Initial Environmental Examination

May 2018

CAM: Fourth Greater Mekong Subregion Corridor Towns Development Project

Stung Treng Subproject
Kratie Subproject
Kampong Cham Subproject

Prepared by the Ministry of Public Works and Transport for the Asian Development Bank.

CURRENCY EQUIVALENTS

(as of 7 May 2018)

Currency unit	=	Riel (KR)
KR 1.00	=	USD 0.00025
USD 1.00	=	KR 4,052

ABBREVIATIONS

ADB	–	Asian Development Bank
AP	–	affected person
CEMP	–	site-specific environmental management plan
CMAA	–	Cambodia Mine Action and Victim Assistance Authority
CSO	–	combined sewer overflow
DOE	–	Department of Environment
DPWT	–	Department of Public Works and Transport
EIA	–	environmental impact assessment
EMP	–	environmental management plan
EO	–	environment officer (of implementing agency)
ESO	–	environmental safeguard officer (of executing agency)
ESS	–	environmental safeguard specialist (of Project Management and Construction Supervision)
GHG	–	greenhouse gas
GMS	–	Greater Mekong Subregion
GMS-CTDP-4	–	Fourth Greater Mekong Subregion Corridor Towns Development Project
GRM	–	grievance redress mechanism
IEE	–	initial environmental examination
MOE	–	Ministry of Environment
MPWT	–	Ministry of Public Works and Transport
PIU	–	Project Implementation Unit
PMCS	–	Project Management and Construction Supervision
PMU	–	Project Management Unit
PMU-ESO	–	PMU Environmental Safeguards Officer
PPE	–	personal protective equipment
PPTA	–	project preparatory technical assistance
SES	–	socio-economic survey
SPS	–	Safeguard Policy Statement
WWTP	–	wastewater treatment plant

WEIGHTS AND MEASURES

ha	–	hectare/s
m	–	meter/s
m^3	–	cubic meter/s
km	–	kilometer/s
tpy	–	tonne/s per year

NOTES:

(i) The fiscal year (FY) 2018 of the Government of Cambodia and its agencies ends on 31 December 2018. “FY” before a calendar year denotes the year in which the fiscal year ends.

(ii) In this report, "$" refers to United States dollars unless otherwise stated

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EXECUTIVE SUMMARY

A. Introduction

1. The Fourth Greater Mekong Subregion Corridor Towns Development Project (GMS-CTDP-4 or Project) will support the Governments of Cambodia and the Lao People's Democratic Republic (PDR) in enhancing the competitiveness of selected towns located along the Central Mekong Economic Corridor in the Greater Mekong Subregion (GMS). It is aligned with the Government of Cambodia's Rectangular Strategy for national development. The third phase (RS-III 2013–2018) identifies integrated urban development as a priority and recognizes the need to manage environment and climate change to ensure the sustainability of Cambodia's economic growth and social development. The Project is also underpinned by Cambodia's National Green Growth Road Map (2010) which promotes access to clean water and sanitation. In Cambodia, the Project will improve urban services and enhance regional economic connectivity in the participating towns of Kampong Cham, Kratie, and Stung Treng.

2. The project environment classification is confirmed as Category B. This report constitutes the initial environmental examination (IEE) and environmental management plan (EMP) for the proposed subprojects in Cambodia.[1] The IEE was carried out in accordance with the Safeguard Policy Statement (2009) of the Asian Development Bank (ADB), and Cambodia's Law on Environmental Protection and Natural Resource Management (Preah Reach Kram/NS-PKM-1296/36) 1996, and its sub-decrees and implementing guidelines.

B. Project Scope

3. The Project outputs include: (i) centralized wastewater and stormwater drainage facilities to improve sanitation and control flood risks, (ii) controlled landfills for improved municipal waste disposal, solid waste collection vehicles to enhance collection activities, and the closure of existing dumpsites (Stung Treng and Kratie), (iii) town center landscaping and rehabilitation to create livable public spaces that foster tourism benefits, (iv) information and communication technology (ICT) based government systems to optimize operational transparency and resource efficiency in managing the new infrastructures, and (v) provincial five-year socioeconomic development plans to promote regional economic connectivity and coordinate their strategies (Table 1).

Table 1: Summary of Project Outputs and Components

Output/Component	LWWTS	MSWCE	TCE	PDS	ICTPM	PMCS
1. Urban environmental infrastructure improved	■	■	■			
2. Institutional effectiveness, and policy and planning environment for regional economic connectivity enhanced				■	■	■

ICTPM = information and communications technology (ICT) for public management; LWWTS = lagoon-based waste water treatment system; MSWCE = municipal solid waste-controlled landfill and equipment; PDS = provincial development strategy; PMCS = project management and construction supervision; TCE = town center enhancement.

C. Key Findings

4. The Project is expected to improve the urban environment in the three towns, reduce their vulnerability to environmental and climate risks, and improve their climate resilience level and

[1] The IEE and EMP (i) identify and assess potential impacts and risks from subproject implementation on the physical, biological, physical-cultural and socioeconomic environments, and (ii) recommend measures to avoid, mitigate and compensate adverse impacts, while enhancing positive impacts.

quality of life. It will provide them with improved stormwater, wastewater and solid waste management services, and in all three, formulate a provincial development strategy and strengthen institutional capacities in resilience town planning. The Project also includes town center enhancements in Kratie and Stung Treng. The anticipated positive impacts and environmental benefits are presented in Table 5.1 of the IEE.

5. **Kampong Cham Subproject.** The proposed combined sewer system in Kampong Cham will be built in the main urban area to serve four communes, namely, (i) Krong Kampong Cham (100%), (ii) Veal Vong (100%), (iii) Sambor Meas (50%), and (iv) Boeng Kok (10%). The sewer lines will be laid along roads in the main urban area and will affect at least eleven schools, businesses, one hospital, an orphanage, two temples, two mosques, and one church along the roads in Boeng Snay and Boeng Bassac. The impacts of the combined sewer will primarily occur during the construction phase. The impacts will be temporary but will potentially affect community health and safety, cause road traffic and blocking of accesses to properties. These impacts will be addressed by implementing good construction practices as outlined in the environmental management plan.

6. The proposed wastewater treatment plant will be located in Boeng Bassac area in Sambor Meas commune. The area is bordered on all sides by roads and is dominated by shrub/grassland and agricultural land but during the rainy season the entire area is waterlogged for about 4–5 months. Traffic is low and there are few houses in the vicinity. Flooding and the assimilative capacity of the Boeng Bassac lagoon will be further evaluated during detailed design. The design will also take into consideration the intended use of the lagoon, the presence of sensitive receptors that are dependent on the lagoon, and the expected effluent quality of the treatment plant. This will also include the design of an emergency response plan for the project.

7. The proposed controlled landfill in Kampong Cham will be located in Preuk Village, Mean commune, Prey Chhor District. The site is about 17–18 km away from the town center. The proposed site is dominated by grassland with scattered shrubs and trees, surrounded by rice fields and upland areas. The nearest residential house is about 500 meters away. There is an intermittent stream located along the western edge of the property while a transmission line is located along the northern boundary adjacent to the access road. Issues that need to be considered in the detailed design of the controlled landfill of Kampong Cham are the impacts of leachate on the intermittent stream, groundwater and surrounding agricultural land, cutting of trees and safety clearance from transmission lines.

8. **Kratie Subproject.** The combined sewer in Kratie will be installed in the main urban center and will serve the sangkats of (i) Krong Kratcheh (100%), (ii) Krakor (25%), (iii) Ou Russei (50%), and Roka Kandal (10%). Adverse impacts during the construction can be mitigated through implementation of best practices to manage community health and safety. Sensitive receptors along the alignment of the sewer lines include at least four schools, the Kratie Referral Hospital, three temples, one mosque, a public library, existing utility lines, businesses, and residential establishments along the roads.

9. The vicinity of the proposed wastewater treatment plant is mainly agricultural. The nearest residential area is about 1.5 km west of the proposed site. The access to the proposed wastewater treatment plant will affect a commercial establishment, a school, agricultural lands, and residences along Road 377. The impacts will primarily occur during laying of the main trunk to the wastewater treatment plant. However, during the operational phase, the anticipated

adverse impacts will not be significant since the area is far from residential communities. The operational phase impacts are primarily positive since wastewater treatment will help improve health and sanitation of the community. During detailed design, the capacity of the receiving lagoon will be evaluated further to ensure that the receiving water can accommodate discharged effluent without causing flooding in the surrounding areas. In addition, the level of treatment and effluent quality for discharge into the lagoon will take into consideration the assimilative capacity and the intended use of the lagoon.

10. The proposed controlled landfill in Kratie will be developed within the existing dumpsite which is about 17 km east of the town center. The site is flat and is surrounded by shrub/grassland with agricultural lands to the west. The nearest agricultural land is about 500 m west of the existing dumpsite while a stream can be found at the eastern boundary of the property. There are no houses in the immediate vicinity of the proposed controlled landfill since the nearest house is about 1.75 km away. However, farmers work in the nearby agricultural lands to grow crops. The issues that should be considered in the detailed design include the proper closure of the existing dumpsite, management of leachate to protect the adjacent stream and groundwater and protection of waste pickers from hazards of exposure to mixed wastes. The detailed design will evaluate air and odor pollution control measures, buffer/fence, and other methods to ensure safety of communities in the vicinity.

11. The town center enhancement in Kratie will be along the riverfront walkway in Preah Soramarith Quay. The impacts are anticipated to occur only during the construction phase. Sensitive receptors that were identified include one temple, at least four schools, a market and businesses and residential establishments. Once the town center enhancement project becomes operational, the impacts are expected to be mostly beneficial to the community and the environment.

12. **Stung Treng Subproject.** The combined sewer and floodgate will be located in the main urban area of Stung Treng and will serve the communes of (i) Krong Stung Treng (75%), (ii) Srah Ruessei (10%), and (iii) Preah Bat (90%). Temporary disturbances are expected to occur during the laying of the sewer lines. Identified sensitive receptors include at least seven schools, the First Region Hospital, Stung Treng Health Center, at least five temples, one mosque, one church, existing utility lines, and residential and business establishments along the roads. The floodgate and four pump stations will be located near Mekong River and Sekong River. The impacts to trees and vegetation as well as to adjacent residential and business establishments and a pagoda will occur during the construction phase. Once the floodgate and pump stations become operational, the communities in Stung Treng will be protected against floods caused by rising waters from Mekong River and Sekong River.

13. The location of the proposed wastewater treatment plant will be within an area that is bordered by roads. The wastewater treatment plant is not expected to cause significant adverse impacts to communities since the vicinity is largely agricultural. However, measures are necessary during detailed design to ensure that the stream within the site can adequately accommodate the discharge from the wastewater treatment plant and that the effluent meets the standards for discharge into Mekong River which is just about 200 m away from the site.

14. The proposed controlled landfill of Stung Treng will be developed in a 100-ha public land about 10 km from the town center. There are no residential communities in the immediate vicinity. The nearest house is about 1 km away from the site. The site is degraded forest with two

perennial streams in the south. During detailed design, the potential impacts on ecology and leachate on water resources needs to be evaluated further.

15. The subproject in Stung Treng will also include the closure of the existing dumpsite located along NR7, about 10 km from the foot of Sekong Bridge across the town main urban area. There are residential communities within 500 m from the existing dumpsite. The impacts of the closure of the existing dumpsite will be mostly positive. The closure activities will be planned to include evaluation of effects of leachate on Sekong River quality and groundwater quality. The dumpsite closure will also include an assessment of livelihood options for the waste pickers that operate at the site.

16. **Pre-construction** issues and concerns primarily relate to (i) ensuring that subproject component designs fully incorporate environmental protection, sustainability and climate resilience measures, and (ii) promoting the preparation and readiness of key subproject stakeholders and affected communities. Mitigation of these impacts includes: (i) engaging qualified environmental personnel, (ii) prioritizing environmental training and capacity building, (iii) complying with mine and unexploded ordnance clearance protocol, (iv) operationalizing a grievance redress mechanism, (v) updating the IEE and EMP, (vi) incorporating the EMP in procurement documents, (vii) prioritizing consultations and disclosure, (viii) conducting supplementary baseline assessments,[2] and (ix) conducting environmental compliance audits (ECAs) on existing dumpsite facilities.

17. Key construction phase environmental issues and mitigation includes the following:

Air Quality. Temporary, moderate air quality impacts are anticipated during construction due to (i) fugitive dust generation associated with earthworks and construction works, and (ii) the movement and disturbance of solid wastes at the existing dumpsites.[3] Receptors of these air quality impacts are residents, businesses, and other affected persons residing nearby, and particularly downwind of construction activities, as well as formal and informal waste workers at the dumpsites.[4] Measures to mitigate air quality issues include (i) water spraying on areas where fugitive dust is generated,[5] (ii) providing dust suppression systems, (iii) covering truck loads, (iv) ensuring vehicle emission standards, (v) providing advance notice to receptors,[6] and (vi) ensuring appropriate occupational health and safety provisions are adhered to.

Noise. Noise impacts, caused by the operation and movement of construction vehicles and equipment,[7] will be temporary and localized. Although noise will be periodically endured by nearby receptors, particularly during pipeline laying activities, it is anticipated that only construction site workers will be subjected to noise impacts for an extended period of time. Mitigation includes (i) utilizing low-noise, well maintained vehicles and equipment, (ii) establishing noise barriers, (iii) installing sound-absorbing enclosures, (iii) restricting heavy and noisy machinery operating hours, (iv) enforcing the use of personnel

[2] These include for example, the sampling and analysis of biodiversity, air quality, surface waters, groundwater, soils (vadose zone), noise, wastewater influents, and existing dumpsite effluents.

[3] These waste movements relate to (i) the currently dumped wastes at the existing Kratie dumpsite, which will be carefully transported to the new, adjacent controlled landfill, and (ii) potentially to the dumpsites in the three towns that are to be closed and remediated.

[4] Dust will also be generated during pipe network installation excavations in urban areas which are by their nature, densely populated.

[5] At borrow pits, construction sites and material handling areas.

[6] Including formal and informal waste workers at the dumpsites, and receptors within 500 m of these facilities, when waste movements and disturbances are planned.

[7] Including excavators, electric saws, pumps, generators and drilling rigs.

protective equipment (PPE), (v) limiting horn blowing, (vi) maintaining close coordination and communications with affected persons and communities,[8] and (vii) monitoring noise levels, particularly of nearby sensitive receptors.

Surface Water. The controlled landfills are to be located on stable, well drained sites. Responding to localized drainage requirements, the final designs of these facilities will incorporate surface drainage features including perimeter drains and the diversion of existing streams to mitigate adverse drainage impacts. The closure plans of the dumpsites to be closed will also prioritize key mitigation features, including (i) surface grading and covering of exposed waste cell surfaces to improve controlled runoff and reduce erosion, and (ii) site perimeter drains to control surface water run-on and runoff. The dumpsite closure final designs will be guided by the ECAs.

The available sites for the lagoon-based WWTPs are at low elevations, comprising of shrub and grasslands, interspersed with agricultural lands. Due to their relatively low elevations, all three sites are subject to extensive flooding. While the Stung Treng and Kratie sites are intermittently waterlogged, reportedly up to five months per year, the proposed Kampong Cham site is waterlogged almost continually, being within an existing lagoonal area.[9] Hydrologically, the potential environmental impacts to surface water resources from WWTP construction are: (i) changes to natural surface hydrology and drainage pathways due to WWTP construction, and (ii) potential flooding of the facilities by elevated surface waters. These impacts will be addressed at final design phase through (i) detailed hydrological assessment to ensure that the final designs fully accommodate and mitigate impacts on natural hydrology, and (ii) incorporating bunds and raising the elevations of the WWTPs above potential flood levels.

Other mitigation measures adopted during WWTP and controlled landfill construction, and dumpsite closures, include (i) maintaining adequate siltation control,[10] (ii) management of solid and hazardous wastes,[11] (iii) minimizing vegetation removal, and (iv) reporting wildlife and rare animal species sightings, and prohibiting poaching. Regarding the combined sewerage system, outfall construction will need to ensure that Mekong River habitats are not impacted.[12] Mitigation measures include (i) minimizing riparian vegetation removals, (ii) installing erosion and sediment controls, (iii) limiting soil stripping and works close to the river to the dry season, (iv) observing proper sanitation and good hygiene, (v) managing any hazardous materials and containing spills, and (vi) monitoring water quality during and after construction.

Wastewater. During construction, wastewater will be generated by (i) sanitation facilities, (ii) equipment maintenance facilities, (ii) vehicle and equipment washing, (iii) construction site surface runoff, (iv) discarded drainpipes, and (v) borings and excavation works. Inadequate wastewater management will impact on the health and safety of construction workers and communities, and will pollute surface water resources, groundwater and soils within the areas of influence. These impacts will be mitigated by (i) maintaining sanitation

[8] To ensure that advanced warning is provided, considerations are given, and the GRM widely understood so that grievances and complaints are handled expeditiously.

