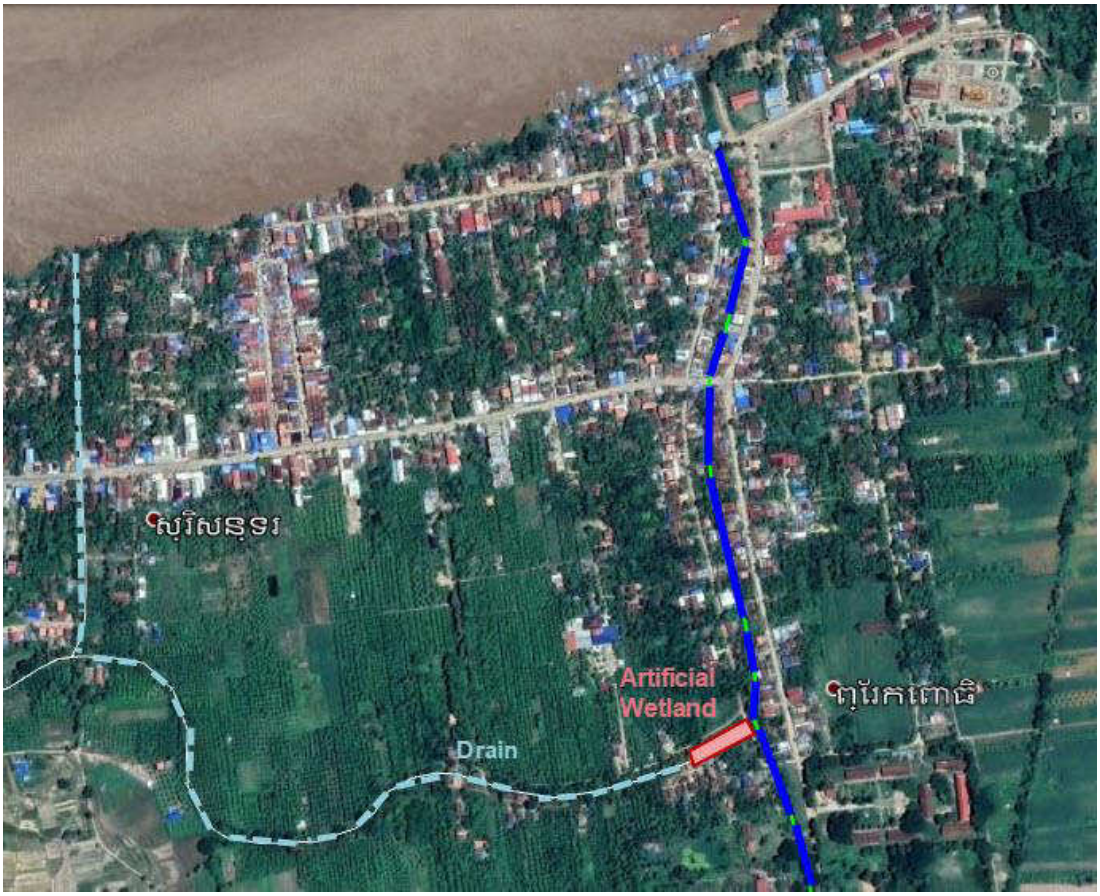
65. The project will support the contracting of a local NGO to assist in the preparation and implementation of O&M improvement activities of tertiary canals within each block. The NGO will also be made responsible for the design and implementation of essential farm level structural improvement works.

66. **Greywater treatment.** The subproject will collect greywater along the route of the main canal in the section 0 + 0000 to 0 + 0750 in separate pipes to ensure that it does not enter the canal. Treatment of the greywater will be in two separate facilities, one on the eastern side of the main canal and one on the western side. On the eastern side, the collection pipe will run northwards, back towards the pump house, to a small primary settlement and detention tank and reed bed before final discharge to the Mekong River (Figure 16).

67. On the western side the collection pipe will convey the greywater southward and discharge it into an artificial wetland built within a drainage line which joins the main canal at a water-gate at 0 + 0750. After treatment the water will be discharged into this drain which, after about 2km reaches the Mekong downstream from Prek Po (Figure 17).

Figure 16: Location of Eastern Treatment Facility for Collected Greywater

Figure 17: Location of Western Treatment Facility for Collected Greywater



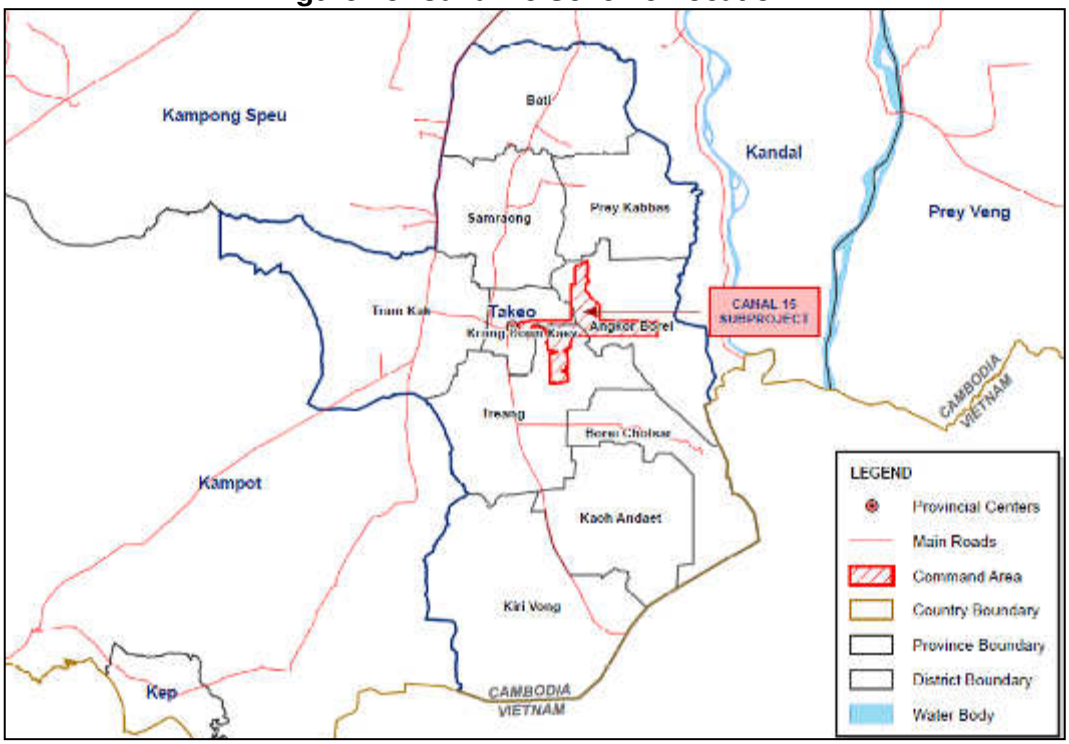
3. Hydrometeorological Station Upgrades

68. The existing hydrometeorological monitoring gauges and data collection and analysis system at one hydromet station on the Mekong, 1.5 km downstream from the Prek Po system inlet, and one automatic rain gauge in the command area will be rehabilitated with new equipment to ensure that the Prek Po FWUC has reliable data upon which to plan and coordinate irrigation water distribution.

D. Canal 15 Subproject

69. The Canal 15 irrigation system lies within the floodplain of the Mekong Delta, connecting Takeo provincial town (Daun Keo district) to Angkor Borey district town of Takeo province. This area is a natural catchment basin for several rivers including the Slakou, Takeo and Prek Thu Lo Lork rivers. However, most water in the system is from the direct connection of the main canal with the Prek Angkor/Prek Sandeck system in the east, which links with overflows from the Bassac River. This lowland area is crisscrossed by a network of distributary channels typical of a river delta and manmade channels constructed for navigation, irrigation and flood control.

Figure 18: Canal 15 Scheme Location



Source: Canal 15 Feasibility Study Report, IAIP TRTA 2018.

70. The subproject comprises two distinct sections:

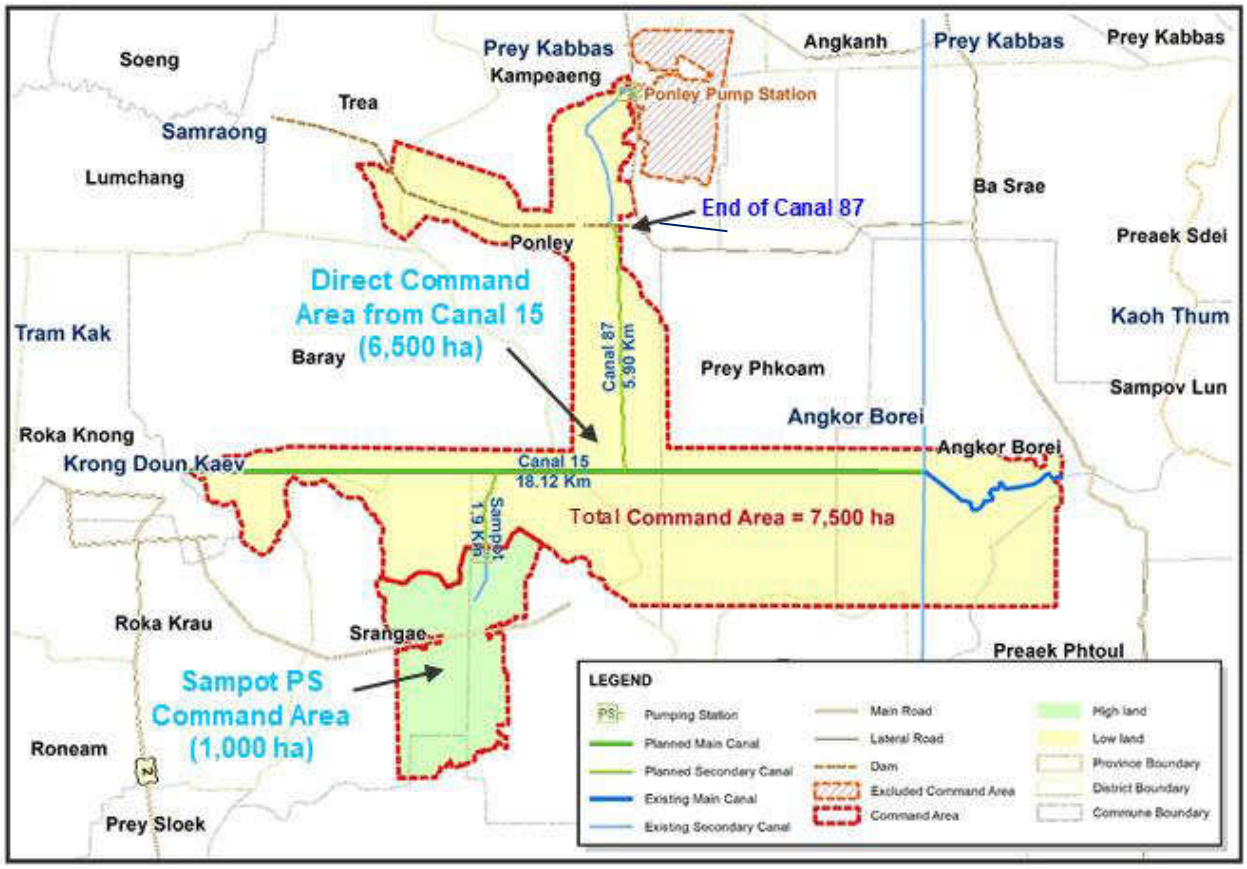
- The command area served directly by the main canal (Canal 15) and the main lateral or secondary canal (Canal 87) totaling 6,500 ha;
- The smaller self-contained command area on higher ground to the south, served by the Samput pumping station, totaling 1,000 ha.

71. The planned rehabilitation and modernization includes: (i) the deepening of Canal 15, the

main canal of the system, for 18.12 km, (ii) deepening one lateral secondary canal (Canal 87) for about 5.9 km, and (iii) modernizing the existing Samput Pumping Station and rehabilitation of canals in the Samput command area. No canal widening is planned. The locations of civil works are shown in Figure 19 and listed at Table 13.

72. Upgrading the Canal 15 system will have direct benefits in three areas; (i) secure water supply for at least two crops per year for a combined target command area of 7,500 ha; (ii) increased drainage capacity to relieve flooding from the upstream catchments; and (iii) improved navigation during dry season or when water level in the canal drops.

Figure 19: Map of proposal for system modernization



Source: Canal 15 Feasibility Study Report, IAIP TRTA 2018.

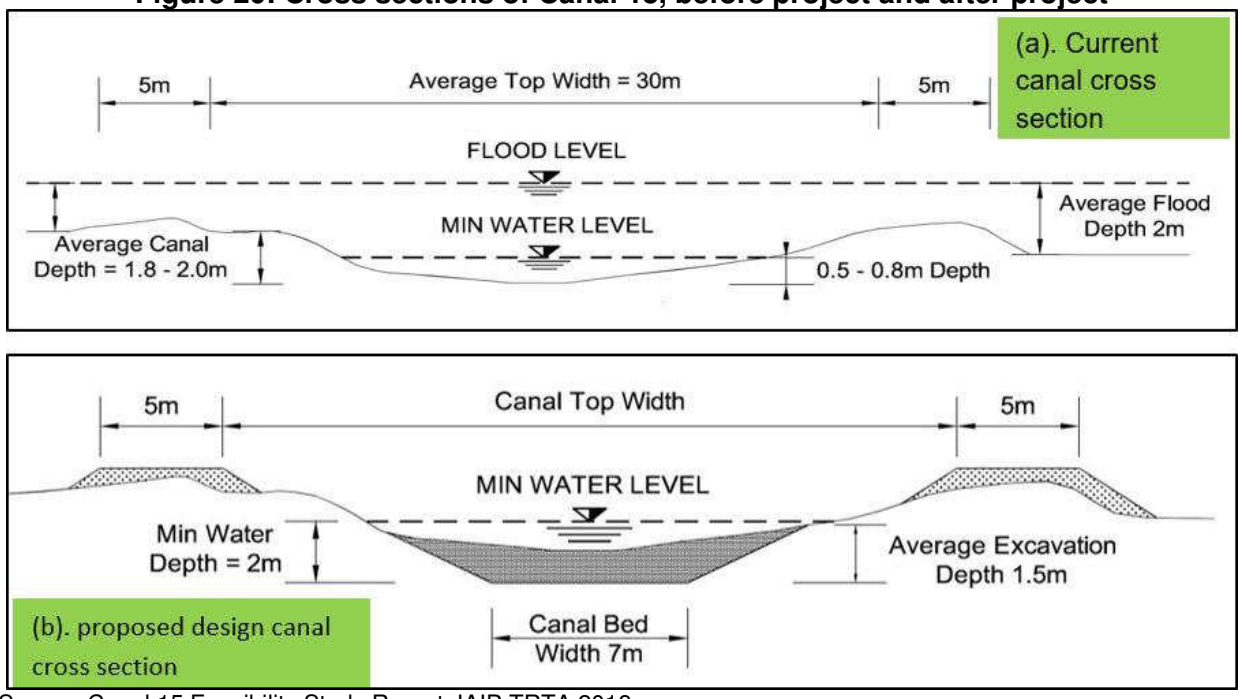
Table 13 Civil Works for Canal 15 subproject

Description	Quantity
Improvement of Canal 15 (Main Canal)	18.12 km canal works. Increasing depth by an average of 1.5 m, no change in width. No structures will be required
Improvement of Canal 87 (Secondary Canal)	5.9 km canal works. Increasing depth by an average of 2 m, no change in width. No structures will be required
Upgrading Samput Pumping Station	Intake canal of 0.9 km. One set of electric pumps (3) and control equipment.
Rehabilitating and modernizing Samput command area canals	Irrigation distribution and drainage network to cover command area of 1,000 ha

Source: Canal 15 Feasibility Study Report, IAIP TRTA 2018.

73. To upgrade its supply capacity, Canal 15 will be excavated to an additional 1.5 m to 2 m depth to drop the canal bed to a level that water will be conveyed into the lateral canal system by gravity. The bed width of the canal (7 m) will be unchanged. Figure 20 shows a typical cross section of the Canal 15. The embankment will not be used for any access roadways or transportation. Boats are widely used in this area, so the Canal will still play key role in providing access into and out of the command area.

Figure 20: Cross sections of Canal 15, before project and after project



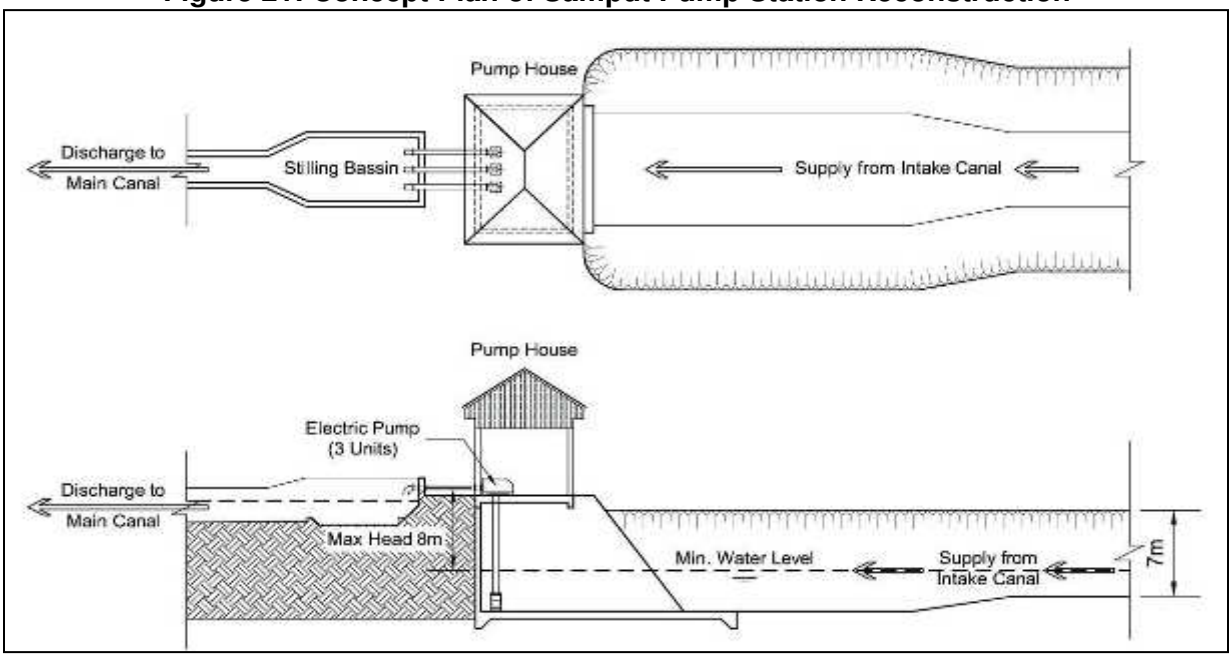
Source: Canal 15 Feasibility Study Report, IAIP TRTA 2018

74. **Lateral Canal (Canal 87).** The average excavation depth for Canal 87 will be about 2 m to achieve a 5 - 6 m depth overall channel depth to ensure water will flow from Canal 15 by gravity and with enough capacity to cope with peak irrigation demand during the dry season. Enlarging the section of Canal 87 will not only provide benefits for irrigation purpose, but also allow canal to drain effectively any surplus water from the paddy field and increase canal capacity to release floodwaters. Deepening the canal bed will also improve boat navigation in the dry season.

75. **Samput Pumping Station.** To irrigate the target command area of 1,000 ha, the pump station should supply at least 1.15m^3/s. For this, three pump sets of the same discharge capacity (0.6m^3/s) are proposed for the pumping station. Two pumps will be running during the peak season (in February) while one pump will be kept as backup. To keep the operation and maintenance cost low, and to simplify the operation, electric pumps will be used. Pump selection will be undertaken during the detailed design stage when suction and discharge head, and irrigation requirement are available. The pump house and stilling basin will be reconstructed to accommodate the pumps. Figure 21 shows the proposed conceptual design for modernizing the Samput pumping system.

76. **Samput irrigation canals.** The whole length of existing main canal, 4.60 km, will be reshaped within the existing canal right-of-way, and the canal will be lined by reinforced concrete. One side embankment will be pavement with laterite and will be used for access road. Eleven secondary canals with a total length of 11.96 km are to be rehabilitated. They will be reconstructed within the right-of-way of the existing secondary canals, and concrete lined with an average bed width of 0.80m and an average crest width of 0.90 m. Controls structures and off-take gates will be provided. Four tertiary canals totalling 4.77 km will be reconstructed along their existing alignments.

Figure 21: Concept Plan of Samput Pump Station Reconstruction



Source: Canal 15 Feasibility Study Report, IAIP TRTA 2018.

E. Capacity Building

77. In all subprojects, new FWUCs will be established by the project. FWUC establishment and capacity building will address the increasing need to coordinate and manage water allocations and practice water conservancy in future higher water demand situations. The improved water governance and competencies of the FWUC will lead climate change adaptive management into the future.

78. A capacity building program has been developed based upon data collected on farming practices by the TRTA team. Farmer training will be key to bringing about the adoption of modern production technology. Farmers will be supported to set up farmer field schools (FFSs). In a FFS, farmers will work to solve their own problems and each FFS will have an external facilitator who will train the farmers on the FFS system. Extension agents will also give technical support.

79. Demonstration plots will be established in association with a number of the FFSs in order to demonstrate on field water management, land preparation, direct seeding, fertiliser application (base dressing and top dressing), weed control, and improving on-farm water management. Integrated pest management (IPM) and low chemical cultivation applicable to cropping conditions and capacities in the subproject areas will be covered in farmer field schools. These will be part of an extensive field school training and demonstration program in the subproject communes (Table 14).

Table 14: Field Schools and Demonstrations

Description	Kamping Pouy		Prek Po		Canal 15	
	Sites	Budget ($)	Sites	Budget ($)	Sites	Budget ($)
Rice agricultural inputs package demonstration	970	450,000	970	450,000	200	120,000
Farmer field schools	970	1,600,000	970	1,600,000	200	80,000

Source: Kamping Pouy, Canal 15 and Prek Po Feasibility Study Reports, TRTA 2018.

80. Training in IPM will coordinate with the Cambodian National IPM Program and is in line

with *IFC EHS Guidelines on Annual Crop Production.* The program will include the safe storage, handling and disposal of agricultural chemicals. The Project will also undertake soil analyses in the command areas and provide farmers with recommendations on appropriate fertilizer regimes and cultivation practices. The field schools will emphasize environmentally sound farming and sustainability and will provide farmers with alternative approaches to a reliance on chemicals.

81. Other direct training programs for MOWRAM, PDRAM and District Office staff will include: Environmental awareness training; Construction management; and On-farm water management. For FWUC members, the training program will include: Water management; Gender and environment; and Environmental awareness (incl. climate change). These are listed in Table 15.

Table 15: Environmental Training Packages in the Capacity Building Component

Description	Kamping Pouy		Prek Po		Canal 15	
	Training Sessions	Budget ($)	Training Sessions	Budget ($)	Training Sessions	Budget ($)
Training for MOWRAM, PDWRAM and District Office Officers						
Environmental awareness training	3	7500	3	7500	3	7500
Construction management	5	10000	5	10000	5	10000
On-farm water management	5	10000	5	10000	7	14000
Training for FWUCs						
Water management	2	5000	2	5000	4	10000
Gender and environment	2	7000	2	7000	2	7000
Environmental awareness (incl. climate change)	31[a]	9300	24[a]	7200	27[a]	8100

[a] Number of villages in command area.

Source: Kamping Pouy, Canal 15 and Prek Po Feasibility Study Reports, TRTA 2018.

E. Analysis of Alternatives

82. The major environmental influence on the analysis of alternatives has been in the final selection of subprojects. Other options considered are determined primarily on economic, agronomic and technical grounds, rather than environmental.

1. With- and Without Project

83. **Without project.** The Kamping Pouy system was constructed during the 1975-1978 period, underwent rehabilitation in 2000, and had some sections improved and modernized in 2005 and 2012. Water for the irrigation system is supplied by the Kamping Pouy reservoir at the western edge of the irrigation system. The Kamping Pouy system has never fully functioned as an irrigation system. During the dry season, only about 8,000 ha are planted to rice and other crops. Flooding problems are experienced in the area caused by local runoff floods and require cross-drainage solutions. The system has no water- measuring devices, no inflow and cropping season records, and no budget for O&M. Flooding problems contribute to a relatively low yield of 2.5 tons per hectare (t/ha) of wet paddy.

84. The Prek Po system was constructed in the 1970s under the Khmer Rouge regime and is a reasonably well-designed system based on a pump station on the Mekong River. However, it has now deteriorated, and no pumping has occurred for the last 18 months. With no irrigation supply, farmers wishing to augment wet season water or undertake dry season cropping use groundwater pumped from small diesel- powered tube wells with an estimated total coverage of around 1,100 ha used mainly for paddy but including a small area of upland crop. Flooding further limits rainfed wet season cropping.

85. The Canal 15 The main canal has never been maintained since its first construction and will continue to silt up. At the present time, Canal 15 has a bottom width of about 10 m with an average minimum water depth of about 0.5 m to 0.8 m during dry season between February and May. Within this dry period, the main canal cannot supply water to its lateral systems, only farmers

whose paddy lands are located about 500m on both sides along the canal alignment get water by pumping. This situation will worsen as the canal fails to provide irrigation and navigation right-of-way for much of the year.

86. Since its initial construction the intake channel of the Samput Pumping Station has not been maintained. Currently, there are no proper distribution networks to deliver irrigation water to the fields. What canals exist have silted up, some canal embankments have eroded and collapsed, and there are no proper control and conveyance structures. Overall, the irrigation efficiency of this system is exceptionally low, at only about 20% to 25%. This will continue to decline without intervention.

87. **With project.** The proposed improvement of the Kamping Pouy system is expected to provide water to five communes for an irrigated dry season crop of 12,000 ha (a 4,000 ha increase). Three subproject options have been examined. Option 1 assumes no substantial canal lining and is the cheapest. Option 2 assumes partial lining of primary and secondary canals and was selected as the baseline, in part to provide a basis for climate proofing of the subproject. Option 3 assumes concrete lining of primary and secondary canals and is the most expensive. The preferred option is Option 2, which is described in this IEE.

88. At Prek Po it is expected that a very large cropping increase of 7,620 ha in the wet season and 6,800 ha in the dry season will be achieved by project year 8, building up steadily from the construction completion year, with significant livelihood benefits to the local community. It will also be feasible to undertake triple cropping on parts of the land with two dry season crops (one early and one late).

89. The planned improvement of the Canal 15 system will arrest the decline in irrigation services. It will ensure that the current recession cropping continues over the current (maximum) area of 5,000 ha with increased yields, and sustainably provide irrigation water for a 250% increase in the area sown to an early wet season rice crop (1,000 ha to 2,500 ha). Since there are no internal access roads within the majority of the command area, the project will support the dependence on water transport by ensuring that the main canal and lateral remain navigable throughout the year.

2. Major Subproject Alternatives

90. At Prek Po the main infrastructure option with environmental implications was whether to rehabilitate/modernize the existing two-stage pumping system or to replace it with a single stage pumping system. The existing two-stage system comprises a set of floating pumps installed on the Mekong River bank which lift water up to an access canal. At the end of the 110-m long access canal, a second stationary pump house creates additional head for supply of water to the main canal. All pumps are diesel-driven. Diesel pumps are both noisy and polluting. The noise affected nearby residences (within 20m), diesel exhaust lowered local air quality and leaking diesel fuel and lubricants contaminated the waterways. Diesel pumps also produce significantly more greenhouse gases than the more efficient electrical pumps. The alternative chose was to replace the two stage diesel pumping system with a single stage submersible electric pump system. The deep submersible pump conveys water from the Mekong to a head which provides gravity flow through the canals of the command area in a single lift. Electric pumps produce no pollutants in the local area and the submersible option ensures minimal noise levels.

91. At Kamping Pouy three options for modernization were evaluated. Though the selection was based on system functionality and cost of civil works and O&M, an overriding environmental requirement was that the preferred option should also provide a solution to mitigate existing drainage and flooding problems.

92. Option 1 had minimal canal lining. Though the lowest cost, the system would require regular maintenance by the PDWRAM and the FWUC. Option 2 had a much longer stretch of the main canal lined with concrete, allowing irrigation water to be delivered to the end of the canal

with less conveyance losses. This option also had a low yearly O&M cost and maintenance effort for the FWUC and PDWRAM. Option 3 involved the full concrete lining of the system and an upgrading of the majority of the canals.

93. Option 2 was preferred, as it involved the concrete lining of only those parts of the canals which need strengthening to avoid collapse when subjected to poor O&M, while also providing effective drainage and flooding control.

94. At Canal 15 the option of pump type for the Samput pumping station is the issue with most environmental implications. The pumping requirement at the Samput station is 1.15 m^3/s. The options for pump replacement are to renew the existing diesel pumps or replace them with electric pumps. Diesels operating at this capacity produce high noise levels and require a strict maintenance regime. Although the pumping station is currently operated by a new FWUC, mechanical maintenance is outsourced and the storage, handling and clean-up of fuels and lubricant is poorly managed. The switch to electric powered pumps is favoured by the project for their lower noise levels, ease of maintenance and low pollution potential. The use of electric pumps also has a 50-60% reduction in greenhouse gas production over diesel.

95. The options for the re-use of canal excavation material at Canal 15 are (i) removal from site; (ii) construction/elevation of embankments; and (iii) construction of embankment roads. Along the main canal and canal 87 at the subproject there are no embankment road. This makes option (i) only possible for small amounts which can be transported by boat. The construction of embankment road in this command area is not possible due to the depth of the yearly floods, which overtops all embankments in a normal year. Not only would the making of flood-free roads be prohibitively expensive but it would also create flood barriers and significantly affect flood behaviour on this large floodplain. Option (iii) was therefore not favoured.

96. The project has selected an option (ii) where excavation spoil is used to consolidate and widen embankments. Taking account of the flood characteristics of the site, the embankments will be as low as possible to avoid blocking wet season overland flow from the upstream catchment of the Takeo and Slakou Rivers and cause early and extended inundation of the northern parts of the command area. The constraints on the size and shape of the new embankments which do not significantly alter flood behaviour, will be confirmed in detailed design.

F. Project Implementation

97. MOWRAM as the proponent of the project shall have the overall responsibility for project implementation. MOWRAM shall coordinate with the Ministry of Environment and Ministry of Agriculture, Fishery and Forestry and other concerned agencies for their active participation in the delivery of the project and to ensure compliance with national requirements. A Project Management Unit (PMU) of MOWRAM shall have the main responsibility of implementation of the project, through contractors selected through a tendering process.

98. Newly-formed FWUCs shall be responsible for the efficient use of water resources and for maximizing the benefits of the projects. FWUCs will also raise awareness of farmers in the proper utilization of the chemical fertilizers, insecticides and pesticides to avoid the impacts on human health. The role and responsibilities of involved institutions are summarized in Table 16 and in the EMP at Table A1.1.

Table 16: Institutional Roles and Responsibilities for Environmental Safeguards

Institutions/ Communities	Roles and Responsibilities
MOWRAM	• Overall responsibility for the project • Coordinating with other government institutions and donor to facilitate project implementation • Coordinate with MOE on environmental safeguards including bird conservation activities.

Institutions/ Communities	Roles and Responsibilities
	• Ensure compliance with social and environmental safeguards as per the ADB SPS (2009), • Submit quarterly progress reports and semi-annual environmental monitoring reports to ADB • Co-ordinate Grievance Redress Mechanism
PMU	• Day to day management of the implementation of the project • Prepare quarterly progress report and report to MOWRAM • Oversee the work of Contractors and implementation of safeguard requirements • Coordinate with local bodies and communities for their participation • Monitor and report on Grievance Redress Mechanism in quarterly project progress reports and semi-annual safeguard reports.
Project management and implementation consultant PMIC	• Support MOWRAM in the coordination with different government ministries and donor for obtaining necessary approvals • Design and implement the capacity building programs for the ministry and provincial department. • Monitoring the work of contractors in compliance with covenants of the contract.
Contractors	• Implementation of the civil works during the construction phase of the project. • Preparing,implementing and reporting on Site Environmental Management Plans (SEMPs) for each subproject. • Ensuring the compliance with the Occupational Health and Safety standards. • Training of the workforce in Good Practices in construction management and waste management in the construction sites.
JOROP Unit (Kamping Pouy SP)	• Implement the Kamping Pouy Joint Reservoir Operation Scheme (KAPOS) • Undertake reservoir operation for water scheduling and release on a 10-days period schedule for 230 days (2 cropping seasons June to January) • Control and operate releases from Mongkol Borey River to Kamping Pouy Reservoir according to KAPOS.
FWUC	• Participate in the management of the command area to the benefit of all water users. • Coordinate with different government departments and other FWUCs to maximize the benefits of the project.
Local authorities and communities	• Participate in the project developments. • Raise issues/concerns via GRM and public consultations carried out during implementation.

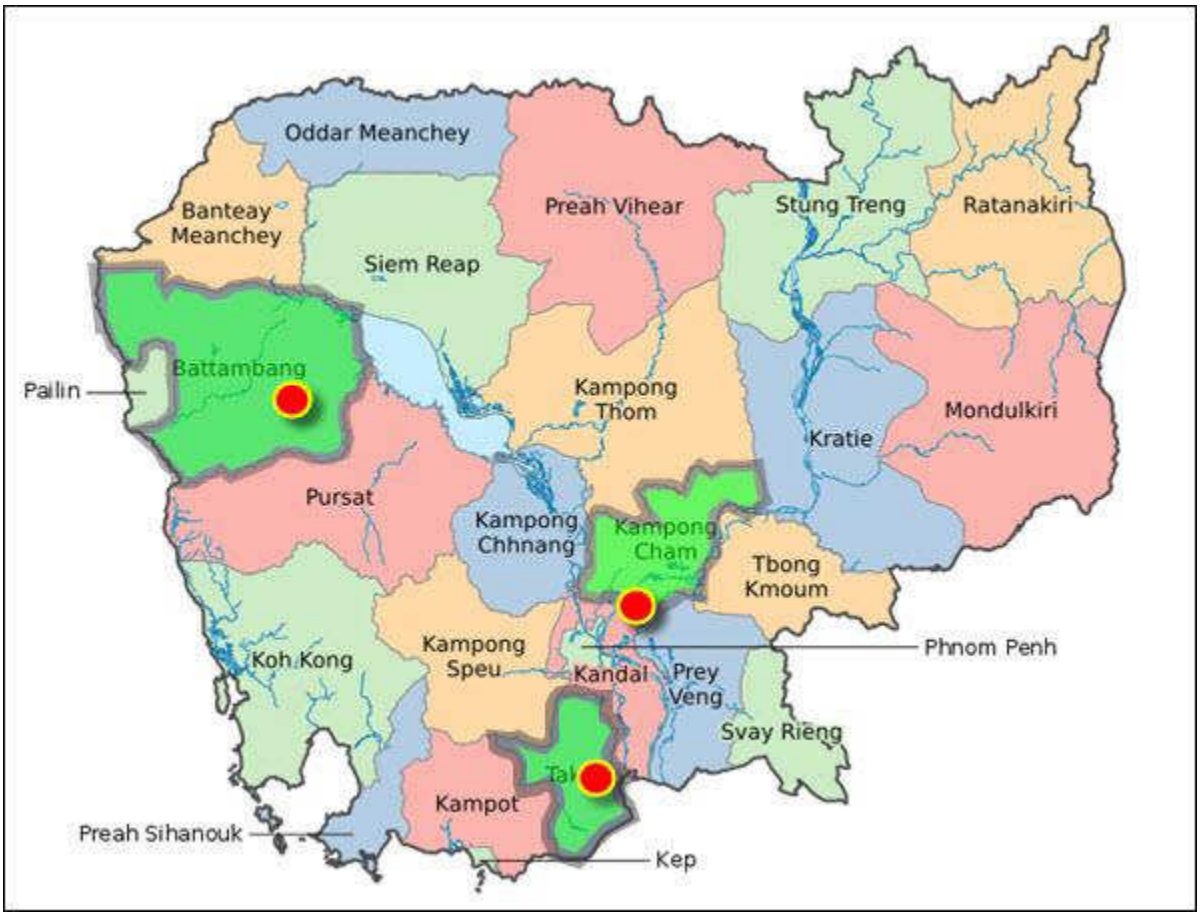
MOWRAM = Ministry of Water Resources and Meteorology, PMU = Project Management Unit, PMIC = Project Management and Implementation Consultant, FWUC = Farmers Water User Communes, JOROP = Joint Reservoir Operations.
Source: Project Administration Manual, 2019.

IV. DESCRIPTION OF THE ENVIRONMENT

A. The Subproject Provinces

99. The planned subprojects are in Kampong Cham, Battambang and Takeo provinces. The GDP of all provinces are dominated by agriculture. Kampong Cham has a population of 710,000. There are a number of significant Angkorian sites in the area, including Prasat Sambor Prei Kuk and Prasat Andet temples. Battambang has a population of 1,036,523, and ranks as the fourth most populous province. In land area, it is the fifth largest province of Cambodia. The province's fertile rice fields have led to a mostly agricultural economy giving rise to Battambang's reputation as "the Rice Bowl of Cambodia". Battambang province features a range of cultures as well as natural resources. Seventy five percent of its area is mountainous. The Canal 15 irrigation system is on the floodplain of the Mekong Delta, connecting Takeo provincial town (Daun Keo district) to Angkor Borey district town in Takeo province. Takeo is the 6th most populated province in the country with a total population of 849,906 in 2008. Takeo has fertile rice fields with good potential for its growing agricultural economy.

Figure 22: Location of Project Provinces



Source: Wikipedia Commons, adapted by TRTA 2018.

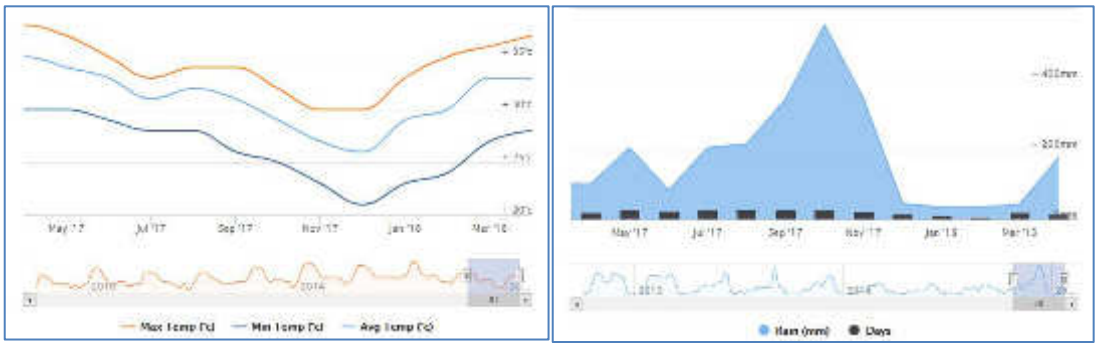
B. Environmental Setting

1. Climate

100. The climates of the Battambang and Kampong Cham are characterized by distinct rainy and dry seasons. The southwest monsoon starts in May and lasts till October, while from November to April the dry northeast weather patterns predominate.

101. For Battambang, the average annual rainfall ranges from 1200 mm to 1300 mm, with peak rainfall occurring in September-October and the lowest rainfall in January. Temperature is lowest in December-January with an average minimum temperature of 26°C and the highest in April with an average maximum of 34°C. The wind direction during the rainy season is prevalent from south-west to north-east and from the south-west during the dry season.

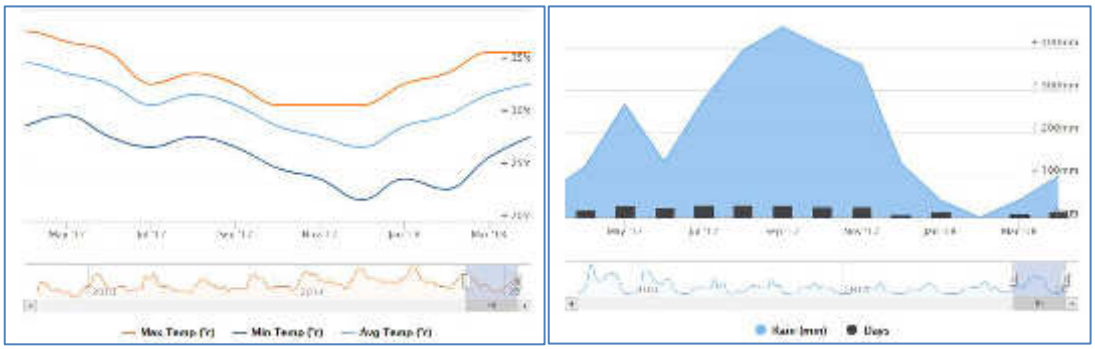
Figure 23: Yearly Temperature and Rainfall for Battambang 2017



Source: https://en.climate-data.org.

102. For Kampong Cham, the rainfall is lower, with average annual falls of 1200 mm to 1300 mm, with peak rainfall occurring in September/October and the lowest rainfall in February. Temperature patterns are similar to those of Battambang.

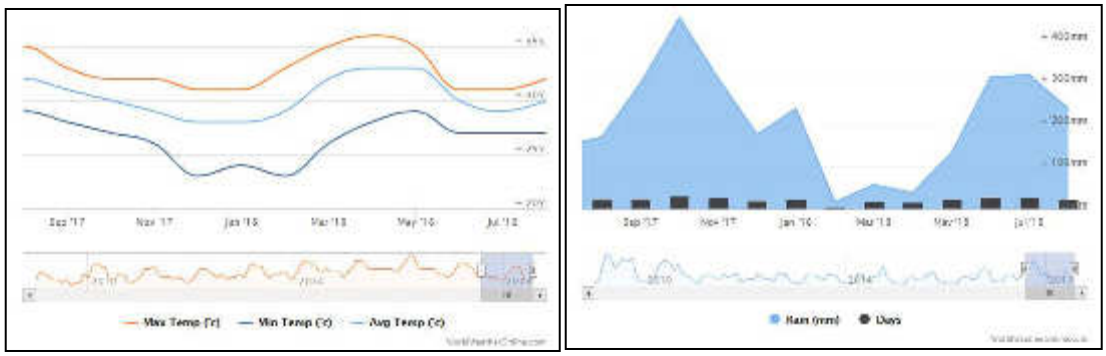
Figure 24: Yearly Temperature and Rainfall for Kampong Cham 2017



Source: https://en.climate-data.org.

103. For Takeo, average temperatures range from 26.06°C in December (coolest) and 29.06°C in April (warmest). Monthly rainfall data shows a seasonal pattern with the wet season occurring from April to November while the short dry season of 4 months begins in December to March. The flood season months generally occur from July to November. The average annual rainfall observed at Takeo for the period 1982-2011 is 1280 mm.

Figure 25: Yearly Temperature and Rainfall for Takeo 2017-2018



Source: https://en.climate-data.org.

2. Climate – Recent Trends

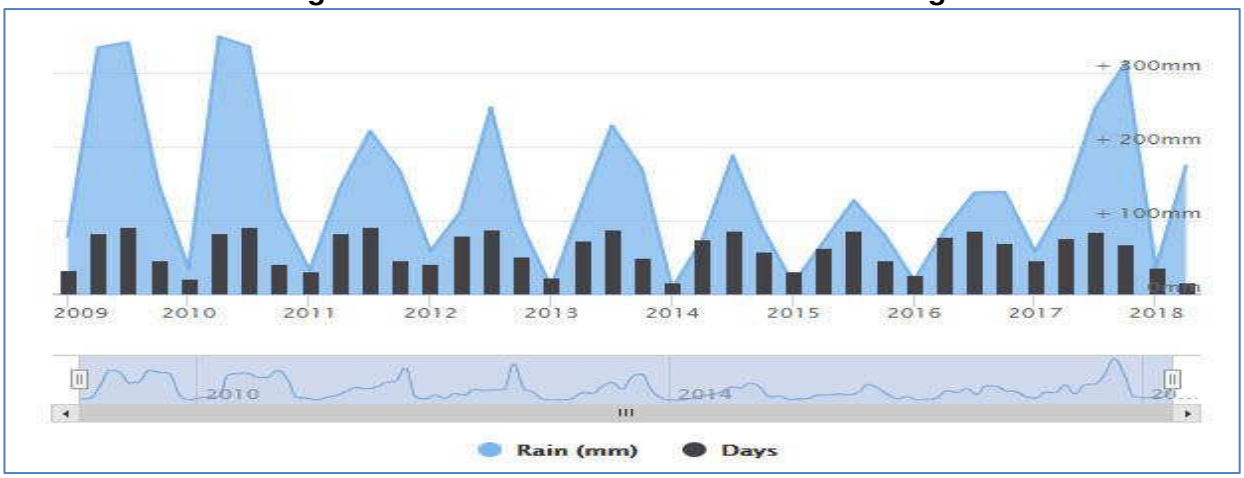
104. Weather data over the last decade for both Battambang and Kampong Cham (Source: (https://en.climate-data.org) show increasing trends in temperature and strong variability in rainfall (Figures 26-31). A more obvious, slight decreasing trend in rainfall is apparent in the Kampong Cham data. Rising temperature trends apply to maximum, minimum and average temperatures. The temperature trend is more pronounced in Kampong Cham, where a 10% rise in average temperature has been recorded. In Battambang the average temperature rise is less than 3%.