[9] While the actual facility boundaries of the Stung Treng site have been confirmed, only the general locations of the sites for Kratie and Kampong Cham have currently been identified. The actual locations of these sites will be confirmed during the final design phase.

[10] Including sediments, soils, stockpiles and aggregate materials utilized in facility construction.

[11] Including (i) provision of adequate waste storage facilities; (ii) enforced sorting and disposal; (iii) separate storage for hazardous and non-hazardous wastes; and (iv) prompt disposal.

[12] Although these are not major works, they will be implemented close to the Mekong River.

facilities, (ii) enforcing hygiene and sanitation practices, (iii) incorporating sediment controls, (iv) maintaining equipment washdown areas, (v) providing retention control for material stockpiles, (vi) designating areas for repair and maintenance, and (vii) ensuring regular wastewater collection by recognized service providers. During construction, any existing septic tanks or soakways connected to existing drains will need to be disconnected. Owners will then need to construct temporary soakway pits as required for effluent if they don't already have a septic tank.

Groundwater. Improperly constructed boreholes during design and construction phases may not be properly sealed, creating a direct contaminant pathway from the surface to the groundwater table. This will be mitigated through the inclusion of detailed borehole construction specifications in contractor's overall method statements for the drilling works to assure correct borehole construction.

Fauna, Flora and Potential Habitat Loss. Although the initial baseline did not reveal specific impacts to fauna and flora at the proposed subproject sites, the precise sites of the proposed WWTPs in Kratie and Kampong Cham are yet to be identified. For this reason, and due to the waterlogged and lagoon nature of these sites and the proposed Stung Treng WWTP site, it is recommended that further site assessment, including site specific ecological surveys, be conducted at the final design stage to identify, evaluate and where necessary mitigate ecological impacts caused by the siting of these facilities.

Physical Cultural Environment. Although subproject sites are not within close vicinity of historical and archaeological sites, the sewer pipelines to be constructed could be located near pagodas, and other religious monuments and facilities. In adherence with cultural heritage protection laws, mitigation measures will include (i) ensuring pre-construction coordination with temple authorities, (ii) ceasing construction works on discovery, and (iii) submitting a declaration to the authorities, which will implement the necessary measures to protect both the discovered items and the site. Chance finds procedures are set out in the EMP and will be followed.

Socioeconomic Environment. Socioeconomic impacts relating to construction include (i) community health and safety, (ii) traffic, (iii) construction workers' health and safety, (iv) impacts on the sustainability of urban services, and (v) disruption of utility services. Having more people and urban activities and services, the main urban areas will be sensitive. However, if works are phased accordingly and anticipated impacts are managed effectively, the risk of significant impacts is low.

18. Regarding **Operation** phase impacts, it is estimated that the largest environmental risks occur in this development phase, primarily relating to the operation of the WWTPs, controlled landfills, and the closed dumpsites. Anticipated impacts and mitigation are summarized in this section.

Air Quality. The controlled landfills and closed dumpsites will generate landfill gas (LFG).[13] These gases form through organic decomposition processes within waste masses, with decomposition being accelerated through saturation due to the ingress of precipitation and surface waters. The subproject transition from uncontrolled open dumping to controlled landfilling will however reduce the impacts of LFG generation and emission to some extent, due to (i) a reduction of LFG generation within the waste,[14] and (ii) through the controlled venting of LFG from the facility, which will reduce fire and

[13] LFG includes the primary greenhouse gases (GHGs) of carbon dioxide, methane and nitrous oxide.
[14] By reducing surface water inundation due to encapsulation by its surface cover (capping) system.

explosion risks.[15] Similar benefits will also accrue at the closed dumpsites, where LFG emissions should also be reduced (due to waste covers) and venting controlled to also reduce fire and explosion risks.

Odor. The WWTPs, controlled landfills and closed dumpsites will generate odor, which in each case will be mitigated through design. The WWTPs will be sited in relatively remote locations, away from major receptors, and odor reduction measures such as berms and tree lines will be incorporated into the designs. Following closure, wastes within closed dumpsites will be covered, thereby significantly reducing odor. Likewise, the controlled dumpsites will be covered daily, and waste tipping areas minimized to limit odor emissions. Significant air quality and odor issues are not anticipated at other subproject facilities.

Surface Water. The WWTPs will be raised to an elevation that is above conventional flood levels, ensuring separation between effluents within the WWTPs and surrounding surface waters. These facilities will also be designed to meet appropriate regulatory standards for effluent discharge. There are conditions however where combined sewer systems may discharge excess wastewater directly to water bodies. Although these overflows can contain raw sewage, other waste, toxic materials and debris, they are estimated to contain about 95% rainwater[16] and therefore pose less risk when compared with the current situation in the towns, where practically all the town's untreated wastewater is discharged directly to the environment. Mitigation measures to improve system efficiency and reduce overflow events will also be provided.[17]

Surface water impacts at controlled landfills (during operations) and closed dumpsites (once closed) include: (i) surface water run-on,[18] (ii) site water runoff, (iii) waste mass inundation, and (iv) leachate emissions. Surface water run-on and runoff will be mitigated through the provision of perimeter and possibly collector drains. The potential for waste mass inundation from precipitation will be mitigated through the provision of cover materials over waste mass surfaces, and drainage of these areas through the contouring of surfaces and installation of surface drains to encourage flow.[19]

Leachate may impact surface waters by its migration through the sidewalls and bases of landfills and dumpsites. This will be mitigated to some extent in controlled landfills through (i) a reduction in leachate generation due primarily to reduced surface water inundation, (ii) base liners to capture leachate, and (iii) a rudimentary leachate collection and disposal system.[20] Although these systems will not be installed in the closed dumpsites, at least the proposed cover systems will reduce surface water inundation and therefore leachate generation within these facilities.

Vadose Zone and Groundwater. A failure of the integrity of the combined sewer systems or the WWTP lagoons could result in leakage of untreated or partially treated wastewater effluents, which in turn could percolate into and contaminate the underlying vadose zone and groundwater. A similar impact could also conceivably occur due to a failure of the

[15] In the future, it may be feasible to install LFG flaring systems at the controlled landfill facilities, however at the present time, such as installation would be difficult due to the challenges in capture such small quantities of generated LFG, and the excessive cost of the system.
[16] PPTA engineering team estimate.
[17] These include (i) specifying maintenance procedures in WWTP operations manuals, (ii) ensuring adequate budget and equipment for routine maintenance activities, (iii) removing flow obstructions in the sewer system, (iv) conducting operator training for WWTP operations and maintenance (O&M), and (v) monitoring water quality of the overflow-receiving water bodies following an overflow event.
[18] Surface water run-on is the movement of surface water onto the site.
[19] Completed waste mass surfaces can also be vegetated to reduce cover material erosion.
[20] That collects and stores leachate for landfill reticulation.

liner or leachate collection systems in the controlled landfills. These impacts will be mitigated however by ensuring system design and operation integrity through both the facility designs (that provide for system sustainability) and facility O&M procedures, which are supported by training, monitoring and evaluation. As the closed dumpsites will not be lined however, leachate emissions will most likely continue to escape through the bases of the dumpsites, however at least the covers over the waste placed as an integral part of closure activities will reduce the amount of leachate being generated to some extent.

Water logging in WWTP sites. The sites of the proposed wastewater treatment plant sites in Stung Treng and Kratie are intermittently waterlogged for up to five months per year while the site in Kampong Cham is waterlogged almost continually. These impacts will be addressed during the final design phase through detailed hydrological assessments so that appropriate measures can be integrated in the design. In addition, an emergency response plan will be developed as part of the operations and maintenance manual.

Disposal of sludge from WWTP. The wastewater treatment plant will be designed with anaerobic lagoons to treat wastewater delivered from the sewer lines. Based on the conceptual plan of the wastewater treatment plant, sludge will be removed annually or every two years. Sludge from anaerobic treatment is largely inert, can be dried and landfilled or applied to agricultural land. During the first two years of operation of the wastewater treatment plants, sludge that will be collected will be analyzed in terms of bacterial content before these are applied to agricultural land. If the results show consistent absence of bacterial contamination, only then can this be applied to agricultural land, otherwise, sludge will only be dried and landfilled.

Health and Safety Aspects. The combined sewer networks include open channels, and as a result, there is a possibility that human receptors could come into contact with wastewater.[21] This will be mitigated through community outreach initiatives, such as consultations, meetings and information campaigns. Operations and maintenance (O&M) activities pose risks to the health and safety of workers. These risks will be mitigated through preparation of an operations manual for combined sewers and WWTP, which shall include an occupational health and safety plan (OHSP).[22] A similar operations manual will be prepared for the controlled dumpsites.

D. Environmental Management Plan

19. The EMP prepared for the Project will serve as the framework for the environmental management of the subprojects, commencing from the detailed design phase through to operation and if applicable, decommissioning. The EMP addresses the potential impacts and risks identified in the IEE. It includes: (i) mitigation measures; (ii) monitoring measures; (iii) implementation arrangements and responsibilities; and (iv) preliminary costs for EMP implementation. The EMP will be updated by the Project Management Unit (PMU) based on the detailed design, with technical assistance from the Environmental Specialists of the Project Management and Construction Supervision (PMCS) Consultant.

20. The Ministry of Public Works and Transport (MPWT), as executing agency of the Project will establish and manage the grievance redress mechanism (GRM). The environmental safeguards officer (ESO) in the PMU will oversee the implementation/ observance of the GRM for

[21] Also, as the channels are open, they attract litter and waste, which often results in channel blockages and vector breeding.

[22] Based on the Environmental, Health and Safety Guidelines for Water and Sanitation of the International Finance Corporation, dated 10 December 2007.

the Project. The ESO's counterparts in the project implementation units (PIUs), called the environmental focal points, will ensure the implementation of the GRM at the subproject level and will be responsible for keeping the PMU informed as prescribed in the GRM. Access points will be set up with the commune council and municipality. Contractors and operators will be required to designate their respective counterpart GRM staff.

E. Conclusion

21. This IEE was prepared to identify the environmental issues and risks associated with the proposed subprojects. The proposed EMP and operations and maintenance requirements for facilities will mitigate subproject impacts on the natural environment and affected people to an acceptable level, if implemented effectively. The assessment confirms that the project is classified as Category B for environment.

22. The most significant environmental risks will arise from poor facility operation and maintenance and future uncontrolled urban development. The main urban areas in Stung Treng and Kratie are bordered by protected riverine habitats, Sekong River to north and Mekong River to west. The riverine habitats within the project area of influence of the urban areas have been altered through years of uncontrolled development and granting of land concessions. The project presents an opportunity to reduce polluted discharges, through closure of the existing dumpsites in Stung Treng and Kratie, establishment of controlled landfills and collection and treatment of wastewater prior to discharge, significantly improving the current situation.

23. The EMP includes measures to minimize potential impacts on water quality and biodiversity associated with the Sekong and Mekong Rivers. The provincial development strategy consulting services include Environment and Climate Change Specialists to ensure integration of environment and climate change considerations in future development plans for project towns. There is a comprehensive training and capacity building component which will include development of operation manuals and procedures. Improving capacity of operators is essential to achieve the anticipated environmental benefits and project outcome[23].

24. Project sites, except the controlled landfills, experience flooding each year, either fully or partly. The proposed subprojects will be designed to ensure resilience to climate risks. The WWTPs have been raised by an additional 1 m and access roads will be paved with concrete instead of DBST. Additional measures will be considered during detailed engineering design, as set out in the Project Climate Risk Management Report and as presented in summary in this IEE.

25. The key parties involved in implementing the proposed mitigation measures are the construction contractors and operators. They will be supported by national and international environmental consultants within the Project Management and Construction Supervision Consultant team and the loan will finance a full-time Environment Safeguards Officer to support the PMU with implementation. The project stakeholders will closely monitor, and report on the implementation of the EMP.

26. Overall, the Project is expected to improve the urban environment in the three towns, reduce pollution impacts, reduce vulnerability to environmental and climate risks, improve health and support a more sustainable development path for the future.

[23] Anticipated project outcome is improved urban services for enhancing regional economic connectivity in participating towns

I. INTRODUCTION

A. Background

1. The Fourth Greater Mekong Subregion Corridor Towns Development Project (GMS-CTDP-4, or Project) will support the governments of Cambodia and Lao People's Democratic Republic (PDR) in enhancing the competitiveness of selected towns located along the Central Mekong Economic Corridor of the Greater Mekong Subregion (GMS).

2. The Project will improve urban services and enhance regional economic connectivity in the towns of Kampong Cham, Kratie, and Stung Treng in Cambodia. It will finance: (i) centralized wastewater and stormwater drainage facilities to improve sanitation and control flood risks, (ii) controlled landfills for municipal waste and solid waste collection vehicles to improve the town built environment, (iii) landscaping and rehabilitation of the town center to create livable public spaces that foster tourism benefits, (iv) information and communication technology (ICT) based government systems to optimize operational transparency and resource efficiency in managing the new infrastructures, and (v) provincial five-year socioeconomic development plans to promote regional economic connectivity and coordinate their strategies. The project will accelerate urban node development along the Greater Mekong Subregion (GMS) Central Corridor in Cambodia.

3. The Project supports the Government of Cambodia's Rectangular Strategy for national development. The third phase (RS- III 2013-2018) identifies integrated urban development as a priority and recognizes the need to manage environment and climate change to ensure the sustainability of Cambodia's economic growth and social development. The Project is also aligned with the National Green Growth Road Map (2010) which has seven goals, including access to clean water and sanitation.

4. The project environment classification is confirmed as Category B. This report is the Initial Environmental Examination (IEE) and Environmental Management Plans (EMPs) (Appendices A1 – A3) for Cambodia subprojects.

B. Purpose of the Report

5. This IEE and EMP have been prepared in accordance with Asian Development Bank (ADB) Safeguard Policy Statement (June 2009), and Cambodia's Law on Environmental Protection and Natural Resource Management (Preah Reach Kram/NS-PKM-1296/36) 1996 implementing guidelines and supporting sub decrees. This IEE and EMP: (i) identify and assess potential impacts and risks from subproject implementation on the physical, biological, physical cultural and socio-economic environments, and (ii) recommend measures to avoid, mitigate and compensate adverse impacts, while enhancing positive impacts.

6. The IEE and EMP will inform the domestic environmental impact assessments that will be carried out during detailed engineering design and will be updated to take account of any changes.

II. POLICY, LEGAL, AND ADMINISTRATIVE FRAMEWORK

A. Cambodia's Safeguard Systems

7. **Policy Framework.** The government has enacted policies and legislation that provide the framework to manage natural and physical cultural resources, protect the environment for the

health and well-being of its people, and achieve and maintain its international, regional and sub-regional commitments. Primary policy documents include:

(i) Rectangular Strategy Phase III 2013: which prioritizes stakeholder cooperation under the framework of green growth and climate change over the next five years.
(ii) National Policy on Green Growth 2013 and National Strategic Plan on Green Growth, 2013-2030: both of which have integrated the National Green Growth Road Map of 2010, which was formulated to provide the supporting framework for environmentally sustainable and socially inclusive development and growth in Cambodia.
(iii) National Strategic Development Plan 2014-2018: which promotes the agenda of the Rectangular Strategy Phase III.
(iv) Cambodia Climate Change Strategic Plan 2014-2023: which mainstreams climate change across sectors at different levels over the medium term, through the development of climate change action plans by line ministries, and national and sub-national programs over the long term.

8. The Ministry of Environment (MOE) has prepared a Climate Change Action Plan 2016-2018 that has 17 priority actions to support the eight strategic objectives of the National Strategic Development Plan. In addition, other sectors have developed action plans, those relating to disaster management, transportation, water resources and meteorology, public health, land management/urban planning/construction, mines and energy have relevance to the Project. The National Environment Strategy and Action Plan, which was developed to its final draft form in January 2017, aligns with the Rectangular Strategy Phase III and the National Strategic Development Plan. It will complement the Draft National Environmental Code, which focuses on establishing a stronger legal framework.

9. **Legal Framework.** The principal legislation relating to environmental safeguards is the Law on Environmental Protection and Natural Resource Management (Preah Reach Kram/NS-PKM-1296/36). Enacted in 1996, it requires all private and public-sector projects to implement an environmental impact assessment (EIA) and prepare an EIA report for MOE approval, prior to consideration and approval by the Royal Government. The current law is supported by the following:

(i) Sub-decree on EIA Process (No. 72 ANRK.BK) 1999: which provides detailed implementation guidelines and lists the projects that require an initial EIA (IEIA) or EIA.
(ii) Declaration on General Guideline for Preparing IEIA and EIA Report: issued by the MOE in 2009, this declaration specifies the contents of IEIA/EIA reports.[24]
(iii) Declaration on the Delegation of Power of Decision-Making on Project Development to the Provincial Department of Environment (PDOE) 2005: which confirms the PDOE as the reviewing and approving authority of IEIA/EIA reports of projects costing below US$ 2 million.

[24] Namely: (i) executive summary, (ii) introduction, (iii) legal framework, (iv) project description, (v) description of the existing environmental resources (physical, biological and socio-economic, including cultural heritage), (vi) public participation, (vii) environmental impacts and mitigation measures, (viii) environmental management plan, (ix) economic analysis and environment value, and (x) conclusion and recommendations.

(iv) Joint Declaration between the Ministry of Economy and Finance and the MOE on the Determination of Service Fee for EIA Reviewing and Monitoring, 2012: which specifies five fee levels.[25]

10. Other laws, policies, regulations and guidelines that will apply to the activities under the Project include (i) the Law on the Protection of Cultural Heritage 1996, (iii) Labor Law 1997, (iii) Sub-decree No. 36 on Solid Waste Management 1999, (iv) Sub-decree on Drainage System and Sewage Treatment Plant Management in Urban Areas, (v) Law on Water Resources Management 2007, (vi) Sub-decree No. 27 on Water Pollution Control 1999, (vii) Sub-decree No. 42 on the Control of Air Pollution and Noise Disturbance 2000, and (viii) Law on Mineral Resource Management and Exploitation 2001. A summary description of these laws, policies, regulations and guidelines is presented in Appendix B.

11. The IEE applies the environmental quality standards presented in Table 2.1. Appendix C presents the limits set in the national standards against those of international standards featured in the Environmental, Health, and Safety Guidelines.[26] The more stringent limits will apply.

Table 2.1: Key Standards to Apply in the IEE

Particular	National Standard	International Standards [a]
Ambient air quality	Annex 1, Ambient Air Quality Standard, of Sub-decree on Control of Air Pollution and Noise Disturbance, 2000	WHO Air Quality Guidelines, global update 2005
Noise	Annex 6, Max. Standard of Noise Level Allowable in the Public and Residential Areas, of Sub-decree on Control of Air Pollution and Noise Disturbance, 2000	WHO Guidelines for Community Noise, 1999
Groundwater quality	Drinking water Quality Standards, 2004	WHO Guidelines for Drinking-water Quality, Fourth Edition, 2011
Surface water quality	Annex 4, Water Quality Standards for Public Waters for Biodiversity Conservation, and Annex 5, Water Quality Standards for Public Waters and Health, of Sub-decree on Water Pollution Control, 1999	US EPA National Recommended Water Quality Criteria MRC Technical Guidelines for the Protection of Aquatic Life MRC Technical Guidelines for the Protection of Human Health
Effluent quality (from landfill & WWTP)	Annex 2, Effluent standard (Discharged wastewater to public water areas or sewers), of Sub-decree on Water Pollution Control, 1999	EHS General Guidelines and Guidelines for Water and Sanitation [b]
Soil Quality [c]		Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health [c]

EHS = Environmental Health and Safety; MRC = Mekong River Commission; US EPA = United States Environmental Protection Agency; WHO = World Health Organization.

[a] Featured or recommended in the Environmental, Health, and Safety Guidelines. IFC. World Bank Group. April 30, 2007.

[b] The selected approach should achieve effluent water quality consistent with applicable national requirements or internationally accepted standards and with effluent water quality goals based on the assimilative capacity and the most sensitive end use of the receiving water. For more on this, see IFC. Environmental, Health, and Safety Guidelines for Water and Sanitation. 2.1 Environmental Performance. 2007

[c] As national standards for soil quality have not been identified, it is recommended that any future soil quality analyses be assessed utilizing Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (Agriculture).

12. Cambodia is committed to the Sustainable Development Goals 2030, has adopted the Sendai Framework for Disaster Risk Reduction 2015-2030, and is also a member country of the Global Green Growth Institute. At the regional level, Cambodia is party to the ASEAN Agreement

[25] Ranging from US$ 500 to US$ 1,750.

[26] Including (i) Environmental, Health and Safety General Guidelines, 30 April 2007, (ii) Environmental, Health and Safety Guidelines for Water and Sanitation, 10 December 2007, and (iii) Environmental, Health and Safety Guidelines for Waste Management Facilities, 10 December 2007. IFC. WBG. These are currently being updated.

on Transboundary Haze Pollution. And at a sub-regional level, it is party to the Mekong agreement for sustainable development, utilization, management and conservation of water and related resources of the Mekong River Basin, and to the minimization of harmful effects that might result from natural occurrences and man-made activities. Cambodia is also party to the following relevant international environmental agreements:

(i) UNESCO World Heritage Convention.
(ii) UN Framework Convention on Climate Change and its associated Kyoto Protocol and Paris Agreement.
(iii) Basel Convention on the Control of Transboundary Movements of the Hazardous Wastes and Their Disposal.
(iv) Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer and all Amendments.

13. **Administrative Framework.** The MOE is the national environmental management agency. Department of EIA (DEIA) is responsible for the review and approval of IEIA/EIA reports and the monitoring of EMP implementation The MOE operates at the municipal and provincial levels through its Departments of Environment (DOEs). The current Sub-Decree on EIA Process prescribes a period of 30 working days for the review of IEIA reports from the date of receipt of the report, and another 30 working days for the review of revised IEIA or EIA reports from date of receipt.

14. **MOE Requirements for the Subproject**. In the consultation and coordination meeting with DEIA on 31 July 2017, MOE emphasized the following:

(i) Government environmental assessment requirements apply to the Project.
(ii) The executing agency (EA) will submit all Project IEIA/EIA reports to the MOE[27]. The MOE will then send copies of the reports to the concerned PDOE and other relevant agencies for their review. If MPWT does not submit an IEIA/EIA report, the project/subprojects will not be allowed to start. One IEIA/EIA report per town is acceptable to the MOE.
(iii) The preparation of IEIA/EIA reports must be performed by an entity or individual that is registered with the MOE.

15. The proposed subproject activities requiring IEIA/EIA preparation are summarized on Table 2.2

Table 2.2: Screening of Proposed Activities Using Sub-decree on EIA Process

Proposed Activities [a]	Activities Requiring IEIA or EIA [a]
Combined sewer system Service area to include Phase 1 of the service area • 8.9 km of trunk sewer/CSO with D1500 mm • 3.973 km of trunk sewer/CSO pipes with D1200 mm • 2.48 km of trunk sewer/CSO pipes with D1000 mm • 1.204 km of trunk sewers D800mm • 0.222 km f trunk sewers D600mm	**Drainage systems, ≥5,000 ha** Remarks: Annex classifies “drainage systems” under “Agriculture”. Prescribed threshold not clear. “Urban drainage” not listed in the Annex.

[27] PPTA Environment Team met with Mr. Duong Samkeat, Deputy Director, EIA Department, MOE on 31 July 2017 at the MOE.

Proposed Activities [a]	Activities Requiring IEIA or EIA [a]
• 0.09km of box culvert 2m wide • 6 WW pumps stations with capacity of max. 270 l/s • 4 pump stations for flood control on riverbank	
Lagoon-based wastewater treatment plant	**Wastewater treatment plant, all sizes** Remarks: Component requires IEIA/EIA.
Municipal solid waste-controlled landfill	**Waste processing/burning, all sizes** Remarks: Component requires IEIA/EIA.
Town center enhancement	Absent from the list. Remarks: The component is likely outside the threshold of projects required an IEIA or EIA.

[a] Thresholds of activities requiring IEIA/EIA preparation were obtained from the Annex of Sub-decree on EIA Process (No. 72 ANRK.BK) 1999.

B. ADB's Safeguard Policy Statement (SPS)

16. All projects funded by ADB must comply with SPS 2009 to ensure that they are environmentally sound, designed to comply with applicable regulatory requirements, and are not likely to cause significant environmental, health, or safety hazards. Depending on the type, location, scale, sensitivity and magnitude of potential environmental impacts, projects are assigned an environmental category, Category A, B or C.

17. This project is classified as environment Category B as impacts are site-specific, few if any of them are irreversible, and in most cases mitigation measures can be designed readily so an IEE and EMP is required. The IEE is based on primary and secondary data, including published reports. Public consultations with government stakeholders, affected persons, and other stakeholders was undertaken, and site reconnaissance conducted to determine community perceptions regarding subprojects and to obtain relevant information.

18. The report structure follows the format outlined in Appendix 1 of SPS 2009. The IEE/EMP and semi-annual environmental monitoring reports submitted by the borrowers/clients during project implementation will be disclosed on the ADB website in accordance with ADB's Public Communications Policy.

III. DESCRIPTION OF THE PROJECT

A. Rationale

19. While Cambodia remains almost 80% rural, urbanization is accelerating with urban population expected to reach 30% by 2030. Economic development has been mostly concentrated in the northwestern, western, and southeastern regions where the large secondary cities, economic infrastructures (e.g. international sea ports and airports), and tourism attractions are located; while the northeastern provinces remain underdeveloped. The five provinces in the north-east contributed less than 8% of the national economy in 2016, suffering from low income per capita and high poverty incidence.

20. The GMS Central Corridor along the Mekong River connects from Vientiane, the national capital of Lao People's Democratic Republic (PDR), through Cambodia's capital of Phnom Penh to Sihanoukville on the gulf of Thailand. Over 1,600 kilometers (km) corridor embraces 13 cities

and towns with a total urban population of about 3 million and corridor population of about 20 million and generates regional economic outputs of over $20 billion. Located along the GMS Central Corridor, Kampong Cham, Kratie, and Stung Treng have geographical advantages and potential to become an engine of growth in the region and reduce regional development disparities.

21. Lack of basic urban infrastructure is a clear bottleneck for the towns to attract more people and investments. Although 42-55% of the total town population have access to piped water supply, their sanitation services have no wastewater collection or treatment facilities other than soakway pits and a small percentage coverage of septic tanks. Solid waste is taken to open dumpsites, waste collection coverage is 30-50% of municipal areas and collection frequency is variable. Seasonal floods from the Mekong River cause estimated annual flood damage of KR 3.4-5.4 billion and the poor sanitation systems exacerbate incidents of waterborne diseases. The provinces lack capacity to identify their comparative advantages, to prepare development strategies or coordinate with neighboring provinces in a collaborative way to achieve the common goals of promoting trade and tourism, integrating markets and economies, and improving value chains.

22. Aligning with ADB's country partnership strategy, 2014-2018 for Cambodia, the urban and water sector support has been focusing on: (i) provinces and towns in the Tonle Sap basin by accelerating the development of Cambodia's second socioeconomic growth center; and (ii) provinces and towns along the GMS corridors by promoting regional socioeconomic integration. The project is consistent with the urban and water sector ongoing projects and ADB's Midterm Review of Strategy 2020, Urban Operational Plan, and Environment Operational Directions as it supports the scaling up support for climate adaptation, public management reforms including use of ICT, expanding regional connectivity and extending value-chains, and competitive, inclusive, and environmentally sustainable urban development.

B. Impact, Outcome and Outputs

23. The impact will be sustainable, inclusive, equitable, and resilient growth achieved, aligning with the government's National Strategic Development Plan 2014–2018 (NSDP, 2014–2018). The outcome will be improved urban services in the participating towns and increased economic activity along the Corridor.

- **Output 1: Urban environmental infrastructure.**
  - **Urban environmental infrastructure in Kampong Cham improved.** The suboutput includes: (i) a centralized wastewater treatment (WWT) facility, (ii) 16.6 km of trunk sewer, (iii) 4.3 km open drainage channel, (iv) four pump stations, (v) a controlled landfill, and (vi) six waste collection and compaction vehicles.
  - **Urban environmental infrastructure in Kratie improved**. The suboutput includes: (i) a centralized WWT facility, (ii) 5.7 km of trunk sewer, (iii) 12 km open drainage channel, (iv) two pump stations, (v) controlled landfill, (vi) six waste collection and compaction vehicles, and (vii) town center environmental enhancement.
  - **Urban environmental infrastructure in Stung Treng improved**. The suboutput includes: (i) a centralized WWT facility, (ii) 16.8 km of trunk sewer with various diameters (600–1,500 mm), (iii) six wastewater pumps and four flood control pump stations, (v) a controlled landfill with a volume capacity of 291,000 m3 compacted waste, (vi) five waste collection and

compaction vehicles, and (vii) town center enhancement including 5,800 m2 of street pavement rehabilitation, 21,000 m2 land scaping.

- **Output 2: Institutional effectiveness, and policy and planning environment for regional economic connectivity enhanced**. The output will strengthen provincial governments' institutional capacity for urban development and climate and disaster resilience planning, ICT and project, social and environment management.

C. Proposed Project

24. The design and technology to be adapted for the lagoon-based wastewater treatment and controlled landfill components, and the facilities to be included for town center enhancement are broadly similar in the three project towns. A detailed analysis of the wastewater treatment and controlled landfill designs and technology is in the Feasibility Study Report Volume 2: Annexes – Planning, Corridor, and Engineering. A summary of the subproject designs relevant to all three town is provided below, followed by a more detailed discussion of the project outputs and components envisaged in each town.

25. **Wastewater Treatment System Design and Technology.** A lagoon-based wastewater treatment system will be adopted which will comprise three sets of ponds connected in a series, starting with a deep anaerobic pond, moving through a facultative pond, and into a large and shallow maturation pond. The wastewater treatment facility will have the following features: (a) three (3) sets of lagoons in series comprising of four units of anaerobic lagoons, two (2) units of facultative lagoons, and two (2) units of maturation lagoons; (b) two (2) treated-sludge drying area; and (c) site office, equipment storage, parking area, site roads, and drainage. The combined sewer service area has been defined using main roads as boundaries to include the main urban area and any periphery residential areas of significance. The collection network will include main trunk sewers, collection pipelines along main roads, box culverts, open channels, and pumping stations.

26. **Controlled Landfill Design and Technology.** The controlled landfill will involve depositing wastes into lined cells, waste compaction and placement of soil cover in layers, leachate collection and recirculation. When full, waste cells are capped and planted. The proposed controlled landfill will be constructed with four lined cells. The capacity of the landfill can store waste up to 2040. The design will include provisions for leachate drains, leachate pump for circulation, monitoring boreholes, leachate pond, leachate treatment lagoon, sorting and recycling area, disposal and incineration area for hazardous wastes, access roads, water supply, site drains, site office with toilet, and perimeter fencing. The facility will also include equipment such as collection vehicles, bull dozer, and a crane.

27. **Town Center Enhancement.** Public amenities will be improved in Kratie and Stung Treng specifically near the riverside and market areas to enhance the recreational and tourism value of the town centers. Riverside improvements will include paving, kerbing, planting of trees, installation of streetlights, and provision of seating amenities, waste bins, and exercise equipment. The existing streets around the market connecting to the riverside will be cleared from encroachments and will be rehabilitated with new paving and kerbs, planting of trees, installation of street lights, and provision of waste bins.

1. Output 1: Urban environmental infrastructure improved.

a. Suboutput 1: Urban environmental infrastructure in Kampong Cham improved

28. Suboutput 1 has two components: (i) a lagoon-based wastewater treatment system, and (ii) a municipal solid waste controlled landfilled and equipment. Each component is described below.

29. **Component 1.1 Kampong Cham lagoon-based wastewater treatment system.** This system includes both a combined sewer system (CSS) and a new wastewater treatment plant (WWTP). The proposed WWTP will be located within the 35-hectare Boeng Bassac area in Sambor Meas Commune. The following will be delivered from the system under the project: (i) lagoon-based wastewater treatment facility with capacity of 5,050 m^3/d; (ii) 9.476 km trunk sewer/CSO with D1500 mm; (iii) 3.478 km trunk sewer/CSO pipes with D1200 mm; (iv) 2.156 km trunk sewer/CSO pipes with D1000 mm; (v) 0.756 km trunk sewer D 800mm; (vi) 0.687 km trunk sewer D 600mm; (vii) 120.3 km Collection Pipeline D300 mm; (viii) 0.89 km box culverts 2-3m wide; (ix) 4.309 km open channels, 5-7m wide; and (x) four pump stations with a maximum capacity of 165 l/s.

30. The combined sewer system will be built in the main urban area, to serve the four (4) *sangkats*[28] of Kampong Cham and the target population within the coverage area as follows: (i) Krong Kampong Cham, 100%; (ii) Veal Vong, 100%; (iii) Sambor Meas, 50%; and (iv) Boeng Kok, 10% of the population. The proposed sewer system is designed as a single system to collect wastewater from domestic and commercial connections in the town center area, and stormwater from the catchment areas, which will be pumped into the new WWTP by four pumping station units. The system will also allow septage to be co-treated in the WWTP. The final treated effluents from the WWTP will be discharged into the Boeng Bassac Lagoon, which has a stream connected to the Mekong River. Figure 3.1 presents the proposed location for Kampong Cham's treatment plant.

31. The lagoon-based WWTP, to be developed on a 10-hectare public land parcel, is designed to treat wastewater and stormwater flows up to 2040. Figures 3.2 and 3.3 show the conceptual layout and site photos of the WWTP facility.

32. The service area of the combined sewer system under the Phase 1 of the project will cover mostly residential and commercial establishments, about 11 educational institutions, 5 religious institutions, and a hospital. There are no protected areas or sites for biodiversity conservation identified within the proposed CSS and WWTP locations.