Data for Takeo shows very slight increasing trends in temperature and strong variability in rainfall. There has been a prolonged dry spell for the province from 2010 to 2016, with a strong recovery and increased rainfall in 2017 and 2018.

Figure 26: 10-Year Temperature Data for Battambang

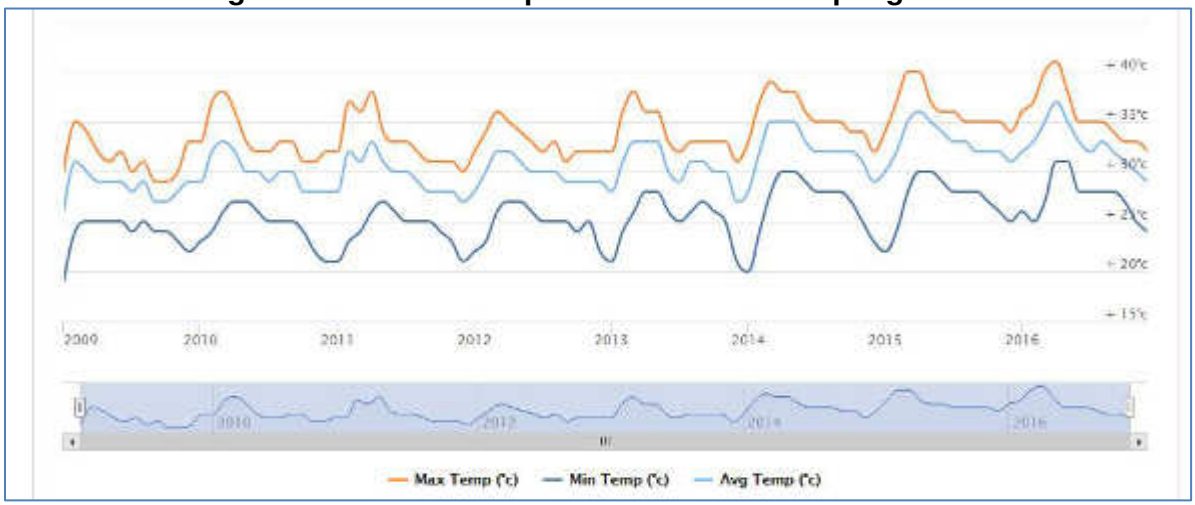
Source: https://en.climate-data.org.

Figure 27: 10-Year Rainfall Data for Battambang



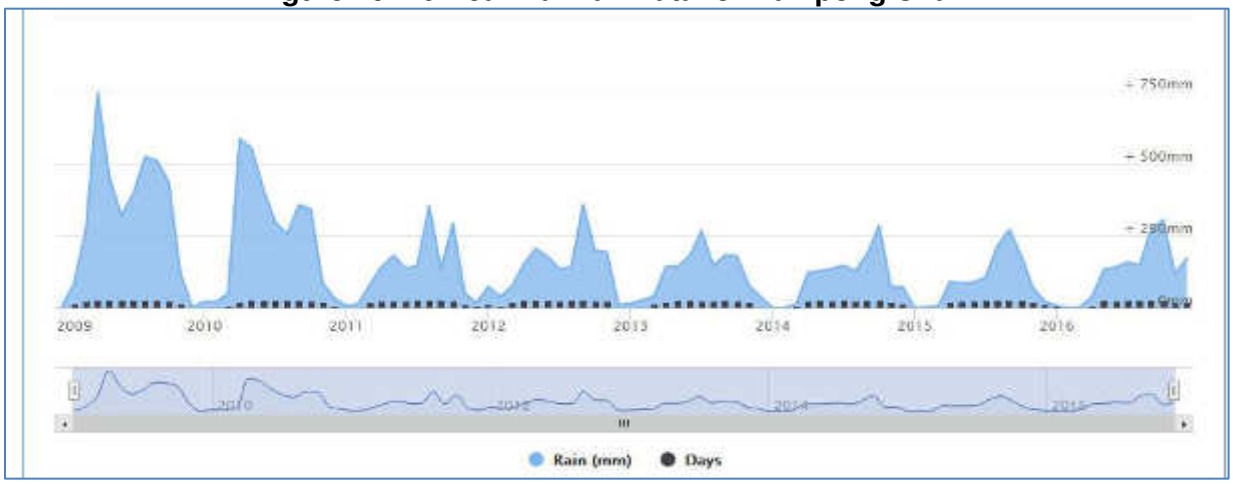
Source: https://en.climate-data.org.

Figure 28: 10-Year Temperature Data for Kampong Cham



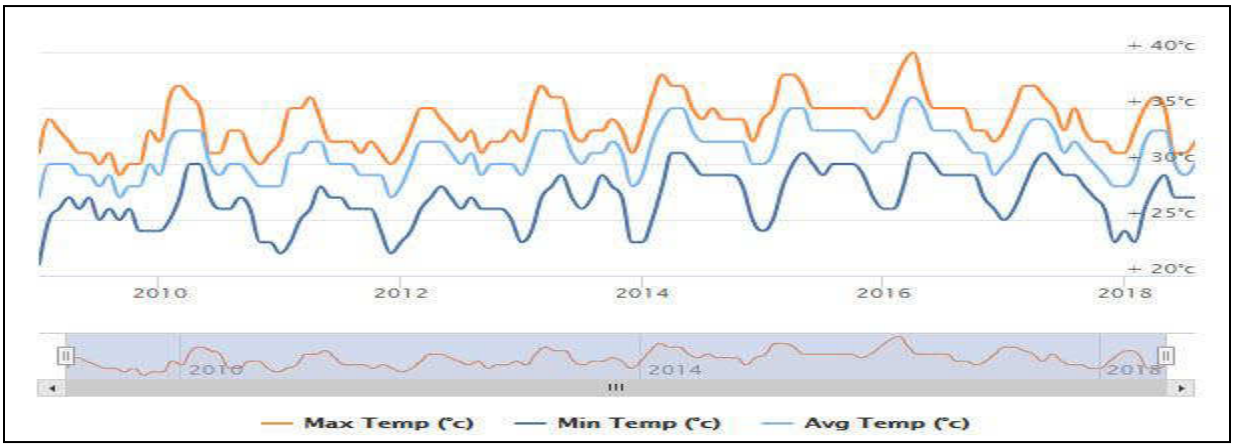
Source: https://en.climate-data.org.

Figure 29: 10-Year Rainfall Data for Kampong Cham



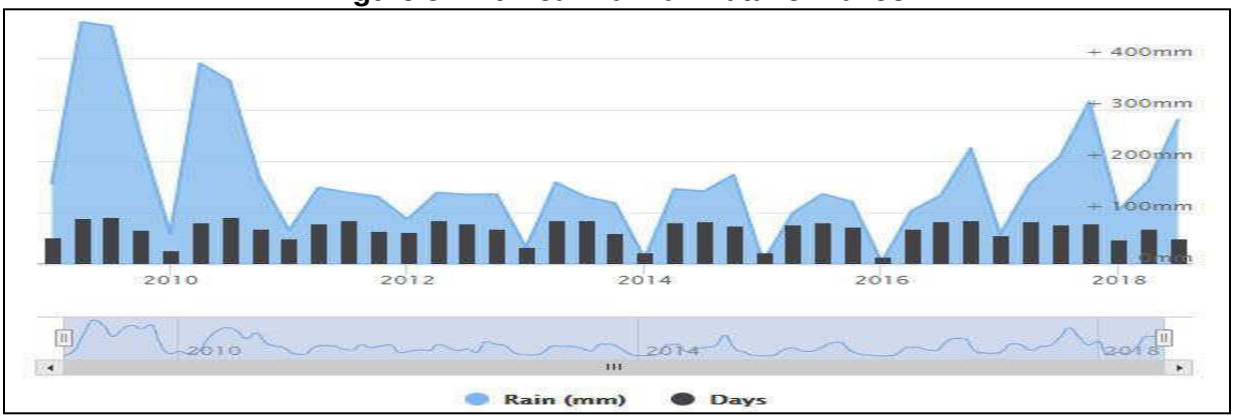
Source: https://en.climate-data.org.

Figure 30: 10-Year Temperature Data for Takeo



Source: https://en.climate-data.org.

Figure 31: 10-Year Rainfall Data for Takeo



Source: https://en.climate-data.org.

105. An important caveat to these trends is that decadal trends are strongly influenced by endpoint bias. Longer term historical climate records (1950-2001) for Cambodia have been statistically analyzed in Thoeun (2015)[1] and show a mean annual temperature trend of +0.023°C per year and an annual rainfall trend of -0.184% per year for that period.

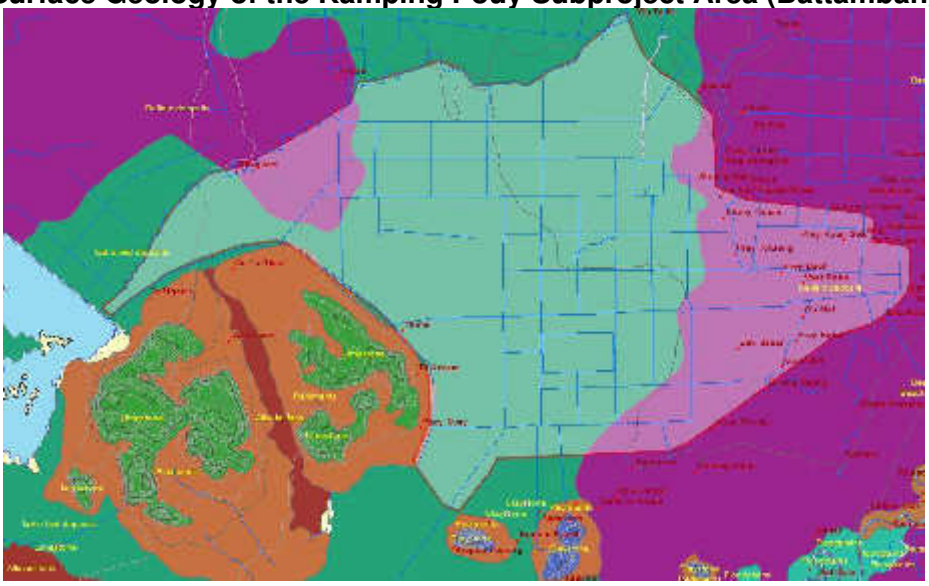
3. Topography and Geology

106. The proposed Kamping Pouy subproject area is on Quaternary alluvium formations, with the western half underlain by lake bed deposits and the eastern half on deltaic deposits. These both weather in situ to a soil classed as gleyic luvisol under the FAO soil classification.[2] This soil has a surface accumulation of humus overlying an extensively leached and saturated subsoil at a depth of about 50cm. (see Figure 32).

[1] Heng Chan Thoeun 2015, "Observed and projected changes in temperature and rainfall in Cambodia", *Weather and Climate Extremes* 7 (2015) 61-71, Elsevier.

[2] Food and Agriculture Organization of the United Nations 1974, *World Soil Classification*. A supra-national classification which groups soils for their pedogenesis and main soil-forming factors.

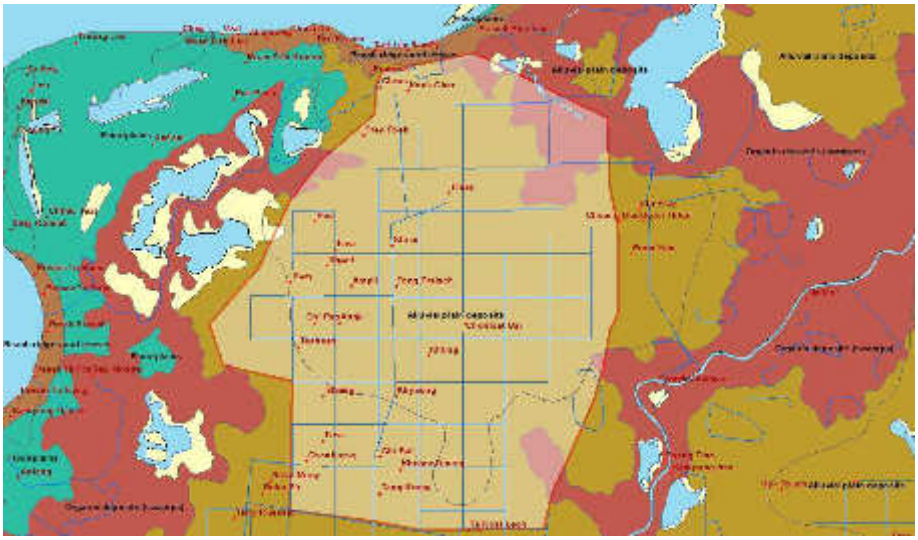
Figure 32: Surface Geology of the Kamping Pouy Subproject Area (Battambang Province)



Source: JICA GIS Survey of Cambodia, 2005.

107. The proposed Prek Po subproject area is on quaternary alluvium formations, with the main part on alluvial plain deposits, with organic deposits (swamps) around the boundaries. These both weather *in situ* to a soil classified as gleyic acrisol under the FAO soil classification, this soil is clay-rich, and is associated with humid, tropical climates. There is also a small area of gleyic cambisol on the southeastern boundary. This is an immature soil with only the beginnings of soil and horizon formations but can support agriculture. Cambisols in temperate climates are among the most productive soils on earth, however both soil types in the command area are low in phosphorus and higher phosphorus rates in fertilizer are commonly used.

Figure 33: Surface Geology of the Prek Po Subproject Area (Kampong Cham Province)

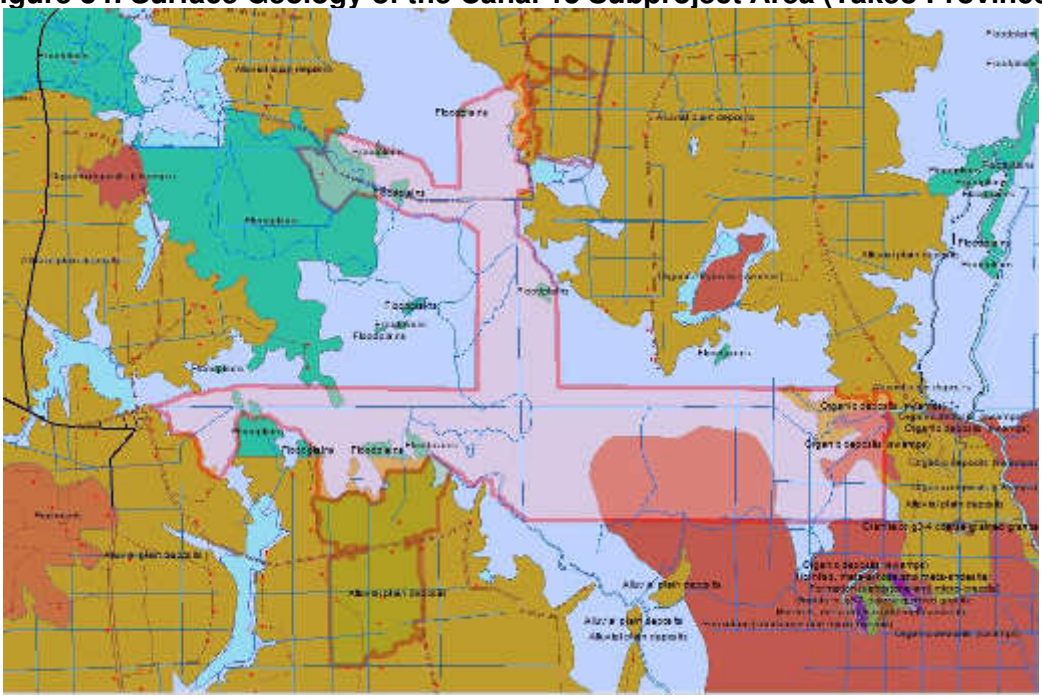


Source: JICA GIS Survey of Cambodia, 2005.

108. The majority of the Canal 15 subproject area is on a combination of recent and quaternary floodplain deposits which have weathered *in situ* to a dystic plinthosol under the FAO soil classification. This is a clayey soil, dark in colour owing to the accumulation of organic matter.

It is very plastic when wet and difficult to puddle. Because of long period of submergence, the soil undergoes chemical changes to its mineral constituents giving it poor nutrient-holding property. The more elevated southern extension of the subproject area is on alluvial plain deposits weathering to a gleyic acrisol, a clay-rich soil associated with humid, tropical climates.

Figure 34: Surface Geology of the Canal 15 Subproject Area (Takeo Province)



Source: JICA GIS Survey of Cambodia, 2005.

4. Hydrology

109. **Kamping Pouy.** The monthly rainfall for the Kamping Pouy subproject is shown in Table 17. This data shows that through the wet season (May to October), the crop water requirement could be largely met from rainfall in an average year. In dry years (80% exceedance is shown as a dry year) irrigation is necessary, particularly in view of the uncertainty of commencement of the wet season.

Table 17: Kamping Pouy data for dry, minimum and maximum rainfalls

(mm)

1985 - 2011	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Average	97	141	131	157	189	227	239	66	6	4	24	49	1,329
Dry Year	41	78	79	111	127	163	163	17	0	0	0	25	1,164
50%	76	135	123	155	181	218	232	34	1	0	13	48	1,340
Wet 20%	158	213	172	203	234	288	318	110	14	9	39	74	1,469
Max year	24	100	100	291	302	248	233	378	397	441	381	20	1,707
Min year	0	0	11	20	24	42	27	77	86	105	0	0	1,062

Source: TRTA Technical Report – Hydrology, 2018.

110. The estimated inflow from the local catchment into Kamping Pouy reservoir is given in Table 18.

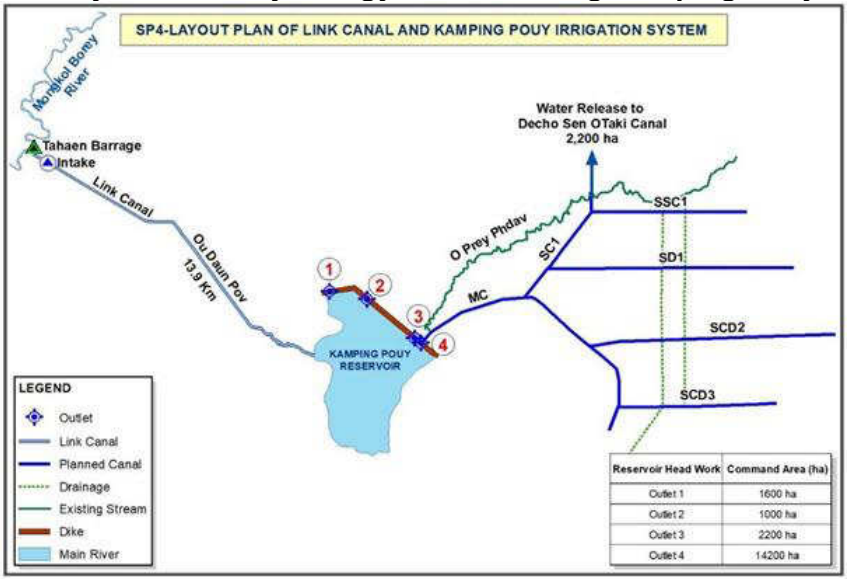
Table 18: Local inflow to Kamping Pouy for dry, minimum and maximum years
(million cubic meter)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	1.05	0.32	0.20	0.15	0.12	0.29	1.08	4.48	11.77	14.81	9.13	3.59
Maximum	3.47	1.07	0.33	0.24	0.19	5.41	6.82	14.69	22.84	22.04	19.10	9.66
Minimum	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.04	0.06	0.08	2.21	0.58
20% Exceedance	1.33	0.38	0.25	0.19	0.15	0.13	1.43	9.89	15.91	19.25	11.51	4.28
50% Exceedance	1.06	0.32	0.22	0.17	0.14	0.12	0.11	2.01	12.87	15.88	9.82	3.70
80% Exceedance	0.43	0.19	0.14	0.11	0.09	0.08	0.07	0.19	7.55	12.52	6.39	2.15

Source: TRTA Technical Report – Hydrology, 2018.

111. The hydrology of the subproject area also includes the Mongkol Borey – a river which is linked to the Kamping Pouy by a canal (the Ou Dounpov) which has a designed flow capacity of 37m^3/s, but through deterioration due to bank collapse and siltation currently operates at a much lower flow.

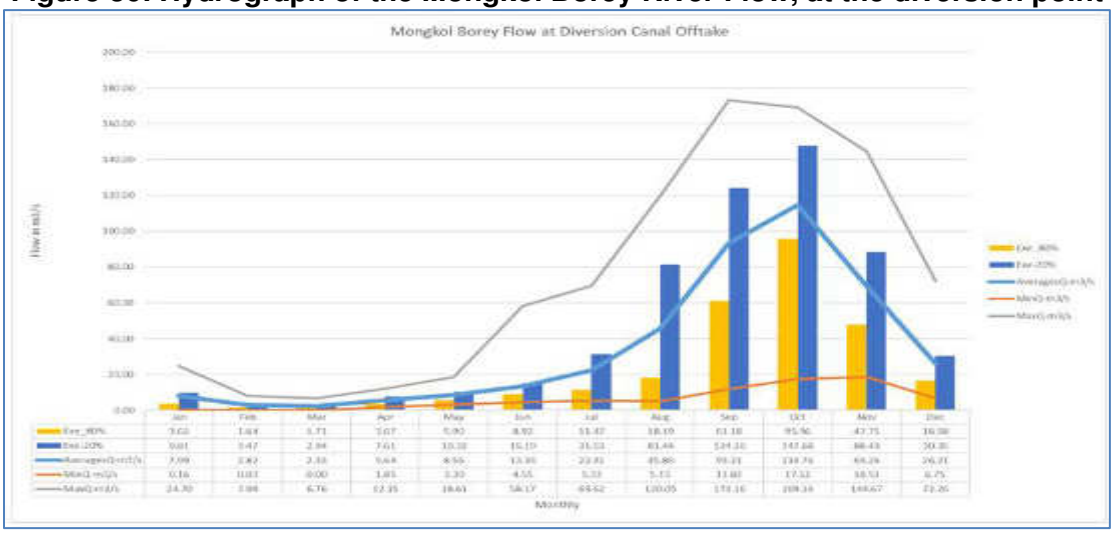
Figure 35: Layout of the Hydrology of the Existing Kamping Pouy Scheme



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

112. The hydrograph for the Mongkol Borey at Figure 36 describes in-river flow at the diversion point, and also shows the cumulative river flows (Q values) from the antecedent wet season.

Figure 36: Hydrograph of the Mongkol Borey River Flow, at the diversion point



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

113. **Prek Po.** The monthly rainfall for the Prek Po subproject area is shown in Table 19. This data shows that through the wet season (May to October), the crop water requirement could be largely met from rainfall in an average year. In dry years (80% exceedance is shown as a dry year[3] in the table), irrigation is necessary, particularly in view of the uncertainty of commencement of the wet season.

Table 19: Averages for dry, minimum and maximum rainfalls, Prek Po

(mm)

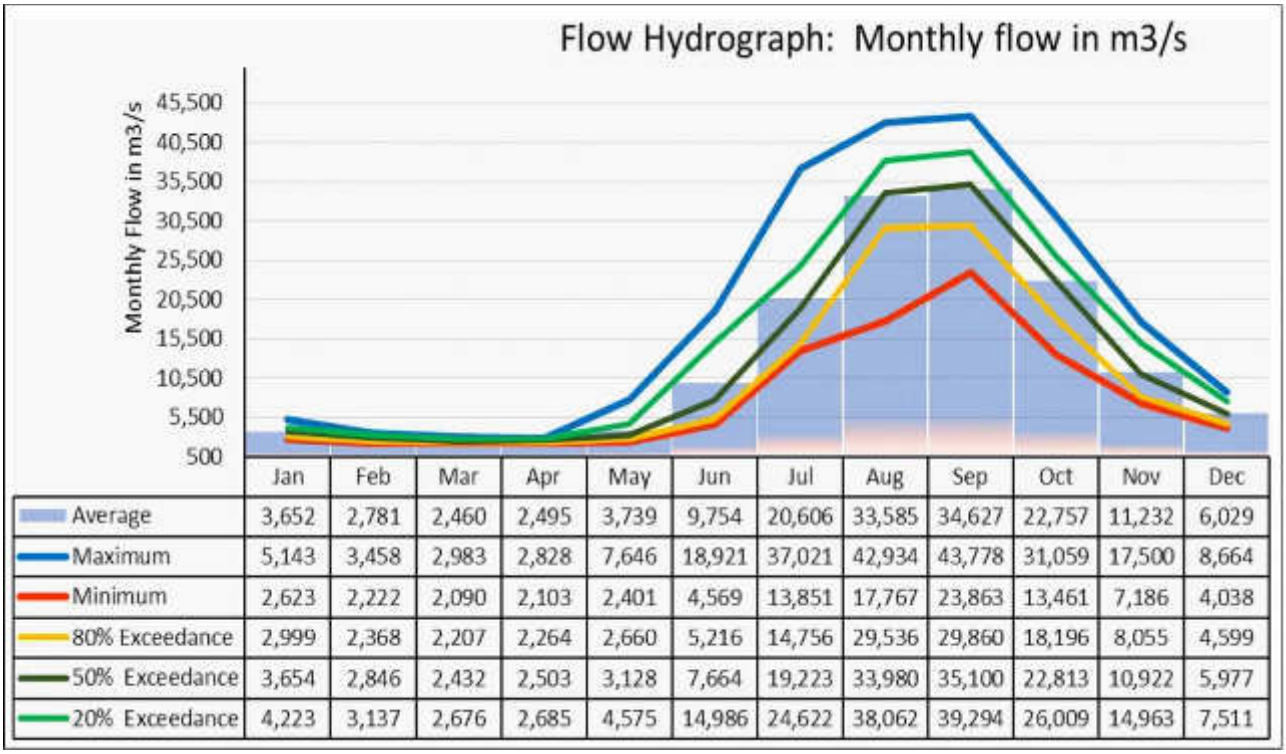
1985 – 2011	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
Average	99	185	189	181	198	270	204	61	13	11	17	55	1,485
Dry 80%	36	122	124	111	125	169	104	6	0	0	0	1	1,219
50%	75	179	165	163	207	259	212	48	2	1	0	38	1,466
Wet 20%	155	249	278	279	264	350	263	103	25	21	7	104	1,617
Max year	335	375	424	376	319	532	484	225	64	63	247	200	2,164
Min year	11	44	66	51	54	100	0	0	0	0	0	0	1,024

Source: Prek Po Feasibility Study Report, TRTA 2018.

114. The major waterbody affecting the area is the Mekong River. The flow records selected to represent the water availability for the Prek Po system in the hydrographic survey was the Mekong River flow at Kampong Cham, just upstream of the subproject area. A hydrograph based upon the monthly flows at this station for different years and flow exceedance probabilities is given in Figure 37.

[3] When 80% of rainfall readings for a normal year would exceed the readings for the subject (dry) year.

Figure 37: Average, minimum and maximum flows in Mekong River at Kampong Cham



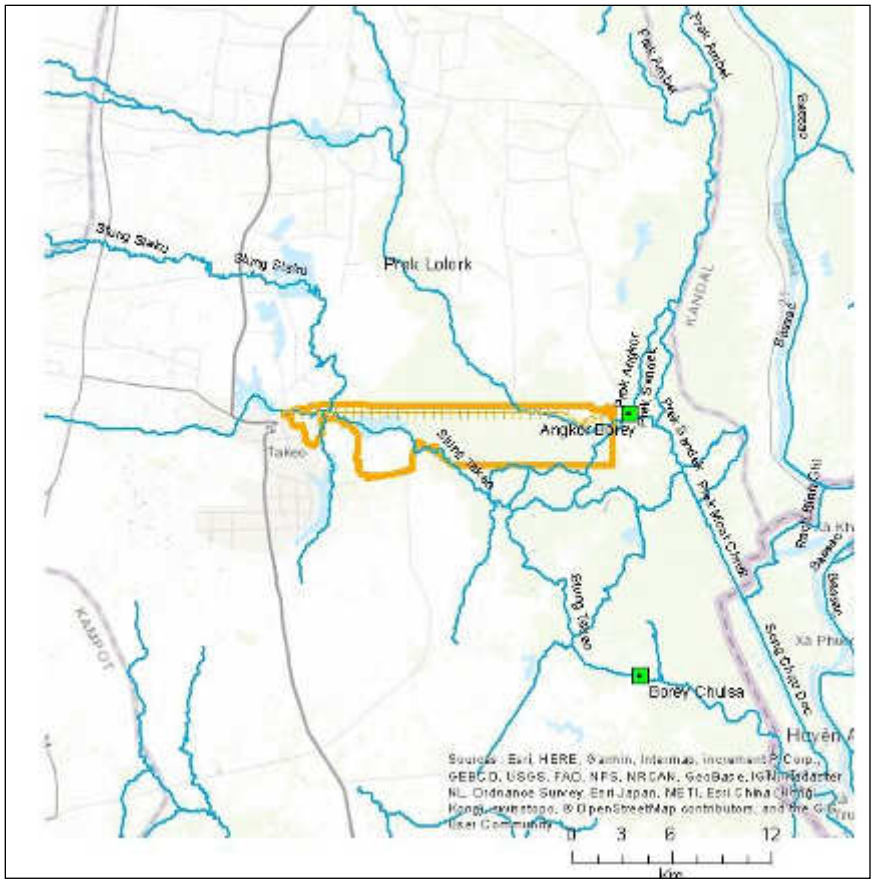
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	3,652	2,781	2,460	2,495	3,739	9,754	20,606	33,585	34,627	22,757	11,232	6,029
Maximum	5,143	3,458	2,983	2,828	7,646	18,921	37,021	42,934	43,778	31,059	17,500	8,664
Minimum	2,623	2,222	2,090	2,103	2,401	4,569	13,851	17,767	23,863	13,461	7,186	4,038
80% Exceedance	2,999	2,368	2,207	2,264	2,660	5,216	14,756	29,536	29,860	18,196	8,055	4,599
50% Exceedance	3,654	2,846	2,432	2,503	3,128	7,664	19,223	33,980	35,100	22,813	10,922	5,977
20% Exceedance	4,223	3,137	2,676	2,685	4,575	14,986	24,622	38,062	39,294	26,009	14,963	7,511

Source: Prek Po Feasibility Study Report, TRTA 2018.

115. **Canal 15.** Water flowing into Canal 15 and the rest of the flooded areas in Takeo comes from upwelling of the Bassac River complex together with the run-off water from the surrounding areas in the western side. The pattern of rainfall in Takeo is common to the region, with the year divided into distinct dry and wet seasons. The wet season is from May to October while the short dry season is from late November to April. The flood season generally occurs from July to early November. The average annual rainfall observed at Takeo is estimated at 1280 mm (1982-2011 average).

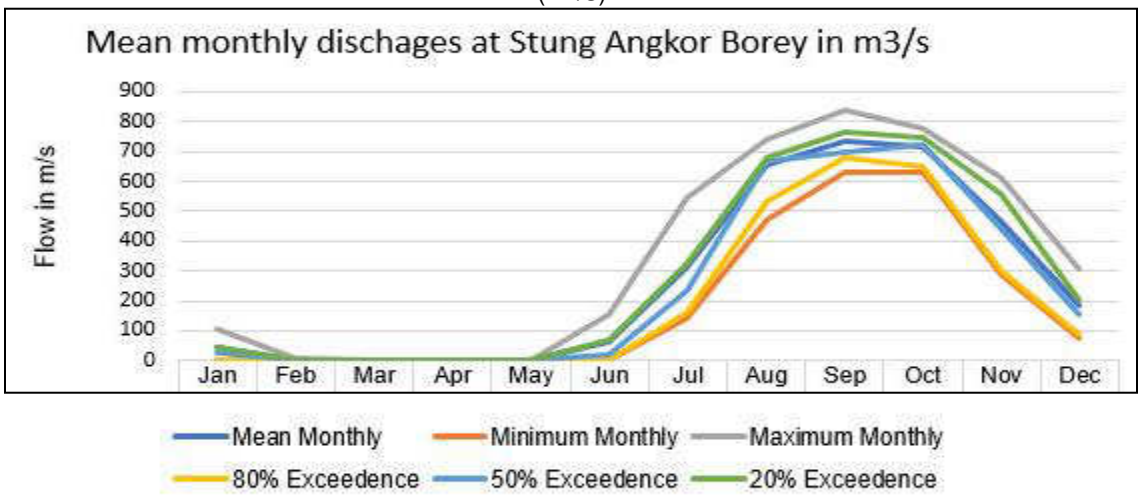
116. The significant annual contribution of water to the Canal 15 command area is from the upwelling of the Bassac River system via the Angkor Borey River at the eastern end of the main canal. Peak flows are between September and November, but hardly flows occur during the driest part of the year, between March and April. The biggest contributor to runoff from the surrounding areas is the Slakou River which originates from the slopes of the western mountains. The next major tributary emptying into the catchment basin is the Takeo River, also originating from the western mountains and on the north is the Prek Thu Lo Lork River. Although Slakou and Takeo rivers are partially diverted for irrigation use, there is still significant runoff from these rivers during the wet season. The rivers that drain into the Canal 15 command area and the channel link to the Bassac River are shown in Figure 38, and the mean monthly discharge at the end of Canal 15 at Angkor Borey (Peam Kley Station) is at Figure 39.

Figure 38: Canal 15 Water Resource and Catchment Area



Source: TRTA Technical Report – Hydrology, 2018.

Figure 39: Mean Montly Discharge at Peam Kley Station
(m^3/s)



Source: TRTA Technical Report – Hydrology, 2018.

5. Water Quality

117. The surface and groundwater sampling sites are shown at Figure 40. These were also used for measurements of acoustic environment. The timing of the nomination (by MOWRAM) and selection of the subprojects (which replaced subprojects rejected by the TRTA team) coincided with the onset of the wet season. A requirement of the EMP environmental monitoring plan (EMoP) is therefore to undertake further surface and groundwater analysis to (i) establish dry season baseline and (ii) monitor any changes against it.

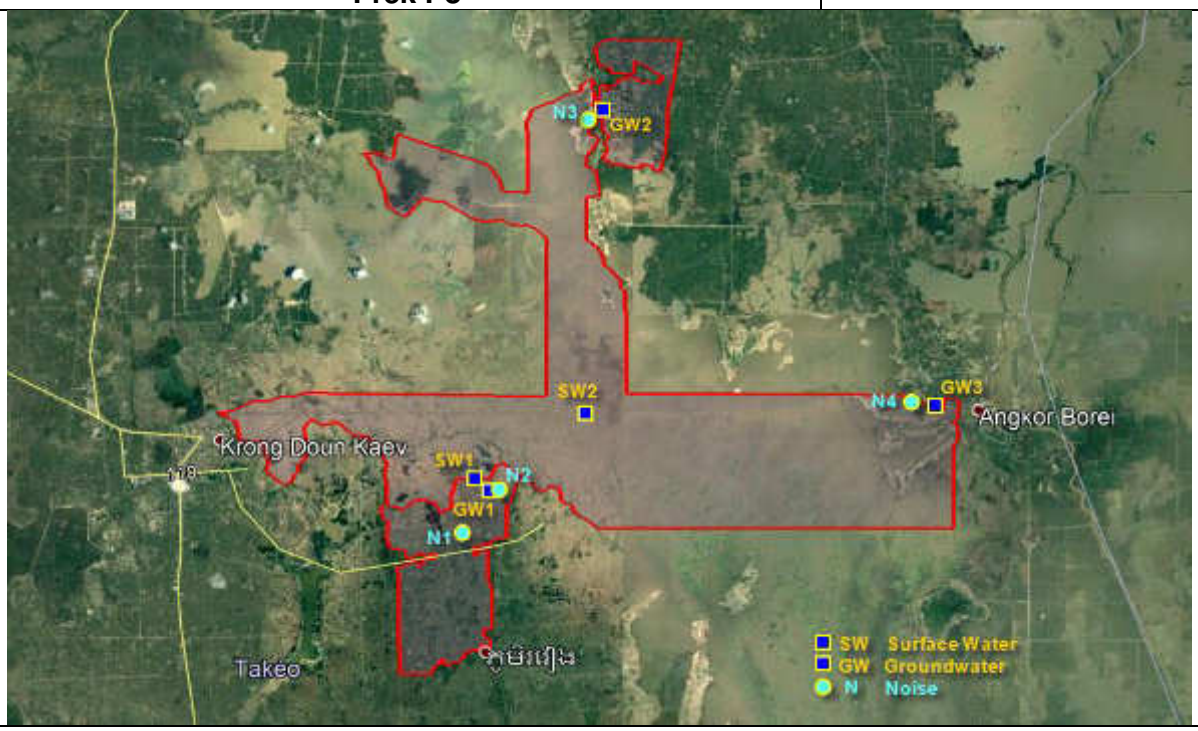
118. **Surface Water.** At Kamping Pouy. the surface water quality in the reservoir at the take-off point and in a secondary canal in the north of the subproject area and from the primary canal at its end, near the village of Paoy Suay was sampled in February 2018 and analysed by the Industrial Laboratory Center of Cambodia. All showed acceptable levels of total nitrogen, heavy metals and arsenic, but water in the reservoir and canals had positive *E. coli* counts (with the highest levels in the reservoir sample) indicating human and animal waste in runoff.

Figure 40: Location of water quality sampling sites and noise monitoring

Kamping Pouy

SW = Surface water (sampling site)
GW = Groundwater (sampling site)
These sites were also used for monitoring ambient noise levels.

Prek Po



Canal 15

Source: Google Earth adapted by TRTA 2018.

Table 20: Water quality results of surface water sampling in the Kamping Pouy scheme

Parameter	Unit	Results			Cambodian Standard Raw Water Quality	Cambodian Drinking Water Standard 2009	US EPA Drinking water
		SW8 Reservoir at Take-off	SW9 Secondary Canal	SW10 Primary Canal (end)			
pH		6.83	6.78	7	5.5-9	5.5-8.5	6.5-8.5
As	µg/L	0	0	0	<50µg/L	0	0
Cu	mg/L	0.174	0.229	0.204	<1mg/L	<1.0	<1.0
Se	µg/L	ND	ND	ND	<10µg/L		
Hg	µg/L	0.10	ND	ND	<1.0µg/L	<0.5	<1.0
Total Nitrogen	mg/L	0.54	0.47	0.62	-	15	50
OC	µg/L	ND		ND		-	10
d-BHC	*µg/L*		*352.60*		-	-	*10*
OP	µg/L	ND	ND	ND			20
Total Coliform	CFU/100ml	2.4 x 10^3	2.3 x 10	ND	<5 x 10^3	3	<1

d-BHC = residue of 4,4 DDT; ND = not detected.
Source: TRTA Team and ILCC: Industrial Laboratory Center of Cambodia.

119. At the Prek Po scheme the surface water quality was sampled in late January 2018 at two points along the primary canal, which runs north-south through the command area. The sample furthest from Prek Po, in the south of the area, showed the poorest water quality, with selenium levels higher than Cambodian raw water standard and elevated levels of *E. coli*. Total nitrogen was elevated in both samples, indicating a degree of wastewater contamination. Neither sample contained detectable pesticide residues.

Table 21: Water quality results of surface water sampling in the Prek Po scheme

Parameter	Unit	Results		Cambodian Standard Raw Water Quality	Cambodian Drinking Water Standard 2009	US EPA Drinking water
		SW6 Primary Canal North	SW7 Primary Canal South			
pH		7.74	7.56	5.5-9	5.5-8.5	6.5-8.5
As	µg/L	0	5	<50µg/L	0	0
Cu	mg/L	0.592	0.526	<1mg/L	<1.0	<1.0
Se	µg/L	***41.19***	ND	<10µg/L		
Hg	µg/L	ND	ND	<1.0µg/L	<0.5	<1.0
Total Nitrogen	mg/L	7.91	4.53	-	15	50
OC	µg/L	ND	ND		-	10
d-BHC	*µg/L*			-	-	*10*
OP	µg/L	ND	ND			20
Total Coliform	CFU/100ml	2.4 x 10^3	2.4 x 10^2	<5 x 10^3	3	<1

d-BHC = residue of 4,4 DDT; ND = not detected.
Source: TRTA Team and ILCC: Industrial Laboratory Center of Cambodia.

120. Surface water quality was sampled in the Canal 15 subproject area at two points in August 2018: one along the main canal at the junction with Canal 87 (the north-flowing secondary canal); and one in the canal though the southern extension of the command area, south of the Samput pump house. The locations are shown in Figure 30. Only one sample was taken within the main command area because it was fully inundated and so no locational inferences relating to sources or flow direction of any pollutants would be made from the analysis results. Instead, the results represent a snapshot of the general water quality.

121. Surface water was found to be generally clear of heavy metals and shows little sign of fertilizer runoff (although sampling in the rainy season provided a high dilution factor). All surface

water samples had detectable coliform levels. The sample taken in the middle of the flooded command area at Canal 15 (SW2) had detectable pesticide residues – a significant reading given the massive dilution by flood waters.

Table 22: Surface Water Quality Sampling Results at Canal 15

Parameter	Unit	Surface water		Cambodian Standard Raw Water Quality	Cambodian Drinking Water Standard 2009	US EPA Drinking water
		SW1	SW2			
Depth	m	0	0			
pH		6.6	6.7	5.5-9	5.5-8.5	6.5-8.5
As	µg/L	0.87	0.56	<50µg/L	0	0
Cu	mg/L	0.015	0.017	<1mg/L	<1.0	<1.0
P	mg/L	0.61	0.28	<3mg/L		
Total Nitrogen	mg/L	0.97	0.54	-	15	50
Herbicide residues	Positive/ negative	negative	Not tested	-	-	Various
Pesticide residues	Positive/ negative	negative	Low positive	-	-	Various
Total Coliform	CFU/100ml	4600	4600	$<5 \times 10^3$	3	<1

CFU = colony-forming unit.
Source: PPTA Team and ILCC: Industrial Laboratory Center of Cambodia.

122. **Groundwater**. Groundwater in the Kamping Pouy command area is shallow, with most domestic wells at 2-5 m depth. These wells tap into the same water table which maintains the level of water in the primary and secondary canals and shares their water quality. Deeper wells only occur around the edges of the command area and two were sampled. The more shallow sample (7 m) showed *E.coli* contamination as well as levels of total nitrogen and arsenic which were detectable but within standard. The single deep well sample (30 m) had good water quality for all parameters measured. The results are listed in Table 23.

Table 23: Groundwater quality results of groundwater at wells in the Kamping Pouy scheme

Parameter	Unit	Results		Cambodian Standard Raw Water Quality	Cambodian Drinking Water Standard 2009	US EPA Drinking water
		GW7 Well at Ta Kream village	GW8 Well at Dak Sasar village			
Depth	m	30	7			
pH		6.99	7.37	5.5-9	5.5-8.5	6.5-8.5
As	µg/L	4	3	<50µg/L	0	0
Cu	mg/L	0.210	0.279	<1mg/L	<1.0	<1.0
Se	µg/L	ND	8.96	<10µg/L		
Hg	µg/L	0.03	0.2	<1.0µg/L	<0.5	<1.0
Total Nitrogen	mg/L	1.91	1.09	-	15	50
OC	µg/L		ND		-	10
d-BHC	*µg/L*	2122.08		-	-	*10*
OP	µg/L	ND	ND			20
Total Coliform	CFU/100ml	ND	ND	$<5 \times 10^3$	3	<1

d-BHC = residue of 4,4 DDT; ND = not detected.
Source: TRTA Team and ILCC: Industrial Laboratory Center of Cambodia.

123. Groundwater in the Prek Po command area is deep, with most domestic wells at 30-40 m in depth. Two wells were sampled at points along the primary canal. Both showed acceptable levels of heavy metals, arsenic and total nitrogen. However, one well, at 40 m depth, showed elevated *E. coli* levels, which suggests direct contamination. Additionally, elevated levels of 4,4 DDT were found in the sample from a deep well in the center of the command area, which was

20 times higher than the local standard. It is possible that this has originated from recent, local misting for mosquitos in the residential area and is unrelated to agricultural activity. The sale of DDT is banned in Cambodia.

Table 24: Groundwater quality results of groundwater at wells in the Prek Po subproject scheme

Parameter	Unit	Results		Cambodian Standard Raw Water Quality	Cambodian Drinking Water Standard 2009	US EPA Drinking water
		GW5 Well at Chi Bai village	GW6 Well at Khnar village			
Depth	m	40	39			
pH		7.55	7.41	5.5-9	5.5-8.5	6.5-8.5
As	µg/L	0	0	<50µg/L	0	0
Cu	mg/L	0.006	0.243	<1mg/L	<1.0	<1.0
Se	µg/L	3.18	ND	<10µg/L		
Hg	µg/L	0.03	0.02	<1.0µg/L	<0.5	<1.0
Total Nitrogen	mg/L	0.38	0.40	-	15	50
OC	µg/L	ND			-	10
d-BHC	*µg/L*		2131.96	-	-	*10*
OP	µg/L	ND	ND			20
Total Coliform	CFU/100ml	2.4×10^3	ND	$<5 \times 10^3$	3	<1

d-BHC = residue of 4,4 DDT; ND = not detected.
Source: TRTA Team and ILCC: Industrial Laboratory Center of Cambodia.

124. Groundwater in the Canal 15 command area is also multi-layered, with wells around the command area (there are none in the center) ranging in depth from 17m to 52 m. The locations are shown in Figure 28. Three samples were collected in August 2018: one at 30 m depth next to the Samput pump house; one at 17 m depth south of the Pon Ley pump house; and one at 52m depth at Angkor Borey Primary School. In all cases residents reported that the well water was only used for washing and cleaning and not for drinking or cooking.

125. Low level pesticide residues were found in deep wells (GW1 and GW3) but no herbicide residues. High coliform levels were also found in a deep well beside the Samput pumping station (GW1). Arsenic levels were slightly elevated, but within standard for non-drinking water at a deep well in a primary school at Angkor Borey (GW3).

Table 25: Groundwater Quality Sampling Results at Canal 15

Parameter	Unit	Groundwater			Cambodian Standard Raw Water Quality	Cambodian Drinking Water Standard 2009	US EPA Drinking water
		GW3	GW2	GW1			
Depth	m	52	17	30			
pH		6.38	6.34	6.28	5.5-9	5.5-8.5	6.5-8.5
As	µg/L	4.91	2	0.25	<50µg/L	0	0
Cu	mg/L	0.042	0.04	0.031	<1mg/L	<1.0	<1.0
P	mg/L	1.37	0.46	0.37	<3mg/L		
Total Nitrogen	mg/L	0.4	0.9	0.58	-	15	50
Herbicide residues	Positive/ negative	negative	negative	negative	-	-	Various
Pesticide residues	Positive/ negative	Low positive	negative	Low positive	-	-	Various
Total Coliform	CFU/100ml	4	240	>11000	$<5 \times 10^3$	3	<1

CFU = colony-forming unit.

Source: PPTA Team and ILCC: Industrial Laboratory Center of Cambodia.

126. The project has used the Industrial Laboratory Center of Cambodia (ILCC) for water quality testing of subprojects, since it is the only facility capable of testing for pesticide and herbicide residues. The laboratory protocol it uses is *AOAC 2007 0.01*, which uses gas chromatography/mass spectrometry to test for the presence of all pesticides in use in Cambodia. However, at the time of water sampling at Canal 15 the gas chromatography/mass spectrometry was unserviceable and a simpler test was performed for threshold levels of a range of common pesticides listed above. The EMoP requires that surface and groundwater be sampled during pre-construction phase to establish dry season water quality and that the full range of agricultural chemicals used at all subprojects be tested for at that time to establish a baseline against which IPM and other interventions can be compared.

6. Air Quality and Noise

127. **Air quality.** The MOE conducted ambient air quality measurements in Battambang in 2017. These are monthly averages of 24-hour averages, and although taken in Battambang city, show good levels of air quality for the months measured (Table 26).

Table 26: Ambient Air Quality, Battambang 2017

Parameter	Month													
	1	2	3	4	5	6	7	8	9	10	11	12	Unit	24 Hr standard
NO_2	-	-	-	0.012		0.01	-	-	0.012	-	-	-	mg/m³	0.1
SO_2	-	-	-	ND		-	-	-	-	-	-	-	mg/m³	0.3
CO				1.25		2.08			2.08				mg/m³	20

Source: Ministry of Environment.

128. No ambient air quality data exists for the other subproject areas. As rural areas, the air quality is sometimes affected by dust from tillage and unpaved road users and smoke from rice stubble burning after harvest. At most times however, due to the absence of industry and low traffic volumes, the air quality can be expected to be high, with low NO_x and SO_x and minimal CO.

129. Ambient noise levels were sampled in the subproject areas with a noise meter. 10 minute averages, maximum and minimum levels were recorded for locations along the main canals. The monitoring sites are shown in Figure 29. The results are at Table 27.

130. At Kamping Pouy, site ambient noise levels are characteristic of rural settings in Cambodia for minimum measurements. The use of numerous small pumps on paddy dykes and along canals and frequent motorcycles along canal levee banks elevate the daytime noise levels. Typical daytime noise levels along primary and secondary canals are 1 hour averages of 33-38 dB, with maximum peaks of 60-70 dB due to vehicles.

Table 27: Environmental Noise levels at Kamping Pouy

Parameter	Unit	Kamping Pouy				42 ANRK.BK Standard	EHS Target[4]
		SW8 Reservoir at Take-off	Main canal at first branch	SW9 Second-dary Canal	SW10 Primary Canal (end)		
maximum	dB	78.1	77.1	69.5	56	-	-
minimum	dB	57.2	33	38.1	30	-	-
10 min average	dB	63.5	46.5	-	33.5	60-50 (1 hour average)	55 (1 hour average)

Source: TRTA Team field measurements.

131. At Prek Po site ambient noise levels are high for a rural setting in Cambodia, due to the

[4] IFC 2007, *Environmental Health and Safety Guidelines: General Guidelines*, World Bank Group.

number of settlements within the command area and proximity to main roads. The use of numerous small pumps on paddy dykes and along canals and frequent motorcycles and other vehicles along canal levee banks also elevate the daytime noise levels. Typical daytime noise levels along primary and secondary canals are 1 hour averages of 50-52 dB, with maximum peaks of 70-80 dB due to vehicles. At the pump station channel on the Mekong at Prek Po, without pumps operating, the noise levels were: 1 hr average 50.4 dB; max 78.9 dB; min 39.1 dB.

Table 28: Environmental Noise levels at Prek Po

Parameter	Unit	Prek Po			42 ANRK.BK Standard	EHS Target
		SW6 Primary Canal North	GW6 Well at Khnar village	Main pump station site		
maximum	dB	69.5	88.9	78.9	-	-
minimum	dB	40	52.8	39.1	-	-
10 min average	dB	52.9	52	50.4	60-50 (1 hour average)	55 (1 hour average)

Source: TRTA Team field measurements.

132. At the Canal 15 subproject site ambient noise levels are typical for an isolated rural setting in Cambodia. The noise monitoring locations are shown on Figure 28. Typical recorded daytime noise levels on the periphery of the command area are 1 hour averages of 32.6, 37.0, 32.4 and 42.2 decibels (dB), with maximum peaks of 56 to 63.4 dB due to vehicles.

Table 29: Environmental Noise levels at Canal 15

Parameter	Unit	N1	N2	N3	N4	42 ANRK.BK Standard	EHS Target
maximum	dB	56.1	63.4	40.2	56	-	-
minimum	dB	-	-	-	33.4	-	-
10 min average	dB	32.6	37	32.4	42.2	60-50 (1 hour average)	55 (1 hour average)

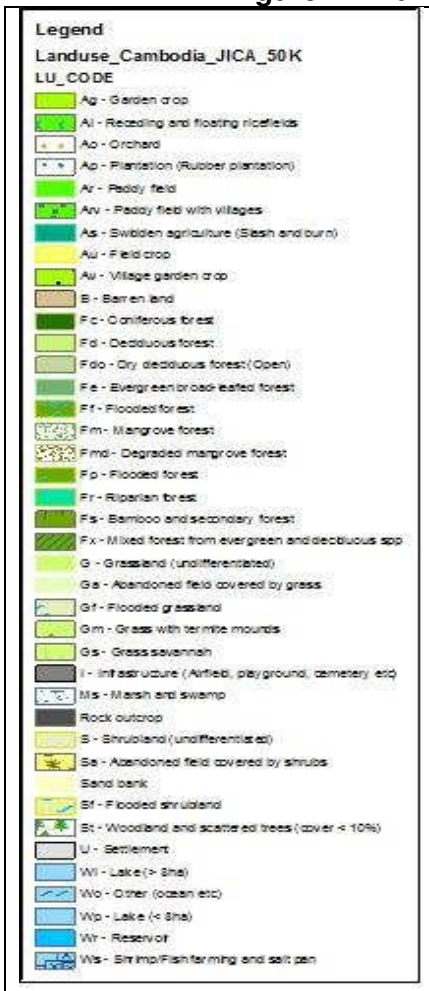
Source: TRTA Team field measurements.

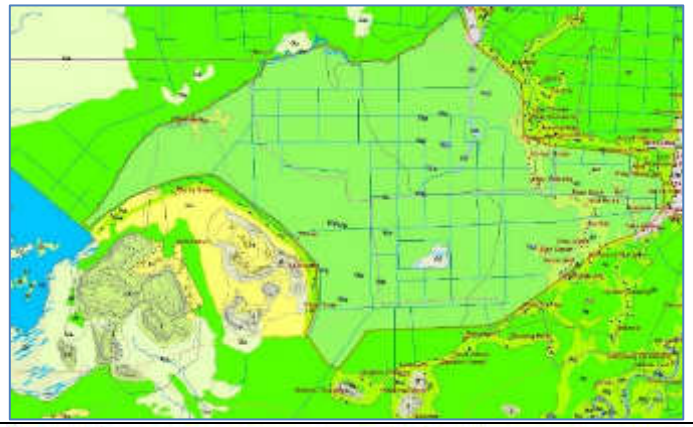
7. Land Use and Vegetation

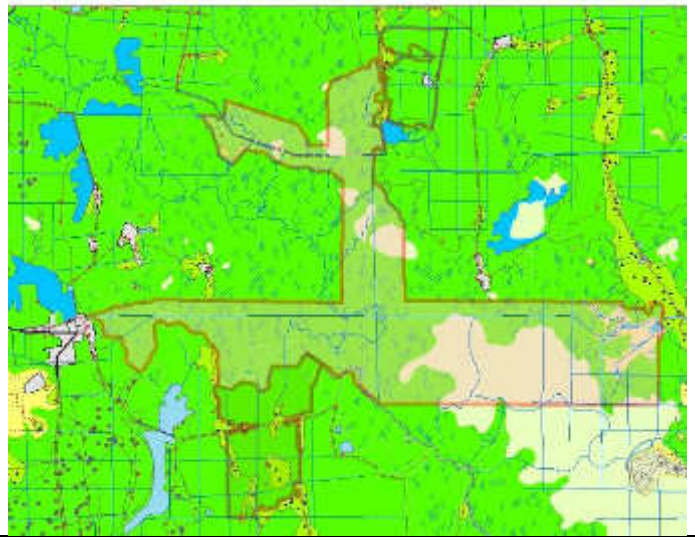
133. The land use of the three subproject areas is illustrated in the 2005 JICA GIS Survey of Cambodia (Figure 41)

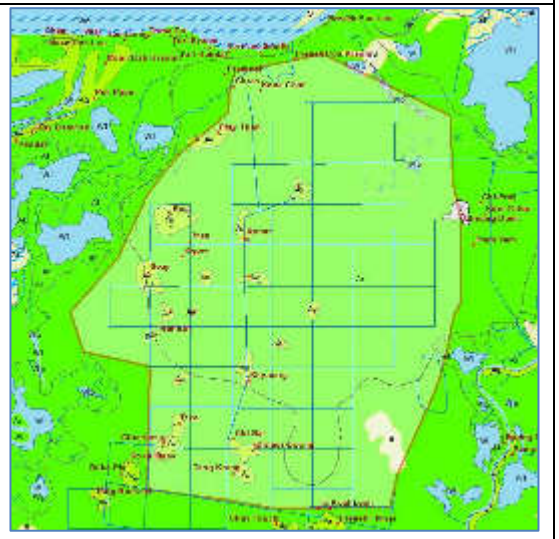
134. At Kamping Pouy, the command area is fully sown to rice in the wet season and partially in the dry. There are village gardens in the eastern part associated with villages of Chrey Thmei, Prey Totueng, Prey Dach, Ou Mai and Prey Ronka. Village gardens also occur along the primary canal which runs parallel to the road linking the reservoir with Road 57. These gardens commonly comprise mango trees, banana, coconut, papaya and kapok. Along the primary canal and secondary canals are occasional large trees (*Albizia lebbeck, Acacia melanoxylon* and *Samanea saman*), but the majority are low trees/tall shrubs of *Zizyphus jujube, Cassia siamensis, Albizia myriophylla, Barringtonia* sp. and *Lanatus* sp. Stands of *Eucalyptus tereticornis* have been planted along the main canal and secondary canals in the south of the command area. The canals themselves are significantly silted and support thick growths of *Mimosa pudica, Ipomea* sp. and rush grasses. No canal fisheries have been noted. Along paddy dykes, away from the canals, are occasional *Bombax ceiba* and *Dipterocarpus elatus*. This is illustrated in Figure 41 below.

Figure 41: Land Use and Vegetation at the Kamping Pouy, Canal 15 and Prek Po Subprojects









Left: Kamping Pouy, Battambang province

Bottom left: Prek Po, Kampong Cham province

Below: Canal 15, Takeo province

Source: JICA GIS Survey of Cambodia, 2005, revised by TRTA Team 2015.

Figure 42: Land use and vegetation in Kamping Pouy command area

Albizia lebbek and *Acacia melanoxylon* trees along the main intake canal adjacent to the dam wall

Isolated *Dipterocarpus elatus* trees among rice paddy fields

Zizyphus jujube, Cassia siamensis, Albizia myriophylla, Barringtonia sp. and *Lanatus* sp. midway along the main canal

Eucalyptus and *Bombax* along southern end of main canal

TRTA Field Observations, 2018

135. The Prek Po command area comprises paddy over most of its area but is currently only partially sown to rice in both the wet and dry season. There are small village gardens along the road network. These gardens commonly comprise mango trees, banana, coconut, and papaya. The first 900 – 1000 m of the primary canal passes through the built-up area of Prek Po and are encroached upon by houses and outbuildings, vegetation and rubbish. In the section of the main canal running south from the town of Prek Po formal plantings of non-native mahogany trees (possibly Senegal mahogany (*Khaya senegalensis*)) line the canal banks. Further into the command area the primary canal and secondary canals are lined with occasional trees of *Acacia melanoxylon* and *Combetrum quadrangulare* and low trees/tall shrubs of *Zizyphus jujube* and *Albizia myriophylla*. The canals themselves are free of vegetation but no canal fisheries have been noted. Along paddy dykes, away from the canals, are occasional *Zizyphus jujube, Cassia siamensis* and clumps of *Bombax ceiba*.

Figure 43: Land use and vegetation in Prek Po command area

Khaya senegalensis trees in Prek Po town and lining the northern portion of the main canal

Acacia melanoxylon and *Combetrum quadrangulare* and low trees/tall shrubs of *Zizyphus jujube* and *Albizia myriophylla* along secondary canals and paddy dykes.

Overgrown and garbage-clogged section of main canal in Prek Po town

Source: TRTA Field Observations, 2018.

136. At Canal 15, before the construction of the main canal in 1980 farmers in the area grew low yielding floating rice using the annual flood pulse from the Mekong and Bassac basin. The construction of the major secondary canals in the mid 1990s completed the change from one floating rice crop per year to recession rice cropping and the possibility of two crops per year.

137. Currently farmers in the main command area of the Canal 15 system grow two crops per year, flood recession rice (December to March) and dry season/early wet season rice (April to July). These are basically dry season crops which make use of residual water left over from the previous wet season floods. 100% of farmers grow the recession crop while only about 30% to 40% grow the second crop due to unreliable water supply and risk of early flooding. However, farmers who are located in the higher lands which are not affected by the seasonal flood can grow two or three crops per year (early wet season rice, recession rice, and dry season rice).

The low-lying areas along Canal 15 are fully flooded for five months of the year and there are no villages or village gardens in this area. Vegetation along the main canal comprises *Eucalyptus camaldulensis* and *Acacia acutangula* trees with *Mimosa* scrub. Occasional trees along the paddy dykes are *Nauclea orientalis* (Yellow cheesewood) and *Barringtonia acutanula* (Freshwater mangrove). All these species can stand long periods of inundation.

Figure 44: Vegetation along the Banks of the Main Canal (Canal 15)	Figure 43: Vegetation among the Paddy Fields along Canal 15
	
Eucalyptus and *Acacia* on canal embankment	*Nauclea* and *Barringtonia* Trees are the only significant vegetation on the floodplain

Source: TRTA Field Observations, 2018.

138. In the southern (Samput) extension of the command area, the elevation is higher and inundation only occasional – so vegetation along the canals and paddy dykes is distinctly different and comprises *Bombax ceiba* (Sugar palm), *Eucalyptus tereticornis* (Forest red gum) and *Acacia obliquefolia* (Madras thorn).

Figure 46: Vegetation along paddy dykes of the Samput Extension Area	Figure 45: vegetation on Secondary Canals in the Samput Extension Area
	
Bombax Ceiba and *E. tereticornis* are Common along the paddy walls	*Acacia obliquefolia* along Secondary Canals

Source: TRTA Field Observations, 2018.

139. None of the vegetation species recorded in the subprojects is listed as threatened nationally or on the IUCN Red List.

140. Only in the southern extension of the command area served by the Samput pumping station do villages exist and the gardens in this area commonly comprise the following:

Table 30: Common Garden Trees in the Samput Extension Area

Limonia acidissia	Wood apple
Albizia lebbeck	Siris tree
Samanea saman	Raintree
Mangifera indica	Mango
Cocos nucifera	Coconut
Ceiba pentandra	Kapock
Garcinia mangostana	Mangosteen
Terminalia chebula	Tropical almond
Bambusa vulgaris	Narrow leaf bamboo

Source: TRTA Field Observations, 2018.

Of the 114 plant species listed as invasive in Cambodia by the GBIF[1] and MAFF, the following were noted as commonly occurring in the subproject areas:

Eucalyptus camaldulensis
Eichornia sp
Mimosa pudica
Ipomea triloba
Jatropha Gossypium
Zizyphus mauritiana
Acacia auriculiformis

141. The first five will be removed from work sites where encountered. Disposal will depend on the time of year and whether seed propagules are evident on the vegetation, but will include drying out on site followed by mulching or burning. The *Eucalyptus* and *Acacia* have an important role in canal bank stabilization. These Acacias will only be removed as necessary for works and sequentially replaced with native species.

8. Fisheries

142. No data on fisheries production or fishing effort in the command areas was available, but observation and discussion indicate that limited fishing is potentially undertaken as a supplementary activity during dry season when the paddy fields are in fallow. Fish catches are primarily for domestic consumption, with only a small proportion of the catch being dried and marketed locally.

143. No fisheries were observed in the Kamping Pouy command area. All canals were significantly silted up and had minimal water – except for the stretch of the main canal from the reservoir offtake to the confluence with the first secondary canal. There is potential for low level household fisheries here. A local fisheries industry exists in the Kamping Pouy reservoir. Lake and larger waterbody fish in Battambang province include those listed in Table 31. None of the species indicated as potentially present in the lower reaches of Kamping Pouy are listed as endangered.

Table 31: Fish likely to be present in the Kamping Pouy Reservoir and lower reaches of the Main Canal

Local Name	Scientific Name	Comments
Trei Ros/ Ptuok	*Channa striata*	Migrates for breeding
Trei Andeng Tun	*Clarias macrocephalus*	Migrates for breeding
Trei Chhpin	*Barbodes gonionotus*	

[1] Global Biodiversity Information Facility https://www.gbif.org/species/search?offset=20&dataset_key=5dc177e0-4651-4ea1-8133-3687fffc963c&origin=SOURCE&advanced=1

Local Name	Scientific Name	Comments
Trei Riel	*Henicorhynchus siamensis*	
Chhlang	*Mystus filamentus*	
Trei Kes	*Micronema bleekeri*	
Trei Kagnchruk	*Botia modesta*	
Trei Kamphleanh	*Trichogaster trichopterus*	Migrates for breeding
Trei Kamphleav	*Kryptopterus moorei*	Migrates for breeding
Kanh Chanh Chras	*Pseudambassis notatus*	
Kanh Chos	*Mystus mysticetus*	Migrates for breeding
Kan Trob	*Pristolepis fasciata*	
Khnong Veng	*Dangila lineata*	Migrates for breeding
Kranh	*Anabas testudineus*	Migrates for breeding
Kros phnom	*Poropuntius deauratus*	Migrates for breeding
Angkat Prak	*Cyclocheilichthys microlepis*	
Slat	*Notopterus notopterus*	
Ta Aun/ Kramorm	*Ompok bimaculatus*	
Sraka Kdam	*Cyclocheilichthys repasson*	Migrates for breeding

Source: TRTA Field Observations, 2018

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144. No fisheries were recorded in the Prek Po command area due to the degraded condition of the irrigation infrastructure. At present the majority of irrigation water is sourced from groundwater pumps rather than the canals. Although Prek Po theoretically sources its water from the Mekong, and will do again with project investments, the pump lift is between 3 and 10 m and few if any mainstream river fish would survive the passage through the pumps to populate the Prek Po canals. Some residual fisheries resource is reported to exist in Boeung Vean reservoir which is outside the project area.

145. At Canal 15, informal fisheries are undertaken in the secondary canals (the main canal is not fished with the same intensity due to continuous water transport traffic). At the time of the field survey, water levels were too high for fishing. Previous survey in Takeo and eastern Kampot in canals similarly subject to overland flooding from the Bassac/Mekong Basin recorded the following fish species from local fishermen, and it is expected that these would reflect the fish species array in Canal 15 and its secondaries.

Table 32: List of Fish Species in Takeo Canals

Common Name	Scientific Name
Whisker Sheatfish	*Kryptopterus limpok*
Blue Danio or Long-barbel Danio	*Danio regina* or *Danio pulcher*

Grey Featherback	*Notopterus notopterus*
Iridescent Mystus	*Mystus villatus*
Batrachian Walking Catfish	*Clarias batrachus*
Striped Tiger Nandid or Temminck's Kissing Gourami	*Pristolepis fasciatus* or *Hetostoma temmincki*
Spotted Spiny Eel	*Macrognathus siamensis*
Tree Spot Gounrami	*Trichogaster trichopterus*

Source: TRTA Field Observations, 2018.

9. Fauna

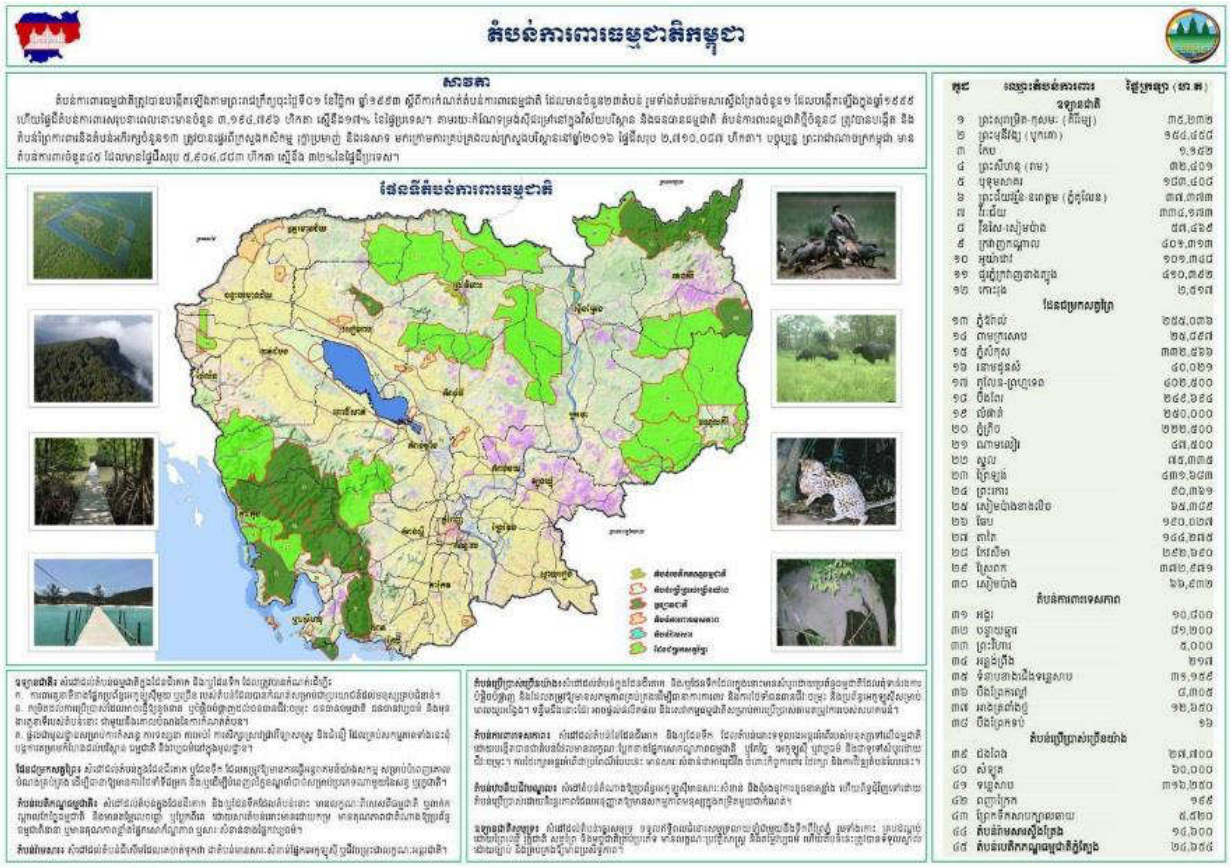
146. The subproject areas have been intensively farmed and irrigated for generations. No natural terrestrial or aquatic habitats exist and natural biodiversity comprises only common wildlife living among humans in agricultural regions, domesticated animals and feral pests and rodents.

10. Protected Areas

147. Cambodia has a network of over 20 protected areas managed through MOE. These areas cover 2.2 million hectares or 18% of Cambodia's land area and include most of its important habitats. The Forest Administration has also designated protected forests (from cancelled logging concessions) bringing the total area under protection to around 25%, which is more than twice the global average.

148. Protected Areas are sites which are protected by Decrees, Laws and Regulations. In 2008 Cambodia introduced the Protected Area Law (No. NS/RKM/0208/007), which defines these areas by their main conservation significance. These are listed on the MOE published map below.

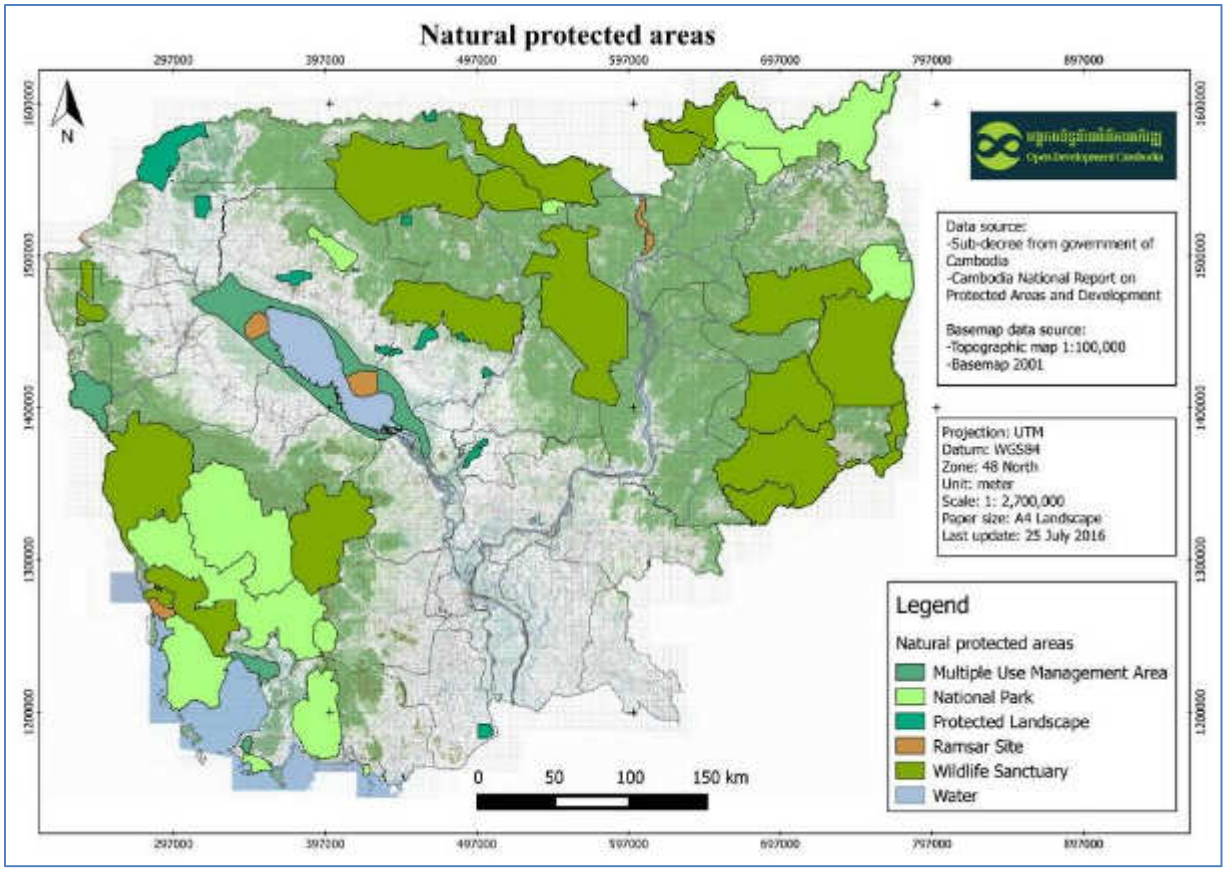
Figure 48: MOE Protected Areas Map – showing National Parks, Wildlife Sanctuaries, Protected Landscapes, Multiple Use Areas, Ramsar Sites and Marine Parks



Source: Ministry of Environment.

149. The NGO Open Development Cambodia has updated the MOE map with all Protected Areas in Cambodia as of July 2016.

Figure 49: Protected Areas in Cambodia. Source: Open Development Cambodia



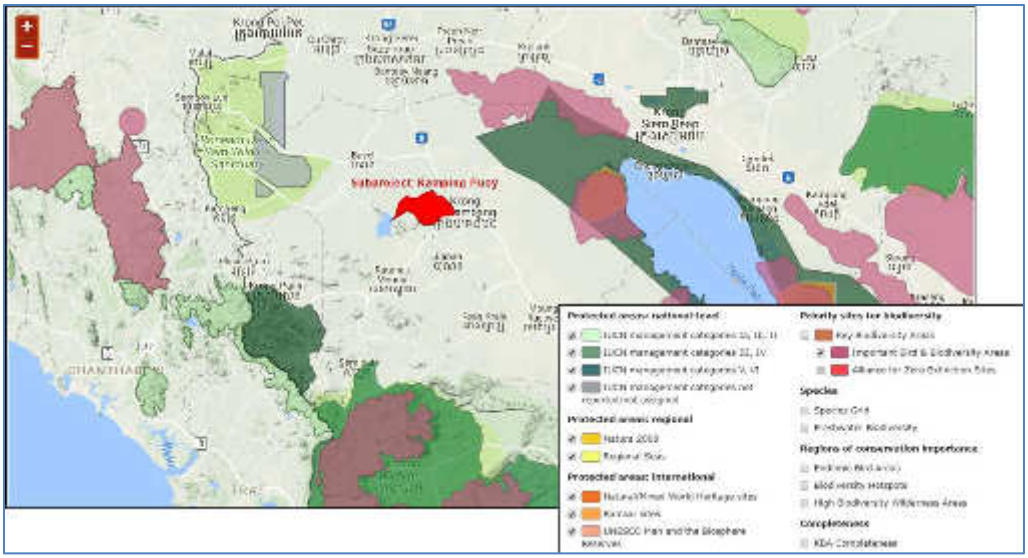
Source: Open Development Cambodia.

11. Critical Habitats

150. The location of the Kamping Pouy subproject has been checked against the data in the International Biodiversity Assessment Tool (IBAT)[2] which showed that the subproject does not encroach upon any nationally protected areas (IUCN management classes), international conservation agreement areas, or key biodiversity areas (KBAs).

[2] www.ibat-alliance.org/ibat-conservation.

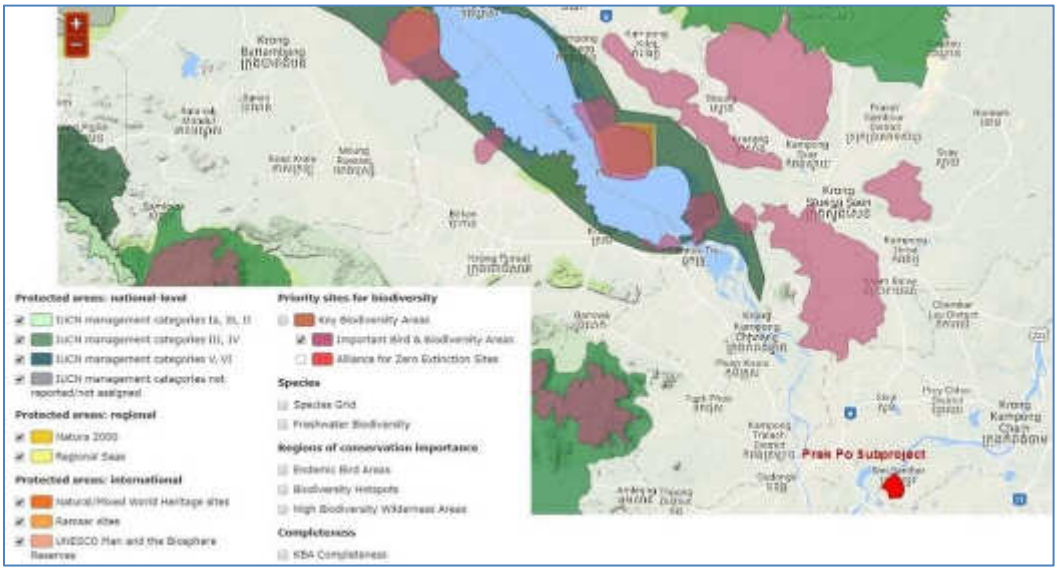
Figure 50: IBAT Identified Areas around Kamping Pouy



Source: www.ibat-alliance.org/ibat-conservation.

151. Similarly, the Prek Po subproject does not encroach upon any nationally protected areas (IUCN management classes), international conservation agreement areas, or key biodiversity areas (KBAs).

Figure 51: IBAT Identification of Areas showing no Encroachment by the Subproject Area on Protected Lands or Critical Habitats



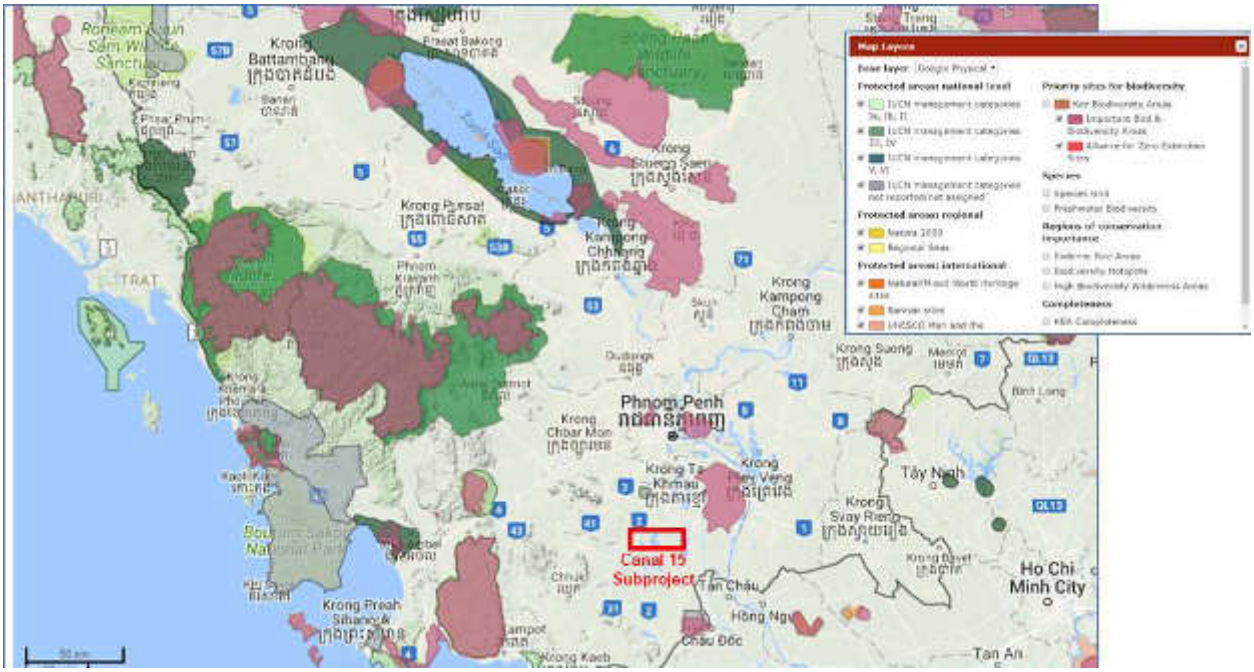
Source: www.ibat-alliance.org/ibat-conservation.

152. The nearest legally protected area to the Canal 15 subproject is the Boeung Prek Lapouv Protected Landscape, which is 23 km south of the Canal 15 command area boundary. Similarly, the nearest priority site for biodiversity identified in IBAT is the Boeung Prek Lapouv Protected Landscape, with the Bassac Marsh IBBA[3] a similar distance from the command area to the north-

[3] Important Bird and Biodiversity Area; a type of KBA.

east.

Figure 52: IBAT Identification of Areas showing no Encroachment by the Subproject Area on Protected Lands or Critical Habitats



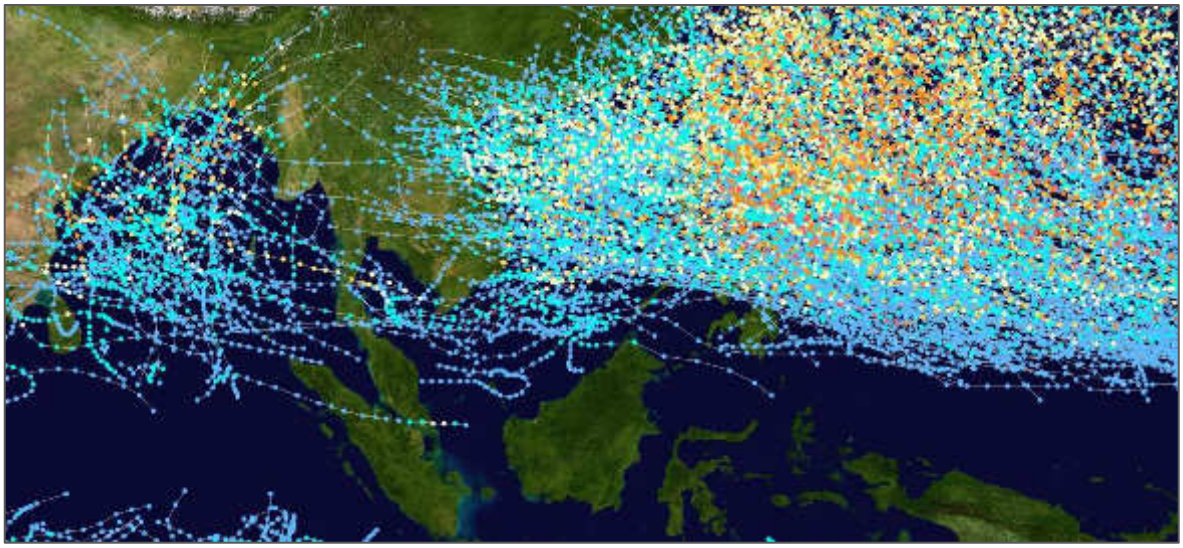
Source: www.ibat-alliance.org/ibat-conservation.

12. Floods and Droughts

153. Flooding is a regular phenomenon in Cambodia, with rainfalls commonly exceeding 500 mm per month in the rainy season. However, recent flooding in the Mekong region has been very damaging and the Mekong River Commission records show an increasingly shorter return period for major floods. Additionally, though major tropical cyclones originating in the South China Sea rarely penetrate into Cambodia (see Figure 53), cyclonic effects in central Cambodia have been more common in the last decade.

154. In particular, the floods of 2011 and 2013 were major events and were very damaging to life, property and livelihoods. The flood statistics for the 2013 flood for the subproject provinces in Table 33 illustrate the levels of damage.

Figure 53: Tropical Cyclone Tracks[4] 1985-2005



Source: National Hurricane Center and the Central Pacific Hurricane Center.

Table 33: Impact of flooding (18 October 2013)

Province		Kampong Cham	Battambang	Takeo
Affected Districts		14	13	
Affected communes		102	84	18
Affected Families		74,160	44,764	2,796
Affected people		341,136	205,914	12,862
Evacuated families		4,504	866	10
Evacuated people		20,718	3,984	46
Houses affects		62,451	32,193	2,796
Victims	Deaths	17	26	5
	Injured	4	-	-
Flood Affected	Schools	77	155	3
	Pagodas	14	53	2
	Health centers and hospitals	9	8	-

Source: Humanitarian Response Forum, Situation Report No.4, 23 October 2013.

155. Table 34 below compares data collected by NCDM in 2013 and 2011, at the peak of the floods in each year, by province. Changes in the number of affected or evacuated families in 2013 compared to 2011, are highlighted.

Table 34: Affected and Evacuated Families in 2013 and 2011

Province	2013	2011	Comparison (affected families) 2013 and 2011	2013	2011	Comparison (Evacuated families), 2013 and 2011
	Affected families	Affected families		Evacuated families	Evacuated families	
Kampong Cham	51,376	33,436	17,940	3,546	6,085	-2,539

[4] Tracking data for storms within the Atlantic and Eastern Pacific basins is taken from the National Hurricane Center and the Central Pacific Hurricane Center's Northeast and North Central Pacific hurricane database.

Battambang	74,160	13,921	+60,239	4,504	1,194	+3,310
Takeo	2,796	7,869	-5.073	10	726	-716

Source: Humanitarian Response Forum, Final Report No.07, December 2013.

156. The effects of flooding on rice production is an important part of the project due diligence. The following table, taken from the Humanitarian Response Forum Situation Report of October 2013 covering the devastating floods of September that year, show that the agriculture of the subproject provinces were significantly affected.