33. Boeng Bassac, the site for the WWTP, used to function with Boeng Snay (88ha) for the natural drainage system of Kampong Cham town. Boeng Snay, however, has been filled for development without alternative provision for drainage or wastewater retention. This has caused stormwater to flow and be stored around the edges of the developed areas near Boeng Snay.

34. Boeng Bassac is separated from Boeng Snay by a raised embankment with a road running north to south. The area block within which Boeng Bassac is situated is bordered on all sides by road. To the east is the road on embankment that separates Boeng Bassac from Boeng Snay.

[28] A sangkat is the Cambodian equivalent of a commune. Cambodia's sub-national administration consists of three tiers, namely: (i) capital city/province, (ii) district/municipality/khan, and (iii) sangkat/commune.

The pump house that will be upgraded under this component is situated here, shown in Figure 3.4. To the north and west, the road is lined with residential development. There are a few residences within 140 to 150 meters from the northwestern edge of Boeng Bassac. Figure 3.5 shows the nearest housing community from the lagoon. To the south the road has least residential development.

35. Land cover within the area block of Boeng Bassac is largely agricultural, shrub/grassland, with some areas planted with trees.

36. There are two streams that flow from Boeng Bassac. On the southeast edge, the stream flows about 900m to Mekong River. On the west, a stream flows at least 1.5km to reach Boeng Smuos.

37. There are no protected area or sites for biodiversity conservation in the proposed project location.

38. Almost the entire area block is waterlogged in the rainy season, about 4-5 months.

39. **Component 1.2 Kampong Cham municipal solid waste-controlled landfill and equipment.** This component will consist of a controlled landfill with volume capacity of 900,000 m^3 sized to receive generated waste from Kampong Cham until 2040. The new controlled landfill will be developed in an 11-hectare government-owned site located in Phkay Proek Village, Mien Commune, Prey Chor District, which is about 17 kilometers from Kampong Cham town center. **Figure 3.6** presents the proposed location of the landfill. Figure 3.7 shows the conceptual layout of the facility.

40. The controlled landfill will include the following features: (i) four waste cells sized at 85m x 85m and 10 m deep, lined with compacted clay/earth and geomembrane (HDPE), (ii) leachate pond, recirculation system and treatment lagoon, (iii) sorting and recycling area, (iv) separate disposal and incineration area for hazardous wastes, (v) site office with toilet, (vi) water supply and monitoring bore holes, (vii) power supply, (viii) concrete access road (1.5 km and 4m wide) and all-weather site roads, (ix) site drains, (x) perimeter fencing, (xi) six waste collection and compaction vehicles and one crane. Existing dumpsites in Kampong Cham are privately owned. Hence, their closure has not been considered for inclusion in the Project.

41. The proposed project location for the controlled landfill has no affected cultural or heritage sites, or areas for biodiversity conservation or protection identified within its proximity. The area is also characterized by high elevation and not prone to flooding. The area is mostly shrub land or grassland with some trees, and the surrounding lands are utilized as rice fields. Along NR7, which is about 500 meters from the estimated center of the proposed site, there are existing houses. A regional national police school is also operating approximately 400 meters from the eastern edge of the site. Site photos are shown in Figure 3.8.

Figure 3.1: Proposed Combined Sewer Service Area and Location of Wastewater Treatment Plant in Kampong Cham

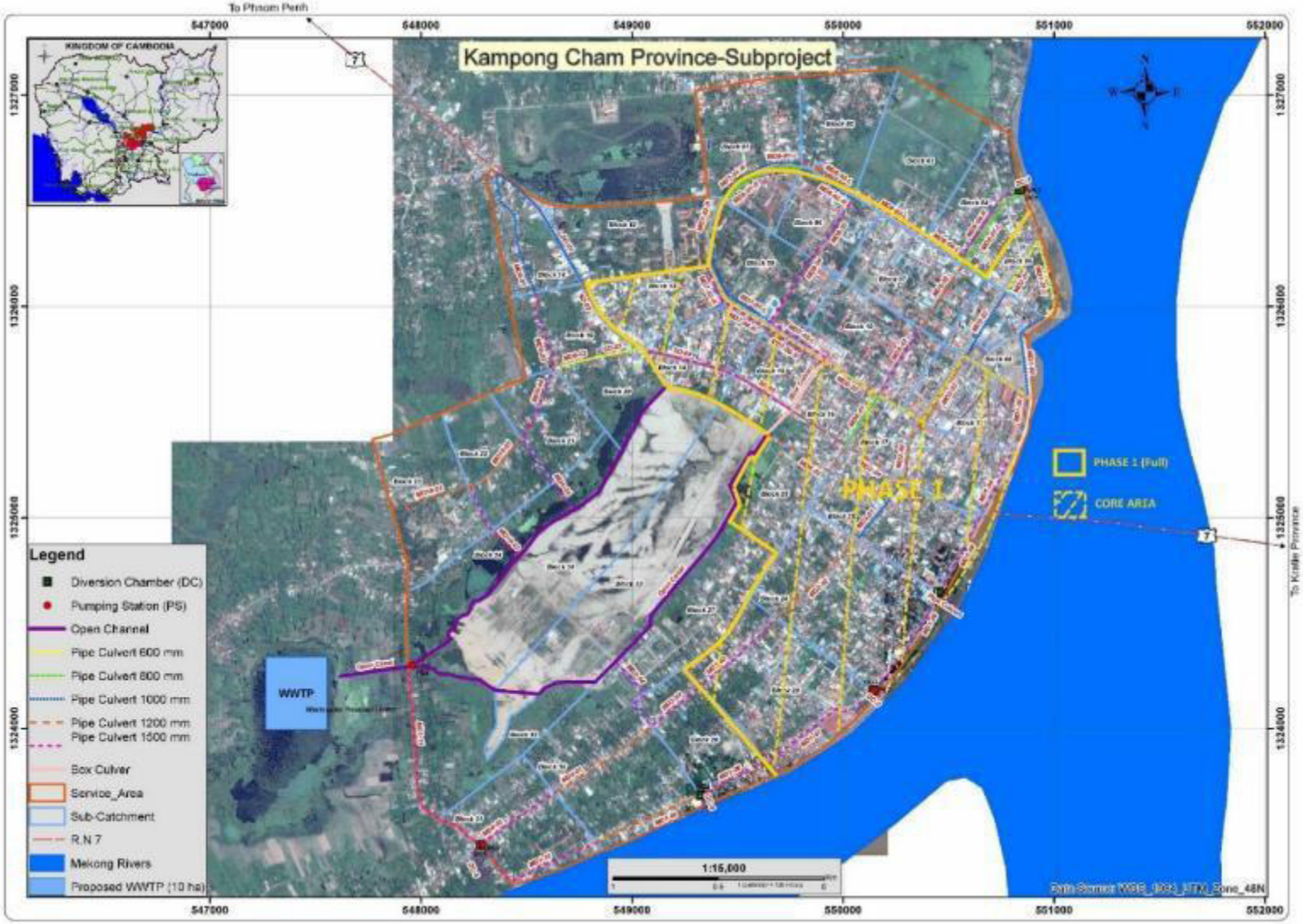


Figure 3.2: Conceptual Layout of the Kampong Cham Wastewater Treatment Plant

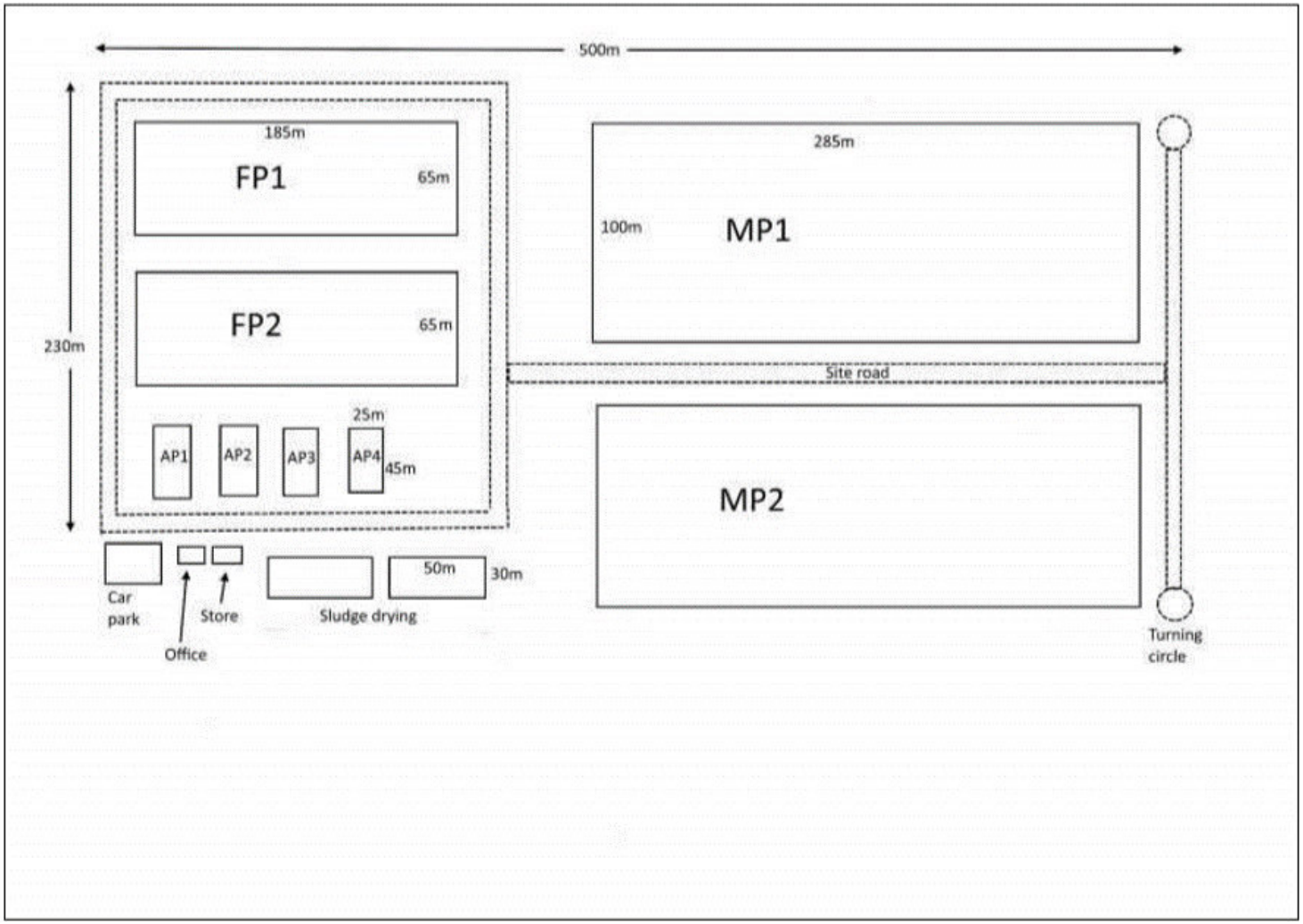


Figure 3.3: Photos of WWTP Site from the Road on its West and of the Pump House

View of WWTP site from the road where the pump station is located

Left Photo: Western end of the culvert that is leading water from the vicinity of the new development area in the east to the lagoon (WWTP site) in the west.
Right Photo: The road under which he aforementioned culvert runs, and the pump house which will be upgraded under the subproject.

Figure 3.4: Photo of the Filled Boeng Snay Taken from the Pump House

View of the filled Boeng Snay new development area from the pump house with surrounding water-logged areas

Figure 3.5: Nearest Housing Community from the NW edge of the Lagoon

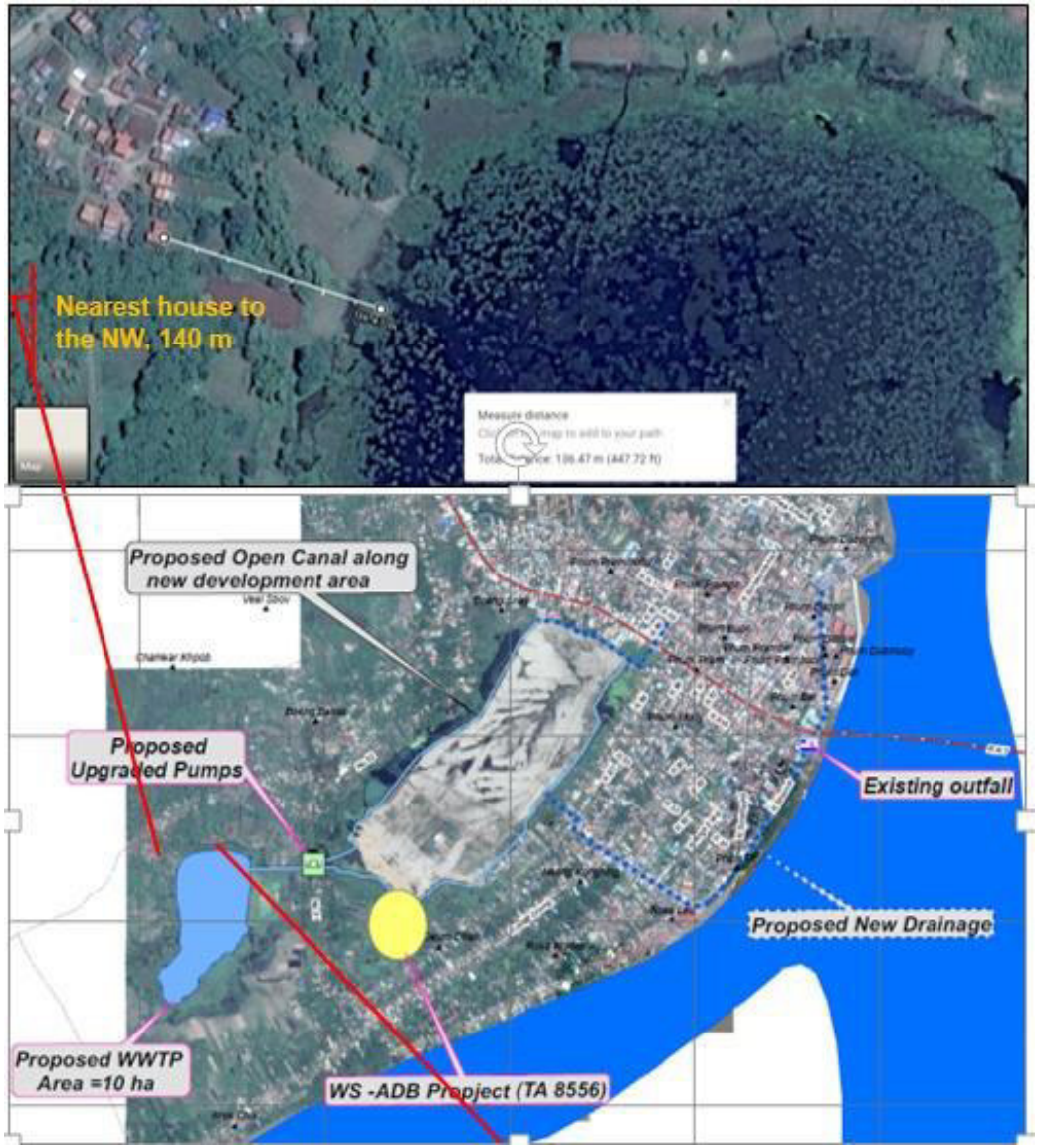
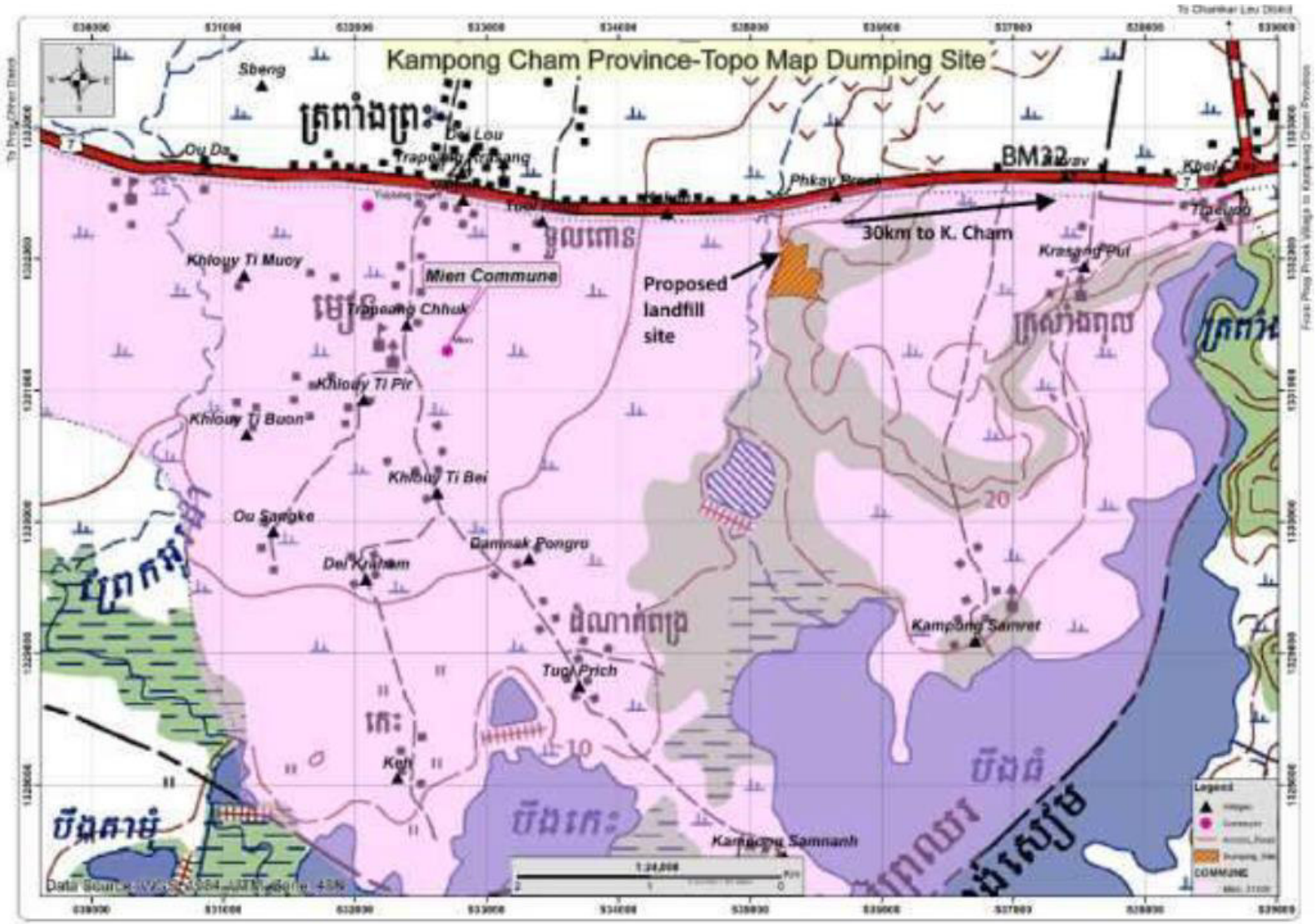