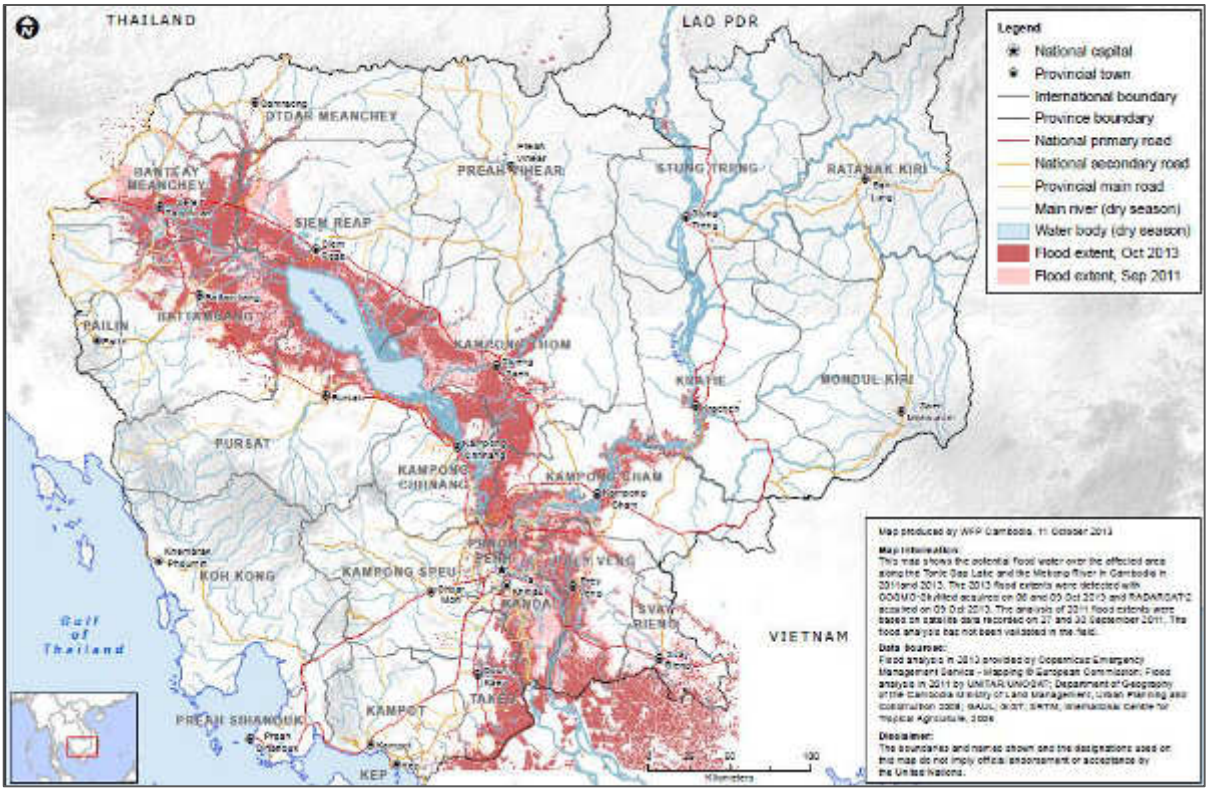
Table 35: Damage to Agriculture Sector by Floods in 2013

Phnom Penh/ Provinces	Area Planted	Affected (ha) Flood (ha)		Destroyed (ha) Flood (ha)	
	Ha	Seedling	Transplanted rice/Direct seedling	Seedling	Transplanted rice/Direct seedling
Banteay Meanchey	230,632	-	38,988	-	197
Battambang	295,314	-	73,667	-	1,048
Kampong Cham	165,927	140	10,798	87	1,661
Kampong Chhnang	120,651	-	1,847	-	-
Kampong Spew	113,732	-	-	-	-
Kampong Thom	215,191	-	5,180	-	-
Kampot	135,095	-	-	-	-
Kandal	39,490	-	4,790	-	-
Koh Kong	10,373	-	-	-	-
Kratie	32,860	-	1,926	-	191
Mondolkiri	22,920	-	480	-	26
Phnom Penh	11,557	-	50	-	-
Preah Vihear	74,093	-	5,166	-	-
Prey Veng	279,894	-	55,840	-	13,647
Pursat	108,374	-	11,772	-	-
Ratanakiri	27,172	-	3,854	-	-
Siem Reap	183,845	-	13,995	-	1,240
Sihanoukville	16,483	-	-	-	-
Stung Treng	27,664	-	8,070	-	5,490
Svay Rieng	166,549	-	915	-	-
Takeo	201,566	-	32	-	5
Otdar Meanchey	64,705	-	7,086	-	-
Kep	3,530	-	-	-	-
Pailin	6,485	-	-	-	-
TOTAL	**2,554,102**	**140**	**244,456**	**87**	**23,505**

Source: Humanitarian Response Forum (HRF) Situation Report No. 03 (as of 15 October 2013).

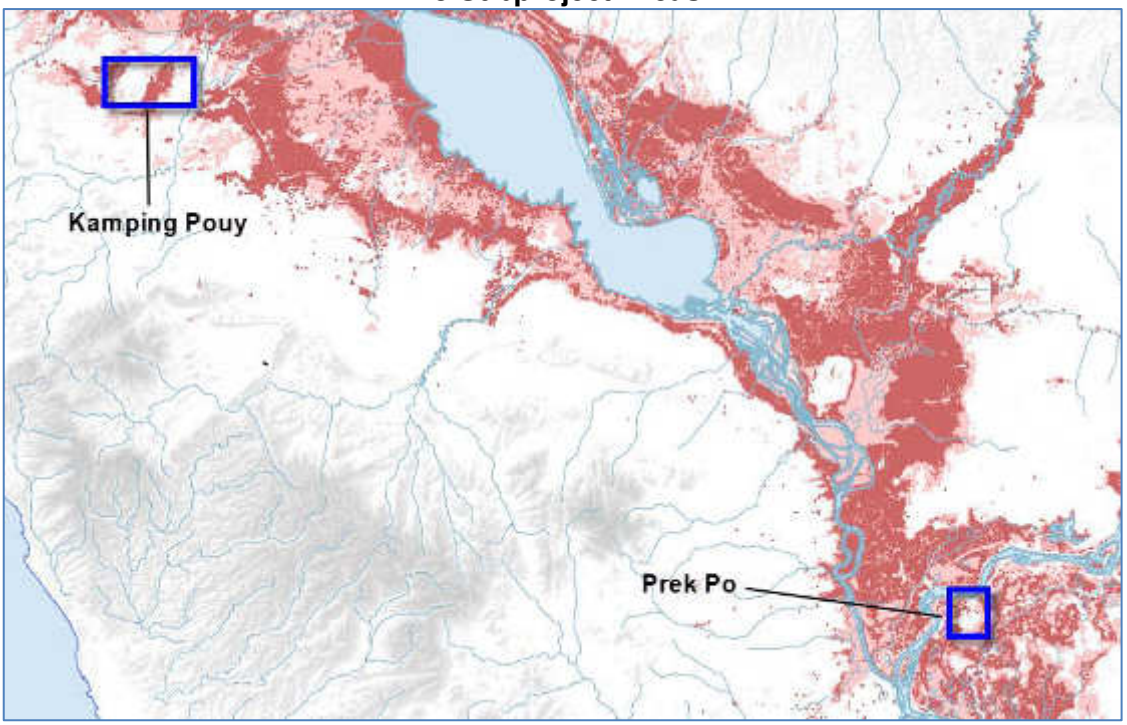
157. Data on flooding in the subproject communes is unavailable, but national mapping of the 2011 and 2013 floods (Figure 54, 55 and 56) shows that the Kamping Pouy subproject in Battambang was flooded through the center of the command area in both 2011 and 2013, and that the Prek Po subproject in Kampong Cham was only peripherally affected by both floods, and that the Canal 15 subproject in Takeo was only fully inundated by both floods (except for the Samput sub-command area which is on higher ground).

Figure 54: 2011 and 2013 Floods at the National Scale



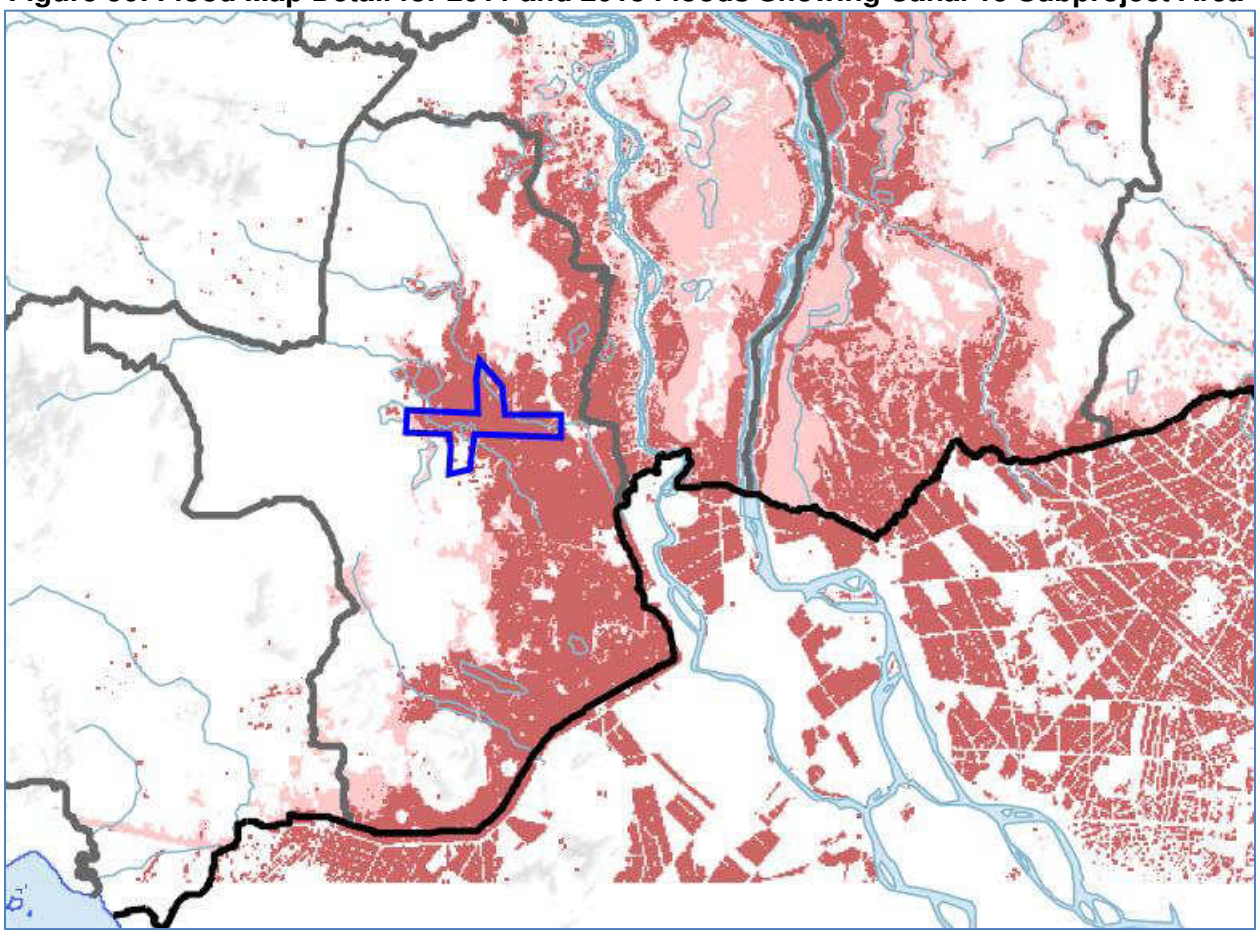
Source: World Food Programme. Cambodia. 2013.

Figure 55: Flood Map Detail for 2011 and 2013 Floods Showing Kamping Pouy and Prek Po Subproject Areas



Source: World Food Programme. Cambodia. 2013.

Figure 56: Flood Map Detail for 2011 and 2013 Floods Showing Canal 15 Subproject Area



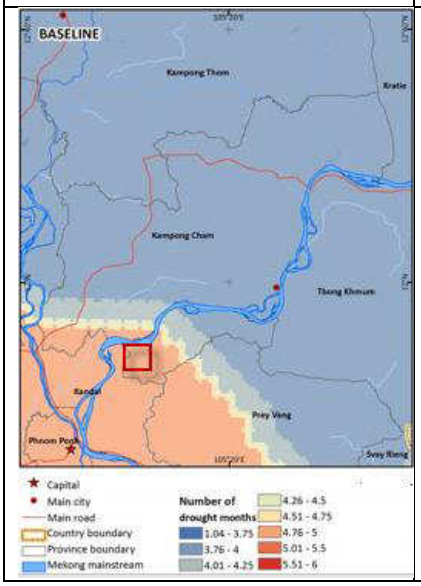
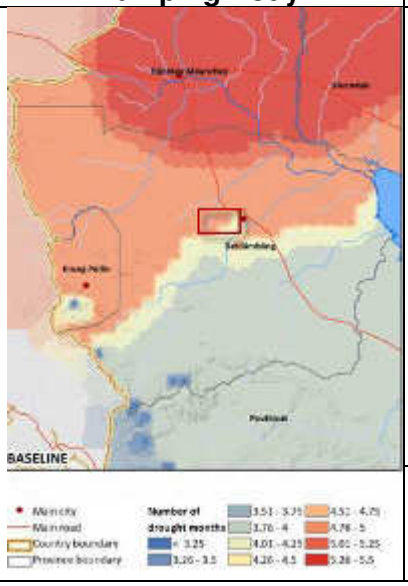
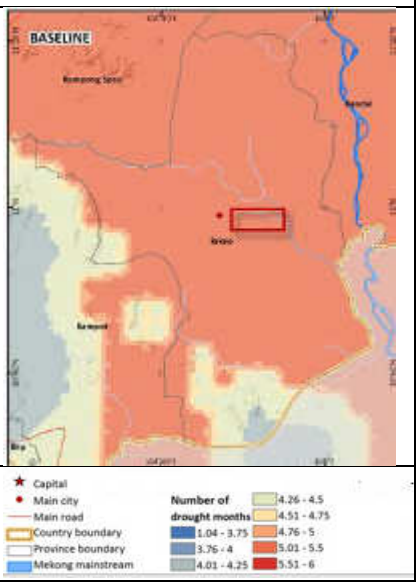
Source: World Food Programme. Cambodia. 2013.

158. Disastrous drought has impacted in a number of areas in 2001, 2002, and 2003. The direct impact has predominantly been in terms of water stress on agricultural crop production, especially rice and vegetable production, with 80% of agricultural fields lying idle in most areas for six months and to a somewhat lesser extent in terms of increased rates of water-related disease mortality and morbidity. The last major drought in the country was in 2002 when unusually dry weather during the rainy season affected some 420 communes in 76 districts located in the 10 provinces. Kampong Cham, one of the project provinces was affected. A recent drought influenced by the 2015-2016 El Nino also greatly impacted rural communities, but statistics indicating its impact have not yet been released.

159. The ICEM report[5] identifies baseline drought conditions for the subproject sites (Figures 57, 58 and 59). All subproject sites have a baseline[6] yearly drought period of 4.5 – 4.75 months, highlighting the need for improved irrigation and water availability.

[5] International Centre for Environmental Management (ICEM) and Development Alternatives Inc. (DAI) 2013, *USAID Mekong ARCC Climate Change Impact and Adaptation Study* Main Report

[6] Baseline is defined as the period 1980 to 2005 - ensuring that average (early 1980s), wet (1996-2005) and dry phases (1985-1995) were captured in baseline trends.

Figure 57: Baseline Yearly drought Months at Prek Po	Figure 58: Baseline Yearly drought Months at Kamping Pouy	Figure 59: Baseline Yearly drought Months at Canal 15
		

Source: ICEM

C. Agricultural Practice

160. **Cropping Calendars**. Traditional rainfed rice farming has been carried out in Kamping Pouy for many years. The area is generally prone to flooding, so rainfed rice cultivation is the best landuse during the wet season, from May to October. With very limited internal and external drainage, the area becomes suitable for paddy production during wet season using long term traditional rice varieties. Farmers grow the traditional rice varieties of varying grain characteristics and growth traits but all are photoperiod sensitive requiring short daylength to stimulate flowering which starts in October. From the original one rice crop system, rice farming has gradually evolved to two-rice and sometimes to a three-rice cropping system.

161. The two basic cropping patterns currently used at Kamping Pouy are described below:

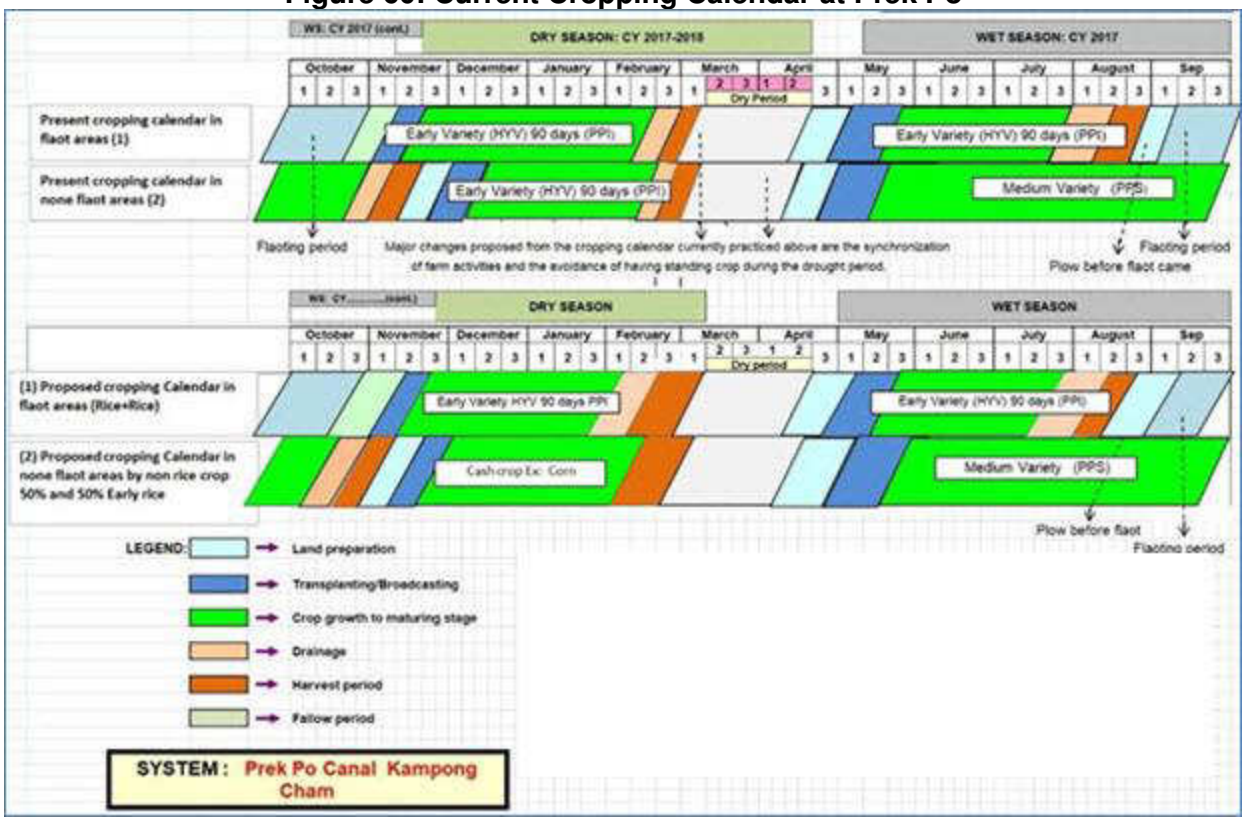
- one single crop of long maturity traditional photoperiod sensitive variety planted in the middle of June and harvested in November.
- two-rice cropping pattern, first crop is an early maturing non-photoperiod sensitive variety followed by a medium (<120 days) to late maturing (>120 days) photoperiod sensitive traditional variety. The first crop is planted in April and harvested in June. The second crop, generally the fragrant Phka Rumduol, is planted in July and harvested in November.

162. There are a number of nutrient limitations (e.g., P, K, and Zn) already identified for the soils in Kamping Pouy but the nutrient limitations are not reflected in what farmers are practicing in terms of fertilizer materials, quantity applied, and timing of application of fertilizers.

163. Current rice production in Prek Po is basically rainfed with limited application of supplemental irrigation individually pumped from ground water or open sources. The non-functional irrigation canals serve as temporary storage of runoff water from higher ground. Pumping of water from open and ground sources has permitted some farmers to produce 2 to 3 rice crops per year by timely establishment of wet season rice in April before the on-set of the wet season. The general rice cropping pattern illustrated below shows when the crop establishment

and harvest of each crop are conducted for the various sequences, including the preferred traditional and early maturing 90-day variety.

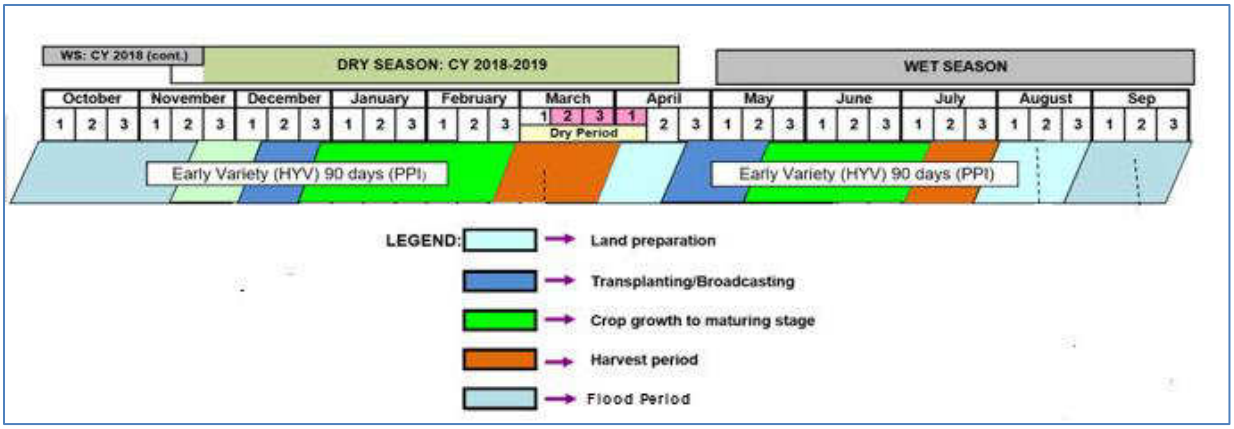
Figure 60: Current Cropping Calendar at Prek Po



Source: Prek Po Feasibility Study Report, TRTA 2018.

164. In the Canal 15 command area the general pattern of two successive dry-season flood-recession rice crops are adopted by farmers. The timing and actual number of crops vary according to location and depending on small difference in elevation and flooding regime. This determines when a specific location will start to be flooded, depth of flooding, and when the flood will recede. Access to portable pumps for supplemental irrigation allows farmers to grow the second dry-season flood-recession rice crop. Based on these conditions, the following dry-season flood recession rice cropping patterns are followed in Canal 15 project area: - one dry-season flood-recession rice crops of early maturing variety with the first crop from December to January and harvested in March to April; and second dry-season flood recession rice crop planted in April to May and harvested in July to August before the annual flood.

Figure 61: Current Cropping Calendar at Canal 15



Source: Canal 15 Feasibility Study Report, 2018.

165. **Agricultural inputs**. No quantitative data is available on the use of agricultural chemicals in the subproject areas. Discussions with farmers and local sales agents suggest that farmers are reasonably inflexible in their usage levels, following either CARDI[7] recommended practice or, more commonly, packet instructions. Fertilizer application rate recommendation of CARDI for direct seeded and traditional, direct-seeded early maturing are shown in Tables 36 and 37 below.

Table 36: Official fertilizer recommendation for direct-seeded 90-day variety

Fertilizer	First Top Dressing	Second Top Dressing	Third Top Dressing	Fourth Application (PI)
Diammonium Phosphate	50 kg			
Urea		40	40	40
Muriate of potash		30	20	
Application time (DAS)	15 days	20 days	30 days	40 days

Source: Kamping Pouy and Prek Po Feasibility Study Reports, TRTA 2018.

Table 37: Official fertilizer recommendation for direct-seeded traditional varieties

Fertilizer	First Top Dressing	Second Top Dressing	Third Top Dressing	Fourth Application (PI)
Diammonium Phosphate	50 kg			
Urea		40 kg	40 kg	40 kg
Muriate of Potash		30 kg		20 kg
Period of Application	**Number of days after sowing (DAS)**			
If sown from 1-30 June	10 DAS	30 DAS	50 DAS	1-15 Se
If sown from 1-15 July	10 DAS	30 DAS	50 DAS	10-15 Sep

Source: Kamping Pouy and Prek Po Feasibility Study Reports, TRTA 2018.

166. In practice, farmers use four different fertilizer materials, namely: Urea, diammonium phosphate (DAP), complete NPK, and muriate of potash. Urea is generally applied as top-dressing together with the complete fertilizer (either 16-16-8 or 20-20-15) at 12 to 15 days after sowing and 40-45 days after sowing, respectively. Application of fertilizers is by hand and pesticide is generally using DC-powered back-pack sprayer. In the Canal 15 command area, farmers report using complete fertilizer (20-20-15 or 18-46-0) amounting to 100 kg/ha together with 50 kg of urea, one to two weeks after seeds have germinated, usually by spreading over the wet field at the rate 100-250 kg/ha. This is followed by applications of 50 kg/ha of urea each at maximum tiller production stage, panicle initiation stage, and early flowering stage together with 50 kg/ha muriate of potash.

[7] Cambodian Agricultural Research Institute

167. **Pesticides and herbicides** identified being used in the subproject areas by the TRTA environment team are listed in Tables 38 and 39. None are listed as banned or restricted in BK-484 issued in 2012 by MAFF, or WHO advisories.

Table 38: Identified Pesticides and Herbicides in use at Kamping Pouy and Prek Po

Name	Components	Use
Tungrius 10WP	Phyrazosulfuron Ethyl (10%)	Herbicide
Bayonsmao (40SC)	Bispyribac Sodium (40%/W/V SC)	Herbicide
70WP Xpert	Quinclorac: 50% + Pyrazonsulfuron-Ethyl: 7% + Fenoxapro-P-Ethlyl	Herbicide
Dithane M-45 (80 WP)	Mancozeb	Fungicide
Best-one (95WP)	Monosuttap 97% WP	Insecticide
888 (750WP) Agrosulfuron	Chlorosulfuron 750g to 1kg of agent	Broad spectrum herbicide

Source: TRTA Field Observations, 2018.

Table 39: Identified Pesticides and Herbicides in use in Canal 15

Name	Components	Use
Sifads 36WP	*Quinclorac (33%) + Bensulfuron Mathyl (3%)*	-
Cybacso 40WP	*Cyhalofop-butyl (30%)+Bispyribac Soduim (3%)*	Herbicide
KATANA 20WG	Flubendiamide (20%)	Insecticide
Longanchess (70WG)	Pymetrozine 70g	Insecticide
Michelle 62EC	Batachlor 62%	Herbicide
Mancolaxyl 72WP	*Mancozeb (64%), Metalaxyl (8%)*	Fungicide
SAAF 75WP	Mancozeb (63%), Carbendazim (12%)	Fungicide
WINTAPHOS 25EC	Quinalphos (25%) and other active substance (75%)	Insecticide
VIRAAT 23EC	Cypermethrin (3%), Quinalphos (20%) and other active substances (75%)	Insecticide

Source: TRTA Field Observations, 2018.

168. The range of different products indicate the different agricultural environments between the subprojects. The wetter environment of the Canal 15 command area appears to require a wider range of insecticide and fungicides.

D. Socio-economic Environment

169. **Demographics**. The population of the 31 villages in the Kamping Pouy command area is 51,569, with a total of 11,124 households (Table 40). Overall, the population density is low in the five communes, at about 2 persons per hectare. While there is some variation among the villages, the average household size and the proportion of female-headed households are similar to provincial averages.

Table 40: Kamping Pouy Command Area Population

Commune	No. of Villages	Population	Household (HH)	HH Size	Female-headed household (FHH)
Phnom Sampov	6	9,928	2,302	4.3	13%
Ta Kream	7	15,372	3,147	4.9	12%
Ou Ta Ki	2	4,807	1,176	4.1	9%
Chrey	7	11,223	2,286	4.9	17%
Ou Mal	9	10,239	2,213	4.6	20%
Totals	31	51,569	11,124	4.6	14%

Source: 2014 Commune Data Base.

170. In the Prek-Po Irrigation Scheme, the total population of the six communes is 43,038 with 36% comprising the female population. Total number of households is 6,116 households, 14% of which are female-headed households. The average size of the household is 4-5 members. The

age distribution is 31.11% in ages below 15 years old, 52.48% in ages 15-60 years old, with 16.41% of those 61 years and above. This means that a little more than 50% of the population is in productive working age. The statistics also shows that in working age (15-60 years old), women accounted for 47.11%, and men accounted for 52.89%.

Table 41: Prek Po Command Area Population

District and Communes	Population			Households (HH)			
Srey Santhor	Total	Male	Female	Total	Female HH	Male HH	Ave HH
Chi Bal	3,813	1,910	1,903	932	82	850	4.1
Khnar Sa	8,675	5,564	3,111	1945	151	794	4.5
Pram Yam	2,653	1,253	1,400	548	174	374	4.8
Preaek Pou	6,120	2,828	3,292	1,356	158	1,198	4.5
Svay Pou	9,397	4,760	4,637	1,780	349	1,431	5.3
Tong Tralach	2,380	1,160	1,220	555	100	455	4.3
Totals	43,038	27,475	15,563 (36%)	6,116	1,014 (14%)	5,102	4.6

Source: Commune Data Base 2014, FGD with FWUC (2018).

171. In the Canal 15 Irrigation Scheme, the 26 villages in the subproject communes have a total population of 86,783 in 19,239 households, with females accounting for 50.5% equivalent to 43,841 persons (Table 30). The average household has 4.51 persons, and female-headed households account for 17.4% of the total households.

Table 42: Canal 15 Command Area Population

District	Commune	No. of Villages	Population (No. of persons)			Household (HH)	HH Size	Female-headed Households (FHH)
			Total	Male	Female			
Angkor Borey	Angkor Borey	2	13,288	6,621	6,667	2,873	4.63	283
	Prey Phkoam	2	10,700	5,305	5,395	2,241	4.77	188
	Ponley	2	2,363	1,211	1,152	410	5.76	37
Samraong	Treang	1	7,785	4,366	3,419	2,521	3.09	298
Doun Kaev	Roka Krau	1	17,057	8,150	8,907	3,741	4.56	1,242
	Baray	3	4,304	2,312	1,992	888	4.85	68
Treang	Sambuor	5	12,570	6,098	6,472	2,484	5.06	616
	Srangae	8	9,718	4,757	4,961	1,972	4.93	337
	Thlok	2	8,998	4,122	4,876	2,109	4.27	278
Total		**26**	**86,783**	**42,942**	**43,841**	**19,239**	**4.51**	**3,347**

Source: Commune Data Base, 2016.

172. **Livelihoods.** In the Kamping Pouy command area villages, people of working age (15-60 years) account for 60% of the population; women slightly outnumber men in this age group. One-third of the population is youth under the age of 15 years; girls account for only 48% of young people. The proportion of youth to working- age adults results in a child dependency ratio of 0.53, that is, approximately one in every two are working.

173. Agriculture is the sector that accounts for the primary occupation of most people over the age of 18 years living in Kamping Pouy communities. Nearly half of men (49%) and 37% of women are engaged in crop cultivation on their own land. Among these farmers, 89% of men and 93% of women cultivate rice as a primary occupation. A further 9% of men and 7% of women work primarily as agricultural laborers. The service sector is the second most important source of primary occupations, including 20% of men and 14% of women. Trading accounts for a larger proportion of women whose primary occupation is in this sector (23%), compared with 17% of men.

Table 43: Primary and Secondary Occupations in Kampong Pouy (% population 18+ years)

	Primary Occupation			Secondary Occupation		
	M	F	T	M	F	T
Crop cultivation	47	37	42	12	7	9
Rice cultivation	42	35	38	8	5	6
Rice as % crop cultivation	89	93	91	64	75	68
Vegetable cultivation	2	1	1	2	1	1
Livestock, fish, NTFP	< 1	< 1	< 1	12	10	11
Agricultural wage labor	9	7	8	3	1	2
Service sector	20	14	17	4	2	3
Trading	3	3	3	< 1	< 1	< 1
Trading as % of service sector	17	23	20	16	25	20
Craft/industry sector	< 1	< 1	< 1	< 1	< 1	< 1

Source: 2014 Commune Data Base.

174. In the Prek Po command area the main sources of income of people are agriculture and services (Table 44). Agriculture includes rice farming, planting of short and long term vegetable crops. Service work includes trading, repair works and transport services. The data in Table IV.17 below shows that 67% of the people in the Prek Po Irrigation Scheme are farmers - they have their main income from rice farming; and 25% of the local people have income from service activities. In addition, there are a few people whose main income is from Mekong River fishing (0.8%), livestock (5.6%) and craftwork (1.2%).

Table 44: Sources of Income or Occupation of Families in Prek Po

District and Commune	Farmer		Fishing		Livestock		Craftwork		Service	
	No.	%	No.	%	No.	%	No.	%	No.	%
Srey Santhor										
Chi Bal	567	67.1	0	-	31	3.7	0	-	247	29.2
Khnar Sa	849	71.8	0	-	0	-	3	0.3	330	27.9
Pram Yam	1394	64.7	28	1.3	14	0.6	13	0.6	706	32.8
Preaek Pou	495	59.2	26	3.1	111	13.3	61	7.3	143	17.1
Svay Pou	910	74.0	9	0.7	36	2.9	14	1.1	261	21.2
Tong Tralach	757	63.6	0	-	228	19.2	0	-	205	17.2
Total	4972	66.8	63	0.8	420	5.6	91	1.2	1892	25.4

Source: 2014 *Commune Data Base*.

175. In the Canal 15 command area, most of the households are engaged in agriculture, such as farming, fishing, and raising livestock. The SES results show that 44.17% of the total surveyed household heads are a farmer or a fisherman. Running a business is the main occupation of 18.5% of the surveyed household heads. The percentage of employees in the public and private agencies is 18.53%. A small percentage (4.62%) of the surveyed household heads are unemployed. There is no significant difference between men and women within most of the occupation groups, where there are significant numbers of employed people, except for employees of public or private agencies where men were mostly engaged, and casual labour where women represent a higher percentage.

Table 45: Sources of Income or Occupation of Families in Canal 15

	Primary Occupation			Secondary Occupation		
	M	F	Total	M	F	Total
Crop cultivation	<1	<1	<1	<1	<1	<1
Rice cultivation	39.6	25.6	32.6	11.6	4.6	8.1
Vegetable cultivation	<1	<1	<1	<1	<1	<1
Livestock, fish, NTFP	3.6	2.7	3.2	3.3	2.2	2.8
Agricultural wage labor	3.3	1.7	2.5	3.2	<1	1.9
Service sector	15.6	12.5	14.1	8.8	6.0	7.4

	Primary Occupation			Secondary Occupation		
	M	F	Total	M	F	Total
Trading	3.0	2.2	2.6	1.3	1.4	1.3
Craft/industry sector	<1	<1	<1	<1	<1	<1

Source: Commune Data Base 2017.

176. **Poverty.** In 2012, the poverty level in Battambang Province was 24.8%. In the communes of the Kamping Pouy command area there have been declines of 30% to over 40% in poverty rates. As a result, poverty levels in the subproject are, in most instances, at or below the national rate for rural areas. Poverty rates in Kampong Cham have decreased from 33.1% in 2004 to 20.4% in 2012. Compared to Battambang Province in 2012, Kampong Cham has a lower poverty rate (poverty rate in Battambang is 24.8%).

Table 46: Poverty Levels, Kamping Pouy Communes (% population)

Commune	2004	2008	2012	Change
Phnom Sampov	31.7	28.2	21.2	- 33%
Ta Kream	41.6	35.5	28.5	- 31%
Ou Ta Ki	34.5	30.5	23.1	- 33%
Chrey	29.7	25.5	18.5	- 38%
Ou Mal	29.2	24.2	16.7	- 43%

Source: Ministry of Planning, 2012. Poverty Reduction by Capital, Provinces, Municipalities, Districts, Khans, Communes, Sangkats Based on Commune Data Base, 2004-2012.

177. Poverty rates in the Prek Po command area (Srey Santhor District) in 2012 were 19.7%. The poorest commune is Tong Tralach with 24.4% of people living in poverty. The lowest poverty rate is Preaek Pou commune with 13.8% of people living in poverty.

Table 47: Poverty rate in the Prek Po Subproject Area

District and Commune	Poverty Rate (%)			
	2004	2008	2012	Trend
Srey Santhor	28.60	23.40	19.70	8.90
Chi Bal	35.70	27.60	21.10	14.60
Khnar Sa	28.40	22.80	22.30	6.10
Pram Yam	28.40	25.40	22.10	6.30
Preaek Pou	23.40	19.10	13.80	9.60
Svay Pou	30.90	26.60	19.80	11.10
Tong Tralach	33.60	27.50	24.40	9.20

Source: Baseline socio data.

178. Poverty rates in the Canal 15 subproject communes have also been steadily decreasing in the last decade (Table 48).

Table 48: Poverty Levels, Canal 15 Communes (% population)

Commune	2004	2008	2012	Change
Angkor Borei	31	27.9	20.6	-33.5%
Prey Phkoam	37	34	24.3	-34.3%
Ponley	26.9	24.8	17	-36.8%
Roka Krau	26.3	23.4	18	-31.6%
Baray	29.7	23.7	18.1	-39.1%
Sambour	30.2	25.7	19.9	-34.1%
Srangae	29.8	24.6	19.1	-35.9%

Source: Ministry of Planning, 2012. Poverty Reduction by Capital, Provinces, Municipalities, Districts, Khans, Communes, Sangkats Based on Commune Data Base, 2004-2012.

179. According to the Commune Data Base (2016), poverty rate in the Canal 15 subproject communes varies from 7.3-27.7%. Angkor Borey Commune has the highest poverty rate, while

Ponley Commune has the lowest (Table 49).

Table 49: Poverty Rate in the Canal 15 Subproject Communes

District	Commune	Poverty Rate (%)
Angkor Borey	Angkor Borey	27.7
	Prey Phkoam	25.6
	Ponley	7.3
Samraong	Trea	10.23
Doun Kaev	Roka Krau	19
	Baray	11.2
Treang	Sambuor	24.2
	Srangae	22.3
	Thlok	13.4

Source: CDB, 2016

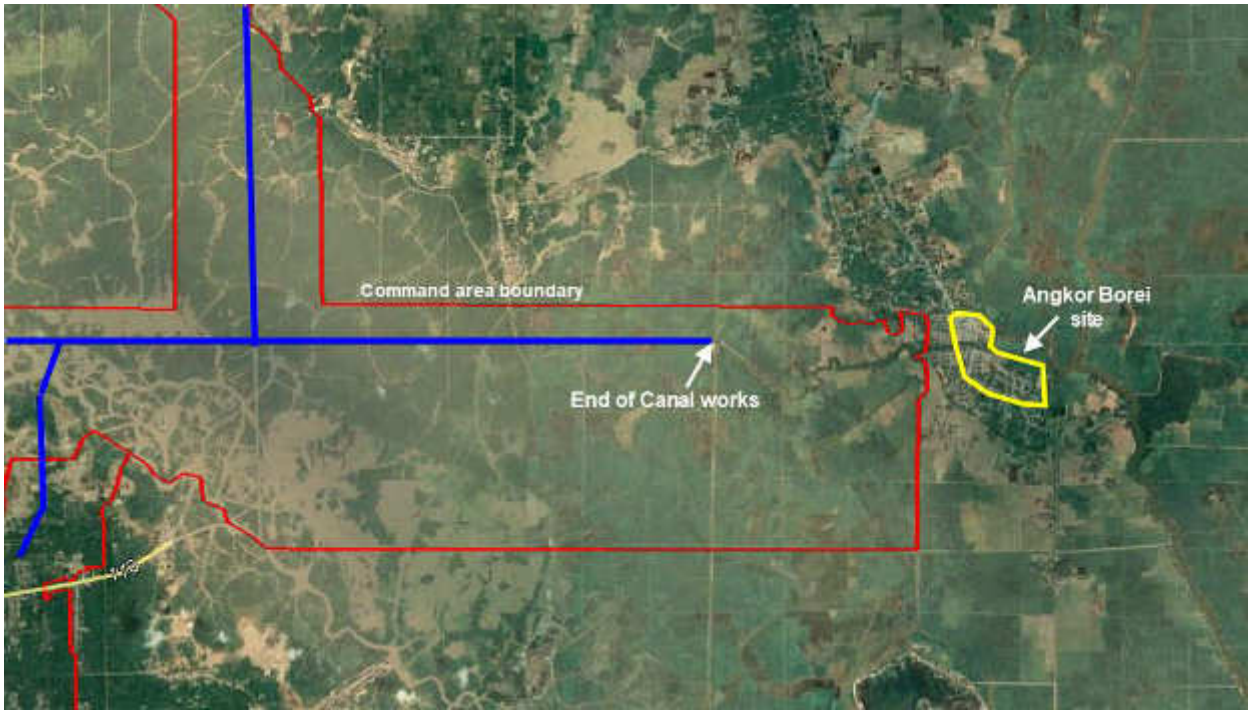
180. The SES results indicate that 77 out of the 477 (16.14%) surveyed households are categorized as poor. Poverty in these households was attributed to: (i) lack of productive land (31 households or 40.26%); (ii) lack of labour opportunities (24 households, 31.17%); (iii) large family size (14 households, 18.18%); and (iv) sick household members (8 households, 10.39%).

E. Physical Cultural Resources

181. There are no recorded Historic Sites covered by the Law of January 25, 1996 on the Protection of Cultural Heritage, or on the list or tentative list of UNESCO World Heritage sites in the subproject areas.

182. Outside the eastern boundary of the Canal 15 subproject is the site of Angkor Borei, which is on the World Heritage tentative list (since 1992). This is the site of the 4th century capital of Vyadhapura and has yielded early archaeological material including ancient Khmer inscriptions. The Angkor Borei site is 4 km away from the nearest construction area (Figure 62).

Figure 62: Canal 15 subproject and Angkor Borei Site



Source: TA Consultants using Google Earth and archaeological data from Stark 2006[8].

[8] Stark M 2006, Textualized Places, Pre Angkorian Khmers, and Historicized archaeology, in Excavating Asian History: Interdisciplinary Studies in Archaeology and History, Chapter: Textualizes Places, Pre-Angkorian Khmers, and Historicized Archaeology, Publisher: University of Arizona Press, Editors: Norman Yoffee and Bradley L. Crowell

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Positive Impact and Environmental Benefits

183. **Benefits.** The result of the project improvements to irrigation and drainage facilities will be (i) an increase in certainty and control of existing irrigation areas; (ii) expansion of reliable irrigation into new areas; and (iii) winning of longer cropping periods on areas previously unavailable for parts of the year due to flooding.

184. Tables 50 and 51 show the beneficial impacts of the project investments in the three subprojects with respect to increases in areas sown and yields which can be expected in the "with" project case in the year 2028 (6 years after commissioning of the civil works). The project investments include the design and management measures for climate change adaptation. These are described below in Sections B.2 and F.2.

Table 50: Project Benefits through Civil Works, Agro-Inputs and Practices of the Kamping Pouy Subproject to 2028

		Without project		With project		
		Wet season traditional variety	Dry season Early variety	Wet season traditional variety	Wet season IRRI variety	Dry season Early (HYV) variety
Area	ha	12000	8000	8400	3600	12000*
Irrigated		no	yes	yes	yes	yes
Planted		May	Jan-Mar	May	May	Jan-Mar
Harvested		Nov	Apr-Jun	Nov	Sep	Apr-Jun
Yield	kg/ha	2500	2565	4500	5000	5000

ha = hectare, kg/ha = kilogram per hectare; IRRI = Irrigated Rice Research Institute; HYV = heavy yielding variety.
Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

Table 51: Project Benefits through Civil Works, Agro-Inputs and Practices of the Prek Po Subproject to 2028

		Without project		With project	
		Wet season traditional variety	Dry season Early variety	Wet season traditional variety	Dry season Early (HYV) variety
Area	ha	380-5600[a]	1200	8000	8000[b]
Irrigated		no	yes	yes	yes
Planted		May	Jan-Mar	Aug	Dec
Harvested		Nov	Apr-Jun	Nov	Mar
Yield	kg/ha	3000	3500	4500	5000

a Variable due to severity of wet season floods. Currently at 380 ha.
b These totals may include non-rice crops.
Source: Prek Po Feasibility Study Report, TRTA 2018.

185. In terms of sustainable areas sown as a result of increased irrigation, the project will increase potential growing areas by 4,000 ha in the dry season in Kamping Pouy, by up to 7,620 ha in the wet season and 6,800 ha in the dry season at Prek Po and by 1,500 ha in the dry season at Canal 15. The beneficiaries of these changes will be local farmers, with flow-on effects to local commercial enterprises. Since rural populations are the poorest sectors of the Cambodian population, poverty alleviation effects will be direct and sustainable.

186. Unlike the other two subprojects, farmers at Canal 15 cannot grow wet season rice because the command area (except the Samput area) is fully inundated. Here, the benefits will accrue from enabling two dry season crops, using residual water retained in the deepened canals from the wet season. These benefits are reported in Table 52.

Table 52: Project Benefits through Civil Works, Agro-Inputs and Practices of the Canal 15 Subproject to 2028

		Without project		With project	
		Dry season early Recession rice	Late Dry Season	Dry season early Recession rice	Late Dry season
Area	ha	1000	5,000	2500	5,000
Irrigated		no	yes	no	yes
Planted		Dec	April	Dec	April
Harvested		March	July	March	July
Yield	kg/ ha	3500	3500	6000	6000

Source: Canal 15 Feasibility Study Report, TRTA 2018.

187. The feasibility report for Kamping Pouy and Canal 15 subprojects provided details on agro-inputs as well as areas of cultivation with and without the project and these are provided in Tables 53 and 54. Equivalent data and projections are not included in the Prek Po Feasibility Study Report but TRTA agronomy specialists have advised that, because of the same agricultural practices and agro-inputs being promoted and supported by the project for that system, similar projections would apply to Prek Po.

Table 53: Agro-Inputs and Practices of the Kamping Pouy Subproject

Characteristic	Season	Unit	Without Project (Current Situation)	With Project		
				Water only	With support project Year 7	With support project Year 12
Cropping intensity	WS	%	100	100	100	100
	DS	%	30	60	100	100
Yield	WS	t/ha	2.5	3.5	4.5	4.5
	DS		3	3.5	5	5
Fertilizer	WS	% using	50	70	100	100
	DS		50	70	100	100
Pesticides	WS	% using	50	30	20	5
	DS	% using	50	40	20	5
Land preparation	Mechanized	%	25	50	100	100
Seed type		Self-saved	80	30	0	0
		Certified seed	20	70	100	100
Non-rice crops	WS+DS	%	0	20	30	40

DS = dry season; WS = wet season.
Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

Table 54: Agro-Inputs and Practices of the Canal 15 Subproject

Agronomic Parameters and Inputs	Cropping	Unit	Without Project	With Project (Year 5)
Cropping intensity	1st RC	% of Target	60	100
	2nd EWSC	% of Target	20	100
	1st RC	ha	5,000	5,000
	2nd EWSC	ha	1,000	2,500
Yield	1st RC	t/ha	3.5	6.0
	2nd EWSC	t/ha	3.5	6.0
Fertilizer	1st RC	Adopting, %	100	100
	2nd EWSC	Adopting, %	100	100
Pesticides	1st RC	Adopting, %	50	20
	2nd EWSC	Adopting, %	50	20
Quality Land Preparation	Deep and Puddled	Adopting, %	25	100
Seed Quality 1st RC	Poor Quality	Adopting, %	80	0

Agronomic Parameters and Inputs	Cropping	Unit	Without Project	With Project (Year 5)
	Certified-Seed Quality	Adopting, %	20	100
Seed Quality 2nd EWSC	Poor Quality	Adopting, %	80	25
	Certified-Seed Quality	Adopting, %	20	0

RC = recession crop; EWSC = early wet season crop.
Source: Canal 15 Feasibility Study Report, 2018.

188. This data not only points towards increases in area and yield but also, through capacity building and training, a number of additional benefits which will improve environmental conditions in the irrigated farming communes. This will include integrated pest management, efficient use of fertilizer and water conservation farming practices

189. Integrated pest management (see section D.4 below) will promote a reduction in the amount of pesticides used, resulting in reduced movement of pesticide residues in surface water, reduced risk of leaching of residues into groundwater, and will include safeguards for farmers in the safe handling and use of chemicals. Fertilizer needs will be matched to soil nutrient levels and crop/water conditions to avoid overuse and leakage of nutrients into water resources. Training in farm water management to use water more efficiently (e.g. through alternate wetting practices rather than flooding) will conserve seasonal water resources.

190. The project investments will increase the subproject areas' resilience to climate change and climate-induced disasters. The measures include design of civil works for extremes of flood and drought as well as capacity building of FWUCs and farmers to understand and plan for a changing climate. A full description of these measures is at section F.2 below.

B. Environmental Measures during Pre-Construction Phase

1. Site Preparation

191. **Loss of vegetation**. The 25 m construction easement for canals (canal channel and levee banks) will require removal of vegetation where it has established along existing canal banks. This vegetation and its local amenity has been described in Section IV.B.7. Trees and vegetation along the canals in villages provide fruit and other products, protect waterways from wind and evaporation and adjacent agricultural land from dust and run-off. Loss of mature native trees and productive fruit trees in the canal easements should be minimized during detailed design. Before construction in all areas, the PMU's environment officer and contractor will clearly mark trees which are to be retained. Contractors will erect fencing around these trees (extending to the canopy drip line) and convey the requirements to all machinery operators and residents to ensure that valuable trees are not damaged. After construction, removed trees and productive shrubs will be replaced with new plantings.

192. At Prek Po, the eastern greywater treatment plant will be constructed on government land adjacent to the existing pump house. The facility has been designed and sited to avoid any loss of vegetation or community assets. The western artificial wetland will be constructed wholly within the easement of the drain, with no encroachment on trees along the bank or residences.

193. **Loss of assets**. The Prek Po and Canal 15 subprojects will not require land acquisition and/or resettlement. However, for the Kamping Pouy subproject, construction activities will require permanent acquisition of a total of 340 m^2 of residential land of five affected households with 22 persons, of which two affected households will have residential land partially affected and two affected households will have residential land fully affected, and one affected household will lose banana trees during the construction phase. Subproject implementation will also impact 147 fruit trees, 34.8 m^2 of houses of different types, 4 m^2 of brick-made toilet, and 54 m of fences.

194. A land acquisition and resettlement plan (LARP) has been prepared for the Kamping Pouy subproject, and draft resettlement due diligence reports (DDRs) have been prepared for the Prek

Po and Canal 15 subprojects in accordance with the principles and requirements of ADB's SPS and the government's laws and regulations on LAR..

2. Features of Design

195. A number of design features guard against environmental impacts and promote environmental sustainability. In the Kamping Pouy subproject, the focus on the establishment of a JOROP and a reservoir management plan to optimize sustainable water availability is central to the scheme. Additionally, the reinforcement of the dam wall and lining of canals will increase long-term durability of the waterbodies and increase irrigation efficiencies and water savings.

196. In the Prek Po subproject: (i) the lowest recorded level of the Mekong River in 10 years is incorporated in the design and lift calculations for the pump station; (ii) the provision of a covered culvert for the main canal for the first 2 km for its length through Prek Po town will minimize asset loss and protect water quality from domestic refuse and runoff; (iii) drainage channels located within the existing 25 m easement of irrigation canals will minimize asset loss.

197. In the Canal 15 subproject, main and secondary canal improvements have been designed with the intention of maintaining navigability as well as irrigation and drainage functions – which will address a range of livelihood benefits. The design of the Samput pumping station, using electric pumps to replace aging diesel pumps will avoid local pollution and reduce greenhouse gas emissions.

198. The designs of the subprojects will be climate change adapted. Measures for climate change adaptation and disaster risk reduction have been drawn from the project's Climate and Disaster Risk Assessment and the Climate Proofing reports for the Feasibility Studies, which reference the ADB's Guidelines for Climate Proofing in the Agriculture Sector, and current ADB Climate Resilience projects in Cambodia.

199. At Kamping Pouy, two drainage canals will be designed for a high flood discharge and two additional drainage canals will be modernized to accommodate increased floodwaters with enlarged culverts with check structures. At Prek Po the main canal pumps will be designed for the lowest level of the Mekong River during the dry season and the pump house control areas elevated above the flood level. The main and all secondary canals will be lined with concrete to reduce seepage losses. Separate irrigation canals will be constructed, and undersized and damaged structures will be removed and replaced. At Canal 15, civil works with a role in adaptation will include the excavation of Canal 15 (the main canal), Canal 87 (secondary canal) and the Samput Intake Canal to increase their hydraulic section.

200. These measures are described in detail in the section below on adaptation for climate change (Section F.2 below).

201. Dredge spoil management planning**.** The canal improvement works will involve dredging of main, link and secondary canals to establish new contoured shape and slopes. The dredge spoil volume is presently not known but will be available during detailed design. Since field canals are the sink for runoff and drainage from paddy fields, the bottom sediment in canals may accumulate agricultural chemical residues. The sediment quality of the dredge spoil will need to be tested and assessed against an appropriate standard before reuse in the structure of embankments. To ensure this, a dredge spoil management plan will be developed in the pre-construction phase in conjunction with detailed design. The plan will comprise four major parts:

- A program for the systematic sampling of sediment in all main and secondary canals for dredging
- Mapping of sediment quality and appropriate reuse, based upon sediment sampling and testing for heavy metals and pesticide residues into three categories:
    - Safe to reuse as required – no contamination above threshold levels

- Managed use – contaminants present at low to medium levels which can be immobilized by incorporation in embankments or building pads if covered with clean (safe) fill
- Restricted use – sediments unsuitable for housing pads or flood refuge areas. Only to be used in canal embankments if contained in impermeable layers (clay or geotextile)

It is recommended that the West Australian *Assessment levels for Soil, Sediment and Water (2010)* should be used to derive these reuse categories using the Sediment quality Guidelines (SQG) for low and high "triggers"[9]

- The requirements for reuse of dredge spoil will be set out in the plan and included in detailed designs and in works contracts.

3. Construction Readiness

202. A number of environmental management measures will also be implemented in the pre-construction phase to ensure that appropriate plans and documentation to determine environmental performance of construction and operation of subprojects are in place. These include:

(i) Assignment of EMO. The PMU will assign a permanent staff member as environmental management officer (EMO). This officer will be the dedicated point-of-contact for the PMU in EMP implementation and coordination of GRM, working with the Environment Specialists of the Project Management and Implementation Consultants (PMIC).

(ii) Updating EMP following detailed design of Canal 15: mitigation measures defined in the EMP in this IEE will be incorporated into the detailed design to minimize adverse environmental impacts, The IEE and EMP will also be updated in response to any significant changes made during detailed engineering design. This will be the responsibility of the PMU.

(iii) Dredge spoil management planning. Dredge sediment testing completed and dredge spoil management plan prepared. Reuse specifications included in detailed design.

(iv) Contract documents: preparation of the environment section in the TOR for bid and construction contracts, and environmental contract clauses for contractors, namely the special conditions (referencing the EMP, environmental monitoring plan, and dredge spoil management plan). Material haulage routes, and spoil and waste disposal arrangements will be defined in the construction tender documents as appropriate. This will be the responsibility of the PMU with the support of the PMIC environment specialist.

(v) Preparation of SEMPs by the successful contractors for each subproject. This will incorporate all relevant measures listed in the project EMP. The SEMPs will include delineation of work areas and clear identification of areas to be protected. It will provide work scheduling and temporary access information as a basis for further consultation with affected communities. The SEMPs will identify sensitive receptors for special mitigation measures against noise and dust (see Construction Impacts below). They will also include a traffic management plan, an emergency preparedness and response plan for construction emergencies and site environmental health and safety plan. The SEMPs will be approved by the PMU in consultation with the PMIC.

(vi) Contractor EHS officer. The contractors will assign an environmental health and

[9] < SQG-low = safe to reuse; >SQG-low<SQG-high = managed reuse; >SQG-high = restricted reuse.

safety (EHS) officer who will be responsible for daily and weekly monitoring and reporting on EHS. This staff member will also be the contractor's contact person for the GRM.

(vii) GRM. Establishment of the GRM in the pre-construction phase.

(viii) Training. The PMIC in conjunction with MOWRAM will provide environmental protection training covering the implementation and supervision of environmental mitigation measures to PMU staff and contractors.

(ix) Checklists and monitoring report templates. The PMIC will establish checklists and monitoring report templates for contractor EHS officers and PMU environment officer.

C. Impacts and Mitigation Measures during the Construction Phase

1. Areas of Influence for Impact assessment

203. The assessment areas for air, noise, water, and ecological impacts are based on the environmental sensitivity of the project areas and surroundings as well as the nature of each subproject and its components. The assessment areas for the infrastructure components are shown in Table 55.

Table 55: Assessment Areas of the Infrastructure Subprojects

Environmental Medium	Area of Influence
Air	Within 50 m of residences along canals and embankments (to cover all distances of dust and emissions impacts during construction).
Noise	Within 100 m in the day and 50 m at night along canals and embankments.
Surface water	Nearest permanent waterbody (canal, reservoir or river).
Groundwater	Within and adjoining irrigation command areas.
Solid waste	Adjoining village and paddy areas where waste could be deposited intentionally or accidently.
Vegetation	25 m easement along canals for canal channel and levees.
Biodiversity	200m from subproject boundary for direct impacts, and 5 km on IBAT screening for induced or indirect impacts
Physical cultural resources	Construction "footprint" and project area of influence
Occupational health and safety	Construction site and adjoining properties.
Community health and safety	Construction site, adjoining properties and haulage routes.

Source: TRTA team.

2. Construction Impacts

204. The following impacts and mitigation measures refer to construction impacts which are common to all subprojects. They will require earthworks, soil stabilization, dust and noise control as well as management of the impacts from machinery operation, transport and haulage of building materials and the domestic needs of the work force. Occupational and community health and safety issues are discussed separately in Section C.4 below.

205. **Works area**. Temporary land occupation for construction will be planned in the SEMPs and approved by relevant commune council and landowners with appropriate written and signed agreements. Construction easement, including stockpile sites and access ways will be clearly delineated in the plan and marked on the ground to ensure equipment operators stay within these boundaries. Any temporary damage that is not covered in the marked and agreed construction easement will be compensated promptly by the Contractor in line with the project entitlement matrix.

206. **Earthworks, borrow and spoil.** Earthworks totals from the detailed design

specifications are summarized in Table 56 below. Since the subprojects focus on rehabilitation and modernization of existing canals, there is a net import of fill material for the formation of more consolidated canal embankments. This data is available for Kamping Pouy and Prek Po, which have undergone detailed design. For Canal 15, The canal improvement works will involve extensive dredging of main and secondary canals to establish new design capacity. The spoil volume is presently not known but will be available during detailed design.

Table 56: Earthworks Summary

Activity	Volume (m^3)
Kamping Pouy	
Fill imported from borrow	614,080
Unsuitable spoil for disposal	13,200
Prek Po	
Fill imported from borrow	563,199
Unsuitable spoil for disposal	14,592

TRTA detailed design documents

207. The small amount of unsuitable spoil for disposal listed in Table 56 above will be mainly from the "scrubbing" of vegetation growth and silt from canal banks and walls. Surplus spoil will be made available to nearby communities for use as flood free refuge areas for livestock, building pads and bunds (subject to the provisions of the spoil management plan – see below).

208. Fill will be sourced locally. Bills of quantities in the detailed design nominate about 60% to be sourced from borrow pits within 2 km of the construction site and 40% from between 2 and 5 km away. Borrow sites will be identified and approved by the PMU EO. Haulage routes and haulage trip intensities will be included in the SEMP as part of the traffic management planning. The haulage routes will avoid schools and school times and must be discussed with the residents in the villages through which the routes pass.

209. In all cases of importing fill or excavated spoil for disposal the contractor will ensure that stockpiles do not encroach upon adjacent areas – especially farmland, vegetated areas or residential areas. All material will be retained within the worksite (i.e. within the 25m canal easement) and frequently removed. Any damage to areas outside the identified corridor of impact will be compensated in line with the entitlement matrix in the subproject Resettlement Plan.

210. At the main canal and secondary canals at the Canal 15 subproject, dredged spoil from canal deepening and widening cannot be easily removed from site due to lack of access, but also cannot be piled high on embankments because it will be eroded by floodwaters and cause siltation in the canal. It could also impede overtopping and overland flow during floods, causing unintended flood afflux in other areas. The embankments here will be widened, rather than increased in height. The calculation of quantities, where it can be placed and the careful contouring of embankments to guard against these potential impacts will be undertaken during detailed design.

211. **Dredge spoil.** The canal improvement works will involve dredging of canals to establish new design capacity, contoured shape and slopes. The bills of quantities for the subprojects are based upon the reuse of this material in heightening and consolidating embankments. Dredge spoil will be reused/disposed of according to the category of contamination described in the dredge spoil management plan and incorporated in detailed design specifications of Canal 15 and in design revisions of Prek Po and Kamping Pouy. This will be in one of three ways: (i) Safe to reuse as required; (ii) Managed use, for contaminants present at low to medium levels; and (iii) Restricted use for higher contamination levels.

212. The contractor will ensure that stockpiles of dredge spoil do not encroach upon adjacent areas and that material is retained within the worksite (i.e. within the 25m canal easement).

213. **Erosion of disturbed surfaces.** The areas most vulnerable to erosion are temporary construction sites and other places where surface soil will be disturbed. This will include "clearing

and grubbing work" along the length of the rehabilitated canals. The most effective erosion control will be interception drainage to protect disturbed surfaces from surface flows. Construction plans will include erosion control prescriptions for construction work areas, including (i) constructing intercepting ditches and drains to prevent runoff entering construction sites, and diverting runoff from sites to existing drainage; (ii) limiting construction and material handling during periods of rains and high winds; and (iii) stabilizing all cut slopes, embankments, and other erosion-prone working areas while works are going on. All earthwork disturbance areas shall be stabilized within 30 days after earthworks have ceased at the sites.

214. **Construction wastewater.** Construction wastewater is produced from the maintenance and cleaning of mechanical equipment and vehicles, maintenance water for mixing and curing concrete, cooling water, and lost water and soil during the construction period which is discharged as pollutants. The effluent, comprised mainly of inorganic wastewater, commonly contains no poisonous and harmful substance, except suspended solid, but, if discharged in an improper manner, still has the potential to impact existing water bodies. Some oil-containing wastewater can arise from machinery repairs.

215. Polluted construction wastewater will not be discharged unto the surrounding soil or into surface water systems. Sedimentation traps will be built, and after settling out of solids the waste residue in the traps will be cleared and transported to an approved site. Oil-containing wastewater will require the installation and maintenance of oil-water separators before the sedimentation trap.

216. **Gaseous air pollution.** Construction machinery on all sites will consume petrol and diesel, releasing gaseous SO_2, CO, and NOx. Equipment will be maintained to a high standard to ensure efficient running and fuel-burning. High-horsepower equipment will be provided with tail gas purifiers. Vehicles and machinery to be used on site by the contractors will be inspected for clean running condition by the PMU environment officer.

217. **Dust.** Construction sites and access roads will potentially produce fugitive dust from material storage areas, dump sites, concrete mixing, excavation and general site usage – especially under windy conditions. Material stockpiles and concrete mixing equipment will be equipped with dust shrouds. The operators will regularly maintain the shrouds to ensure their effective operation. For both construction sites and construction roads, water spraying for the suppression of dust and maintenance of driving surfaces will be standard site management practice. Vehicles carrying soil, sand, or other fine materials to and from the construction sites will be covered. Dust-producing works in close proximity to sensitive receptors will be provided with additional safeguards (see below at "Sensitive Receptors").

218. **Noise.** Noise can be expected during construction due to machinery operation and transport activities. Construction activities will involve haulage vehicles, bulldozers, excavators, concrete-mixing plants, rollers, and other heavy machinery. Noise intensity from these large machines operating is typically around 80 decibels at the site (5 m from operating machinery). The transport of material, aggregate, concrete, and waste material to and from sites will also cause noise impacts along the haulage routes. Activities with intensive noise levels will not only have an impact on the residents, but may also cause injury to construction workers operating the equipment.

219. Noise levels at different distances are gained after calculating the impact scope of equipment noise during construction as in Table 57. The EHS noise guidelines for residential areas are used here.

Table 57: Construction Equipment Noise Impact Distance

Level dB (A) / Machinery	Distance								EHS guidelines for residential areas dB (A)		Impact Range (m)	
	1	10	20	40	60	80	100	150	Day	Night	Day	Night
Bulldozer	102	80.0	74.0	68.0	64.4	62.0	60.0	56.5	55	45	150	700
Roller	102	80.0	74.0	68.0	64.4	62.0	60.0	56.5	55	45	150	700
Excavator	95	78.0	72.0	66.0	62.4	60.0	58.0	54.5	55	45	150	300

dB = decibel, m= meter, EHS = Environmental Health and Safety.
Source: TRTA consultants using data from Atkins Acoustic, 2013.[10]

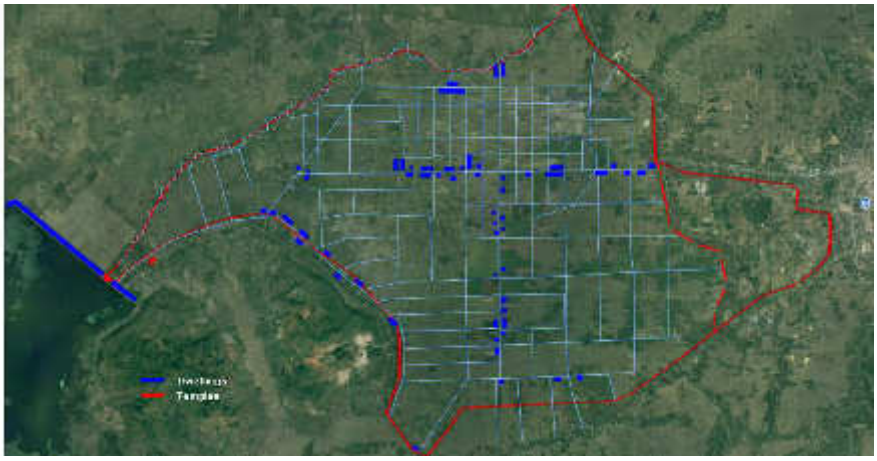
220. The data shows that the impact distance can be 150 m away from the source in daytime. Beyond these distances, the noise levels meet standards for residential areas.

221. Activities with intensive noise levels will not only have an impact on the residents, but also may cause injury to construction workers operating the equipment. Although the noise impacts will be transient and temporary the following mitigation measures are essential for construction activities to meet construction site noise limits in the daytime and to protect sensitive receptors. Construction at night within 700 m of residences shall be strictly prohibited.

222. During daytime construction, the contractor will ensure that: (i) equipment with high noise and high vibration are not used in village or town areas and only low noise machinery or equipment with sound insulation is employed; and (ii) sites for concrete-mixing plants and similar activities will be located at least 500 m away from sensitive areas such as residences and schools and only operated in daytime. When daytime construction is scheduled to move within 150m of identified sensitive receptors (see below) residents will be notified by the PMUs and/or contractors and any site-specific concerns or working arrangements addressed.

223. **Sensitive receptors.** There are schools, pagoda precincts and a number of houses within 150 m of the work sites at the Kamping Pouy and Prek Po subprojects. The locations of these sensitive receptors are shown on Figures 63 to 66. There are no sensitive receptor sites within the direct command area of Canal 15, since the area is a floodway. Only in the Samput sub-command area are there villages and sensitive receptor sites are identified here (Figure 65).

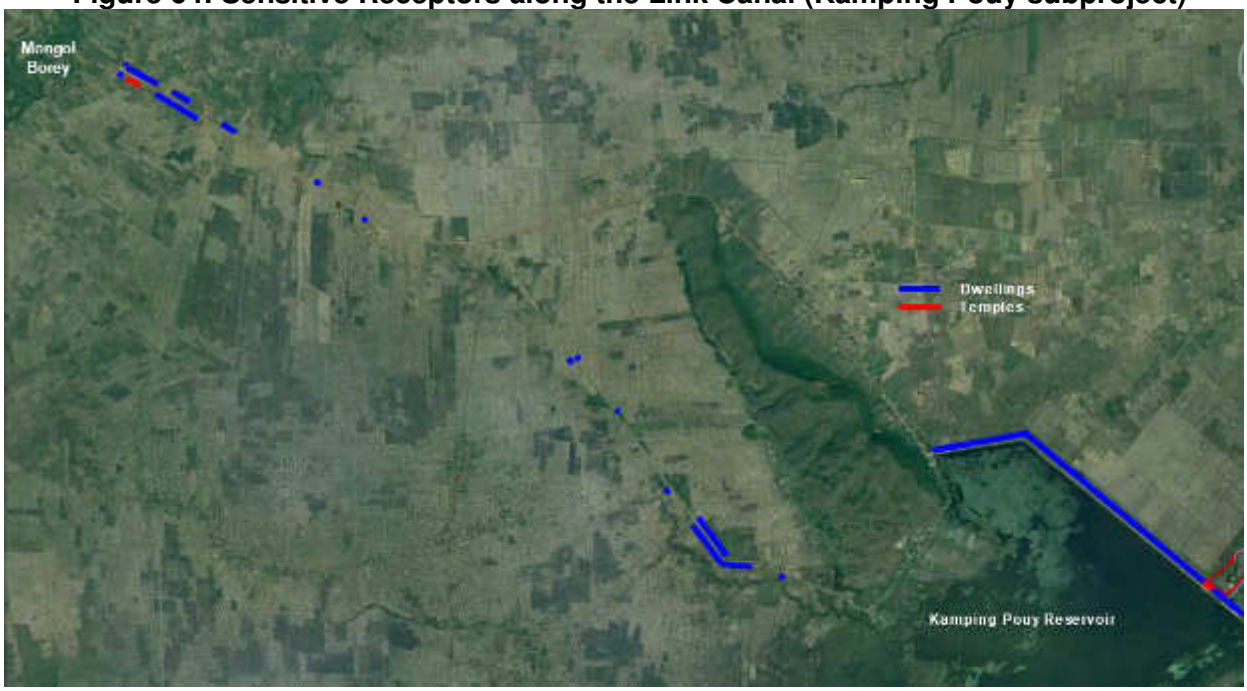
Figure 63: Sensitive Receptors at Kamping Pouy Command Area



Source: TRTA consultants.

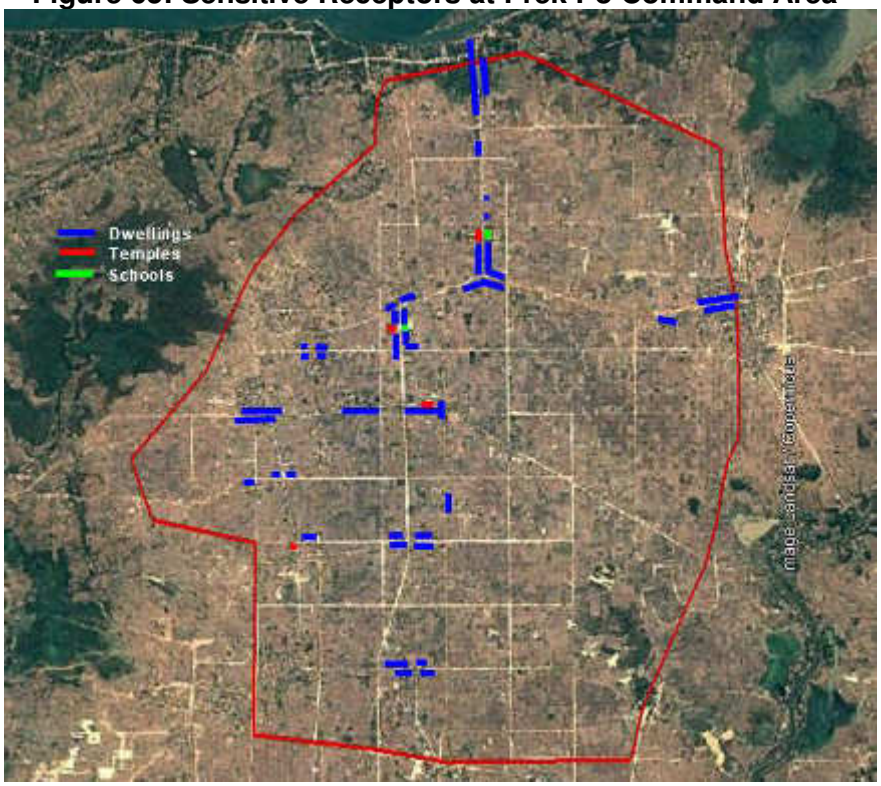
[10] Atkins Acoustics. 2013. Noise and Vibration Impact Assessment Upgrade Marrickville Railway Station, report prepared for Department of Transport for NSW.

Figure 64: Sensitive Receptors along the Link Canal (Kamping Pouy subproject)



Source: TRTA consultants.

Figure 65: Sensitive Receptors at Prek Po Command Area

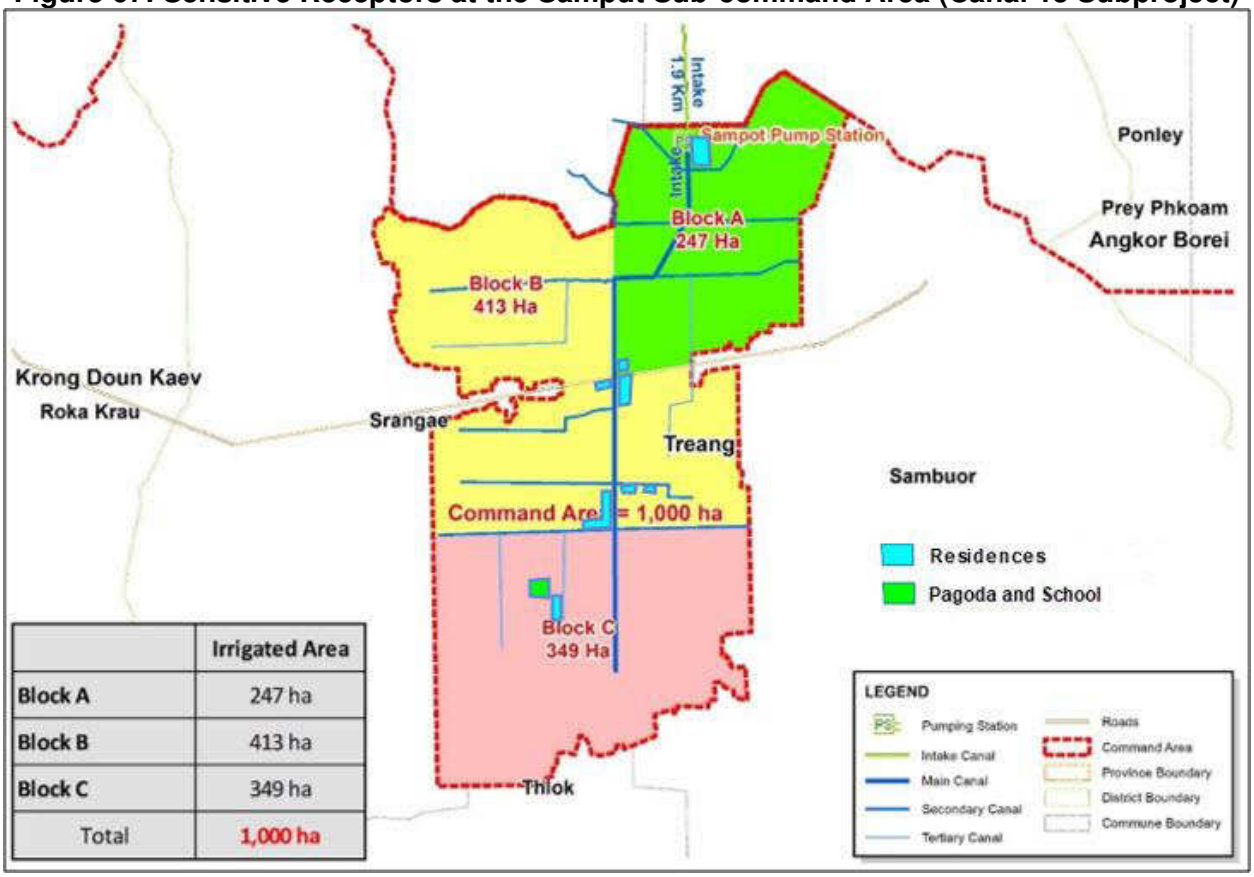


Source: TRTA consultants.

Figure 66: Sensitive Receptors along covered area of Main Canal, Prek Po

Source: TRTA consultants.

Figure 67: Sensitive Receptors at the Samput Sub-command Area (Canal 15 Subproject)



	Irrigated Area
Block A	247 ha
Block B	413 ha
Block C	349 ha
Total	1,000 ha

Source: Canal 15 Feasibility Study Report, 2018.

224. Additional noise and dust mitigation will be required for the residential areas adjacent to works on the main canal in Prek Po town (Figure 44). This will include extensive public consultation before works commence, temporary noise barriers and dust shrouds for work sites and careful planning of access routes with informed consent of residents. Community safety issues will also be covered (see Section C.4 below).

225. **Construction solid waste.** The construction contractors will establish site offices and vehicle/equipment parks in the subprojects. The construction workforce will generate domestic wastewater and garbage (food wastes, kitchen wastes, paper, and other solid waste including food-laden wash water). Proper disposal of this waste will be essential. It will be the responsibility of the construction contractors to provide toilets with pump-out and disposal facilities and sufficient garbage bins at strategic locations and ensure that they are (i) protected from birds and vermin; (ii) disposed regularly (using the nearest licensed solid waste landfill); and (iii) avoid overflow.

226. **Hazardous and polluting materials.** Construction material handling and disposal guidelines and directions that include spill responses will be prepared and implemented as part of the SEMP and supervision manual of each subproject. The following measures will be taken to prevent pollution of soil and surface water/groundwater: (i) storage facilities for fuels, oil, cement, and chemicals will be within secured areas on impermeable surfaces, provided with bunds and spill salvage equipment; (ii) vehicles and equipment will be properly staged in designated areas to prevent contamination of soil and surface water; (iii) vehicle, machinery, and equipment maintenance and re-fuelling will be carried out in such a way that spilled materials do not seep into the soil; (iv) oil traps will be provided for service areas and parking areas; and (v) permanent (at works site) and temporary fuel storage and refilling areas will be located at least 50 m from canals and channels and will be protected by spill trays and temporary drainage bunds. All spills will be cleaned up and spill material removed from site.

227. **Work Schedules.** The preparation and approval of works schedules is required by the EMP in the pre-construction period as part of each SEMP. The work plan and scheduling will be approved by the commune councils, taking into account the need for access during harvesting and planting periods. They will include (i) sequential work scheduling (to ensure that only short stretches are worked on at a time), and (ii) provision of access to existing residences and services.

228. Temporary land occupation will be planned well ahead of construction to minimize its impact on seasonal agricultural activities In particular, construction adjacent to paddy fields during rice planting or harvesting should be avoided or carried out strictly in consultation with the appropriate farm operator and written agreement on any compensation to be paid. All land will be reinstated to its original condition after construction.

229. **Construction traffic**. Haulage of materials and movement of plant and machinery will take place on canal levee tracks and local roads, which are often barely able to cope with local traffic demands. Potential impacts include: Disruption to livelihood, commercial and social activities; noise; dust; road safety; road surface and drainage damage.

230. The SEMP will include a traffic management plan which will be prepared in consultation with the communities through which transport routes pass. The plan will cover identified haulage routes and identified haulage times.

231. Identified haulage routes should (i) be with the informed consent of affected communities; and (ii) avoid schools, temples and village centers. Haulage times will (i) define the set periods of truck movements; and (ii) avoid times of school start, lunch and school finish. The plan will also include access planning around working areas to avoid plant operators choosing their own routes and accidental land loss, erosion and disruption of paddy drainage.

232. **Flora and fauna.** All protected areas listed in Section IV (Description of the Environment) are more than 25 km distant from the subproject sites. The subproject areas have been intensively farmed and irrigated for generations. No natural terrestrial or aquatic habitats exist on site. No

commune within the subproject areas is on the NCDD environmental watch list.[11] The vegetation comprises cultivated crops, agricultural weeds and tree plantations along canal banks and dyke walls. There will be no impacts on critical, natural or modified habitats or associated species of conservation significance.

233. **Cultural heritage.** The significant archaeological site of Angkor Borei situated outside the Canal 15 boundary will not be impacted by construction works, which are all more than 4 km distant. There are no roads linking the construction areas to the Angkor Borei site so there will be no impact from vibration or other disturbance from haulage vehicles.

234. For all subprojects, in the event of chance finds, work at the locality will cease and local representatives of the Ministry of Fine Arts and Culture will be called in to advise what actions, if any, need to be taken before work can continue.

235. During construction, contractors will ensure that any local cultural sites (including small shrines and graves) in the construction area will be kept clear of construction material and protected from dust and other disturbance. Access to these sites will not be impeded, and after construction is finished any disturbed surroundings will be restored to pre-construction standards.

3. Contractor Performance and Site Management

236. Following the award of construction contracts, the successful head contractor(s) will prepare a SEMP for each subproject. The SEMP will include delineation of work areas and clear identification of areas to be protected, including trees. It will provide work scheduling and temporary access information as a basis for further consultation with affected communities. The SEMPs will identify sensitive receptors for special mitigation measures against noise and dust. The SEMP will include an emergency preparedness and response plan for construction emergencies and site environmental health and safety plan, for approval by the PMU. The SEMP will also set out GRM recording and reporting requirements, in line with the EMP.

4. Environmental Health and Safety

237. Safety and health of both workers and residents may be threatened by construction activities. Numerous workers will gather within the construction site, with potentially relatively low quality living conditions. Surrounding residents may also be affected by noise and dust. Workers will be exposed to construction safety risks as well.

238. Measures to protect the community will include:

(i) Publicizing planned work schedules and locations well in advance of construction.

(ii) Planning construction activities (including demolition work) so as to minimize disturbances to residents, utilities and services. Temporary land occupation will be planned well ahead of construction in consultation with farmers. Where existing access is temporarily obstructed, temporary alternative safe access will be provided and affected persons are informed in advance of access issues and alternatives.

(iii) Implementing safety measures around the construction sites to protect the public, including warning signs to alert the public to potential safety hazards, and barriers to prevent public access to construction sites and unsafe areas, especially deep excavations, unstable soil and areas where machinery is operating.

[11] NCDD. 2010. Finalization of Environmental and Highland People Watch Lists and Recommendations and Implications for the Further development and implementation of safeguards Work, report prepared for NCDD by Seak Sophat.

(iv) Ensure regular co-ordination and consultation between contractor's EHS officer and village heads to ensure that any concerns are addressed quickly.

(v) Ensure community is aware of the project GRM and its contact points.

239. For the residential areas bounding the covered main canal works in Prek Po town (see Figure 42) community health and safety will be safeguarded by the following initiatives:

(i) Extensive consultation by PMU and contractors with residents before construction commences;

(ii) Agreement with residents on work schedules and work periods each day;

(iii) Dust suppression, through watering and dust shrouds, to be maintained throughout the construction phase. Dust protection to be provided for residences as required;

(iv) Noise suppression, through maintenance of noise insulation on machines, scheduling and minimizing machine running, to be maintained throughout the construction phase. Temporary noise barriers to be erected along both sides of the construction easement to protect residences;

(v) Obtain informed consent from residents for vehicular and worker access along the easement.

(vi) Ensure all potentially affected persons are made aware of Grievance Redress Mechanism (GRM), GRM entry points and procedures.

240. Measures to ensure occupational health and safety will center on the requirement for contractors to ensure that their workers and other staff engaged in the proposed constructions are in a safe environment. To assist in this responsibility each major contractor will have an environmental health and safety officer to undertake induction training for workers and day-to-day monitoring, implementation of corrective actions and reporting as necessary on health and safety issues. This will be overseen by the PMU and design and supervision consultant. Contractors shall ensure that: (a) all reasonable steps are taken to protect any person on the site from health and safety risks and that workers are provided with personal protective equipment (and use them); (b) the construction site is a safe and healthy workplace; (c) machinery and equipment are safe; (d) adequate training or instruction for occupational health and safety is provided; (e) adequate supervision of safe work systems is implemented; and (f) means of access to and egress from the site are without risk to health and safety.

D. Environmental Impact and Mitigation Measures During Operation

1. Managing Water Demand and Water Supply – Kamping Pouy

241. **Water balances.** The irrigation scheme must be sustainable and responsibly managed to ensure that agreed irrigation flows are maintained and other water users are not disadvantaged. It must also take into account the whole irrigation system of 18,000 ha (not just the 12,000 ha of the subproject) because the reservoir is the water source for this whole irrigation area.

242. Irrigation resources will be drawn from the reservoir, which is fed from its immediate catchment and will be augmented by water from the existing Ou Dounpov canal, which links with the Mongkol Borey River. The hydrological analysis of these sources, which was undertaken by the TRTA team, indicates that it is possible to irrigate an additional 8,000 ha of the subproject area for a dry season crop, while still satisfying the water demand of the rest of the system, by: (i) compacting the cropping calendar; (ii) making use of tail-end effective rains at the beginning of the dry season; and proper management of the reservoir, diversion channel and command area. This is demonstrated by the following water balances, developed as part of the Kamping Pouy Feasibility Study.

243. A water balance of the Kamping Pouy Reservoir (entire water source for the Kamping Pouy command area) is based on a 50% inflow scenario, is presented in Table 58 and Figure 68. A 50% scenario represents an average year for water availability. It has the following features:

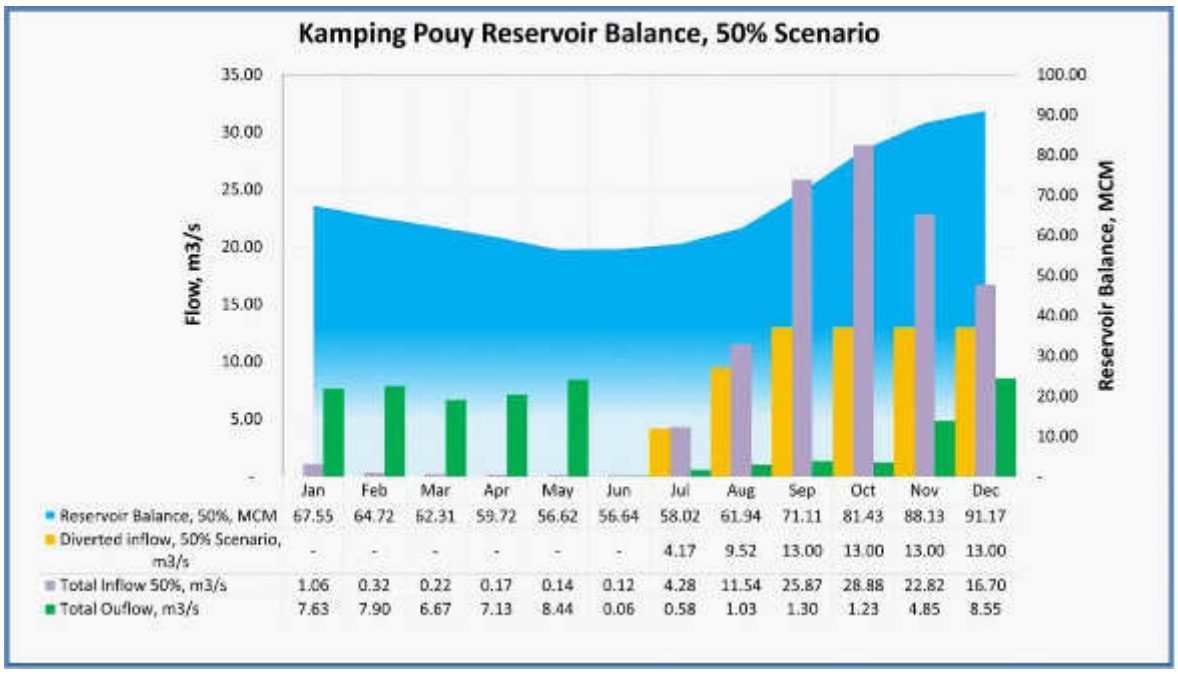
- The water balance at the beginning of each month in the reservoir is determined by the adjusted outflow from the reservoir for irrigation water supply, the cropping pattern and evaporation from the reservoir surface.
- The inflow from the local catchment (Kamping Pouy Reservoir catchment) and from diversion of water from Mongkok Borey River through the Link Canal with a planned maximum diversion capacity of 13m^3/s only in the wet season.
- The proposed cropping pattern of 2.3 crops per year: (1) May to August = 100%; (2) September to December = 100%; and (3) January to March = 30% of the total combined command area.