Figure 3.6: Location of the Proposed Kampong Cham Controlled Landfill



Source: PPTA Consultant

Figure 3.7: Conceptual Layout of the Proposed Kampong Cham Controlled Landfill

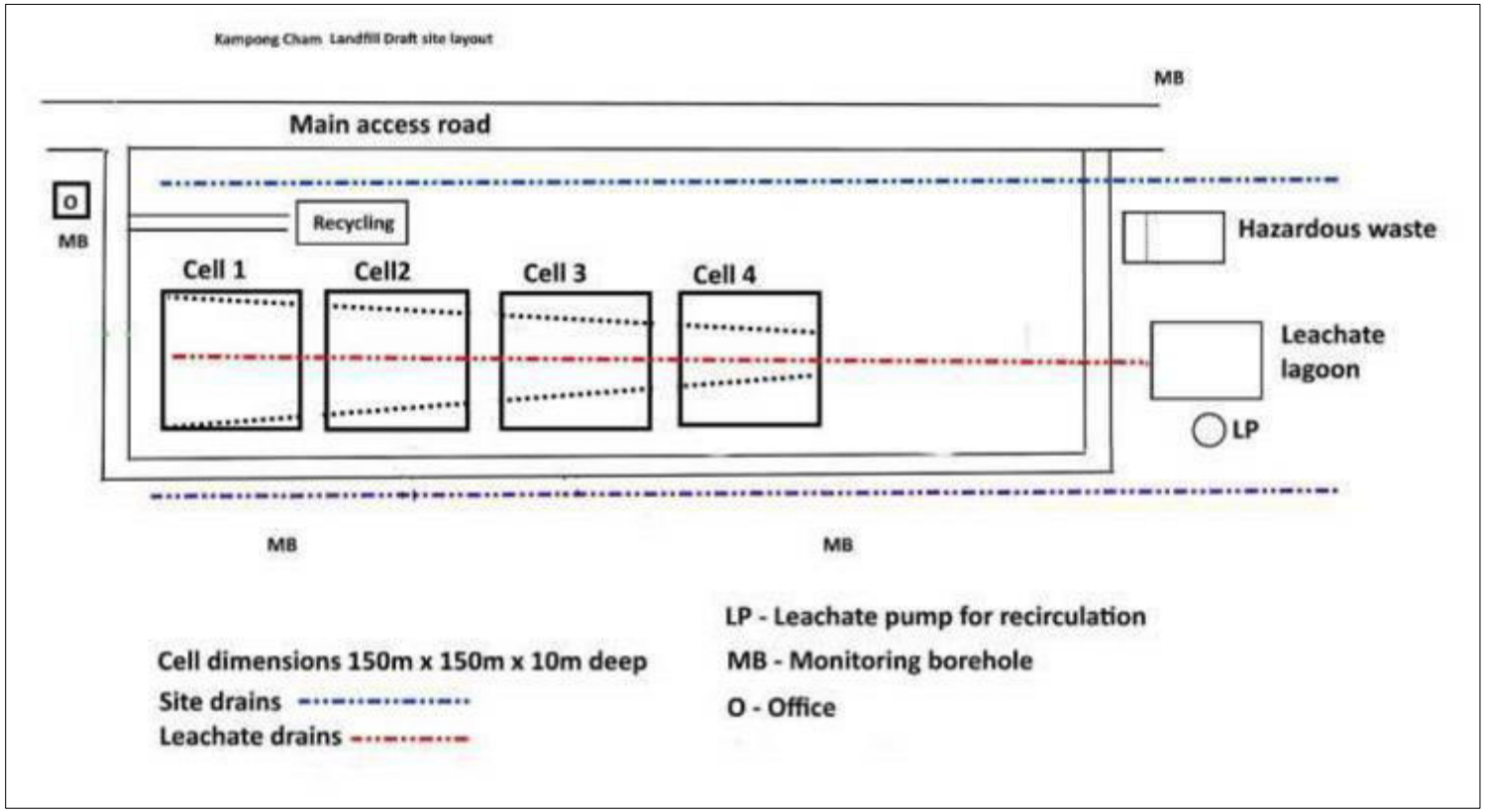


Figure 3.8: Photos of the Proposed Controlled Landfill Site in Kampong Cham

The existing vegetation/forest resources in proposed landfill site

Small stream is near the proposed landfill site

The transmission line and electric pole in the proposed landfill site (the north part at entrance)

b. Suboutput 2: Urban environmental infrastructure in Kratie improved

42. Output 2 consists of three components: (i) a lagoon-based wastewater treatment system, (ii) a municipal solid waste controlled landfilled and equipment, and (iii) town center enhancement. Each of these is described below.

43. **Component 2.1 Kratie lagoon-based wastewater treatment system**. The proposed wastewater system will comprise a WWTP and combined sewer system that will address the drainage requirements and the collection and treatment of wastewater from domestic and commercial sources in Katie's urban center. The system comprises the following: (i) lagoon-based wastewater treatment facility with capacity of 4,900 m^3/d; (ii) 4.722 km trunk sewer/CSO with D1500 mm; (iii) 0.603 km trunk sewer/CSO pipes with D1200 mm; (iv) 0.399 km trunk sewer/CSO pipes with D1000 mm; (v) 137.5 km Collection Pipeline D300 mm; (vi) two pumps stations with capacity of 245l/s; (vii) 1.1 km access road (10 m wide); and (viii) 1 bunded drainage canal (80m x 7m x 12000m, W-H-L).

44. The proposed combined sewer will include the main urban center along the Mekong River, and the new urban area eastwards along Road 377. The service area will cover parts of sangkats Krong Kratcheh, Krakor, Ou Russei, and Roka Kandal, to serve 100%, 25%, 50% and 10% of their population, respectively. The location of the WWTP system and the CSS layout are shown on Figure 3.9.

45. The WWTP will be constructed on a 10.5-hectare public land site, located to the southeast of the main urban area as shown on Figure 3.9. Initially designed to collect and treat stormwater and wastewater until 2040, the WWTP may be extended either by acquiring further land for a parallel set of lagoons, or by retrofitting to increase the capacity such as the installation of aerators or trickling filters. The final treated effluents from the WWTP will be discharged into the nearby lagoon. Figure 3.10 shows the features of the proposed WWTP.

46. The WWTP will be developed at the northwest section of the big lagoon. The site has been observed to be waterlogged for 4 to 5 months during the rainy season. The surrounding vicinity of the WWTP site is mainly agricultural and grass lands on the north, east, and southeast directions, with some crops currently cultivated by the farmers. The nearest residential area is about 1.5 kilometers west of the WWTP site, and the approach of the Kratie Airport runway is about 2 kilometers southeast of the project location. The access road to be constructed will be along a commercial establishment, a school, some agricultural lands, and nearby residences. There were no observed protected area, biodiversity conservation, or cultural and heritage protection sites noted near the proposed WWTP. Photos of the open channel and proposed WWTP site are shown in Figure 3.11.

47. The proposed combined sewer system will mainly cover the main urban area, to serve the residential and commercial establishments, including schools, temples and mosques, hospital, and a public library. The urban area falls within the Mekong River Important Bird Areas (IBA) from Kratie to the Lao Border.

Figure 3.9: Location of the Proposed Kratie WWTP, Combined Sewer System Coverage, and Existing Dumpsite

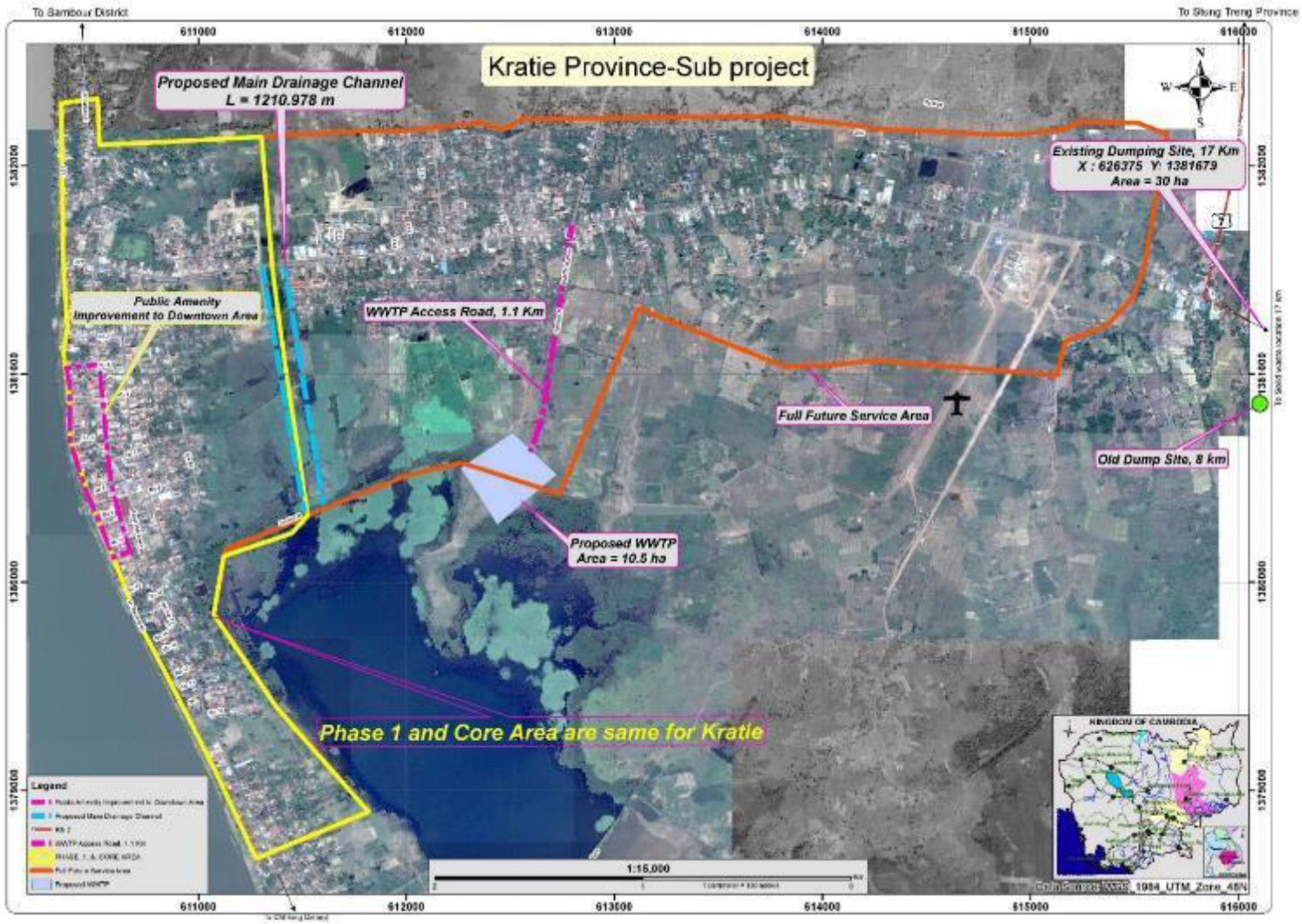


Figure 3.10: Conceptual Layout of the Proposed Kratie Wastewater Treatment Plant

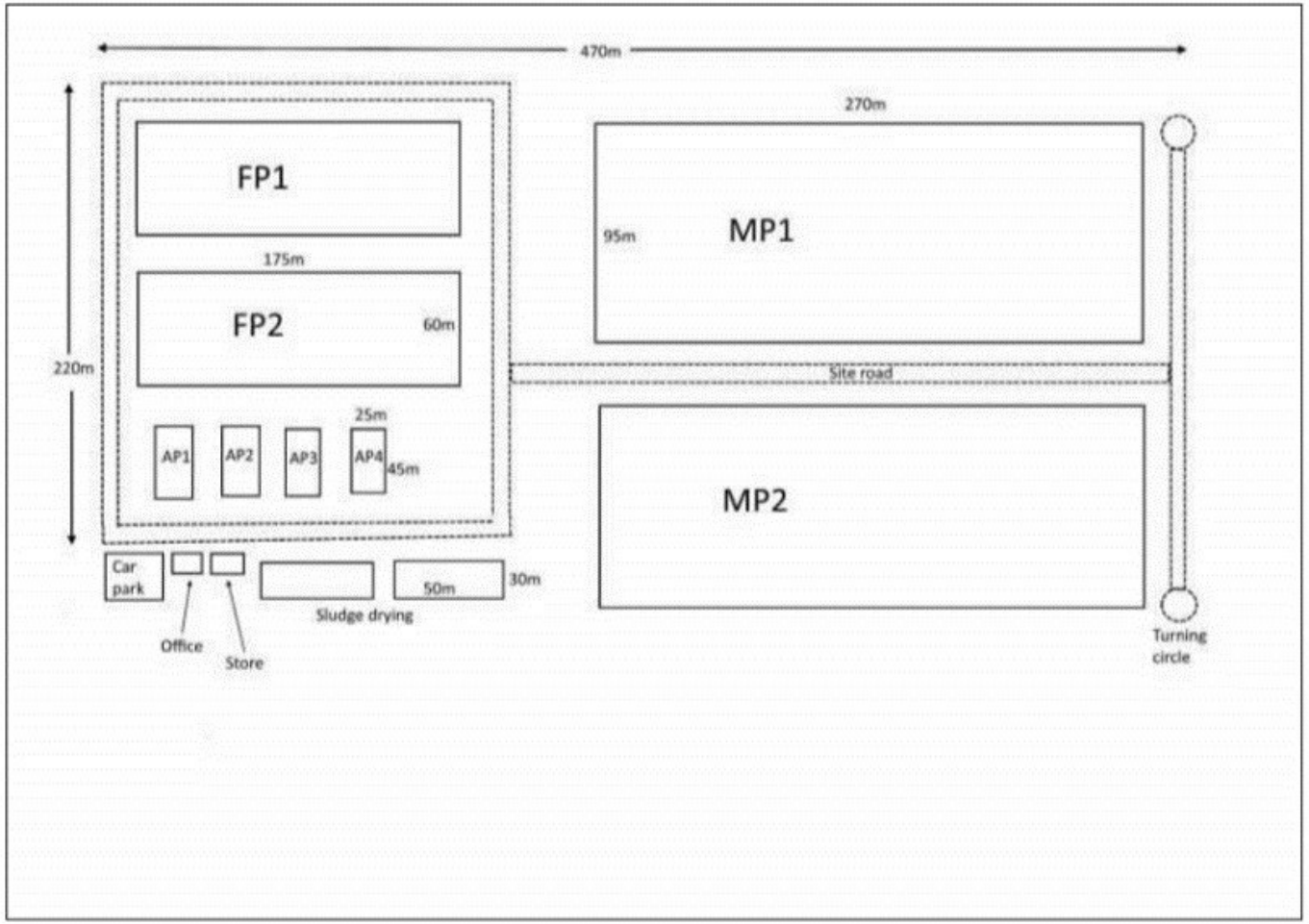


Figure 3.11: Photos of the Open Channel and Proposed WWTP Site

Site for main drainage channel

View of the WWTP, pumping station and ring road (section A) sites from the main drainage channel site

48. **Component 2.2 Kratie municipal solid waste-controlled landfill and equipment.** The proposed controlled landfill will be developed at the 30-hectare site within the 100-hectare public land parcel where the existing dumpsite is located. The site is about 17 kilometers east of the town center and can be accessed from National Road No. 7 through a 1.6-kilometer N-S road that connects to a SW-NE road that forms the southern boundary of the landfill property, as shown in Figure 3.9.