Table 58: Water Balance in Kamping Pouy Reservoir based on a 50% Inflow Scenario

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inflow from Cat. 50%, m3/s	1.06	0.32	0.22	0.17	0.14	0.12	0.11	2.01	12.87	15.88	9.82	3.70
% Of diversion flow from MBR	0%	0%	0%	0%	0%	0%	30%	30%	20%	20%	20%	50%
Diversion from MBR 50%, Max = 13m3/s	-	-	-	-	-	-	4.17	9.52	13.00	13.00	13.00	13.00
Total Inflow 50%, m3/s	1.06	0.32	0.22	0.17	0.14	0.12	4.28	11.54	25.87	28.88	22.82	16.70
Total Ouflow, m3/	7.63	7.90	6.67	7.13	8.44	0.06	0.58	1.03	1.30	1.23	4.85	8.55
Inflow-Outflow, m3/s	-6.57	-7.57	-6.45	-6.96	-8.31	0.06	3.71	10.51	24.57	27.65	17.97	8.15
Inflow-Outflow, MCM	-2.45	-2.83	-2.41	-2.60	-3.10	0.02	1.38	3.92	9.17	10.32	6.71	3.04
Start Up Storage, MCM	**70**											
Reservoir Balance, 50%, MCM	67.55	64.72	62.31	59.72	56.62	56.64	58.02	61.94	71.11	81.43	88.13	91.17

Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

Figure 68: Kamping Pouy Reservoir Balance, 50% Scenario



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

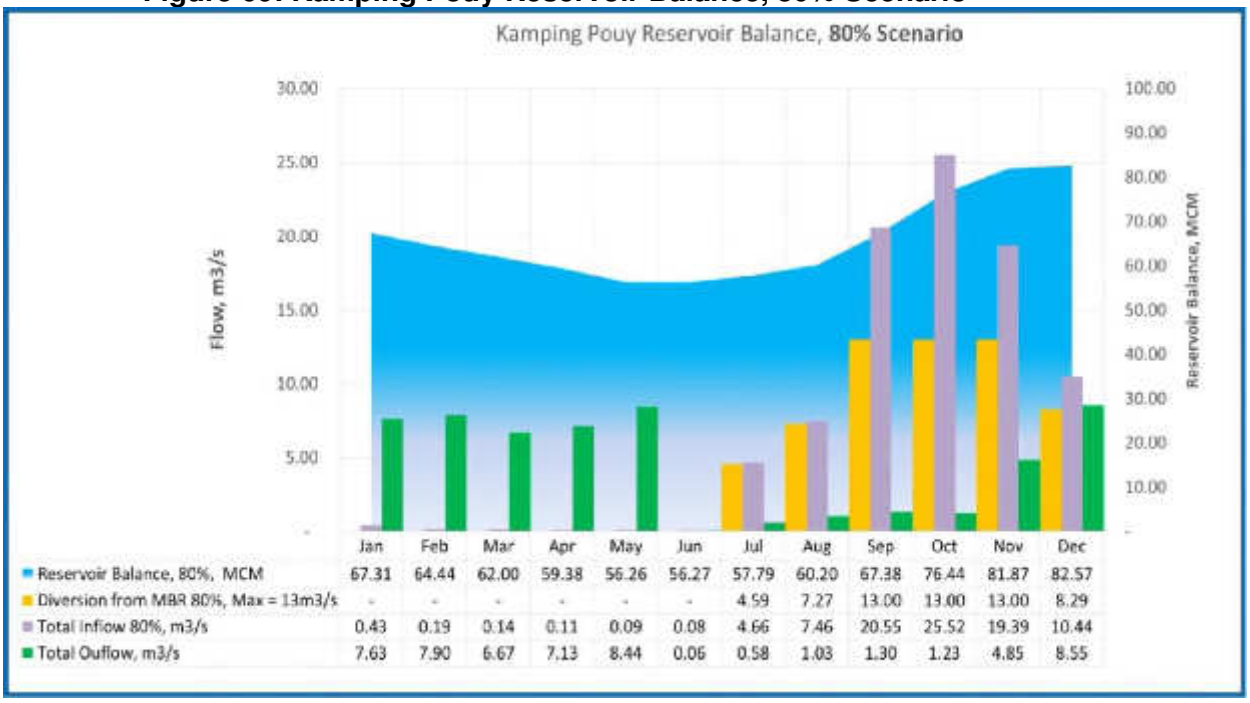
244. To simulate a dry year, a water balance of the Kamping Pouy Reservoir (entire water source for the Command area) based on a 80% inflow[12] scenario, is presented in Table 59 and Figure 69, and has the same input features as the 50% scenario[13] balance:

Table 59: Water Balance of Kamping Pouy Reservoir, 80% Inflow Scenario

Conditi on	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inflow from Cat. 80%, m3/s	0.43	0.19	0.14	0.11	0.09	0.08	0.07	0.19	7.55	12.52	6.39	2.15
% Of diversion flow from MBR	0%	0%	0%	0%	0%	0%	40%	40%	30%	20%	30%	50%
Diversion from MBR 80%, Max = 13m3/s	-	-	-	-	-	-	4.59	7.27	13.00	13.00	13.00	8.29
Total Inflow 80%, m3/s	0.43	0.19	0.14	0.11	0.09	0.08	4.66	7.46	20.55	25.52	19.39	10.44
Total Ouflow, m3/s	7.63	7.90	6.67	7.13	8.44	0.06	0.58	1.03	1.30	1.23	4.85	8.55
Inflow-Outflow, m3/s	-7.20	-7.71	-6.53	-7.02	-8.35	0.02	4.08	6.44	19.25	24.29	14.54	1.89
Inflow-Outflow, MCM	-2.69	-2.88	-2.44	-2.62	-3.12	0.01	1.52	2.40	7.18	9.06	5.43	0.71
Start Up Storage, MCM	**70**											
Reservoir Balance, 80%, MCM	67.31	64.44	62.00	59.38	56.26	56.27	57.79	60.20	67.38	76.44	81.87	82.57

Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

Figure 69: Kamping Pouy Reservoir Balance, 80% Scenario



Source: Kamping Pouy Feasibility Study Report, TRTA 2018.

245. The water balances show that, with a combined and managed inflow and outflow, the reservoir can supply irrigation water for 2.3 rice crops every year (including dry years at 80%) over the whole system command area of 18,000 ha.

246. **Water users outside the Kamping Pouy system**. The intensive management of the reservoir, based upon the movement of 10-day irrigation water releases from the reservoir and

[12] 80% exceedance: When 80% of rainfall readings for all years within a given sample would exceed the readings for the subject (dry) year.

[13] 50% exceedance: A normal year, when 50% of rainfall readings for all years within a given sample would exceed the readings for the subject year (and 50% would be lower).

into different parts of the command area as required, will ensure that the diversions drawn from the Mongkol Borey will be controlled and sustainable. Under the planned reservoir management regime, the majority of water will be drawn from the Mongkol Borey during June-December wet season when flows are high (see Q values in Figure 25) in order to maintain the reservoir at a high level entering the dry season. The appropriate use of this “water bank” will ensure that minimal water will be required from inflow to the reservoir (catchment and Mongkol Borey diversion) in the dry season. This will, in turn, ensure that the Mongkol Borey will not be dewatered in any season and that minimal water will be drawn from it in the lowest part of the dry season to protect environmental functions.

247. The Mongkol Borey flows 50 km northwards from the diversion point, meeting up with the much larger Serei Sophom River which in turn flows into the Sangar River which empties into Tonle Sap. From data provided by MOWRAM, in this 50km reach of the Mongkol Borey before it meets the Serei Sophom River, there are 15 irrigation schemes drawing water from the Mongkol Borey. The location of these schemes is shown on Figure 70 and their specifications are listed in Table 60.

Table 60: Specifications of Mongkol Borey Irrigation Schemes Downstream of Diversion Point

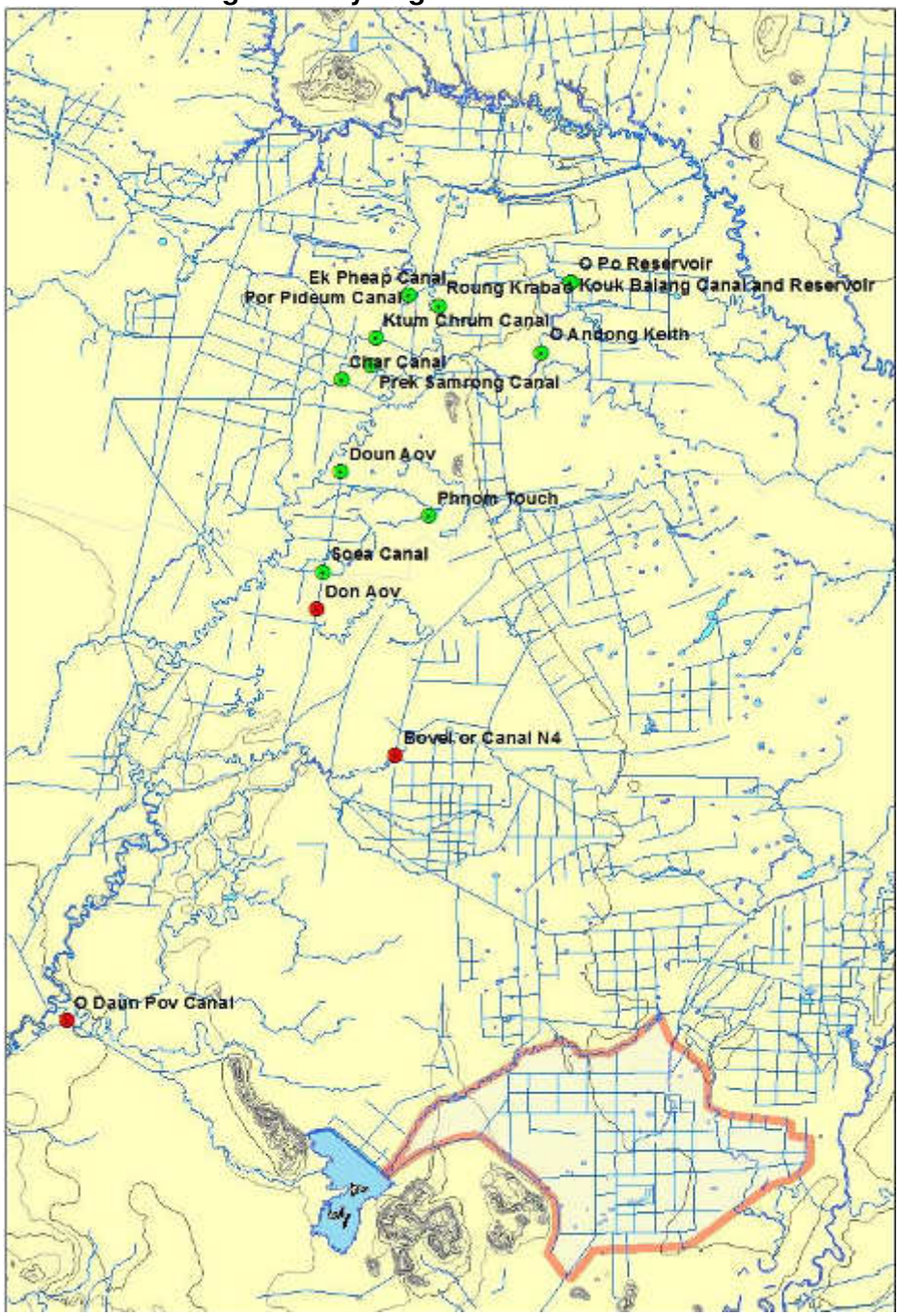
Scheme	Constructed	Last Rehabilitated	Potential Dry Season Irrigation (ha)	Potential Wet Season Irrigation (ha)	Actual Dry Season Irrigation (ha)	Actual Wet Season Irrigation (ha)	FWUC in Operation
Por Pideum Canal	1978	2011	1500	12000	850	7000	Yes
Ktum Chrum Canal	1978	2002	20	350	0	210	Yes
Prek Samrong Canal	1978	2002	50	1254	0	1254	Yes
Kouk Balang Canal	1978	1989	350	2012	0	2012	Yes
Char Canal	1975	2003	230	634	0	634	No
Doun Aov	1976	2013	350	1908	0	1908	Yes
Ek Pheap Canal	1976	2010	1324	757	1324	757	Yes
O Po Reservoir	1977	2014	1300	231	1091	231	No
Soea Canal	1976	2010	150	998	0	998	No
O Andong Keith	1991	2001	50	300	0	200	No
Phnom Touch	1976	2012	0	956	0	956	No
Roung Krabao	1976	2010	186	186	0	186	No
Bovel or Canal N4	Pre 1953	1994	300	7300	0	7300	No
Don Aov	2010	n.a	1000	5000	0	4100	No
O Daun Pov Canal	1975	2013	0	2112	0	2112	No

Source: MOWRAM.

248. The data shows that of the 15 schemes only six of them have formed FWUCs, indicating that the schemes are being operated in a piecemeal fashion and without coordination of water extractions. Only three of the 15 grow an irrigated dry season crop, making demands on the Mongkol Borey in that season. Since significant extractions from the Mongkol Borey by the Kamping Pouy subproject avoid that season, there will be little impact on these downstream schemes. All grow a wet season crop with the majority already regularly sowing up to the maximum potential area according to the MOWRAM data.

249. Due to the abundance of rain and water storage in these downstream areas in the wet season, it is unlikely that significant extractions from the Mongkol Borey occur during this season. However, to ensure that the planned topping-up of the Kamping Pouy reservoir during the wet season by the subproject does not impact on wet season flows downstream, the JOROP (see below) should consult with FWUCs or communes of the downstream schemes. This consultation should be supported by the PDWRAMs of Battambang and Bantheay Meanchey provinces.

Figure 70: Location of Mongkol Borey Irrigation Schemes Downstream of Diversion Point



red = Battambang Province, green = Banteay Meanchey Province.
Source: MOWRAM.

250. **Operational management**. Water sharing among the subsystems linked to the Kamping Pouy Reservoir requires joint reservoir operation (JOROP) to manage water distribution through the four outlets of the reservoir, which provide irrigation water to four different parts (or sub-schemes) of the entire Kamping Pouy command area of 18,000 ha.[14]

[14] The subproject is one part of this scheme.

251. A new irrigation management facility - the Joint Reservoir Operation for the Kamping Pouy Scheme (JOROP-KAPOS) Unit – will be established and supported by the project to ensure that water release through the reservoir outlets is regulated, based on water distribution plans that will specify how much and when the water will be released to each sub-scheme every 10 days, as agreed to by the managers of the four sub-schemes. Its management of the systems water resources will include ensuring that (i) minimal water is diverted from the Mongkol Borey in the dry season; and (ii) the planned topping-up of the Kamping Pouy reservoir during the wet season by the subproject does not negatively impact on wet season flows downstream.

252. Project training will be provided to both PDWRAM and FWUC in the strict enforcement of the irrigation schedule agreed to by the water managers of the four subsystems.

253. The setting up and operational guidelines for the functioning of the JOROP are detailed in the Kamping Pouy Irrigation Scheme Feasibility Study Report.

2. Managing Water Demand and Water Supply – Prek Po

254. The hydrology of the Prek Po subproject is highly dependent on the Mekong regime, as the Mekong is the only direct source of water supply for the system. Table 61 shows that more than sufficient water is available from the Mekong River to meet the irrigation demand of the Prek Po command area all months of the year.

Table 61: Monthly Average, Dry, Minimum, and Maximum Flows (MCM x 10^3), Mekong River at Kampong Cham

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average	9.8	6.7	6.6	6.5	10.0	25.3	55.2	90.0	89.8	61.0	29.1	16.1	406.0
Dry 80%	8.0	5.7	5.9	5.9	7.1	13.5	39.5	79.1	77.4	48.7	20.9	12.3	324.1
Dry 50%	9.8	6.9	6.5	6.5	8.4	19.9	51.5	91.0	91.0	61.1	28.3	16.0	396.8
Wet 20%	11.3	7.6	7.2	7.0	12.3	38.8	65.9	101.9	101.9	69.7	38.8	20.1	482.4
Max year	13.8	8.4	8.0	7.3	20.5	49.0	99.2	115.0	113.5	83.2	45.4	23.2	586.4
Min year	7.0	5.4	5.6	5.5	6.4	11.8	37.1	47.6	61.9	36.1	18.6	10.8	253.8

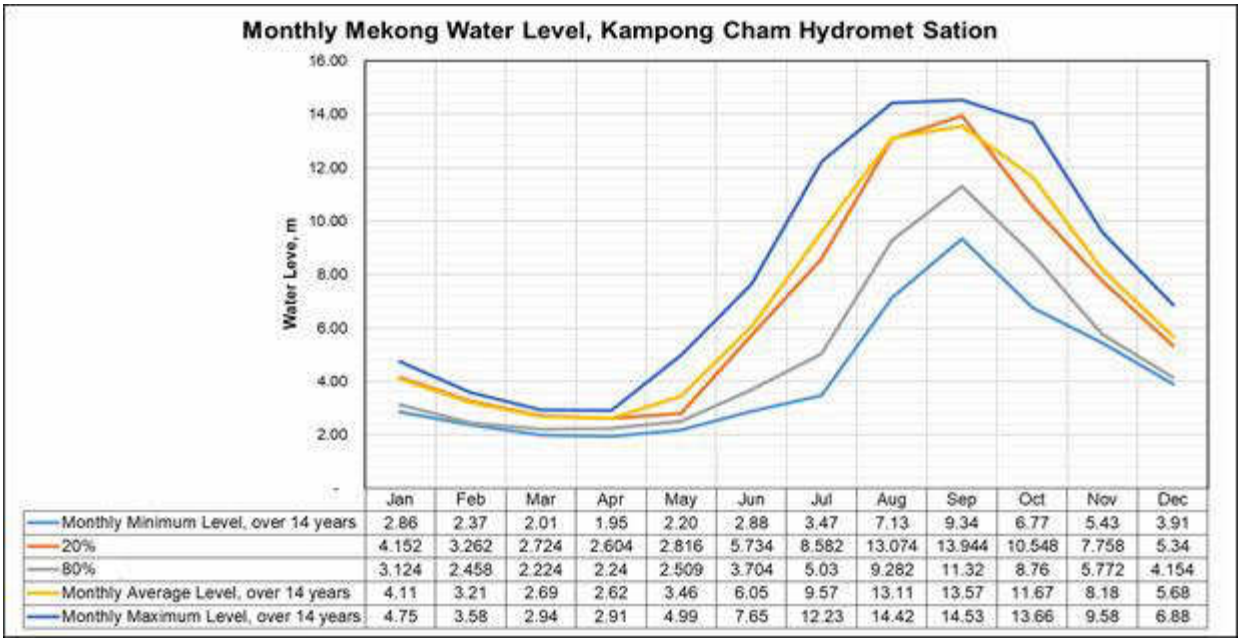
Source: TRTA Technical Report – Hydrology, 2018.

255. The additional irrigation areas at Prek Po will be 14,420 ha (an extra 7,620 ha irrigated in wet season and an extra 6,800 ha irrigated in the dry season). A guide to the size of the irrigated water demand, by assuming a water demand of 1.2 l/s/ha in the growing season, gives an indicative monthly water demand of 44 MCM for each growing month. This amount is only 0.0077 of the lowest monthly flow in the driest year (80% exceedance) in the Mekong flow at the extraction point.

256. While the data show that more than sufficient water is available to meet the irrigation demand at the Prek Po command area in all months of the year, the height of the river will vary depending on the flow, and the required pumping lift will also vary from high in the months of January to May and lower in the remaining months.

257. The water level in the Mekong at Kampong Cham for the period, January 1986– December 2011, is shown in Figure 71. The design of the pumping station will incorporate these levels and consequent height of lift required in some months – from a Mekong level of 2 m in March to 10 m in September.

Figure 71: Mekong River Heights



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Minimum Level, over 14 years	2.86	2.37	2.01	1.95	2.20	2.88	3.47	7.13	9.34	6.77	5.43	3.91
20%	4.152	3.262	2.724	2.604	2.816	5.734	8.582	13.074	13.944	10.548	7.758	5.34
80%	3.124	2.458	2.224	2.24	2.509	3.704	5.03	9.282	11.32	8.76	5.772	4.154
Monthly Average Level, over 14 years	4.11	3.21	2.69	2.62	3.46	6.05	9.57	13.11	13.57	11.67	8.18	5.68
Monthly Maximum Level, over 14 years	4.75	3.58	2.94	2.91	4.99	7.65	12.23	14.42	14.53	13.66	9.58	6.88

Source: Prek Po Feasibility Study Report, TRTA 2018.

3. Managing Water Demand and Water Supply – Canal 15

258. The question of water availability relates to the amount of the water resource and the delivery of that water. The water resource for the Canal 15 subproject is from two sources: (i) upwelling flow from the Bassac River system; and (ii) runoff from the upstream catchment.

259. **Flow contribution of Bassac River System.** Canal 15 is connected to the Bassac River by way of navigable channels and several natural waterways. The water from Bassac River flows year-round into Canal 15, and the water level at Canal 15 follows the daily fluctuation at Bassac River. During the dry months, from March to June, the water level at Canal 15 is only 1 m, which is mainly derived from the seepage flow from Bassac River. This river commands a large catchment area and exhibits very high discharge throughout the year, contributing significantly to the available water in Canal 15.

260. **Runoff from upstream catchment.** There are three major rivers flowing into Canal 15: the Slakou, Takeo, and Prek Thu Lo Lork rivers. A study was conducted by the Japan International Cooperation Agency (JICA) on the Slakou River which was, in turn, used as a reference for the assessment of runoff by the TRTA hydrology survey. The mean monthly streamflow at Canal 15 was estimated from the Peam Kley station in Prek Khnot River in proportion with the catchment area.

261. The hydrological survey undertaken for the feasibility of the Canal 15 subproject concluded that there is sufficient water available at Canal 15 all year round from a combination of runoff from the upstream catchment and inflow from the Bassac River. However, the delivery of water to the paddy field is by overland flow from overtopping of the Canal 15 and its lateral canals during periods of high flow and by pumping in the dry months. In this latter period the water in the main canal is only about 0.5 – 0.8 m deep and the smaller lateral canals and ponds annually dry up. Delivery is therefore constrained and correcting this delivery problem will be the prime focus of the project's civil works.

262. Under the project, the main and lateral canals will be deepened and widened to increase storage. In addition, new lateral canals will be excavated to expand the irrigable area and improve

the accessibility to surface water to all farmers.

4. Impacts from Intensification of Agriculture

263. The benefits resulting from the project's irrigation and drainage facilities will accrue to the beneficiaries through both intensification and expansion of agriculture in the areas. With an increase in agriculture comes a potential increase in the use of agricultural chemicals.

264. At current application rates of approved chemicals the following indicative increases in fertilizer and pesticide applications can be expected from the increases in agricultural activity (see Table 62 below). The increase in agricultural activity is based upon the maximum cultivation of each subproject area made possible by the improvements in irrigation.

Table 62: Estimated Potential Fertilizer and Pesticide Use Before and After the Project

Province	Subproject	Cultivated land (ha)		Change	Increment of fertilizer (ton/year)	Increment of pesticides (litre/year)
		Without project	With project			
Kampong Cham	Prek Po irrigation system	1,580	16,000	+14,420	2,884	72,100
Battambang	Kamping Pouy irrigation system	20,000	24,000	+4,000	800	20,000
Takeo	Canal 15 irrigation system	6,000	7,500	+1,500	150	7,500
Total increment of Fertilizer & pesticides					3,734	99,600

Note: Average fertilizer use: 0.1 tons/ha/crop. Irrigation area: 2 crops per year for the subprojects. Average pesticide use: 5.0 litre/ha/yr.
Source: Kamping Pouy, Prek Po and Canal 15 Feasibility Study Reports, 2018.

265. The potential incremental increase of fertilizer use for the three subprojects combined is 3,734 tons per year, and the increment increase in pesticide use is 99,600 litres per year. Nitrogen and phosphorus in liquid effluents can contribute to eutrophication in water and risk of oxygen depletion in waterbodies. Excessive nitrogen as ammonia can lead to gradual acidification of soils. Organochlorines, organophosphates, pyrethroids and carbamates (the common pesticide types used) can lead to direct poisoning of farmers through misuse and unsafe handling. Organochlorines and organophosphates can enter the food chain and groundwater resources.

266. Farmer surveys carried out by the TRTA team in Kamping Pouy found that 50% of all farmers apply fertilizer and pesticide, but that applications are not based on specific soil/crop needs. In Canal 15, it found that 100% of all farmers apply fertilizer to both dry season crops, 50% apply pesticide to the early dry season crop, and 100% to the second dry season crop. Additionally, an estimated 80% of farmers in all subprojects rely on self-saved seed from under performing crops for subsequent sowing. To address this, the project will deliver, as part of its Capacity Building and Training component, training modules specifically tailored to the needs of farmers on IPM and low chemical cultivation applicable to cropping conditions and capacities in the subproject areas. Training in IPM will coordinate with the Cambodian National IPM Programme and be in line with *IFC EHS Guidelines on Annual Crop Production.* The program will include the safe storage, handling and disposal of agricultural chemicals. The Project will also undertake soil analyses in the command areas and provide farmers with recommendations on appropriate fertilizer regimes and cultivation practices.

267. The training package will emphasise environmentally sound farming and sustainability and will provide farmers with alternative approaches to a reliance on chemicals.

5. Pump Station Noise

268. **Prek Po pumping station**. It is proposed to install five submersible pumps and operate four in concert to achieve a discharge capacity of 5.5 m^3/s. No noise modelling of the proposed

new pumping station at Prek Po is available, however, existing large capacity pumping stations in the region operate surface pumps with much higher noise ratings. Due to the sound absorption of the water which surrounds the submersible pumps, the absence of cavitation noise, and the concrete surrounds of the pump shaft and covers, submersible pumps typically produce between 1/3 and 1/4 of the noise levels of equivalent capacity surface pumps.

269. A similar sized pump station, Pump Station No. 2 on the Traebek River in Prey Veng province, was monitored[15] with all pumps running and producing a combined discharge of 5.44 m^3/s (comparable to the design capacity at Prek Po of 5.5 m^3/s). Noise levels within that pumping station were 81.5 dB, but reduced to 51.3 dB at the nearest residence 20 m away. For submersible pumps the equivalent noise would be about 30 dB, which is below the ambient noise level at the Prek Po location.

270. There will however be potential for noise from the discharge of water into the pump outlet tank for transmission into the main canal. The pump outlet will be designed to minimize the drop from the outlets to the tank to avoid cascade noise. It is expected that cascade noise will be at a level which does not impact the nearest residence, 20m distant. Operational noise levels will be monitored at the nearest house, and if they exceed 55dB, a permanent noise barrier will be constructed along the western side of the outlet tank. This is specified in the EMP measures. Operational guidelines will also include limitations on pump running to a maximum of 10 hours per day in daytime. Occasional higher noise operations such as pump purging will only be undertaken with informed consent of nearby residents.

271. **Canal 15 (Samput) pumping station**. At the Samput pumping station it is proposed to install three pumps and operate two in concert to achieve a discharge capacity of 1.2 m^3/s. When the specifications of the pumps are confirmed noise modelling will be undertaken to determine the level of noise impact on nearby residences (the nearest is 40m). Previous work on other pump stations (see above) indicate that noise attenuation from a properly sound-insulated pump house is in the order of 35% noise reduction at a distance of 20m. These levels of noise mitigation will be targeted by the pump house design and, since the nearest houses are double this distance away, no noise impacts are anticipated. These levels of noise mitigation will be targeted by the pump house design.

272. Operational guidelines will include limitations on pump running to a maximum of 10 hours per day in daytime. Occasional higher noise operations will only be undertaken with informed consent of nearby residents.

6. Solid Waste Management – Prek Po

273. At Prek Po the main canal is clogged with domestic garbage. This is due to the deficiencies of solid waste management services in Prek Po commune and the convenient disposal option provided by the canal as it flows through the town. The issue of solid waste management was the issue most concerning respondents in the public consultation (Chapter VI). It will also pose a maintenance issue for the operation of the pump house and will have a deleterious effect on water quality flowing to the command area.

274. A solid waste management component for Prek Po commune has been designed for the project implementation phase. The description, terms of reference and indicative budget for the component are in the project administration manual. The component will comprise: (i) direct support for existing disposal site improvements and expansion of collection; and (ii) development of a community based waste management and action plan for the local Prek Po authorities.

[15] During field surveys for TA9167-CAM: Tonle Sap Poverty Reduction and Smallholder Development Project (TSSD) - Additional Financing. (International Environment Specialist field notes).

7. Greywater Drainage Management – Prek Po

275. The planned enclosure of the previously open main canal through a 750m residential section of Prek Po commune necessitates the inclusion of separate pipes to intercept and convey the domestic greywater and yard runoff which currently flows into the open canal. The greywater drainage pipelines will run parallel to the enclosed main canal on each side and will discharge into the Mekong River.

276. No data is available for greywater quality in Cambodia, so data from the Malaysian province of Selangor has been used. Generalized data on greywater from WHO has been used to check the order of magnitude for these data (Table 63).

Table 63: Greywater quality data used in design of treatment facilities

	Selangor mean greywater (from 30 samples) mg/l	Typical greywater WHO mg/l
COD	115.4	-
BOD	36.75	90-290
N	2.5	2.1-31.5
P	2.25	0.6-27.3
SS	97.1	45-330

277. To ensure that water entering the Mekong complies with Cambodian and EHS standards for discharged treated wastewater, the collected greywater is directed to two separate treatment facilities – one for the eastern collector pipeline, and one for the western collector. Treatment facility design was matched with the number of potential households along each side which would contribute greywater.

278. **Eastern treatment site**. On the eastern side of the main canal, the greywater collection pipe will flow back towards the pump house to a site on a government compound adjacent to the old disused pump house. There it will pass through a primary settlement and detention tank followed by a reedbed (of *Eliocharis dulcis* and *Cyperus malaccensis*) for final polishing before release to the river (Figures 72 and 73).

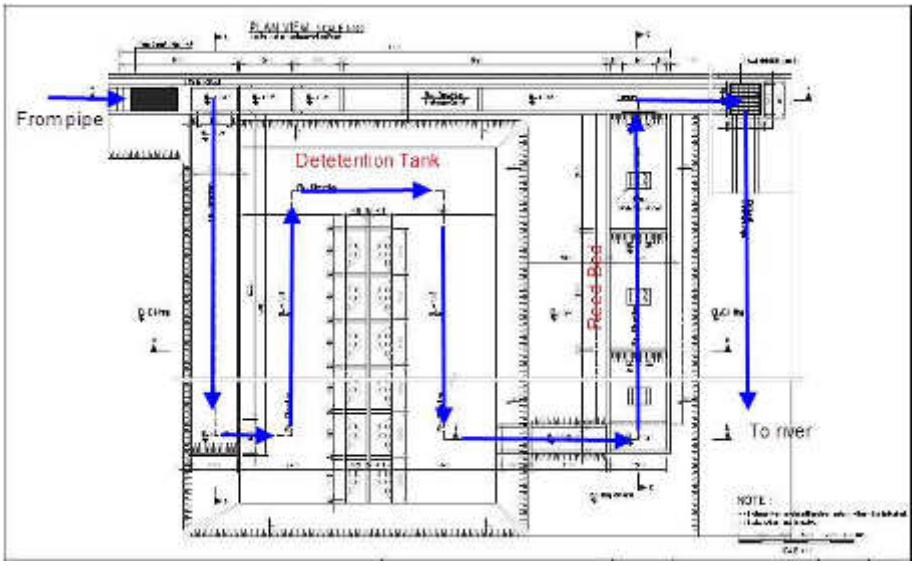


Figure 72: Eastern Treatment Facility for Greywater

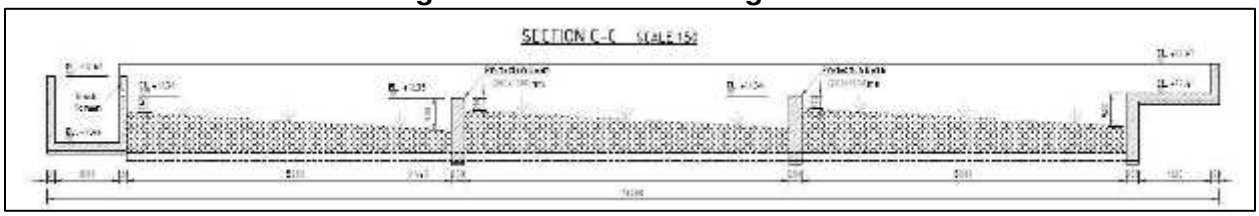
279. The detention tank is designed to achieve the concentration reductions in column 2 of Table 64 below. It can thus reduce the concentration of key parameters to comply with the most

stringent combination of Cambodian standard and EHS guidelines, except for COD. The reedbed second stage (Figure 73) is designed to polish the effluent exiting the detention tank to bring the COD concentration further down to comply with standards before discharge.

Table 64: Design Performance of Detention/Settlement Tank

	Conc of influent (mg/l)	Design Reduction % of detention tank	Discharge (to River) (mg/l)	Standard for discharge to Public Waters mg/l	IFC EHS Guideline for treated wastewater discharge mg/l
COD	115.4	35	75.01	<30	125
BOD	36.75	35	23.89	<50	30
N	2.5	10	2.25	<10	10
P	2.25	10	2.03	<3	2
SS	97.1	65	33.99	<50	50

Figure 73: Reedbed Configuration



280. **Western treatment site**. On the western side of the main canal the collector pipe runs south, in the same direction as water flow in the main canal, and enters a side drain/canal at 0 + 0750. This drain flows for a further 2km before it reaches the Mekong. An artificial wetland has been designed for the initial portion of this drain to treat the greywater flowing into it. The wetland plants will be *Cyperus malaccensis, Scirpus grossus, Scirpus mucronatus,* and *Saccharum spicatum.*

281. The major greywater treatment targets for this wetland are: (i) settling out of 60% of suspended solids; (ii) reduction of total phosphorus (TP) and total nitrogen (TN) by 45%; and (iii) partial disinfection by passive UV absorption.

282. With influent levels of TP and TN of 2.25 mg/l and 2.5 mg/l respectively[16]. A reduction of 45% would bring these levels to within Cambodian "Public Waters" standard and EHS guidelines. Reduction of these parameters in artificial wetlands is also taken as an indicator for COD and BOD reduction, which can exceed 45%.

283. To achieve these reduction targets in an artificial wetland requires the following design parameters:

- A water surface area[17] of not less than 430 m^2;
- A variable depth not exceeding 0.9 m which allows for UV penetration and emergent vegetation growth;

[16] Paired samples from 15 urban and rural sites. Reported in Leong et al 2018, Assessment of greywater quality and performance of a pilot-scale decentralized hybrid rainwater-greywater system, *Journal of Cleaner Production* 172, 81-91.

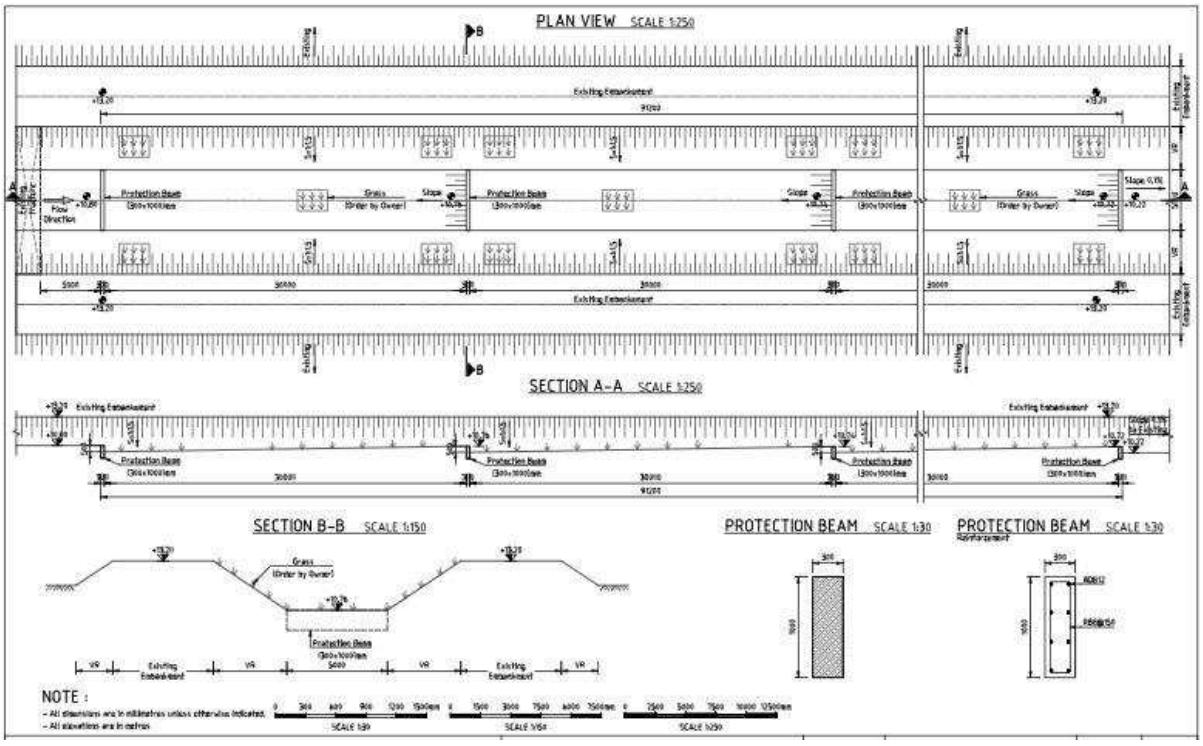
[17] Using correlation of hydraulic loading and TP/TN output in: Wong et al 1998. Managing Urban Stormwater Using Constructed Wetlands. Cooperative Research Centre for Catchment Hydrology and Cooperative Research Centre for Freshwater Ecology, Industry Report 98/7.

- Capacity to detain one week's discharge[18] of greywater and yard runoff (245 m^3).

An additional design constraint is that the wetland must fit within the main drain easement, requiring no land take.

284. The concept design for the wetland at Prek Po is at Figure 74 below. This has been incorporated into subproject detailed design during design modification in the pre-construction phase.

Figure 74: Western Treatment Facility – Artificial Wetland

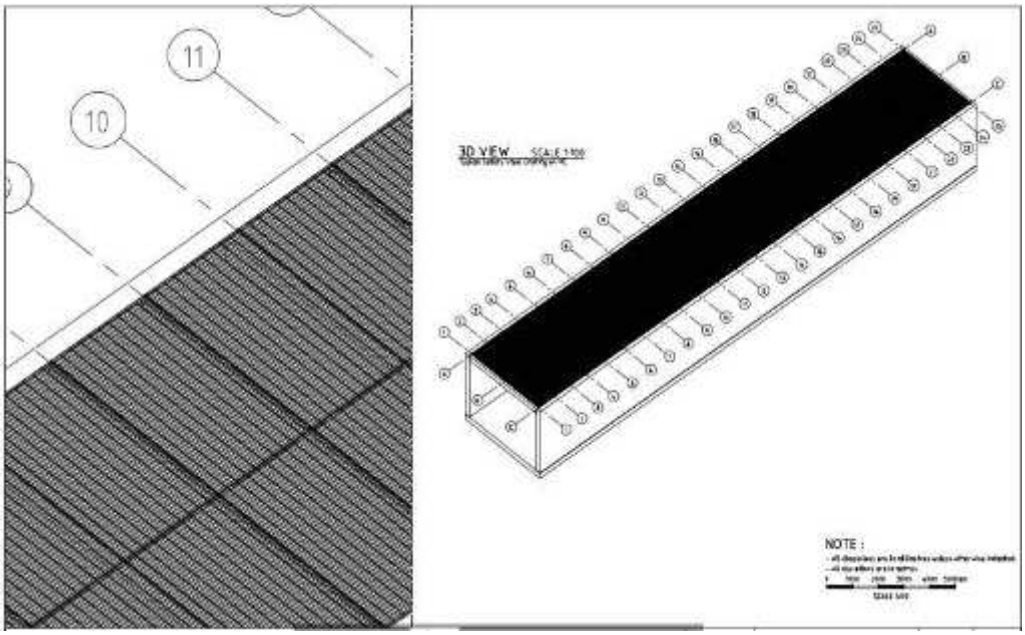


8. Community Safety – Prek Po Main Canal

285. The main canal, as it passes through the built-up residential part of Prek Po from 0 + 0000 to 0 + 0750, will be in a concrete box culvert up to 2m deep with vertical walls extending 1.2m above ground level (see Figure 13). To ensure public safety, especially for children, the culvert will be covered throughout this section with a metal mesh, fixed in place (Figure 75).

[18] Calculated as a future population of 270 (60 houses) on the western side and 280 (62 houses) on the western side and a discharge rate of 130 l/person/day.

Figure 75: Metal Covering of Culvert Section of Main Canal



E. Unanticipated Impacts during Construction and Operation

286. If any unanticipated impacts become apparent during project implementation, the borrower will (i) inform and seek ADB's advice; (ii) assess the significance of such unanticipated impacts; (iii) evaluate the options available to address them; and (iv) prepare or update the IEE including EMP. ADB will help the borrower mobilize the resources required to mitigate any adverse unanticipated impacts or damage.

F. Climate Change Impact Assessment

287. The environmental risks from climate change need to be addressed in two different but complementary ways: (i) consideration of greenhouse gas emissions; and (ii) adaptation to help ensure resilience of infrastructure against the effects of future climate change.

1. Greenhouse Gas Emissions

288. Net greenhouse gas emissions from the project will derive from GHGs emitted by agricultural activities – in particular the CH_4, N_2O and CO_2 emissions from rice paddy flooding and cultivation and fossil fuel consumed either as small pumps to convey water into tertiary canals and paddies or electrically powered pump station (at Prek Po).

289. **Emissions from paddy**. The greenhouse gas emissions from rice paddy fields have been studied in India, Philippines and Japan (Table 65), and to a lesser extent in China and the USA. Only the studies in northern India have studied the emission of the suite of GHGs (CH_4, N_2O and CO_2) in combination with different ranges of nitrogen fertilizer applications and on a range of soils. Studies have also compared the GHG emission consequences of different periods of inundation of rice crops.

Table 65: GHG Emissions from Rice Paddy

Location	Methane (CH_4) from Rice Paddy
Northern India	40 – 100 Kg/ha
Philippines	100 – 150 Kg/ha
Japan	150 – 200 kg/ha

[a]

Sources: H. Pathak, C. Li, and R. Wassmann. 2005. *Greenhouse gas emissions from Indian rice fields: calibration and upscaling using the DNDC model*. Biogeosciences Discussions, 2, 77–102.; Corton et al. 2000. *Methane emission from irrigated and intensively managed rice fields in Central Luzon* (Philippines). Nutrient Cycling in Agroecosystems 58, 37–54..; and Yagi. et al 1996. *Effect of water management on methane emission from a Japanese rice paddy field: Automated methane monitoring*, Global Biogeochemical Cycles 10(2):255-268 · June.

290. The Indian study approximates the subproject conditions for comparable levels of fertilizer application and temperatures. The yearly indicative emission levels used for this project are therefore:

66 kg/ha CH_4 : 690 kg/ha CO_2 : 1.93 kg/ha N_2O.

291. These emission rates are calculated for the combined subproject areas in Table 66 below, and converted into equivalent levels of CO_2 using the following formula:

*Global warming potential (GWP) = CO_2 emissions + CH_4 emissions*21 + N_2O emissions*310*

Table 66: GHG Emissions and GWP from Rice Paddy Increases

Increase in Rice Paddy (ha)	CH_4 emissions (kg/yr)	CO_2 emissions (kg/yr)	N_2O emissions (kg/yr)	GWP (tons/yr CO_{2e})
Kamping Pouy				
4,000	224000	2760000	7720	2992
Prek Po				
14,420	807520	9949800	27830.6	10785
Canal 15				
1,500	99,000	1,035,000	2,895	3075.45
Total				**16,852.45**

Source: TRTA calculations.

292. **Fossil fuels**. Water from the Kamping Pouy reservoir feeds into the main and secondary canals by gravity. Small capacity diesel pumps (rarely petrol) are used to raise water from the secondary canals into tertiary canals or directly into paddy fields. In Prek Po however, the water is first lifted from the Mekong River through the pump station and then small pumps are used to raise water from the secondary canals into tertiary canals or directly into paddy fields. In Prek Po, the worst case scenario is used for the lift from the Mekong River (lowest level).

293. The calculations for estimation of GHG from fossil fuels is shown in Table 67. They assume:

- a total growing season of 230 days (one early maturing rice crop (90 days) plus one traditional rice crop (120 days)) for Kamping Pouy and Prek Po
- a total growing season of 90 days (one early maturing 90 day rice crop) for the incremental second crop annually in the subproject using pumping from the main canal and secondaries at Canal 15
- the Samput extension using water delivered by the pumping station, provides irrigation for a command area of about 130 ha for early wet season rice and top-up irrigation for a wet season command area of about 700 ha. For this calculation, this is assumed to be a water demand for 430 ha of cropping (130 + 700/2.33) for a total cropping duration

of 140 days

- an average water demand of 1.2 l/s/ha during the growing season for all subprojects.
- for the Prek Po pumping station a pump capacity of 5.5 m3/s and a lift of 12.10 m (requiring 651.689 kW).
- for the planned Samput pumping station a pump capacity of 1.2 m^3/s and an average lift of 5 m (requiring 58.75 kW).
- for the current Samput pumping station a pump capacity of 0.07 m^3/s and an average lift of 5 m (requiring 30-35 l/hr diesel).
- for small farmer pumps used, 60 - 240cc size, average performance assumed of 750 l/min and average fuel consumption of 1.66 l/hr of diesel.[19]

294. The calculations employ the conversion factors:

- 7.03 * 10^{-4} tons CO_2/kWh (US EPA), which is based on a mixture of coal and gas-fired base load generation; and
- 2.67 kg CO_2/l diesel (European Union)

[19] From interviews with farmers in command areas.

Table 67: GHG Calculation for Pump Usage

Subproject	Area irrigated (ha)	Total water demand (m^3)	Pumping Station		Small Pumps		Total CO_2 (t/year)
			Power usage (kWh)	CO_2 (t)	liters diesel	CO_2 (t)	
Kamping Pouy	4000	95385600	0	0	1277000	3409.59	3409.59
Prek Po	14420	343865088	3139627	2207.158	4603000	12290.01	14497.17
Canal 15 total	1500 (total incremental area with project)	13996800	0	0	516327	5114.385	5114.39
Samput pumps (planned)	1000 (full area serviced by planned Samput pump station)	20736000	282000	198.25			198.25
Samput pumps (existing)	430 (area serviced by existing Samput pump station)	6241536			(24768)	(66130.56)	
	Total						**23,219.4**

Note: the shaded row is CO2 savings.
Source: TRTA Consultant

295. The total CO_{2e} emissions generated by the combined subprojects will be approximately 40,072 tons/annum. This is below the threshold of 100,000 tons/annum where the ADB SPS (2009) and therefore, no further monitoring is required.

296. The reconfiguration and modernization of secondary canals and the planning of tertiary canals in the subprojects to maximize water delivery to farm fields through gravity will reduce the use of small pumps (which accounts for just under 50% of the total GHG generation) and will further reduce the GHG generation from this source. In the case of the Canal 15 subproject, the replacement of inefficient diesel pumps (highlighted in grey in Table 67) at the Samput pumping station with higher capacity electric pumps will result in significant savings in GHG emissions.

2. Adaptation to Future Climate Change

297. **Climate Change projections.** A Climate and Disaster Risk Assessment has been prepared by the TRTA team. The relevant parts of this have been included in the Kamping Pouy, Canal 15 and Prek Po Irrigation Systems Feasibility Reports. These include costings of climate proofing measures.

298. The report found that for Kamping Pouy, projected climate change[20] is expected to: (i) increase the frequency, intensity, and peak flood height; (ii) increased occurrence and length of drought conditions that could damage irrigation infrastructure and disrupt access to water; and (iii) reduced agricultural productivity. Of particular concern is the projection that climate change will make the onset of the wet season more erratic. By 2050, it is projected that the average maximum temperature during the dry season will warm by 1.9°C (from 32.2°C to 34.1°C). The wet season average maximum temperature will have a larger increase of 2.7ºC (from 30.6°C to 33.3°C). Dry season rainfall will slightly decrease from 273.5 mm to 272 (-0.6%), while the wet season will see an increase of 7.8% (from 1,429 mm to 1,540 mm) (Table 68).

Table 68: Baseline and Projected Changes to Average Maximum Temperatures and Rainfall, Kamping Pouy Reservoir and Mongkol Borey, 2050

Variable unit	Season	Period		
		Baseline	2050	Change
Maximum temperature (ºC)	Dry	32.9	34.7	1.8
	Wet	31.4	33.9	2.5
Rainfall (mm)	Dry	273.5	272.0	- 0.6%
	Wet	1,429.0	1,540.4	**7.8** %

[20] Using the IPCC AR4 SRES A1B scenarios in Cambodia Climate Change Toolbox, http://icem.com.au/CambodiaCC/.

Source: TRTA Climate and Disaster Assessment Report, 2019

299. For Prek Po, rainfall is projected to decrease by 0.9% in the normal dry period (from 202.5 mm to 201 mm) and to increase by 11.1% during the wet period (from 1,089.7 to 1,210.6 mm) by 2050. Projected temperature increases are 2.5°C and 2.9°C in the wet season (from 29.1°C to 32°C) and dry season (from 30.7°C to 33.1°C), respectively. Baseline and projected changes in rainfall values for 2050 (i.e., average for the period 2036-2065) are shown in Table 69 for the wet and dry seasons.

Table 69: Baseline and Projected Average Maximum Temperatures and Rainfall in Prek Po, 2050

Variable Unit	Season	Period		
		Baseline	2050	Change
Maximum temperature, ^{0}C	Dry	30.7	33.1	2.5
	Wet	29.1	32	2.9
Rainfall, mm	Dry	202.5	201	-0.9 %
	Wet	1089.7	1210.6	11.1%

Source: TRTA Climate and Disaster Assessment Report, 2019

300. The projected change in flow in the Mekong River with climate change is an increase in the dry season flow and increased variability in the wet season flow.[13] Given that the current irrigation practices rely on regular flooding, the anticipated increase in wet season flows may present a threat to livelihoods, particularly from higher floods.

301. For Canal 15, the future climate is expected to be: (i) significantly hotter and wetter in the wet season; (ii) significantly hotter and slightly drier in the dry season; and (iii) will have a slightly greater number of drought months.

Table 70: Projected Changes to Climate Variables in 2050 from Baseline in Takeo

Climate Change Variables	Baseline	2050	Change
Average annual rainfall:	**1,246 mm**	**1,333 mm**	**+7.0 %**
Total rainfall in wet season:	993 mm	1,089 mm	+9.6 %
Total rainfall in dry season (Nov-Apr)	253 mm	244 mm	-3.9%
Average annual number of drought months	4.9 months	5.0 months	+0.1 months
Average daily maximum temperature (annual)	31.25°C	33.9°C	+2.65°C
Average maximum temperature in wet season	30.8°C	33.8°C	+3.0°C
Average maximum temperature in dry season	31.7°C	34.0°C	+2.4°C

Source: TRTA Climate and Disaster Assessment Report, 2019

302. The frequency, intensity, and peak flood height and increased occurrence and length of drought conditions are expected to increase in the subproject site. These could damage irrigation infrastructure, disrupt access to water, reduce agricultural productivity, and reduce the conveyance ability of Canal 15. Of particular concern is the projection that climate change will make the onset of the wet season more erratic.

303. **Project response to climate and disaster risks**. The CDRA report identifies a range of civil works and capacity building measures which respond to the projected changes in future climate and attendant disaster risk. These are summarized for all subprojects below in Tables 71 and 72 addressing climate change adaptation and disaster risk reduction respectively. These measures have been incorporated into the designs of the subprojects and their costs included in project budgets. All costs in the following tables are before contingency and tax.

Table 71: Climate Change Adaptation Measures included in Project Design

Adaptation Activity	Target Climate Risk	Estimated Adaptation Finance (US $)*	Adaptation Finance Justification
Prek Po Subproject- Kampong Cham Province			
Construction of new pumping station which provide water for command area during low level flow period of Mekong River	Lower water availability for irrigation in dry season.	15,000	Incremental cost of extending pumping depth from 2.76 m (average low water level in Mekong) to 2 m (0.3 m below lowest recorded river level). 10% of pump shaft excavation and construction costs.
Cement lining of all main and secondary canals to minimize seepage water loss		2,246,439	No incremental costs separated. Estimated at 10% of civil works costs contribute to climate change adaptation (after Frankhauser, 2009)[21]
Subproject O&M cost		362,038	No incremental costs separated. Estimated at 10% of O&M costs contribute to climate change adaptation (after Frankhauser, 2009)
Hydromet upgrade for Prek Po (equipment, infrastructure, installation)	Climate and river flow monitoring for the proper management of water releases and allocations	10,000	For timely and actionable warning and forecasts on climate events and onset of seasons. No incremental costs separated. Estimated at 10% of civil works costs contribute to climate change adaptation (after Frankhauser, 2009)
FWUC establishment and capacity building.	Increased need to coordinate and manage water allocations and practice water conservancy in higher water demand situations.	6,000	To improve water governance and increase the FWUCs' capacities to adapt to climate change. An estimated 30% of the improved water governance and increase in FWUCs' capacities will be directed to dealing with climate change.
FWUC and farmer training and awareness raising on:	Farmer need to understand and adapt	12,700	To reduce the impacts of seasonal low water

[21] Frankhauser S. 2009: "The costs of adaptation." Centre for Climate Change Economics and Policy Working Paper No.8. Grantham Research Institute on Climate Change and the Environment Working Paper No. 7.

Adaptation Activity	Target Climate Risk	Estimated Adaptation Finance (US $)*	Adaptation Finance Justification
- Climate change, gender and environment; - Current climate and future climate, the difference, cause and effect; - Effects on people (e.g. health), livelihood and resources (in particular, water) and local solutions.	to increased warming and rainfall variability in the sub-project area and impacts on the farming and water-users communities' livelihoods and well - being.		availability on agricultural production and increase the adaptive capacity of farmers. Direct costs from training budget for climate change-related training components.
Farmers field school component on climate change, with topics that will include: - Changes in climate and effects on productivity; - Crop/weather relationships and use for increased productivity; - Climate and disaster information needs and how/where to get them.	The need to learn field skills in practice which emphasize adaption to increased warming and rainfall variability in the sub-project area leading to higher crop water demand.	24,200	Part of farmer field schools training component to increase farmers' adaptive capacity to long-term climate change risks. No funding breakdown of farmer field schools. Cost of climate change field school components derived from an average of Canal 15 and Stung Chinit South field school costs
Kamping Puoy Subproject- Battambang Province			
Improvement of drainage facilities. Provision of separate drainage canals separated from the irrigation canals, to accommodate excess water from the farmlands, and Increase of drainage capacity of drainage canals and infrastructure	Increased flooding during the wet season and at the start of the dry season,	1,568,632	Actual incremental costs of enlarging drains and drainage structures to provide an additional 25% drainage capacity over standard, minus the component contributing to DRR (see below)
Hydromet upgrade for Kamping Pouy (equipment, infrastructure, installation)	Climate and river flow monitoring for the proper management of water releases and allocations	30,000	For timely and actionable warning and forecasts on climate events and onset of seasons. No incremental costs separated. Estimated at 10% of civil works and O&M costs contribute to climate change adaptation (after Frankhauser, 2009)

Adaptation Activity	Target Climate Risk	Estimated Adaptation Finance (US $)*	Adaptation Finance Justification
FWUC establishment and capacity building.	Increased need to coordinate and manage water allocations and practice water conservancy in higher water demand situations.	6,000	To improve water governance and increase the FWUCs' capacities to adapt to climate change. An estimated 30% of the improved water governance and increase in FWUCs' capacities will be directed to dealing with climate change.
FWUC and farmer training and awareness raising on: - Climate change, gender and environment; - Current climate and future climate, the difference, cause and effect; - Effects on people (e.g. health), livelihood and resources (in particular, water) and local solutions.	Farmer need to understand and adapt to increased warming and rainfall variability in the sub-project area and impacts on the farming and water-users communities' livelihoods and well - being.	14,800	To reduce the impacts of seasonal low water availability on agricultural production and increase the adaptive capacity of farmers. Direct costs from training budget for climate change-related training components.
Farmers field school component on climate change, with topics that will include: - Changes in climate and effects on productivity; - Crop/weather relationships and use for increased productivity; - Climate and disaster information needs and how/where to get them.	The need to learn field skills in practice which emphasize adaption to increased warming and rainfall variability in the sub-project area leading to higher crop water demand.	24,200	Part of farmer field schools training component to increase farmers' adaptive capacity to long-term climate change risks. No funding breakdown of farmer field schools. Cost of climate change field school components derived from an average of Canal 15 and Stung Chinit costs
Canal 15 Subproject- Takeo Province			
Excavation to remove siltation from Canal 15 to increase its hydraulic section.	Increased variability in rainfall and flooding, increased erosion and sedimentation.	825,660	To assure water availability for the dry season cropping, and to hold more water during early flooding season. More water holding
Excavation to remove siltation from Canal 87 to increase its hydraulic section.			

Adaptation Activity	Target Climate Risk	Estimated Adaptation Finance (US $)*	Adaptation Finance Justification
Excavation to remove siltation from Samput Intake Canal to increase its hydraulic section.			capacity means continued navigability of Canal 15 even during dry season to allow mobility of communities and farmers. Actual incremental costs of increasing canal excavation depth to provide an additional 30% capacity over standard, minus the component contributing to DRR (see below)
FWUC establishment and capacity building.	Increased need to coordinate and manage water allocations and practice water conservancy in higher water demand situations.	6,000	To improve water governance and increase the FWUCs' capacities to adapt to climate change. An estimated 30% of the improved water governance and increase in FWUCs' capacities will be directed to dealing with climate change.
FWUC and farmer training and awareness raising on: - Climate change, gender and environment; - Current climate and future climate, the difference, cause and effect; Effects on people (e.g. health), livelihood and resources (in particular, water) and local solutions.	Farmer need to understand and adapt to increased warming and rainfall variability in the sub-project area and impacts on the farming and water-users communities' livelihoods and well - being.	18,810	To reduce the impacts of seasonal low water availability on agricultural production and increase the adaptive capacity of farmers. Direct costs from training budget for climate change-related training components.
Farmers field school component on climate change, with topics that will include: - Changes in climate and effects on productivity; - Crop/weather relationships and use for increased productivity; Climate and disaster information needs and how/where to get them.	The need to learn field skills in practice which emphasize adaption to increased warming and rainfall variability in the sub-project area leading to higher crop water demand.	26,400	Part of farmer field schools training component to increase farmers' adaptive capacity to long-term climate change risks. Direct cost from training budget of climate change field school components.

Source: TRTA Climate and Disaster Assessment Report, 2019

** Excluding contingency and tax*

Table 72: Disaster Risk Reduction Measures included in Project Design

Disaster Risk Reduction Activity	Target Disaster Risk	Estimated Cost (US$)*	DRR Component Justification
Prek Po Subproject – Kampong Cham Province			
Extension of depth of pump shaft to lowest recorded level of Mekong (2000-2017)	Drought	13,544	Extreme low level of Mekong (meteorological drought) = 1 year in 10 years. (10% of excavation and shaft construction cost)
Hydromet repair, rehabilitation and training	Flood and drought (early warning for both)	20,000	Early warning for most frequent disaster risk (flood: 1 year in 5 years at PP). 20% of total cost.
Kamping Pouy Subproject – Battambang Province			
Increase of drainage capacity of drainage canals and infrastructure by 25% for future increased rainfall intensity (calculated for climate change adaptation)	Flood	174,293	Part of the total incremental cost calculated for increasing drainage capacity by 25% will address extreme floods (average 1 year in 10 years in Battambang) - which is taken as 10% of the incremental cost.
Strengthening KP Reservoir weir wall along 6.5km.	Flood (weir failure) and drought (loss of water)	468,075	Dual purpose of wall strengthening is water security (prevent water loss through leaks) and weir safety (strengthen weir against failure). Estimated 25% of cost as contribution to weir safety.
Hydromet repair, rehabilitation and training	Flood and drought (early warning for both)	30,000	Early warning for most frequent disaster risk (flood: 1 year in 10 years at KP). 10% of total cost.
Canal 15 Subproject- Takeo Province			
Increase in depth of main and secondary canals	Flood risk reduction.	206,415	Part of the total incremental cost calculated for increasing depth of main canals will address extreme floods. Flood disasters in Takeo average 1 year in 5 years - DRR cost is therefore estimated at 20% of the incremental excavation cost.
All Subprojects			
Commune-based training in DRR and disaster preparedness	Flood, drought, typhoons	114,000	Extend NCDMS training package (linking community, district and provincial levels) to 6

Disaster Risk Reduction Activity	Target Disaster Risk	Estimated Cost (US$)*	DRR Component Justification
		34,200 for Prek Po, 28,500 for Kamping Pouy and 51,300 for Canal 15.	communes in Prek Po, 5 communes in Kamping Pouy and 9 communes in Canal 15. $3,500/commune for participatory assessment and analysis of risk, and $2,200/commune for participatory exercises in disaster management planning.

Source: TRTA Climate and Disaster Assessment Report, 2019
** excluding contingency and tax*

304. The total cost for climate change adaptation measures in the three subprojects is $5,196,879 and for disaster risk reduction, $1,026,327 (excluding contingency and tax).

305. An additional important disaster risk reduction measure, which covers the whole IAIP and which cannot be meaningfully apportioned to each subproject, is its support for the establishment and equipping of a national water resources data management center (NWRDMC) in MOWRAM under project Output 2. This will include the installation of a doppler radar unit. In weather stations, doppler radar is used to locate precipitation, calculate its motion, and estimate its type to track. In this way the radar tracks the progress of storm cells and their rain potential in real time and can give early warning of extreme weather events which can be location and time specific. This allows communities and stakeholder agencies to prepare for disaster response.

VI. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

A. Consultation and Participation Process

306. Public consultations were undertaken in the Kamping Pouy and Prek Po communes on 6 and 9 April 2018, respectively, and at Canal 15 on 24/25 September 2018 in conjunction with the project household surveys. The consultations were undertaken by the TRTA national environmental specialist, national irrigation engineer and international and national social specialists.

307. Information dissemination was undertaken by the national irrigation engineer in a presentation before each workshop followed by discussion led by the national environment specialist. Areas covered included present experience and perceptions of environmental problems and anticipated environmental issues in subproject construction and operation. These will be addressed in the mitigation measures of the IEE. The readiness of community members to complain if things go wrong and the avenues of complaint/ redress were also examined.

308. **Kamping Pouy**. Meeting was held at Takream Commune, Banan District, Battambang Province. Participants comprised ADB's consultant team members, representatives of GDR (of MEF), local farmers, commune and village officials, and FWUC members. Potentially affected persons totalled 99 of whom 16 were women.

309. **Prek Po**. The meeting at Prek Po was held at Prek Po Commune, Srey Santor District, Kampong Cham Province. Participants comprised ADB's consultant team members, local farmers, and commune and village officials. Potentially affected persons totalled 49 of whom five were women. Six communes were represented - Prek Po, Khnar Sa, Pram Yam, Svay Pou, and Tong Tralach.

310. **Canal 15**. The meeting at Canal 15 was held at the Prey Run Pagoda in Daun Keo. Participants comprised ADB's consultant team members, local farmers, and commune and village officials. Potentially affected persons totalled 19 of whom 3 were women. Three communes were represented - Baray, Sambur and Sangar.

311. The format of all meetings was a presentation of the project by the TRTA team followed by open discussion and the filling out of questionnaires. A summary of environmental issues raised both during discussion and in the questionnaires is given in Table 73.

Table 73: Environmental/Agricultural Issues arising from Public Consultation

Questions	Kamping Pouy SP		Prek Po SP		Canal 15 SP	
	Frequency (No.)	Percentage	Frequency (No.)	Percentage	Frequency (No.)	Percentage
Q 1. Are you satisfied with local environmental quality?						
Q.1.1 Very satisfied	0	0	0	0	0	0
Q.1.2 Satisfied	79	80	45	92	0	0
Q.1.3 Not satisfied	20	20	4	8	16	100
Q 2. What is the main local environmental issue?						
Q.2.1 Bad air quality	69	70	0	0	0	0
Q.2.2 Bad water quality	0	0	0	0	0	0
Q.2.3 Noise pollution	0	0	0	0	0	0
Q2.4 Solid Waste	30	30	49	100	16	100
Q.2.5 Bad ecological environment	0	0	0	0	0	0
Q3. What impact that you think the project will bring?						
Q3.1. Good impact	89	90	49	100	16	100

Questions	Kamping Pouy SP		Prek Po SP		Canal 15 SP	
	Frequency (No.)	Percentage	Frequency (No.)	Percentage	Frequency (No.)	Percentage
Q3. 2. Adverse impact	0	0	0	0	0	0
Q3.3. No idea	10	10	0	0	0	0
Q4. What is your main concern during the project construction period?						
Q4.1. Noise					0	0
Q4.2. Dust	10	10	5	10	0	0
Q4.3. Water Resource Pollution	0	0	5	10	0	0
Q4.4. Ecological damage	0	0	0	0	0	0
Q4.5. Not convenient for farming	89	90	39	80	0	0
Q4.6. Not convenient for getting to school	0	0	0	0	0	0
Q4.7. Siltation from improvement canal	0	0	0	0	16	100
Q5. Are you going to make complaint if the project has impact to your daily life?						
Q5.1. Yes					16	100
Q5.2. No					0	0
Q5.3. It depends on the level of impact	99	100	49	100	0	0
Q6. Who you will refer to if you are going to make complaint?						
Q6.1. Contractor	0	0	0	0	0	0
Q6.2. Local PDRAM office	0	0	0	0	0	0
Q6.3. Other government agency	0	0	0	0	0	0
Q6.4. Village Leader	99	100	49	100	16	100
Q6.5. Commune Leader	0	0	0	0	0	0
Q7. Do you agree the project location?						
Q7.1. Yes	99	100	49	100	16	100
Q7.2. No	0	0	0	0	0	0
Q7.3. Do not care	0	0	0	0	0	0
Q8. What impact that you think the project will bring to your daily life?						
Q8.1 Good impact	89	90	49	100	16	100
Q8.2. Adverse impact	0	0	0	0	0	0
Q8.3. No idea	10	10	0	0	0	0

Source: TRTA consultants, from respondent data.

B. Project Responses

312. Similar issues concern farmers in all the schemes. These are reported below as (i) current environmental issues; (ii) concerns about design; and (iii) concerns during construction.

313. **Current environmental issues**. The main existing environmental issue was garbage – expressed as:

- discarded pesticide packaging;
- no garbage management service or disposal site; and
- garbage accumulating in canals.

314. The accumulation of waste in canals restricts flow and degrades water quality. There are also health and safety risks from the accumulation of garbage and discarding of pesticide packaging. The TRTA has designed a solid waste management component to be included in project implementation to assist local authorities in managing this problem. The component will focus primarily on the commune of Prek Po, but will have the potential for wider application where loan funds allow.

315. **Design issues**. There was general agreement that the subprojects should ensure that main and secondary canals were provided with sufficient bridges to allow convenient access of farmers to their blocks, and that canal bank roads should be constructed to withstand erosion and gullying.

316. Canal bridges and consolidated levee roads are included in project concept design. Detailed design has taken into account the movement patterns in the command area to finalize siting and specifications of these features.

317. **During construction**. Concerns were expressed for scheduling of construction and it's potential to interfere with farming activities – particularly harvest. Farmers expected "many negotiations" with the PMU and contractor during this period to ensure smooth operations. Dust creation during construction was another concern. Construction scheduling is an important part of impact mitigation. At Canal 15, the project will remove silt from the main and secondary canals, however there is no road to transport to remove spoil from the construction site. Participants suggested widening embankments with the spoil.

318. Agreement on construction schedules with community and continued consultation during construction is included in the IEE (Sections V.C.2 and 4 above) and EMP. Dust management is included in the IEE at section V.C.2 above.

319. The issues raised during public consultation, the project response (in terms of mitigation and/or management) and follow-up are listed in Table 74.

Table 74: Issues Raised and Project Response

Issue	Project Response	Confirmation and Follow-up
Discarded pesticide packaging	IPM training and support will include the proper handling of chemicals and safe disposal of packaging.	Training refreshers and training impact assessment by PMIC.
Lack of garbage management service or disposal site and garbage accumulating in canals	TRTA has designed a solid waste management component for project implementation. Will focus on enhancing and extending any existing arrangements.	Project implementation monitoring and Project Monitoring Framework.
Provision of sufficient canal bridges to allow access	Bridge locations designed after consultation on access needs with farmer communities during site surveys	Confirmation by PMIC during DED phase. Public consultation during pre-construction (see ongoing Public Consultation Plan below).
Canal bank roads to withstand erosion and gullying	Major canal bank roads designed as laterite roads.	Road maintenance and O&M supported by project in year 1.
Construction interfering with farming activities	Scheduling of construction activities to be based on informed consent of local communities.	EMP compliance monitoring by PMIC.
Reuse of dredge spoil on embankments and difficulty in removal from site (Canal 15)	Detailed bill of quantities and design to investigate use of spoil on embankments without raising profile significantly.	Detailed design and EMP compliance monitoring by PMIC
Dust creation during construction	Site watering, dust shrouds and public consultation prescribed in EMP.	EMP compliance monitoring by PMIC.
Expectation of "many negotiations" with the PMU and contractor	Ongoing Public Consultation Plan included in EMP implementation.	Plan has its own follow-up in post construction consultations.

Source: TRTA Consultants.

320. **Grievances and complaints**. Participants from the subproject areas were asked how they normally went about lodging complaints about environmental issues affecting livelihood, safety and amenity. The common response was that first contact for complaints is the village leader, who passes the complaint to the commune chief who either deals with the complaint directly or engages the appropriate district or provincial government agency for a response. This accepted pathway for complaints is included as sub-project-specific entry points into the project grievance redress mechanism (GRM).

C. Ongoing Public Consultation

321. Meaningful consultation to safeguard the environment and local residents will continue throughout the construction and operation phases. The implementing agencies will be responsible for organizing the public consultations, with the support of the project implementation consultant. Civil works contractors will be required to frequently communicate and consult with the communities in the project area of influence, especially those near the project areas. Eye-catching public notice boards will be set at each work site to provide information on the purpose of the project activity, the duration of disturbance, the responsible entities on-site (contractor, implementing agency), and the grievance redress mechanism (GRM). This plan is included as part of EMP and costs are included in EMP implementation costs.

Table 75: Environment Consultation and Communication Plan

Organizer	Format	Frequency	Subject	Attendees
Pre-Construction Stage				
PMUs, FWUCs, CCs, Implementation consultant	Targeted public consultation & site visits	Before construction at each site	Agreement with affected persons and sensitive receivers on heavy machinery work. Consultation on safety of nearby communities.	Affected persons in impacts zone of construction activities
Construction Stage				
PMUs, FWUCs, CCs, Implementation consultant	Public consultation & site visits	Once each year during construction	Adjusting of mitigation measures, if necessary; construction impact; comments and suggestions	Residents in project areas

CC = commune council; EMP = environmental management plan; FWUC = farmer water use communes; PMU = project implementing unit.
Source: TRTA consultants.

VII. GRIEVANCE REDRESS MECHANISM

322. A grievance redress mechanism (GRM) will be established for the subprojects in compliance with ADB SPS (2009). ADB requires that the borrower/client establish and maintain a GRM to receive and facilitate resolution of affected peoples' concerns and grievances about the borrower's/client's social and environmental performance at the project level.

323. The PMU will establish a Project Public Complaint Unit (PPCU) which will act as a central recording and coordinating unit for all subprojects under the Project. The PMU will ensure that the GRM is publicized locally so that the community is fully aware of the mechanism and the local points of entry to it.

324. The entry points for the GRM will be, first of all, at the local level. Since the contractor will be the most direct contact for the initial complaint and also for correcting the work practice which causes the complaint and providing redress, the contractor will assign an employee as the GRM contact person and ensure that people know how to contact them at all times.

325. Before construction starts, signs will be erected at each construction site and put on bulletin boards at the commune council office and community centers providing the public with updated project information and summarizing the grievance redress mechanism process including details of the GRM entry points.

326. The preferred action sequence for complaints handling is that the complaint should be investigated and resolved by the local unit receiving the complaint. If this is not possible, the complaint can be referred to higher levels. At any stage affected persons can report issues to ADB project team, Cambodia Resident Mission, or South-East Region Department (SERD). If issues cannot be effectively resolved through the project GRM and ADB project teams, the ADB accountability mechanism can be accessed.

327. The PPCU will maintain records of complaints and actions taken to correct them. This data will be included in MOWRAM's quarterly and semi-annual safeguard reports to the ADB.

328. A full description of the GRM processes, as well as the establishment, recording and reporting required for its successful operation is in the EMP (Section G).

VIII. CONCLUSION AND ASSURANCES

A. Positive Impact and Environmental Benefits

329. The result of the project irrigation and drainage facilities will be (i) an increase in certainty and control of existing irrigation areas; (ii) expansion of reliable irrigation; (iii) longer cropping periods on areas previously unavailable for parts of the year due to flooding; and (iv) more robust infrastructure and practices against climate change and natural disasters. This will not only lead to increases in area and yield but also, through capacity building and training, a number of additional benefits which will improve environmental conditions in the irrigated farming communes. This will include integrated pest management, efficient use of fertilizer and water conservation farming practices

330. Integrated pest management will promote a reduction in the amount of pesticides used, resulting in reduced movement of pesticide residues in surface water, reduced risk of leaching of residues into groundwater, and will include safeguards for farmers in the safe handling and use of chemicals. Fertilizer needs will be matched to soil nutrient levels and crop/water conditions to avoid overuse and leakage of nutrients into water resources. Training in farm water management to use water more efficiently (e.g. through alternate wetting practices rather than flooding) will conserve seasonal water resources.

331. In terms of sustainable areas sown as a result of increased irrigation, the project will increase potential growing areas by 4,000 ha in the dry season at Kamping Pouy, up to 7,620 ha in the wet season and 6,800 ha in the dry season at Prek Po and 1,500 ha in the early wet season at Canal 15. The beneficiaries of these changes will be local farmers, with flow-on effects to local commercial enterprises. Since rural populations are the poorest sectors of the Cambodian population, poverty alleviation effects will be direct and sustainable.

332. At Prek Po the main canal becomes clogged with domestic garbage due to the deficiencies of solid waste management services. A solid waste management component for Prek Po commune, comprising support for existing disposal site improvements and development of a community based waste management and action plan, has been designed and will be included in the project implementation phase, and supported by a solid waste specialist on the PMIC team.

333. The total CO_{2e} emissions generated by the combined three subprojects is low, at 40,072 tons/annum. The reconfiguration and modernization of secondary canals and the planning of tertiary canals in the subprojects to maximize water delivery to farm fields through gravity will reduce the use of small pumps (which accounts for just under 50% of the total GHG generation) and will further reduce the GHG generation from this source. The replacement of inefficient diesel pumps at the Samput pumping station with electric pumps will also result in significant GHG savings.

334. The project investments will increase the subproject areas' resilience to climate change and climate-induced disasters. The measures include design of civil works for extremes of flood and drought as well as capacity building of FWUCs and farmers to improve understanding and planning for farming in a changing climate and disaster preparedness.

B. Potential Negative Impacts and Mitigation

335. During construction, the main potential impacts will be air and water pollution, noise and dust, and earthworks and spoil disposal - all of which will be managed by strict control by construction contractors and supervisors.

336. Disruption to local livelihood activities can occur during construction and this will be minimised by work scheduling, site access, consultation and safety planning. Mitigation of construction-phase impacts relies heavily on responsibility of works contractors to follow specified clauses and to effectively implement measures to minimise pollution of air and water and soil

erosion. The sediment quality of spoil from channel dredging in the subprojects will need to be tested and assessed against the relevant standards before reuse. The sediment testing results will determine the requirements to ensure safe reuse.

337. In the operation phase, potential for local increases in the levels of agricultural fertiliser and pesticide residues and their effects on water quality and people will be addressed by capacity building and training under the project to use fertilisers and pesticides efficiently and responsibly. Training in farm water management to use water more efficiently will conserve seasonal water resources.

338. The Feasibility Study Reports for the subprojects have demonstrated that water for the planned levels of irrigated cropping is available and sustainable. To ensure the sustainability of the Kamping Pouy subproject and protection of the Mongkol Borey system from over-extraction, the Kamping Pouy Reservoir JOROP will manage water extractions so that that water is only drawn from the Mongkol Borey during wet season.The EMP requires clear and detailed water extraction plans for the cropping seasons, in line with the water use parameters established in the Feasibility Study Reports, to be prepared as part of the schemes' operating procedures and submitted before construction commences.

339. The release of untreated urban greywater at Prek Po into the irrigation area will be managed. Domestic greywater runoff from houses along the main canal at Prek Po, which will be intercepted by pipelines as part of the redevelopment of the main canal, will be treated before discharge.

C. Assurances

340. The most important assurance, which will be guaranteed by a loan covenant, is that: The Government will ensure that the preparation, design, construction, implementation, operation and decommissioning of the Project and all Project facilities comply with (a) all applicable laws and regulations of the Kingdom of Cambodia (Cambodia) relating to environment, health and safety; (b) the provisions in ADB's Safeguards Policy Statement, 2009 (SPS) relating to the environment; and (c) all measures and requirements set forth in each Initial Environmental Examination (IEE), Environment Management Plan (EMP), and any corrective or preventative actions set forth in a Safeguards Monitoring Report to be provided to ADB.

341. An assurance in support of the GRM is that: The Government will ensure that separate safeguards grievance redress mechanisms acceptable to ADB are established in accordance with the provisions of the IEE, EMP, and Resettlement Plan at the project management unit, within the timeframes specified in the relevant IEE, EMP, and Resettlement Plan, to consider safeguards complaints; and that any contractor damage outside the compensated guidelines of the project is to be compensated at the contractor's expense in accordance with agreed rates in the entitlement matrix and any temporary damage restored to pre-project condition.

D. Conclusion

342. The majority of identified environmental impacts are not assessed as significant. It is concluded that: (i) the infrastructure subprojects planned for the Kamping Pouy, Prek Po and Canal 15 subprojects have significant potential benefits for the rural populations of these areas, and that: (ii) the design features, operational regimes and construction management safeguards will address the range of potential environmental impacts identified and will be actioned through the Project EMP and effectiveness verified through the environmental monitoring program and reports.

343. The environmental assessment has confirmed that the subprojects are environment Category B under the ADB SPS and that the design, mitigation measures and management identified in the IEE, when effectively implemented, reduce impacts to an acceptable level.

ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

1. The environmental management plan (EMP) covers all phases of subproject implementation from preparation through commissioning and operation, and it aims to ensure the monitoring of environmental impacts and effective implementation of environmental mitigation measures. Relevant EMP management measures will be incorporated into the pre-construction, construction and operation phases of the project. Environmental protection measures will (i) avoid, and (ii) where avoidance is not possible, mitigate environmental impacts, and (iii) achieve compliance with national environmental regulations and ADB Safeguard Policy Statement (SPS) 2009.

2. Environmental monitoring programs will be carried out and the results will be used to evaluate the extent and severity of actual environmental impacts against the predicted impacts, the performance of the environmental protection measures and any need for adjustments.

3. The detailed design for the civil works in two of the three subprojects was completed in the first half of November 2018. This EMP has been amended following detailed design.

B. Responsibilities for Implementation

4. The implementation arrangements are summarized in Table A.1 below.

Table A.1: Institutional Arrangements

Institutions/ Communities	Roles and Responsibilities
MOWRAM	• Overall responsibility for the project • Coordinating with other government institutions and donor to facilitate project implementation • Coordinate with MOE on environmental safeguards including bird conservation activities. • Ensure compliance with social and environmental safeguards as per the ADB SPS (2009), • Submit quarterly progress reports and semi-annual environmental monitoring reports to ADB
PMU	• Day to day management of the implementation of the project • Appoint Environmental Management Officer (EMO), who will coordinate with the environment specialists of the PMIC on EMP and GRM implementation, environmental monitoring and reporting. • Prepare quarterly progress report and report to MOWRAM • Supervise the work of Contractors • Coordinate with local bodies and communities for their participation
Design and Supervision Consultant (DSC)	• Ensure pre-construction EMP measures are implemented • Work with PMU and PMIC on detailed design (Canal 15 subproject) • Update EMP as required in detailed design phase (Canal 15 subproject)
Project management and implementation consultant PMIC	• Support MOWRAM in the coordination with different government ministries and donor for obtaining necessary approvals • Design and implement the capacity building programs for the ministry staffs and staffs of provincial department of the ministry • Monitoring the work of contractors in compliance with covenants of the contract.
Contractors	• Implementation of the civil works during the construction phase of the project. • Preparing,implementing and reporting to the PMU (monthly) on Site Environmental Management Plans (SEMPs) for each subproject. • Ensuring the compliance with the Occupational Health and Safety standards.

Institutions/ Communities	Roles and Responsibilities
	• Appointing an EHS officer who will be responsible for daily and weekly monitoring and reporting on EHS. • Training of the workforce in Good Practices in construction management and waste management in the construction sites.
FWUC	• Participate in the management of the command area to the benefit of all water users. • Coordinate with different government departments and other FWUCs to maximize the benefits of the project.
Local authorities and communities	• Participate in the project developments. • Raise issues/concerns via GRM and public consultations carried out during implementation.

MOWRAM: Ministry of Water Resources and Meteorology; PMU: Project Management Unit, PMIC: Project Management and Implementation Consultant, FWUC: Farmer Water User Communes
Source: TRTA Consultants.

5. Support in bid preparation, and construction supervision will be undertaken by a Design and Supervision Contractor (DSC). The DSC will support the PMU to prepare tender and contract construction documents.

6. The PMU will remain the subproject owners and will award the contract, manage the contract, and monitor the construction. The DSC will assist them to monitor construction standards and facilitate monthly coordination.

7. For the environmental aspects of the project, the PMU will assign a suitably qualified staff member to be the project Environmental Management Officer (EMO), who will inspect active work sites monthly and report quarterly on the results of the Environmental Monitoring program to the EA. Terms of reference for the EMO position is at **Annex A** of the EMP.

8. Project Management and implementation consultants (PMIC) will include environment specialists who will work with the EMO and assist the PMU to fulfil its environmental responsibilities in implementing subproject EMPs. The specialist will also prepare inputs for the quarterly project progress report to MOWRAM and to the semi-annual environmental monitoring reports for ADB. The PMIC specialists will be contracted for the duration of the loan implementation period, and will ensure that:

(i) The mitigation measures and monitoring of these activities are carried out in accordance with the EMP;
(ii) The environmental monitoring program, comprising the of taking samples and analysis are being carried out;
(iii) The environmental training (in EMP implementation) is delivered;
(iv) The GRM is properly established and publicized; and
(v) Reporting is performed in compliance with ADB and government requirements.

9. Terms of reference for the PMIC international and national environment specialist positions are included in **Annex B** and **C** of the EMP.

C. Summary of Potential Impacts and Mitigation Measures

10. Table A.2 summarizes the potential impacts of the subprojects during construction and operation as identified by the initial environmental examination (IEE), as well as corresponding mitigation measures designated to minimize those impacts.

11. The mitigation measures will be incorporated into tender documents, construction contracts, and operational management procedures. Contractors, commune councils and the PMU will implement these measures, depending upon subproject phases. The effectiveness of these measures will be carefully monitored to determine whether adjustments are needed.

12. The majority of costs associated with the implementation of the following measures will be absorbed within the costs for (i) detailed design, (ii) construction contracts, and (iii) operation and maintenance budgets. Estimated costs are provided in the following table as line items (EMP Implementation training and GRM establishment) or, in the case of construction costs, to provide an indication of the scale of the measure and to assist in assessing construction tenders (to see whether adequate allowance is made for mitigation measures).

13.

Table A.2: Summary of Potential Impacts and Mitigation Measures

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
Pre-construction							
1.1 Design stage	Final site designs	Final designs of embankments, siting of control structures and canal cross-sections for Canal 15 will be completed after taking into account all the provisions of the EMP (below).	PMU and PMIC	EA	Design costs		
		Undertake a program of systematic sampling of sediment in all main and secondary canals for dredging	PMIC and PMU	EA and ADB	Costs in monitoring plan (Table A3.3)		
		Prepare dredge spoil management plan based upon the sampling program and contamination "triggers" in West Australian *Assessment levels for Soil, Sediment and Water (2010).* Incorporate reuse categories in detailed design.	PMIC and PMU	EA and ADB	Design costs		
		At Canal 15 spoil disposal from canal dredging needs to be disposed of on site (due to lack of access). The calculation of quantities, where it can be placed and the careful contouring of embankments to guard against changing flood behaviour will be undertaken during detailed design.	PMU, DSC and PMIC	EA	Design costs		
	Irrigation extraction planning and command area management	Water allocations and drainage will be documented and approved by the FWUCs, EA and ADB before procurement and construction commences.	PMU and PMIC	EA, ADB	Design costs		
		At Kamping Pouy scheme, JOROP will be set up and operational plan developed by stakeholders (PDWRAM and FWUCs).	PMU and PMIC	EA	Design costs		
	Samput pump station (Canal 15)	Undertake noise modelling of operating pump station and received noise levels at nearest residence.	PMU/DSC to contract	PMIC	-	-	5
		Design of Samput pump station to include noise insulation of pump house and covering of pump outlet areas to achieve operational	PMU and DSC	PMIC, EA	Design costs		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		noise levels not exceeding 55 dB at nearest residence,					
	Prek Po Solid Waste Management component	Implement the solid waste management component as specified in the project PAM, comprising: (i) direct support for disposal site improvements and collection; and (ii) development of a community based waste management and action plan for local authorities.	PMIC and Prek Po Commune Council	ADB	Project loan funds		
1.2 Construction preparation stage	Environmental management budget	Confirm budgets for the implementation of environmental management measures and environmental supervisory responsibilities. Assign final budget allocations against each of the items in the EMP.	PMU and DSC	EA, PMIC	Design costs		
	Environmental approvals	Approval of project will be obtained from MOE before contracts are awarded	DSC, PMU	EA	Design costs		
	Incorporate environmental management into contract documents	Contract documents: Preparation of the environment section in the terms of reference for bidders for construction contracts, and environmental contract clauses for contractors, namely the special conditions for the protection of the water, soil and air environments (referencing the EMP and monitoring plan).	DSC, PMU and PMIC	EA	Design costs		
1.3 Construction support preparation	Environmental education and awareness	Environmental protection training: Environmental specialist of the PMIC will provide training on implementation and supervision of environmental mitigation measures to PMU and contractors. This will include training in the preparation and implementation of construction Site Environmental Management Plans (SEMP)	PMIC	EA	EMP training budget		
					5	5	5
	Complaints procedures	Grievance redress mechanism established and local contact points publicized. Install sign boards with GRM contacts and procedures at each construction camp and active construction site.	EA and PMU	PMIC	Part of project design		
					4	4	4

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
	Site planning	Prepare a SEMP for each subproject which incorporates the relevant provisions of this EMP for each subproject construction site. The plan will also include an emergency preparedness and response plan for construction emergencies, site environmental health and safety plan, identification of sensitive receptors and vegetation to be retained.	Contractors	PMU	Part of construction costs		
		The main contractor for each subproject will appoint an EHS officer who will be responsible for daily and weekly monitoring and reporting on EHS.	Contractors	PMU	6	4	6
		At all sites, trees to be retained will be clearly marked.	PMU, DSC	PMIC	Design costs		
	Work Schedules	Prepare works schedules as part of each SEMP. The work plan and scheduling will be approved by the commune councils, taking into account the need for access during harvesting and planting periods. To include (i) sequential work scheduling (to ensure that only short stretches are worked on at a time), and (ii) provision of access to existing residences and services.	Contractors	CC, PMU	Part of construction costs		
					In SEMP preparation costs above		
	Temporary land occupation	Temporary land occupation for construction planned in the SEMPs and approved by CC and landowners with appropriate written and signed agreements. Construction easement, including stockpile sites and access ways will be clearly delineated in the plan and marked on the ground to ensure equipment operators stay within these boundaries. Construction adjacent to paddy fields during rice planting or harvesting should be avoided or carried on strictly in consultation with the appropriate farm operator.	Contractors, CC, PMU	PMIC	Part of construction costs		
					In SEMP preparation costs above		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		All land will be reinstated to its original condition after construction.					
	Traffic management	The SEMP will include a traffic management plan which will be prepared in consultation with the communities through which transport routes pass. The plan will cover identified haulage routes and identified haulage times.	Contractors	PMU	In SEMP preparation costs above		
	Monitoring and reporting checklists	Establish checklists and monitoring report templates for contractor EHS officers and PMU environment officer.	PMU, PMIC		In SEMP preparation costs above		
Construction							
2.1 Water	Construction wastewater	Construction wastewater will not be discharged directly onto the surrounding soil or into surface water systems. All wastewater to be passed through silt traps or temporary sedimentation screens. Oil-containing wastewater will be intercepted, collected and transported to vehicle servicing area for treatment and disposal.	Contractors	PMU	4	3	5
		Construction work in canals with existing water will: (i) ensure irrigation water is unpolluted by construction wastewater or siltation; (ii) ensure that work during any irrigation period is co-ordinated through consultation with farmers using the canal.	Contractor	PMU	Construction costs		
	Polluting materials	To prevent pollution of soil and surface water/groundwater: (i) storage facilities for	Contractors	PMU	Construction costs		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		fuels, oil, cement, and chemicals will be within secured areas on impermeable surfaces, provided with bunds and clean-up installations; (ii) vehicle, machinery, and equipment maintenance and re-fuelling will be carried out in such a way that spilled materials do not seep into the soil; (iii) oil traps will be provided for service areas and parking areas; (iv) fuel storage and refuelling areas will be located at least 50 m from canals and channels and will be protected by spill trays and temporary drainage bunds. All spills will be cleaned up and spill material removed from site.			7	7	7
2.2 Air	Air quality	Equipment will be maintained to a high standard to ensure efficient running and fuel-burning. All vehicles and machinery to be used in construction to be inspected and approved for clean running.	PMU and PMIC	EA	Construction costs		
					3	4	3
	Dust	Material stockpiles and concrete mixing equipment will be equipped with dust shrouds. For both construction sites and construction roads, water spraying for the suppression of dust and maintenance of driving surfaces will be standard site management practice. Vehicles carrying soil, sand, or other fine materials to and from the construction sites will be covered. For the residential areas alongside the covered main canal works in Prek Po town (Figure A.4), this will include extensive public consultation before works commence, temporary dust shrouds for work sites and planning of access routes with informed consent of residents.	Contractors	PMU	Construction costs		
					3	7	3