49. This controlled landfill with lined cells will have a capacity of 433,500 m^3, sized to receive the town's solid wastes until 2040. The location of which is also shown in Figure 3.9. The specific features of the landfill include (i) four (4) waste cells (104 m x 104m x 10m) lined with compacted clay/earth and geomembrane (HDPE); (ii) leachate pond, recirculation system and treatment lagoon, (iii) sorting and recycling area, (iv) separate disposal and incineration area for hazardous wastes, (v) site office with toilet, (vi) water supply and monitoring bore holes, (vii) power supply, (viii) concrete access road (1.5 km and 4m wide) and all-weather site roads, (ix) site drains, (x) perimeter fencing, (xi) six waste collection and compaction vehicles and one crane for handling recyclables. The conceptual layout of the proposed controlled landfill is in Figure 3.12. Photos of the controlled landfill site are shown on Figure 3.13.

50. The proposed controlled landfill site is flat and is surrounded by shrub/grassland, with agricultural lands on the west which are being cultivated by some farmers. During the rainy season, the access road to the site is often not passable, leading to the continued use of the old dumpsite. The nearest agricultural land is about 500 meters west of the existing dumpsite, and the nearest residential area is about 1.75 kilometers away. Along the access road connecting to the landfill site are a few residential houses, a commercial establishment, a university, and agricultural lands. A stream can be found within the property near the eastern boundary and this flows to a small lagoon in the south. Two families are part-time waste pickers at the existing dumpsite.

51. This component will also include the closure of the old dumpsite, the location of which is also shown in Figure 3.9. The old dumpsite for closure is composed of one lined cell with leachate drains, with a dimension of 120m x 120m x 10m (length, width, depth), and a capacity of 146,000 cubic meters. The dumping operations at this site started in 2006, but officially closed in 2015 in response to requests from communities to have the dumping operations moved to another place. However, the dumpsite continues to receive wastes, with approximately 40 tonnes per day disposed at the site. The dumpsite is left open, without fence, and waste picking operations continue. An environmental compliance audit of the dumpsite will be completed early in the detailed design stage by the Environmental Specialist of the PMCS. The findings of the ECA will inform the closure proposals. Figure 3.14 is a photo of the old dumpsite and photos of waste picking operations are shown in Figure 3.15. The dumpsite is about 4.5 km away from the runway of Kratie Airport which is still operational. Housing structures can be found along the access road. The closest water body is a pond, at least 1km to the southeast. A big buddha statue is one of the structures near to the dumpsite access road. Surrounding the site are agricultural lands with shrub/grasslands and forested areas in between. Aside from the Buddha statue located near the dumpsite, the proposed location for the controlled landfill has no affected protected area or areas for biodiversity conservation identified within its proximity.

52. **Component 2.3 Kratie town center enhancement.** The proposed town center improvements intend to enhance the public or recreational amenities along the riverside and market square areas. The specific improvements will cover the (a) area along the riverfront walkway along Preah Soramarith Quay, for approximately 1,500 meters between the water supply department (Road No. 12) to the south, and the roundabout where Road No. 377 enters town to

the north, and (b) the block of streets around the central market house where restaurants and guesthouses are located.

53. Kratie derives income from tourism as an attractive riverside town which offers views of colonial buildings, excursions to view Mekong Irrawaddy River dolphins, and as popular stop en route to and from Lao PDR. However, the riverside and market square areas, and interconnecting side roads, are in poor condition. While there is some tree planting along the riverfront and concrete seating, improvements are proposed to include (i) installation of 92 energy-efficiency streetlights, (ii) pavement rehabilitation covering an area of 10,600 m^2, (iii) 2,300 meters of kerbing, and (iv) provision of auxiliary equipment.

54. The proposed town center improvements fall within the potential impact area of the Mekong River IBA, and will impact the residents, commercial establishments, religious establishments, and some schools within the subproject coverage area. Although improvements are proposed to the riverside walkways, there are no planned channel or bankside works that would impact on the river. The riverside walkways are estimated to be at least within 20 meters of the Mekong River.

Figure 3.12: Layout for the Proposed Kratie Controlled Landfill

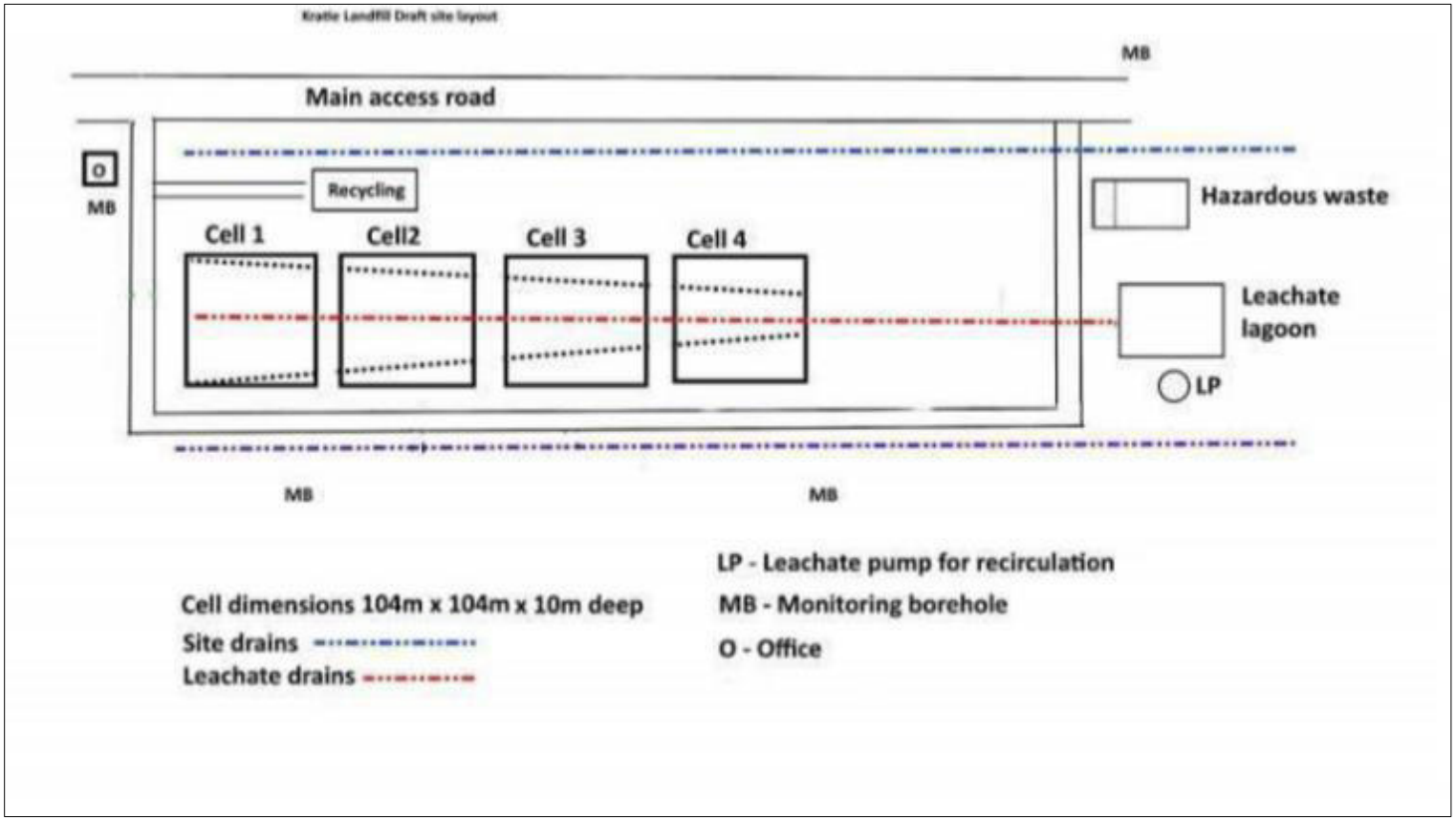


Figure 3.13: Photos of the Controlled Landfill Site

Figure 3.14: Photo of the Old Dumpsite

Figure 3.15: Photo of Continuing Waste Picking Operations in the Old Dumpsite

c. Suboutput 3: Urban environmental infrastructure in Stung Treng improved

55. **Component 3.1. Stung Treng lagoon-based wastewater treatment system.** Similar to the wastewater components in the other two towns, this component includes a combined system incorporating a combined sewer system and a WWTP. The proposed combined sewer system will be designed to address drainage requirements and the collection and treatment of wastewater from domestic and commercial sources in the urban center. The deliverables of this component include: (i) lagoon-based wastewater treatment facility with capacity of 3,800 m^3/d; (ii) 8.9 km of trunk sewer/CSO with D1500 mm; (iii) 3.973 km of trunk sewer/CSO pipes with D1200 mm; (iv) 2.48 km of trunk sewer/CSO pipes with D1000 mm; (v) 1.204 km of trunk sewers D800 mm; (vi) 0.222 km of trunk sewers D600 mm; (vii) 130.1 km Collection Pipeline D300 mm; (viii) 0.09 km of box culvert 2m wide; (ix) six wastewater pumps stations with capacity of maximum 270 l/s; and (x) four pump stations for flood control on riverbank.

56. The combined sewer will serve the three (3) sangkats and the target population within the coverage area are as follows: (i) Krong Stung Treng, 75%; (ii) Srah Ruessei, 10%; and (iii) Preah Bat, 90% of the population.

57. The WWTP will be constructed on a 10-hectare public land parcel and is designed to collect and treat wastewater until 2040. Treated effluents from the WWTP will be discharged into an existing stream within the site which flows into the Mekong River. No water users were observed but this should be further investigated during detailed engineering design. The general location of the wastewater system is shown in Figure 3.16, and the conceptual layout of the WWTP is shown in Figure 3.17.

58. The WWTP site is within an area block that is bordered on all side by roads as shown in Figure 3.18. Residential structures exist to the south of the WWTP site, and a low-density residential development exists to the west. About four to five houses are at the southeast area of the block, close to the E road. The surrounding vicinity of the WWTP site is mainly agricultural, grassland, and forested land, with some crops currently cultivated by farmers on agricultural lands.

59. The proposed combined sewer system with the floodgate and pumping stations will mainly cover the main urban area, to serve the residential and commercial establishments, including schools, temples, mosques, pagodas, a provincial government office, hospital, and health center. The proposed WWTP and CSS system falls within the potential impact area of the Mekong River Important Bird Areas (IBA) from Kratie to the Lao Border and Sekong IBA. Photos of floodgate sites are shown on Figures 3.19–3.22.

60. **Component 3.2 Stung Treng municipal solid waste-controlled landfill and equipment.** A new controlled landfill covering an area of 12 hectares will be developed in a 100-hectare public land across the town, about 13 kilometers from the town, as shown in **Figure 3.23**. The facility will have a capacity of 291,000 m^3, sized to receive the town's generated wastes until 2040. It will also have 5 waste collection and compaction vehicles; and one crane for handling recyclables.

61. The landfill will include (i) four (4) waste cells (85 m x 85m x 10m) lined with compacted clay/earth and geomembrane (HDPE); (ii) leachate pond, recirculation system and treatment lagoon, (iii) sorting and recycling area, (iv) separate disposal and incineration area for hazardous wastes, (v) site office with toilet, (vi) water supply and monitoring bore holes, (vii) power supply,

(viii) concrete access road (1.5 km and 4m wide) and all-weather site roads, (ix) site drains, and (x) perimeter fencing. The conceptual layout of the proposed controlled landfill is shown as Figure 3.24.

62. The site is elevated, not flood prone, and mostly degraded forest, scrub with scattered trees with at least two perennial streams flowing southward. The estimated center of the property is about 860 meters from the main road, and about 1 kilometer away from the nearest house. The southern boundary of the site is at least 3 kilometers from the western bank of the Mekong River, while the center of the site is about 5.8 kilometers from the confluence of Mekong and Sekong Rivers (edge of Sekong River IBA), and about 13.5 kilometers from the confluence of Sekong and Sesan Rivers (edge of the Sesan River IBA). There are two historical sites near the proposed landfill location, namely, Preah Ko Temple (5.5 km) and Phnom Preah Theat Temple (6.5km).

63. This component will also include the closure of the existing dumpsite, the location of which is also shown in Figure 3.23. The existing dumpsite, which comprises at least five (5) non-contiguous dumping grounds, is located along NR7, approximately 10 kilometers from the foot of the Sekong Bridge across the town center. The eastern boundary of the dumpsite property is about 300 meters from the west bank of the Sekong River; and the center of the property is about 4 kilometers from the north bank of Sesan River, and 4 kilometers from the east bank of the Mekong River. Photos of the existing old dumpsite are shown in Figure 3.25. Based on the information on protected areas by UN Environment World Conservation Monitoring Centre (UNEP-WCMC), the property is within the RAMSAR site boundary. There is only one house inside the property which belongs to the caretaker assigned by Government, and with three (3) waste pickers operating in the area. An environmental compliance audit will be undertaken early in the detailed design stage by the Environmental Specialist of the PMCS. The findings will inform the closure design.

64. The proposed controlled landfill falls within the potential impact area of the Mekong River, IBA from Kratie to Lao Border. The closure of the existing dumpsite falls within the potential impact area of the Mekong River RAMSAR site, Mekong River IBA from Kratie to Lao PDR border, and Sekong IBA. An environmental compliance audit will be undertaken early in the detailed design stage by the Environmental Specialist of the PMCS. The findings will inform the design of the dumpsite closure.

65. **Component 3.3 Stung Treng town center enhancements.** Town center enhancements are proposed to improve the recreational value of selected streets of the Stung Treng town. The target areas for improvement will be (a) along the riverfront walkway, for a distance of approximately 1,100 m between the Four Rivers Hotel (near Road 69) to the west, and Road 55 to the east; (b) at the 30 meter-wide strip between the main double carriageway boulevard (Roads 63 and 64) that run through the center of Stung Treng in a south-north direction down to the riverfront; and (c) around the market square specifically Roads Nos. 51,12, and 14 (Figure 3.16).

66. Improvements are proposed to include the following: (a) installation of 72 energy-efficiency streetlights, (b) pavement rehabilitation covering an area of 5,800 m^2, (c) 1,800 meters of kerbing, and (d) provision of auxiliary equipment.

67. The Sekong river IBA is within the area of influence of the proposed town center improvements. Although there are planned riverside walkways, there will be no channel works or something of a similar nature that would impact on the river.

Figure 3.16: Location of the Stung Treng Lagoon-Based Wastewater Treatment System and Coverage of the Combined Sewerage Sytem

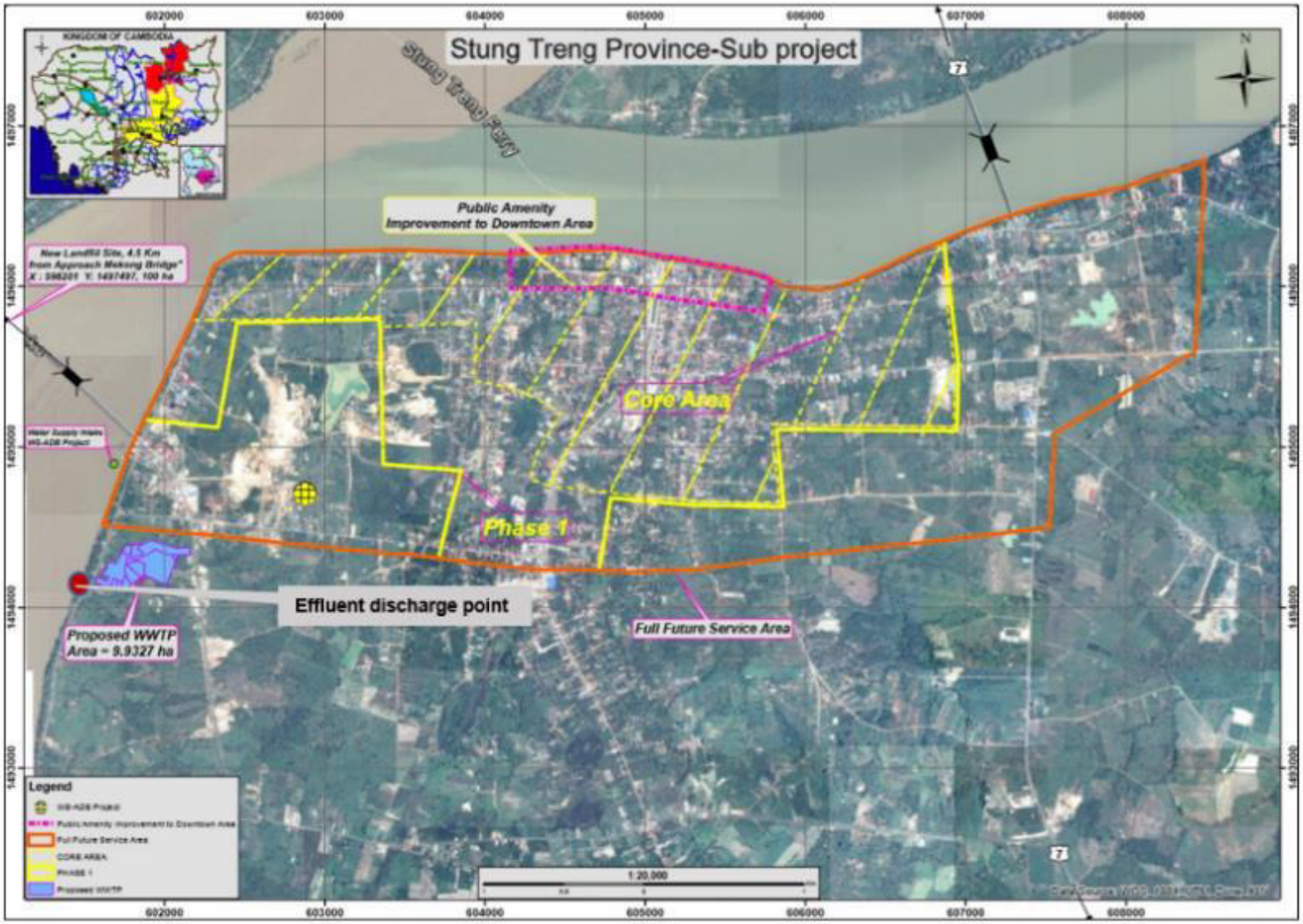


Figure 3.17: Conceptual Layout of the Stung Treng Wastewater Treatment Plant

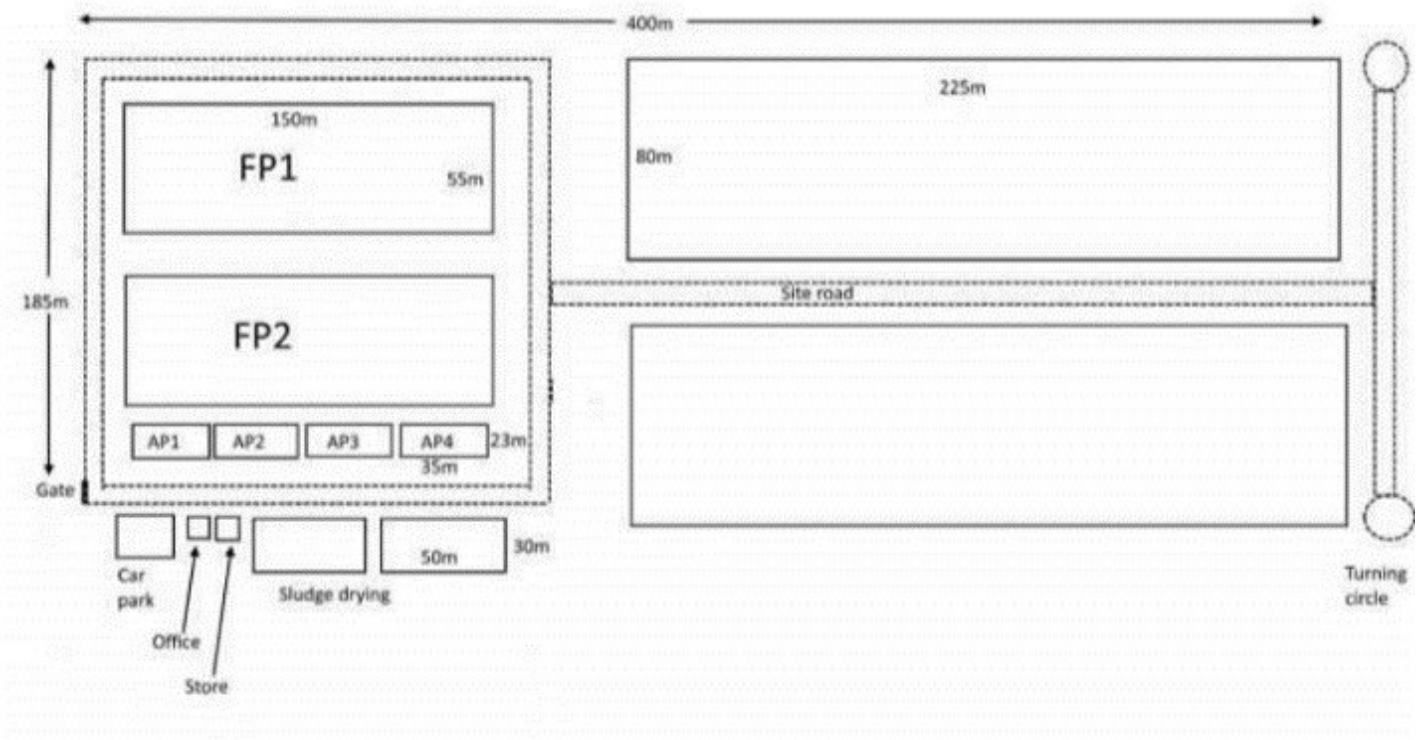


Figure 3.18: Roads East and West of the Stung Treng Wastewater Treatment Plant

Left: East road of the block where access road is proposed to start.
Right: West road of the area block. The bridge shown here is over the stream that comes from the WWTP site.

Left: The road south of the proposed wastewater treatment plant site.
Right: One of the 5 houses along the south road of the area block. The rest are small houses.

Figure 3.19: Proposed Automation of Floodgate and Installation of Pump Station at Road 2

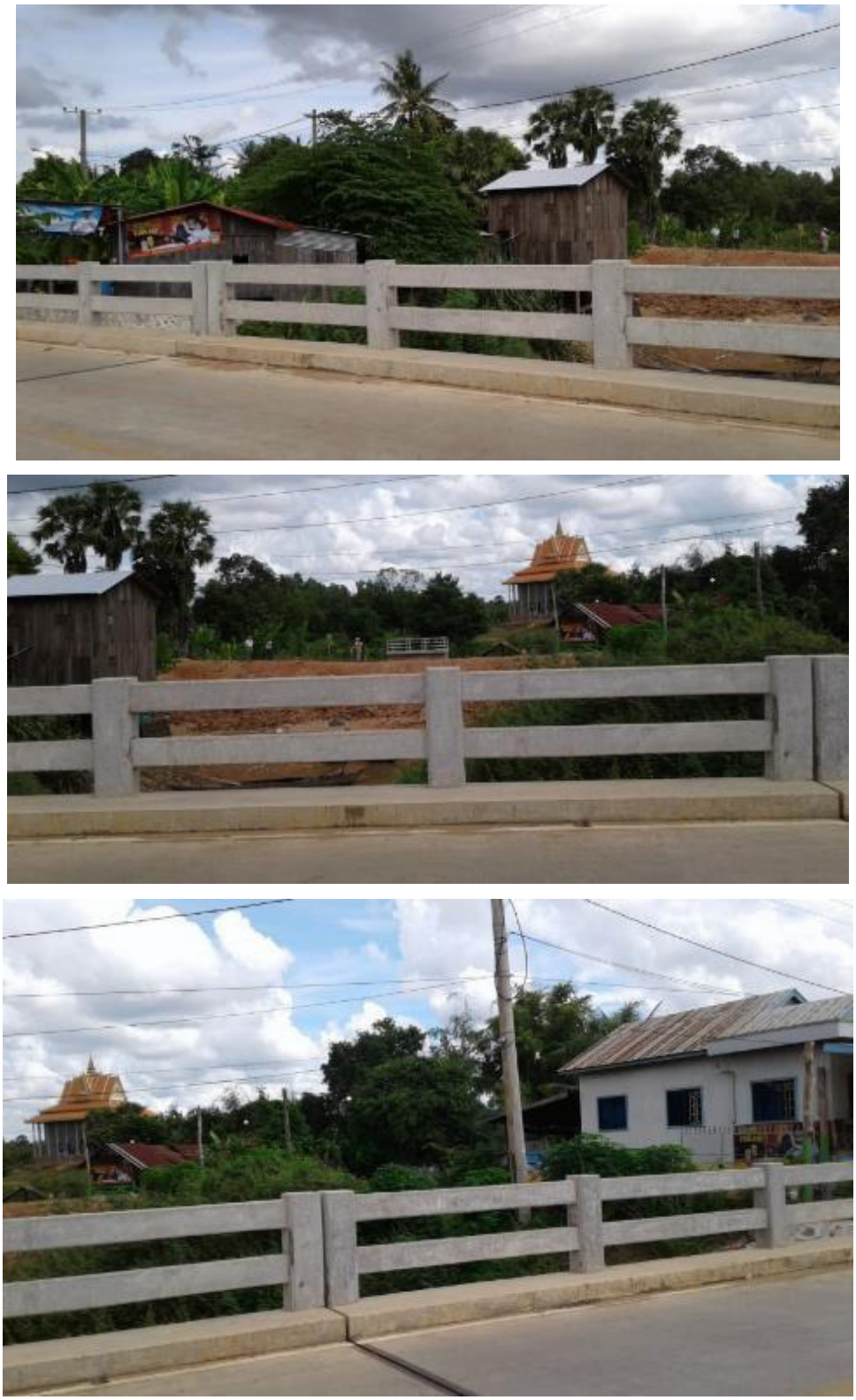


Figure 3.20: Proposed Automation of Floodgate and Installation of Pump Station at Dam Nak Bridge

Figure 3.21: Proposed Automation of Floodgate and Installation of Pump Station at O Thmor Leat Bridge

Figure 3.22: Proposed Automation of Floodgate and Installation of Pump Station at Prek Pou Bridge

Figure 3.23: Location of the Proposed Stung Treng Controlled Landfill and Existing Dumpsite

Figure 3.24: Conceptual Layout of the Stung Treng Controlled Landfill

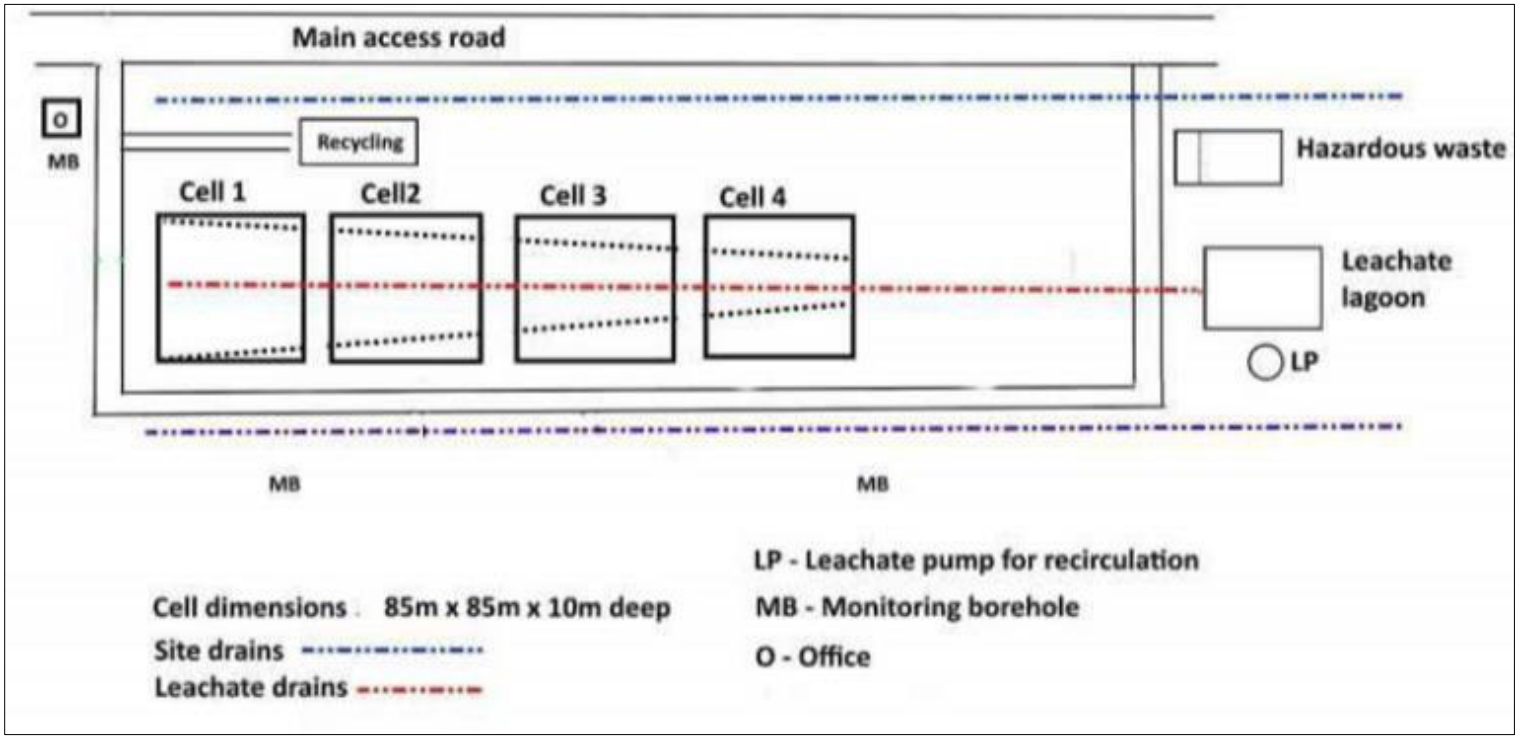


Figure 3.25: Photos of the Stung Treng Existing Dumpsite

Lower left: The only house in the property, occupied by the caretaker assigned by the government. This house is located along the access road.
Lower right: Access road from NR7, showing here the house of the site caretaker.

2. Output 2: Institutional effectiveness, and policy and planning environment for regional connectivity enhanced

68. This output comprises three components: (i) provincial development strategy;[29] (ii) ICT for public management; and (iii) project management and construction supervision. The provincial development strategy component will include: (i) provincial comprehensive socioeconomic survey and assessment report, (ii) provincial agriculture value-chain survey and assessment report; (iii) provincial tourism industry development survey and assessment report; (iv) provincial human resource development survey and assessment report; (v) regional connectivity study report for formulating the provincial 5-year strategic development plan, 2024-2028; and (vi) draft provincial town master plan. The ICT for public management component will develop the following: (i) public asset management system and database; (ii) driver license and vehicle registration system, and (iii) e-billing for public utilities and tax management system. Under project management and construction supervision, the following will be delivered: (i) periodic project progress report; (ii) periodic safeguards and social development monitoring report; (iii) project completion report; (iv) design-build contracts technical audits; (v) bidding documents for town enhancement component (including detailed engineering design); (vi) WWTP, SWM, and urban asset O&M training; and (vii) awareness raising campaign. The conduct of a rapid strategic environmental assessment is

[29] Through a regional economic corridor development analysis on commodity value-chains, tourism, and human resources.

included in the scope of work for the formulation of the Provincial Development Strategy (PDS) and included in the cost and consultant Terms of Reference in the Project Administration Manual.