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
2.3 Noise and vibration	Noise impacts on sensitive receivers	Construction at night within 700 m of residences and sensitive receptors shall be strictly prohibited. During daytime construction, the contractor will ensure that: (i) equipment with high noise and high vibration are not used in village or town areas and only low noise machinery or equipment with sound insulation is employed; and (ii) sites for concrete-mixing plants and similar activities will be located at least 500 m away from sensitive areas such as residences and schools and only operated in daytime. When daytime construction is scheduled to move within 150m of identified sensitive receptors residents will be notified by the PMUs and/or contractors and any site-specific concerns or working arrangements addressed. These are located in Figures A.1, A.2, A.3, A.4 and A.5 below: For the residential areas that are close to the covered main canal works in Prek Po town (Figure A.4) this will include extensive public consultation before works commence, temporary noise barriers for work sites and planning of access routes with informed consent of residents.	Contractors	PMU, PMIC	Construction costs		
					5	15	2
2.4 Solid wastes	Demolition waste	Any waste from the demolition of structures will be either sold to building material recyclers or collected and transported to official landfill sites. Metal parts will be broken up and sold to scrap metal merchants. Any excess spoil will be made available to nearby communities for use as building pads and bunds.	Contractors	PMU	Construction costs		
					3	5	3
	Excavated channel spoil	Implement dredge spoil management plan. Dispose of sediment in one of three ways, depending upon sediment quality testing:	Contactor and PMU	EA	Monitoring costs included in monitoring plan (Table A.3)		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		• Safe to reuse as required – no contamination above threshold levels • Managed use – contaminants present at low to medium levels which can be immobilized by incorporation in embankments or building pads if covered with clean (safe) fill • Restricted use – sediments unsuitable for housing pads or flood refuge areas. Only to be used in canal embankments if contained in impermeable layers			Construction costs		
					8	8	14
	Waste from workers	Contractors will provide sufficient garbage bins at strategic locations and ensure that they are (i) protected from birds and vermin; (ii) are not left to overflow; and (iii) the garbage is removed from site for proper disposal at local licenced facility.	Contractors	PMU	Construction costs		
					1	1	1
2.5 Soil erosion and ecology	Erosion impacts	Erosion control will include: (i) limiting construction and material handling during periods of rains and high winds; and (ii) temporary protection of all cut slopes, embankments, and other erosion-prone working areas while works are going on. All earthwork disturbance areas shall be stabilized within 30 days after earthworks have ceased at the sites.	Contractors	PMU	Construction costs		
					3	2	2
	Flora and fauna	Clearing of vegetation along canal embankments and levees will be minimized, to assist in stabilization and retention of habitat values. Trees marked for retention will be protected and any removed native trees will be replaced.	Contractor	PMU	Construction costs		
					3	2	2
2.6 Social and cultural	Impacts to local cultural sites	The baseline survey reported no physical cultural sites in the subproject areas. There	Contractors	PMU	Construction contingency costs		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		may still be sites or items which are important at a local or household level, contractors will ensure that all local cultural sites (including small shrines and graves) will be kept clear of construction material and protected from dust and other disturbance. Access to these sites will not be impeded. After construction is finished any disturbed surroundings will be restored to pre-construction standards.			1	1	1
	Physical cultural resources – chance finds	In the event of chance finds, work at the locality will cease and local representatives of the Ministry of Fine Arts and Culture will be called in to advise what actions, if any, need to be taken before work can continue.	Contractors	PMU	-	-	-
	Construction damage	Ensure that any temporary damage that is not covered in the marked and agreed construction easement is compensated promptly by the Contractor in line with the project entitlement matrix.	Contractor, PMU	CC, PMIC	Construction contingency costs		
2.7 EHS	Community health and safety	Community health and safety will be safeguarded by: Planning construction activities so as to minimize disturbances to residents, utilities and services. Temporary land occupation and access to work sites will be planned well ahead of construction in the CEMP to minimize its impact and after consultation with the affected community. Where existing access is temporarily obstructed, temporary alternative safe access will be provided and affected persons are informed in advance of access issues and alternatives.	Contractors and contractor's EHS officer	PMU, DSC	Construction costs		
					4	7	4

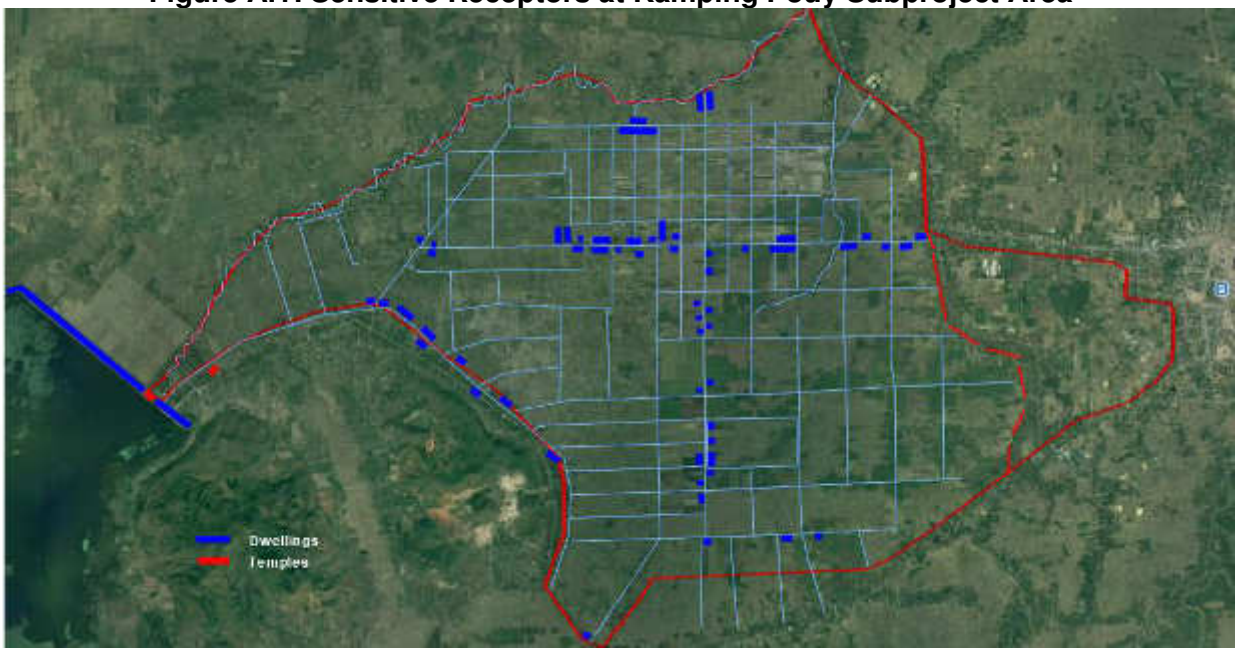
Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		Implementing safety measures around the construction sites to protect the public, including warning signs to alert the public to potential safety hazards, barriers to prevent public access to construction sites and a watch person, where necessary. Ensure regular co-ordination and consultation between contractor's EHS officer and village heads to ensure that any concerns are addressed quickly. Ensure community is aware of the project GRM and its contact points. The Contractor EHS officers will carry out daily inspections and weekly audits to ensure safe and hygienic working environment is maintained. They should provide induction and regular informal refreshers to contractors on site on subproject EHS requirements.					
	Occupational health and safety	Contractors shall ensure that: (i) all reasonable steps are taken to protect any person on the site from health and safety risks; (ii) the construction site is a safe and healthy workplace; (iii) machinery and equipment are safe; (iv) adequate training or instruction for occupational health and safety is provided; (v) adequate supervision of safe work systems is implemented; and (vi) means of access to and egress from the site are without risk to health and safety.	Contractors and contractor's EHS officer	PMU, DSC	Construction costs		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
		The Contractor EHS officers will carry out daily inspections and weekly audits to ensure the works area is safe and hygienic for farmers and community members passing through or using the areas. They should provide induction and regular tool box talks to contractors on subproject EHS requirements.			3	3	3
2.8 Unexpected environmental impacts		If unexpected environmental impacts occur during project construction phase, the PMU and PST will update the EMP, and environmental protection measures will be designed and resources will be utilized to cope with these impacts.	PMU	EA	Construction contingency costs		
					2	2	2
Operation							
3.1 Management of irrigation	Implementation of extraction and drainage plans	Irrigation schemes to be operated strictly in concurrence with agreed extraction and irrigation plans which ensure sustainability of supply.	EA and PMU	EA, PMIC	Operations cost and capacity building outputs		
	JOROP operation at Kamping Pouy	The Joint Reservoir Operation for the Kamping Pouy Scheme (JOROP-KAPOS) will ensure that (i) water release from the reservoir and diversion from the Mongkol Borey is regulated, based on water storage and distribution plans; (ii) minimal water is diverted from the Mongkol Borey in the dry season; and (iii) the planned topping-up of the Kamping Pouy reservoir during the wet season by the subproject does not impact on wet season beneficial uses downstream. The JOROP should consult with FWUCs or communes of the downstream schemes.	JOROP	PMIC, PDWRAMs of Battambang and Bantheay Meanchey provinces	Operations cost		

Item	Environmental Impacts and issues	Mitigation Measures and/or Safeguards	Who Implements	Who Supervises	Budget Source and Cost estimates ($1000)		
					KP	PP	Cnl15
	Agricultural chemicals use	Farmers will be trained in IPM to reduce chemical use. Training will include safe handling, application and disposal of pesticides.	PMIC and PMU	EA	Costs under project capacity building outputs		
3.2 Pump noise	Noise impact on residents	Based on monitoring results of actual noise levels in operation (Table A.3), erect noise barrier to mitigate noise levels at houses on the western side of the Prek Po pump station Pumps will not operate overnight between the hours of 22.00 and 08.00.	PMU	PMIC	Included in monitoring costs. Noise protection cost in scheme improvement funds		
		Based on monitoring results of actual noise levels in operation (Table A1.3), adjust sound insulation of Canal 15 (Samput) pump station to achieve design noise generation level	PMU	PMIC	Included in monitoring costs, Adjustment cost in operational contingency		
3.3 Treatment plants	Maintenance and sediment removal	At Prek Po greywater treatment facilities, the operator will establish and implement a program of routine 6-monthly sediment inspection and removal as necessary to ensure operational efficiency.	PMU	PMIC, EA	Operations costs		
3.4 Emergency response planning	Floods and extreme weather events	The project will promote the enhancement of community based disaster risk reduction and disaster management programs at the irrigation and drainage communes with particular reference to flooding, drought and other natural disasters.	Project output	ADB	Directly funded under DRR Grant funds		

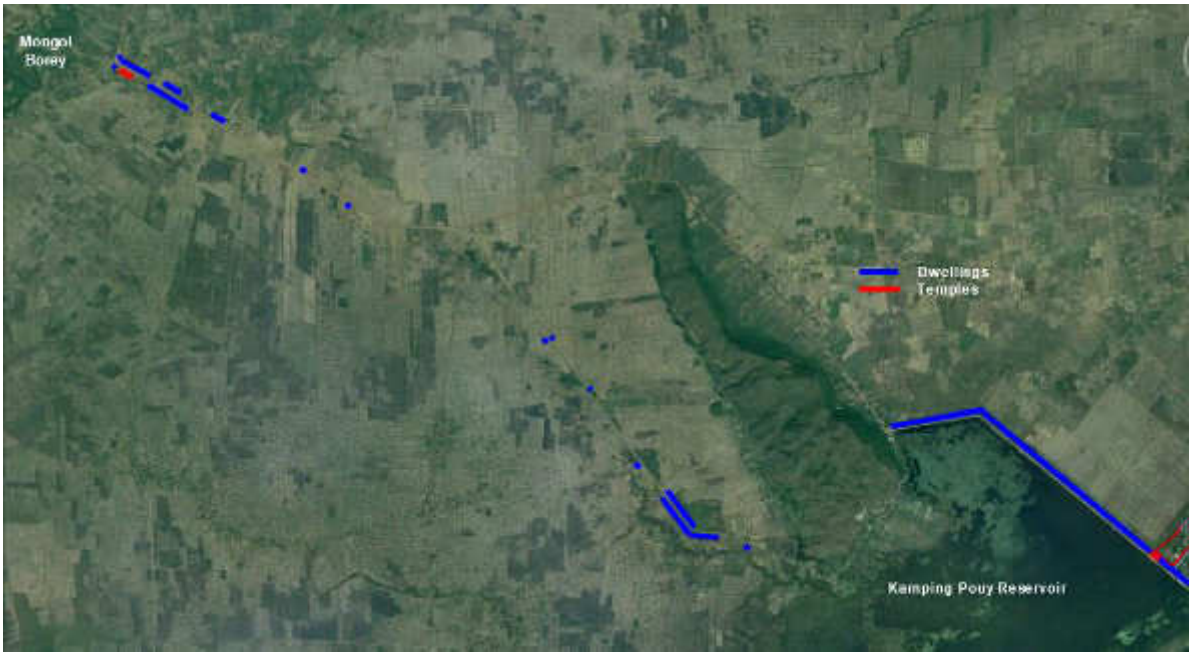
KP = Kamping Pouy; PP = Prek Po; Cnl15 = Canal 15; ADB = Asian Development Bank; PMU = Project Management Unit; EHS = World Bank Group's Environmental, Health and Safety Guidelines; CEMP = construction environmental management plan; EA = executing agency; DSC = Design and Supervision Consultant; EMP = environmental management plan; IPM = Integrated Pest Management; PMIC = Project Management and Implementation Consultant; MOE = Ministry of Environment; O&M = operation and maintenance.
Source: TRTA consultants.

Figure A.1: Sensitive Receptors at Kamping Pouy Subproject Area



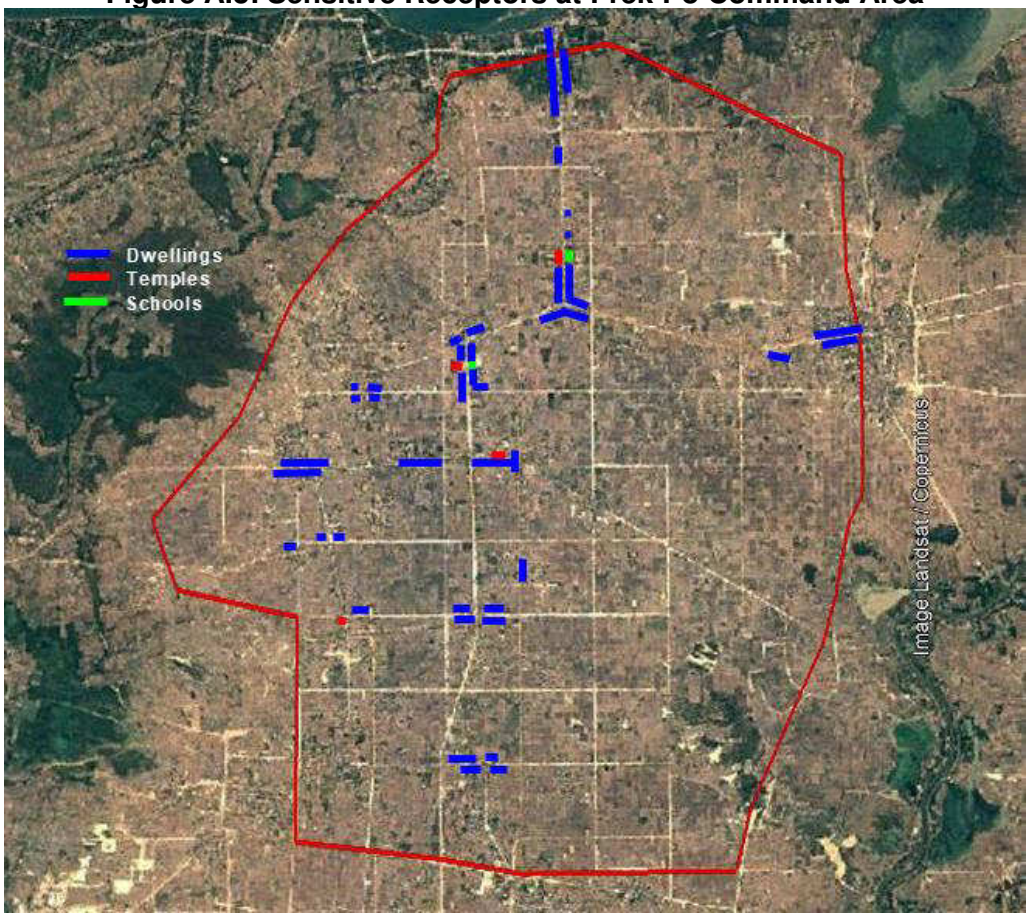
Note: Cross-referenced to Item 2.3 in Table A.2: Summary of Potential Impacts and Mitigation Measures.
Source: TRTA consultants, from Field Observations 2018.

Figure A.2: Sensitive Receptors along the Link Canal (Kamping Pouy subproject)



Note: Cross-referenced to Item 2.3 in Table A.2: Summary of Potential Impacts and Mitigation Measures.
Source: TRTA consultants.

Figure A.3: Sensitive Receptors at Prek Po Command Area

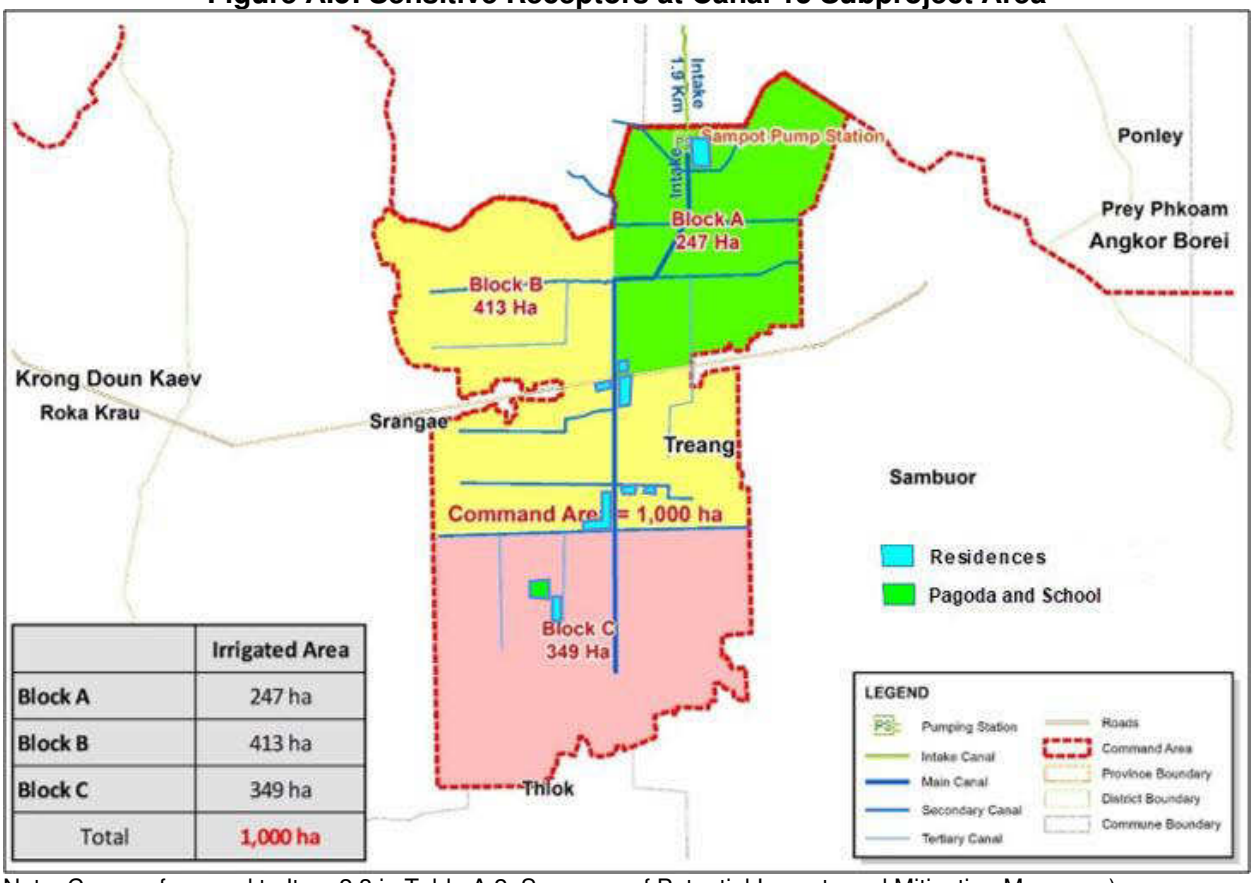


Note: Cross-referenced to Item 2.3 in Table A.2: Summary of Potential Impacts and Mitigation Measures.
Source: TRTA consultants.

Figure A.4: Sensitive Receptors along Main Canal in Prek Po Town

Note: Cross-referenced to Item 2.3 in Table A.2: Summary of Potential Impacts and Mitigation Measures.
Source: TRTA consultants.

Figure A.5: Sensitive Receptors at Canal 15 Subproject Area



	Irrigated Area
Block A	247 ha
Block B	413 ha
Block C	349 ha
Total	1,000 ha

Note: Cross-referenced to Item 2.3 in Table A.2: Summary of Potential Impacts and Mitigation Measures).
Source: TRTA consultants.

D. Environmental Monitoring

14. The project monitoring program will focus on the environment within the project's area of influence. An environmental monitoring program is summarized in Table A.3 below. The program considers the scope of monitoring and frequency. The monitoring results will be assessed against the following standards and corrective management implemented in cases of non-compliance.

(i) The sub-decree No. 27 ANRK.BK on Water Pollution Control is dated 13 Oct 2009. (Table for Lake and Reservoir)
(ii) Ministry of Industry Mines and Energy Drinking Water Quality Standards, January 2004.

15. For the re-use and disposal of silt from canal cleaning or dredging, the pre-construction monitoring will be as set out in the dredge spoil management plan (which will be prepared during detailed design) and will use contamination triggers referenced in West Australian *Assessment levels for Soil, Sediment and Water (2010).*

Table A.3: Environmental Monitoring Plan

Parameters	Location	Frequency	Responsibility	Cost
Pre-construction				

Parameters	Location	Frequency	Responsibility	Cost
Greywater drainage outflow at Prek Po: pH, SS, EC, NH_4+, NO_3-, PO_4 $_3$-, DO, BOD5, COD, Oil & Grease, Coliform	At discharge points into eastern and western treatment facilities, at Prek Po. to establish baseline greywater parameters	One time in dry season and in wet season (non flood)	PMU to contract an organization to do sampling and testing.	2000
Establish baseline water quality for surface water in dry season: pH, SS, EC, NH_4+, NO_3-, PO_4 $_3$-, DO, BOD5, COD, oil and grease, pesticide residues, coliforms.	Canal waters at midpoint of main canals and one secondary canal for the subproject.	One time in dry season	PMU to contract an organization to do sampling and testing.	2250
Establish baseline water quality for groundwater in dry season "Priority Parameters": pH, turbidity, arsenic, iron, TDS, pesticides residues, coliforms.	Five household wells located within the water user commune area of the subproject	One time in dry season	PMU to contract an organization to do sampling and testing.	2250
Silt and canal excavation material: Heavy metals (Zn, Cu, Pb, Hg, As, Cd) and pesticide residues (organophosphates and organochlorines).	Systematic sampling as required by the dredge spoil management plan. At least once in every secondary canal and every 2 km in main canal.	One time in dry season	PMIC to coordinate. PMU to contract an organization to do sampling and testing.	15,000
During Construction				
Dust and noise: Site inspection and visual appraisal. Compare to baseline.	At all subproject sites	Weekly	Contractor EHS	Construction costs
		Monthly	PMU to inspect	3,600
Surface water quality: Turbidity and petroleum products	Visual inspection of canal waters downstream of major construction sites.	Weekly	Contractor EHS	Construction costs
		Monthly	PMU to inspect	3,600
Operation Phase				
Surface water quality: pH, SS, EC, NH_4+, NO_3-, PO_4 $_3$-, DO, BOD5, COD, Oil & Grease, Coliform	Canal waters at midpoint of main canals and one secondary canal for each subproject.	Semi-annual until Project Completion Report (PCR)	PMU to contract an organization to do sampling and testing.	8,700
Treated greywater quality:	At outflows from eastern and western treatment facilities, at Prek Po..	Semi-annual until Project	PMU to contract an organization to	6,000

Parameters	Location	Frequency	Responsibility	Cost
pH, SS, EC, NH_4+, NO_3-, PO_4 $_3$-, DO, BOD5, COD, Oil & Grease, Coliform		Completion Report (PCR)	do sampling and testing.	
Groundwater quality: "Priority Parameters": pH, Turbidity, Arsenic, Iron, TDS, Pesticides, coliforms.	Five household wells located within the water user commune area of each subproject	Semi-annual until PCR	PMU to contract an organization to do sampling and testing.	18,000
Noise levels (Prek Po pumping station)	Measure 1 hour average noise levels at nearest residence (outside) when 4 pumps operating at full capacity.	One-time after full commissioning of pump station with 4 pumps operating (to trigger erection of noise barrier if exceeds 55 dB at nearest house)	PMU to contract an organization to do testing.	1,000
Noise levels (Canal 15 Samput pumping station)	Measure 1 hour average noise levels at nearest residence (outside) when 4 pumps operating at full capacity.	One-time after full commissioning of pump station with 2 pumps operating (to trigger erection of noise barrier if exceeds 55 dB at nearest house)	PMU to contract an organization to do testing.	1,000

PMU = project management unit; EA = implementing agency; PCR = project completion report.
Source: TRTA consultants.

E. Reporting

16. To ensure proper and timely implementation of the EMP and adherence to the agreed environmental covenants, the following reporting arrangements will be implemented (Table A.4):

Table A.4: Reporting Schedule

Report	Frequency	Purpose	From	To
Construction				
Contractor's progress Report	Monthly	EMP Implementation Progress and EHS Monitoring Results	Contractor	PMU
EMP Progress and Compliance Report	Quarterly	Confirm Mitigation Measures	PMIC	PMU
Environmental Monitoring	Quarterly	Environmental Parameters in monitoring Plan	PMU (EMO)	EA
Environmental Monitoring Report (Integrated Safeguards Monitoring)	Semi-Annual	Full EMP Implementation and Compliance with Environmental Covenants and Standards	EA	ADB
Operations				

Environmental Monitoring Report (Integrated Safeguards Monitoring)	Annual until PCR	Full EMP Implementation and Compliance with Environmental Covenants and Standards	PMU	ADB

Source: TRTA Consultants.

F. Training and Capacity Building

17. Training for PMU staff and contractors in the preparation and implementation of construction/site environmental management plans and implementation of the mitigation and management measures listed in Table A.2, will be delivered by the PMIC.

Table A.5: EMP Training Program (all subprojects)

Training	Attendees	Contents	Times	Period (days)	No. of persons	Cost ($/person/day)	Total Cost
EMP adjustment and implementation	PMU, contractors	Development and adjustment of the EMP. Preparation and implementation of SEMP. Roles and responsibilities, monitoring, supervision and reporting procedures	Once prior to project implementation	2	24	100	$4,500
Grievance Redress Mechanism	PMU, contractors, commune chiefs, village leaders	Roles and responsibilities, Procedures	Once prior to project implementation	1	75	100	$7,500
Environmental protection	PMU, contractors	Pollution control on construction sites (air, noise, wastewater, solid waste)	Once (at beginning of project construction)	1	15	100	$1,500
Environmental monitoring	PMU, O&M units, contractors	Monitoring methods, data collection and processing, reporting systems	Once (at beginning of project construction)	1	15	100	$1,500

Source: TRTA Consultants.

18. Other training requirements promoting environmental sustainability and referenced in this EMP (other than the EMP implementation training) will be undertaken as part of the IAIP Capacity Building and Training component and are costed in the Feasibility Study Reports for each subproject and are described and costed in detail in the project administration manual (PAM). They are therefore not included as EMP implementation costs.

19. Integrated pest management (IPM) and low chemical cultivation applicable to cropping conditions and capacities in the subproject areas will be covered in farmer field schools. These will be part of an extensive field school training and demonstration program in the subproject communes (Table Training in IPM will coordinate with the Cambodian National IPM Program and is in line with *IFC EHS Guidelines on Annual Crop Production (World Bank Group, 2016).* The program will include the safe storage, handling and disposal of agricultural chemicals. The Project

will also undertake soil analyses in the command areas and provide farmers with recommendations on appropriate fertilizer regimes and cultivation practices. The field schools will emphasize environmentally sound farming and sustainability and will provide farmers with alternative approaches to a reliance on chemicals.

20. Other training for MOWRAM, PDRAM and District Office staff will include: Environmental awareness training; Construction management; and On-farm water management. For FWUC members, the training program will include: Water management; Gender and environment; and Environmental awareness (incl. climate change).

G. Grievance Redress Mechanism and Public Consultation

21. A grievance redress mechanism (GRM) will be established for each subproject in compliance with ADB's SPS (2009). ADB requires that the borrower/client establish and maintain a grievance redress mechanism to receive and facilitate resolution of affected peoples' concerns and grievances about the borrower's/client's social and environmental performance at the project level..

22. The GRM will be accessible to diverse members of the community, including more vulnerable groups such as women and youth. Multiple points of entry, including face-to-face meetings, written complaints, telephone conversations, or e-mail, will be available. Opportunities for confidentiality and privacy for complainants will be honored where requested.

1. Proposed Mechanism

23. The PMU will establish a Project Public Complaint Unit (PPCU) which will act as a central recording and coordinating unit for all subprojects under the Project. The PMU will ensure that the GRM is publicized locally so that the community is fully aware of the mechanism and the local points of entry to it. The setting up of the GRM in the PMU and its initial implementation will be supported by the environmental consultant of the PMIC.

24. The entry points for the GRM will be, first of all, at the local level. These are: the contractor, the village leader, FWUC leaders, the commune chief, and operators of project facilities. Since the contractor will be the most direct contact for the initial complaint and also for correcting the work practice which causes the complaint and providing redress, the contractor will assign an employee as the contact person and ensure that people know how to contact them at all times. It is appropriate that this employee should also be the EHS officer for the contractor (see section V.C.4) since the duties will be complimentary.

25. All these entities will be equipped with logbooks and will report complaints received and acted upon, or received and passed up to the next level for resolution. These monitoring and reporting procedures will be designed and established by the PMU supported by the PMIC. Before construction starts, signs will be erected at each construction site and put on bulletin boards at the commune council office and community centers providing the public with updated project information and summarizing the grievance redress mechanism process including details of the GRM entry points. The contact details for the entry points (names of officers, phone numbers, addresses, e-mail addresses, etc.) will be publicly disseminated on information boards at construction camps and active sites and on the website of the local government.

26. . The preferred action sequence for complaints handling is that the complaint should be investigated and resolved by the local unit receiving the complaint. If this is not possible, the

complaint should be referred to the District Chief's office and PMU. The next level, if a resolution is still not found, is the Provincial Grievance Redress Committee (whose wider membership will enable coordinated action in response).

27. The PPCU will maintain records of complaints and actions taken to correct them. This data will be included in MOWRAM's quarterly reports to the ADB. To accomplish this, the PPCU will establish a GRM tracking and documentation system. The system will include the following elements: (i) tracking forms and procedures for gathering information from project personnel and complainant(s); (ii) staff to update the database routinely; (iii) systems with the capacity to analyze information so as to recognize grievance patterns, identify any systemic causes of grievances, promote transparency, publicize how complaints are being handled, and periodically evaluate the overall functioning of the mechanism; (iv) processes for informing stakeholders about the status of a case; and (v) procedures to retrieve data for reporting purposes, including the periodic reports to the ADB.

28. All efforts should be made to resolve complaints at the local level. If, after all the procedures described above, the AP is still dissatisfied the complaint can be taken to the ADB Resident Mission and beyond that to the ADB's Office of the Special Projects Facilitator[1] and the Accountability Mechanism.[2]

2. GRM Procedure and Timeframe

29. The procedure and timeframe for the grievance redress mechanism are described as follows (see Figure A.5).

30. **First stage**: APs will present their complaints and grievances verbally or in writing to the contractor or other local entry point. The receiving agent will be obliged to provide immediate written confirmation of receiving the complaint. If after 15 days the aggrieved AP does not hear from the local bodies, or if he/she is not satisfied with the decision taken in the first stage, the complaint may be brought to the District Office.

31. **Second stage**: The District Office has 15 days within which to resolve the complaint to the satisfaction of all concerned. At this stage the PMU will be closely involved to ensure that complaint/response data is captured and the resolution properly implemented. If the complaint cannot be solved at this stage, the District Office will bring the case to the Provincial Grievance Redress Committee.

32. **Third stage**: The Provincial Grievance Redress Committee meets with the aggrieved party and tries to resolve the situation. Within 30 days of the submission of the grievance, the Committee must make a written decision and submit copies to the MOWRAM, PDWRAM and the AP.

33. **Final stage**: If the aggrieved AP does not hear from the Provincial Grievance Redress Committee or is not satisfied, he/she will bring the case to Provincial Court. This is the final stage for adjudicating complaints. The Court will make a written decision and submit copies to the MOWRAM, PDOWRAM and the AP. If any party is still unsatisfied with the Provincial Court judgment, he/she can bring the case to a higher-level court.

34. At any stage affected persons can report issues to ADB project team, Cambodia Resident

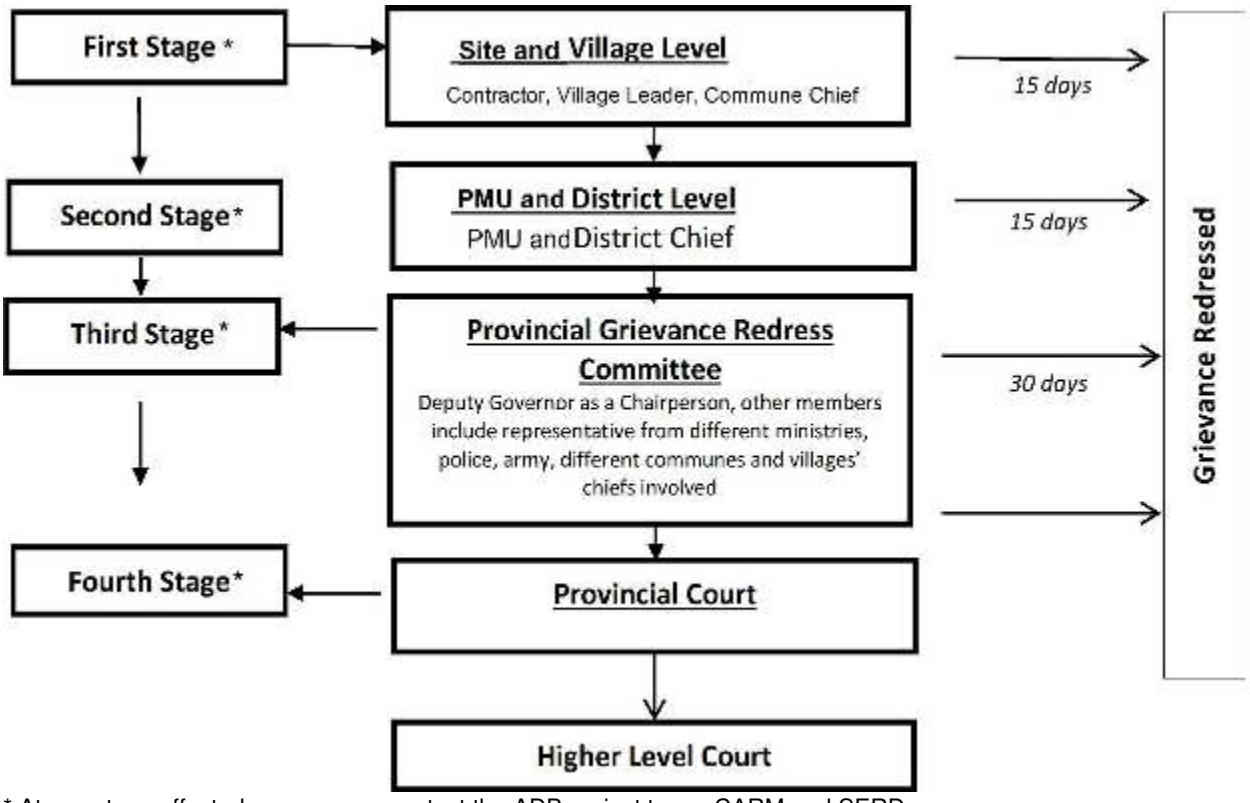
[1] https://www.adb.org/site/accountability-mechanism/problem-solving-function/office-special-facilitator
[2] https://www.adb.org/site/accountability-mechanism/overview

Mission CARM), or South-East Asia Department (SERD). If issues cannot be effectively resolved through the project GRM and ADB project teams, the ADB accountability mechanism can be accessed.

35. The PIC will provide training for GRM entry points on GRM record-keeping, resolution, monitoring and reporting to ensure that all issues and concerns raised are effectively recorded and resolved in a timely fashion to the satisfaction of the affected persons. It will be emphasized during the training that resolution of issues at a local level is far more effective and that reporting of issues is seen as positive, not negative as it demonstrates that the GRM is effective and working.

36. **Reporting**. During construction, the PPCU will be informed by contractors and construction supervisors, village leaders, commune chiefs or FWUC staff if people complain about the project. During operation, the PPCU will be advised of complaints by the village leaders, commune chiefs, FWUC and PDWRAM.The PPCU will inform data on complaints and resolutions can be included in MOWRAM's progress reports to ADB.

Figure A.5: Grievance Redress Process



* At any stage affected persons can contact the ADB project team, CARM and SERD
Source: TRTA Consultants.

3. Public Consultation during Project Implementation

37. Meaningful consultation to safeguard the environment and local residents will continue throughout the construction and operation phases. The implementing agencies will be responsible for organizing the public consultations, with the support of the PMIC. Civil works contractors will

be required to frequently communicate and consult with the communities in the project area of influence, especially those near the project areas. Eye-catching public notice boards will be set at each work site to provide information on the purpose of the project activity, the duration of disturbance, the responsible entities on-site (contractor, implementing agency), and the GRM. Costs will be covered by the PMU and are included in Table A.6 below.

Table A.6: Environment Consultation and Communication Plan

Organizer	Format	Frequency	Subject	Attendees	Cost ($)
Pre-Construction Stage					
PMUs, FWUCs, CCs, PMIC	Targeted public consultation & site visits	Before construction at each site	Agreement with affected persons and sensitive receivers on construction work. Consultation on safety of nearby communities.	Affected persons in impacts zone of construction activities	9,000
Construction Stage					
PMUs, FWUCs, CCs, PMIC	Public consultation & site visits	Once each year during construction	Adjusting of mitigation measures, if necessary; construction impact; comments and suggestions	Residents in project areas	6,000
PMU Contractors	Grievance Redress Mechanism	Ongoing	Continuous publicizing of GRM, especially contact points, as contruction moves across the subproject area	Residents and farmers around works area	Incl in GRM costs

CC = commune council; FWUC = farmer water use communes; PMIC = project management and implementation consultant; PMU = project implementing unit.

Source: TRTA team.

H. Total Environmental Management Costs

38. The costs of implementing the environmental management and impact mitigation measures listed in the EMP matrix (Table A.2) are included in the design costs, construction contracts and operational budgets. The costs of the environmental monitoring program are set out in Table A.4. These costs are combined in Table A.7 below to give total EMP costs.

Table A.7: Estimated Total Environmental Management Plan Costs

($)

Subproject	EMP Training	GRM. Establishment and Operation	Pre-construction Environmental Measures	Pre-construction Environmental Monitoring	Construction Environmental Impact Mitigation (2 years)	Construction Environmental Monitoring (2 years)	Operational Environmental Monitoring (first 3 years)	Public Consultation	Total
Responsibility	**PMU**	**PMU**	**Contractor**	**PMU/PMIC**	**Contractor**	**PMU**	**PMU / PDWRAM**	**PMU**	
Kamping Pouy	5,000	4,000	6,000	6,500	49,000	2,400	8,900	5,000	86,800
Prek Po	5,000	4,000	13,000	6,500	66,000	2,400	15,900	5,000	117,800
Canal 15	5,000	4,000	11,000	6,500	52,000	2,400	9,900	5,000	95,800
Total	15,000	12,000	30,000	19,500	167,000	7,200	34,700	15,000	300,400

Source: TRTA consultants.

ANNEX A: TERMS OF REFERENCE FOR PMU ENVIRONMENTAL MANAGEMENT OFFICER (EMO)

A. BACKGROUND

The Irrigated Agricultural Improvement Project (the project) is a project loan to support the Ministry of Water Resources and Meteorology (MOWRAM) of the Government of Cambodia in the development of improved irrigation schemes.

The executing agency is MOWRAM which has established a project management unit (PMU) for the implementation of the project. The project will involve the implementation of environmental safeguards in the construction and operation of subprojects whose environmental due diligence is already complete, and the environmental selection and assessment of new subprojects. An environment officer is required to supervise, coordinate and assist in the implementation of environmental safeguards for the ongoing project. These terms of reference describe the requirements for this position.

B. SCOPE AND DURATION OF WORK

The officer will work on behalf of the executing agency and PMU to ensure that environmental safeguards are implemented in all subprojects. The officer will report directly to the Project Director and Project Manager in the PMU. The position is full time and its duration is for at least the first 4 years of the project.

C. DETAILED TASKS

In coordination with government counterparts and working closely with the environment specialists in the project management implementation consultant (PMIC) team, the officer will:

1. Assist the PMU to implement the environmental management plan (EMP) measures for each subproject.
2. Review contractor's monthly progress reports.
3. Prepare quarterly environmental monitoring reports (based on contractor reports and site inspections) covering environmental performance of all parties, training progress, issues outstanding and further actions recommended and submit to executing agency.
4. Assist PMIC in EMP compliance monitoring and reporting.
5. Assist PMU in preparation of semi-annual environmental monitoring reports to ADB.
6. Set up PMU complaints unit for administration, record-keeping and reporting on grievance redress mechanism (GRM).
7. Working with the PMU's complaint unit, implement the project GRM, including: (i) instruct all stakeholders on their responsibilities in the GRM; (ii) establish a simple registry system, to document and track grievances received; (iii) monitor complaints received and their timely resolution; and prepare reports on progress of the GRM for inclusion in the quarterly project progress reports to ADB.
8. Assist in the delivery of environmental training to PMU, contractors and farmer water user communities.
9. Based on regular site visits and contractor monthly reports, provide the Project Director and Project Manager with progress reports which cover environmental performance of all parties, training progress, issues outstanding and further actions recommended.
10. Undertake other tasks as requested by the Project Directors and Project Managers.

ANNEX B: TERMS OF REFERENCE FOR ENVIRONMENT SPECIALIST – ON PMIC TEAM

International Environment Specialist (4 person-months): The specialist will have: (i) a masters degree or equivalent in environmental management or related field; (ii) at least 15 years of experience in environmental management, monitoring, and/or impact assessment; (iii) familiarity with ADB environmental safeguards requirements and national environmental management procedures; (iv) ability to analyse data and prepare technical reports; and (v) proficiency in spoken and written English. The expert will:

1. Assist Design Supervision consultant (DSC) in the update of EMP as required following detailed design of canal 15 subproject;
2. Deliver the environmental management plan (EMP) implementation training program to PMU and contractors;
3. Oversee and monitor the implementation of impact mitigation and management measures prescribed in the EMPs for the subprojects, and report quarterly to the project mangement unit (PMU);
4. Assist the PMU or executing agency in the preparation of semi-annual environmental monitoring (safeguards) reports to the ADB;
5. Contribute EMP compliance reports for inclusion in the PMU's environmental monitoring reports to the ADB;
6. Organize, oversee and monitor the disaster risk reduction participatory workshops and training delivered to communes by National Committee for Disaster Management Secretariat (NCDMS);
7. oversee and monitor the implementation of climate change adaptation measures and disaster risk reduction measures measures prescribed for the subprojects

National Environment Specialist, (8 person-months): The specialist will have: (i) an undergraduate degree or higher in environmental management or related field; (ii) at least 10 years of experience in environmental management, monitoring, and/or impact assessment; (iii) familiarity with ADB environmental safeguards requirements and national environmental management procedures; (iv) ability to communicate and work effectively with local communities, contractors, and government agencies; (v) willingness and health to regularly visit the subproject sites; and (vii) proficiency in spoken and written English.

The specialist will:

1. Assist the International Environment Specialist in undertaking the tasks listed 1 – 7 in the terms of reference for that position.
2. Working closely with the PMU and the PMU Environmental Management Officer, and other relevant personnel and agencies, the specialist will also:

    - Assist the PMU to establish and publicize the grievance redress mechanism (GRM) for subprojects, ensuring that the GRM publicity is appropriate to the scale and complexity of the subproject and includes, as a minimum, the disclosure of all contact persons for lodging complaints; and
    - Assist the PMU and the executing agency to prepare project environmental monitoring progress reports for submission to ADB.