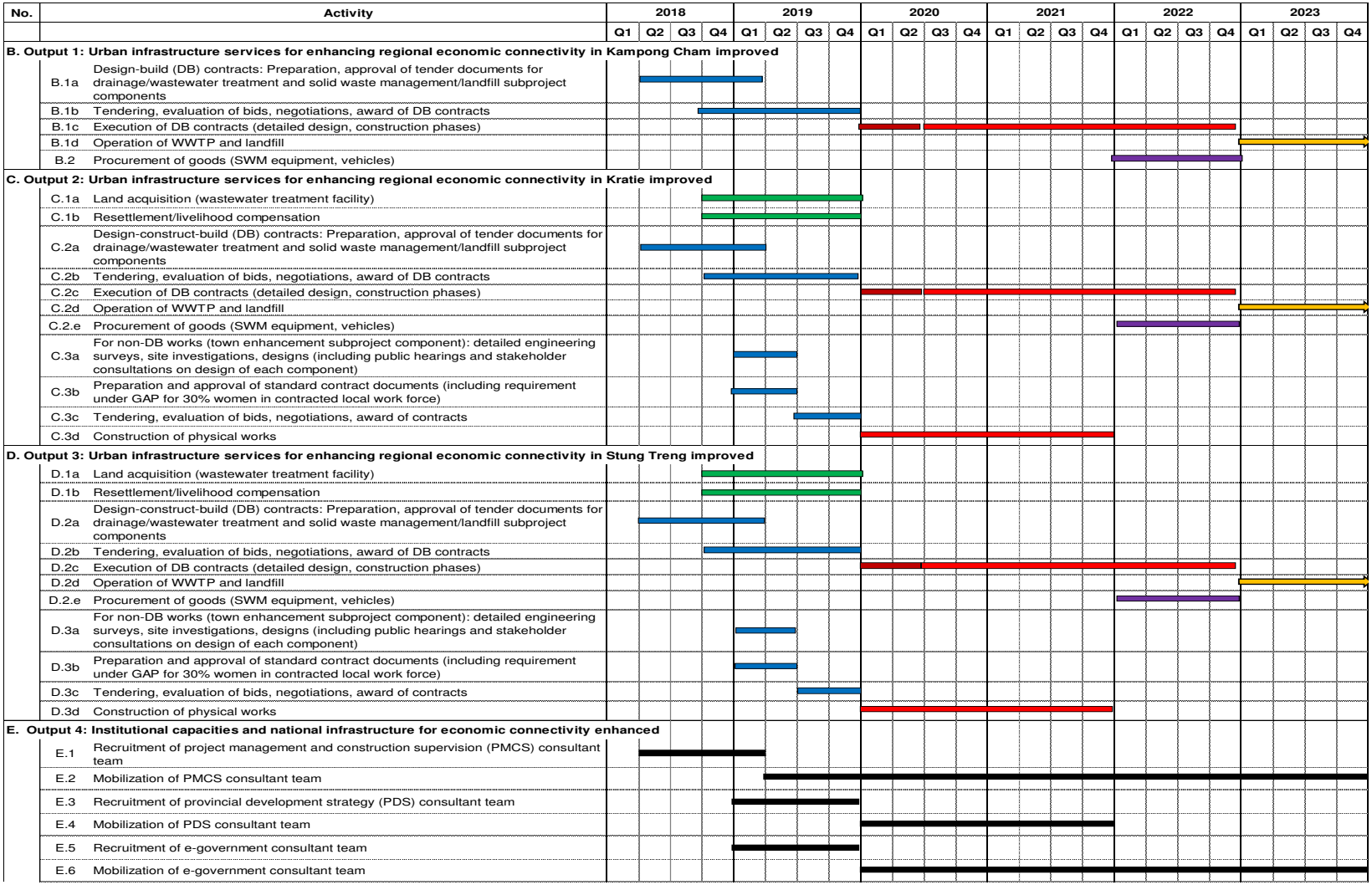
3. Project Implementation Schedule

69. The overall project implementation plan is presented in Figure 3.26. As shown, project is scheduled to commence in mid-2018, and be completed in late 2023.

D. Project Areas of Influence

70. The project areas of influence in each town include: (i) the directly impacted areas or main areas of influence, covering the subproject construction footprints and surrounding areas, considering the potential reach of noise, dust, surface water and groundwater contamination, impact on biodiversity and socio-economic impacts; and (ii) indirect or extended areas of influence which include quarry sites, waste disposal site/s, sources of water for construction use, workers' campsites and sources of labor. Potentially affected receptors within the main areas of influence are summarized in Table 3.1.

Figure 3.26: Overall Project Implementation Plan



ADB = Asian Development Bank; DB = design-build; GAP = gender action plan; O&M = operation and maintenance; RRP = Report and Recommendation of the President
Source: Asian Development Bank

Table 3.1: Identified Environmentally Sensitive Receptors in the Main Areas of Influence

Component	GPS	Surface Water Receptors	Socioeconomic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
Kampong Cham					
Kampong Cham lagoon-based wastewater treatment system					
○ Combined sewer ○	11°59'16.62" N 105°27'34.65" E (approx. center of Phase 1 of service area)	Mekong River •	• Residents, workers, business and/or other establishments - in the main urban area (Phase 1 service area) - influence area (say at least within 200m) of trunk drains around the Bung Snay, - At least 3 houses close to the pump house to be upgraded. • At least 11 schools - School of Pedagogy and Evidence - Provincial School of Pedagogy - Kampong Cham National School of Agriculture - Chea Sim University of Kamchaymear Kampong Cham Branch - Preah Sihanouk High School - Pek Vanna General Education School - Tuol Thmor Secondary School - Boeng Kok Public School - Western University - University of Management and Economics - Cambodian University for Specialties • Kampong Cham Hospital • Orphanage Center of Kampong Cham Province • At least 2 temples, 2 mosques and 1 church - Dei Doh Pagoda - Chroy Thma Pagoda - Masjid Phum Roka - Surao Phum Roka - Baptist Church • Existing utility lines • Road users of the road separating Boeng Snay and Boeng Bassac. • The proposed new water treatment plant at the SW edge of Boeng Snay (which could have started construction prior to start of GMS 4 project). •	• Main urban area with small pockets of green areas •	None
○ WWTP	11°58'40.71" N 105°26'08.72" E	• Boeng Bassac (receptor discharge of WWTP)	• Residents of the housing community on the NW (nearest to the lagoon). Nearest house of this	• Lagoon • Shrub- & grassland, trees	None

Component	GPS	Surface Water Receptors	Socioeconomic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
		• Stream that connects Boeng Bassac to Mekong River, meandering length of about 900m before reaching Mekong River • Stream that connects Boeng Bassac to Boeng Smuos, meandering length of at least 1.5+km	housing community is about 140-150 m from the NW edge of Boeng Bassac. • Farmers working in their agricultural lands. • Crops grown on the agricultural lands. • Trees and vegetation in the vicinity	• Agricultural lands • Residential development land cover along the roads that bound the area block of Boeng Bassac	
Kampong Cham municipal solid waste-controlled landfill and equipment					
○ **Controlled landfill**	12^{O}02'54.44" N 105^{O}19'34.07" E	An intermittent stream on the west, within 250m from the approx. center of the landfill property (connects to the lagoon south of the landfill site). Lagoon's northernmost edge is about 2km from the approximate center of the landfill property.	• Nearest residents & house is within 500m from the approximate center of the landfill property. • Farmers working in their agricultural lands. • Crops grown on the agricultural lands. • Trees and vegetation. Regional National Police School, within 500m east of the approximate, center of landfill property.	• Shrub-grassland, trees • Agricultural lands • Residential development along NR 7	None
Kratie					
Kratie lagoon-based wastewater treatment system					
○ Combined sewer	12^{O}29'15.31" N 106^{O}01'05.87" E (approx. center of Phase 1 of service area)	Mekong River	• Residents, workers, business and other establishments • At least 4 schools • Kratie Referral Hospital • At least 3 temples, 1 mosque • A public library • Existing utility lines • Farmers working in their agricultural lands Crops grown on the agricultural lands	Main urban area with pockets of green areas	Mekong River IBA from Kratie to the Lao border.
○ WWTP	12^{O}29'07.08" N 106^{O}02'02.72" E	Lagoon	• Farmers working in their agricultural lands • Crops grown on agricultural lands • Nearest residential area, about 1.5km west of the WWTP • Access road will be along a commercial establishment, a university and agricultural lands, and close o residences. Users of Road 377.	• Lagoon • Shrub- and grassland and trees Agricultural lands	None
Kratie municipal solid waste-controlled landfill and equipment					
○ Controlled landfill	12^{O}29'50.52" N 106^{O}09'55.14" E	A stream within landfill property, near the eastern boundary	• Users of access roads • Nearest house is 1.75km away. • Farmers working in their agricultural lands Crops grown on agricultural lands	• Shrub-grassland, trees Agricultural lands nearest agricultural land is about 400 west of site)	None

Component	GPS	Surface Water Receptors	Socioeconomic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
○ Closure of existing dumpsite	12^{O}28'33.25" N 106^{O}05'54.56" E	None Closest is a pond, about 1.32 km away.	• Nearest building structure is within 100m from the edge of the dumpsite. • Farmers working in their agricultural lands • Crops grown on agricultural lands A big buddha statue is close to the dumpsite.	• Shrub- & grassland, trees, Agricultural lands	None
Kratie town center enhancement					
○ Town center enhancement	12^{O}29'10.94" N 106^{O}01'00.30" E	Mekong River	The following within the covered area for enhancement: • Residents, workers, business and other establishments (market) • 1 temple At least 4 schools	Main urban area with pockets of green areas	Mekong River IBA from Kratie to the Lao border.
Stung Treng					
Stung Treng lagoon-based wastewater treatment system					
○ Combined sewer	13^{O}31'42.40" N 105^{O}03'28.44" E (approx.)	Mekong River Sekong River At least 4 streams	• Residents, workers, business and other establishments • At least 7 schools • First Region Hospital • Stung Treng Health Center • At least 5 temples, 1 mosque, 1 church Existing utility lines	Main urban area with pockets of green areas	• Mekong River IBA from Kratie to the Lao border. • Sekong IBA
○ Floodgate and pump stations	13^{O}31'52.53" N 105^{O}56'45.15" E	Mekong River	• Residents • 1 pagoda Trees and vegetation	Main urban area with pockets of green areas	• Mekong River IBA from Kratie to the Lao border
	13^{O}31'56.48" N 105^{O}59'15.10" E	Sekong River	• Residents Trees and vegetation	Main urban area with pockets of green areas	• Sekong IBA
	13^{O}31'50.94" N 105^{O}58'35.76" E	Sekong River	• Residents, business establishment Trees and vegetation	Main urban area with pockets of green areas	• Sekong IBA
	13^{O}31'55.31" N 105^{O}57'52.39" E	Sekong River	• Residents, business establishment • 1 Pagoda • Stung Treng Provincial Government Office Trees and vegetation	Main urban area with pockets of green areas	• Sekong IBA
○ WWTP	13^{O}30'51.86" N 105^{O}56'24.91" E	Stream within the site	• Nearest residents (at least 2, south of the WWTP) could be almost at the edge of the WWTP property. • Farmers working in their agricultural lands Crop grown on agricultural lands	• Agricultural lands, • Forest cover (trees)	• Mekong River IBA from Kratie to the Lao border, about 200m

Component	GPS	Surface Water Receptors	Socioeconomic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
					from the WWTP site.
Stung Treng municipal solid waste-controlled landfill and equipment					
○ Controlled landfill	13^{O}32'51.30" N 105^{O}54'06.67" E	Perennial streams within the 100-ha landfill property	• Farmers using access road to access their farms Nearest house is about 650m from the southern edge of the landfill property. (Along the road south of the landfill property.)	Mainly forest land	• Mekong River IBA from Kratie to the Lao border, about 3km from the southern edge of the landfill property.
○ Closure of existing dumpsite	13^{O}35'22.63" N 106^{O}03'28.56" E	Sekong River	• Trees and vegetation Nearest resident, about 500m from nearest dumping ground to NR7	Forest land	• RAMSAR site (Mekong) • Sekong IBA
Stung Treng town center enhancement					
○ Town center enhancement	13^{O}31'42.40" N 105^{O}03'28.44" E	Sekong River	• Residents, workers, business and other establishments (market) • 2 temples At least 1 school	Main urban area with pockets of green areas	• Sekong River IBA

IV. DESCRIPTION OF THE ENVIRONMENT

A. Physical Environment

1. Geographic Location, Landform, Geology and Soils

71. **Kampong Cham.** Kampong Cham town is located approximately 80 km northeast of Phnom Penh. It lies along the west bank of the Mekong River and is in a floodplain. The town is at an elevation of 20 meters above mean sea level (msl) and with generally flat terrain. The town is largely underlain by basalt, which originated from Pliocene and Pleistocene volcanic activities, and thick Pleo-Pleistocene sediments such as clay lithosols.[54] (Figure 4.1)

72. **Kratie.** Kratie is located approximately 160 km from Phnom Penh along National Road 7. It is about 150 km from the Lao PDR border. The town is largely on the east bank of the Mekong River and is within the floodplain. The town center is largely at elevation 20-29m with flat to gently sloping terrain.[55] It is located on the Northern Plains (a major physiographic zone of Cambodia), which features either flat sandstone plains or rolling terrain interrupted by occasional flat-topped hills or scarps, and rounded hills of Andesite and Basalt.[56] Soils in Kratie are generally plinthite podzols and red-yellow podzols (acidic and low fertility potential), grey hydromorphic (high fertility and alluvial soils (alluvial lithosols).[57]

73. **Stung Treng.** Stung Treng town is located 250 km from Phnom Penh and is about 50 km from the Lao PDR border. It lies along the east bank of the Mekong River and National Road 7 and is near the confluence of the Sekong and Mekong rivers. The town is situated in a lowland area, however, Stung Treng town is above the normal elevation of the Mekong and Sekong Rivers. The elevation of the riverside areas along the Mekong and Sekong rivers ranges from 47-55m.[58] The terrain is flat at the riverside, and slopes further inland.

74. The local geomorphology consists of a flood plain with a natural levee adjacent to the Sekong River, and shallow depressions behind it that hold swamps or wetlands. Dark grey fine sand is found to a depth of about 9 m, being underlain by Mesozoic shale and sandstone. This bedrock is exposed along the river and forms the many islets of the Stung Treng Ramsar Wetlands and the Siphandon further north.[59] Soils in Stung Treng town are generally red-yellow podzols, acid lithosols and grey hydromorphic.[60]

2. Climate

75. Cambodia's tropical monsoon climate is characterized by a rainy season and a dry season. The rainy season, which lasts from May to early October, accounts for 90% of annual precipitation. The dry season, from November to April, brings drier and cooler air from November

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[54] Soil Types in Cambodia (MOE, 2004), obtained from Country Environmental Profile. Royal Kingdom of Cambodia. April 2012. European Union Delegation to Cambodia.
[55] General elevation at the town center strip close to the Mekong River. Obtained from Google Earth Pro.
[56] Major Physiographic Zones of Cambodia (after Wharton 1968). Cambodia Tree Seed Project, FA, DANIDA. http://www.treeseedfa.org
[57] As interpreted from the map on Distribution of Soil Types in Cambodia (Crocker, 1962). Obtained from Open Development Cambodia. https://opendevelopmentcambodia.net
[58] General elevation at the town strip close to the Mekong River. Obtained from Google Earth Pro.
[59] From: IEE Report for Stung Treng Urban Water Supply Project. September 2014.
[60] As interpreted from the following maps: (i) Map on Soil Types in Cambodia (MOE, 2004), obtained from Country Environmental Profile. Royal Kingdom of Cambodia. April 2012. European Union Delegation to Cambodia. (ii) Soil Type. Obtained from https://data.opendevelopmentmekong.net.

to March, and then hotter air in April and early May.[61]

76. **Kampong Cham.** During the 25-year period 1991-2015, Kampong Cham had (i) a mean monthly temperature ranging from 26.86 ^{O}C in December to 29.94 ^{O}C in April; and (ii) a mean annual temperature of 28.37 ^{O}C.[62] During the 25-year period 1992-2016, the town had (i) a mean monthly rainfall ranging from 12.4 mm in January to 281.6 mm in September; (ii) a mean annual rainfall of almost 1,500 mm; (ii) highest annual rainfall of 2,164 mm in 1996; and (iv) lowest annual rainfall of 1,024 mm in 1998.[63] Temperature and rainfall data are shown in Figure 4.1.

Figure 4.1: Mean Monthly Temperature (1991-2015)[a] and Total Annual Rainfall (1992-2016)[b] - Kampong Cham

[a/] Data source: World Bank Climate Change Knowledge Portal. http://sdwebx.worldbank.org
[b/] Data source: Second Integrated Urban Environmental Management in the Tonle Sap Basin Project, ADB.

77. **Kratie.** During the 25-year period 1991-2015, Kratie had: (i) a mean monthly temperature ranging from 26.03 ^{O}C in December to 29.94 ^{O}C in April; and (ii) a mean annual temperature of 27.70 ^{O}C.[64] During the 19-year period 1998-2016, the town had a: (i) mean monthly rainfall ranging from 7.2 mm in January to 504.1 mm in September; (ii) mean annual rainfall of 1,837 mm; (iii) highest annual rainfall of 2,550 mm in 1999; and (iv) lowest annual rainfall of 1,209 mm in 2015 (Figures 4.2 and 4.3).[65]

78. **Stung Treng.** Figures 4.4 and 4.5 provide a graphical summary of the temperature and rainfall patterns in Stung Treng. During the 25-year period 1991-2015, Stung Treng had (i) a mean monthly temperature ranging from 25.5 ^{O}C in December and 30.5 ^{O}C in April; (ii) a mean annual temperature of 27.82 ^{O}C; (iii) a mean monthly rainfall ranging from almost 0.0 mm in January to 347.27 mm in September; and (iv) a mean annual rainfall of 1,822 mm.

[61] Lifted from: GSSD 2015. Cambodia's Second National Communication under the United Nations Framework Convention on Climate Change. General Secretariat, National Council for Sustainable Development/Ministry of Environment, Kingdom of Cambodia, Phnom Penh.
[62] World Bank Climate Change Knowledge Portal. http://sdwebx.worldbank.org
[63] Second Integrated Urban Environmental Management in the Tonle Sap Basin Project, ADB.
[64] Data source: World Bank Climate Change Knowledge Portal. http://sdwebx.worldbank.org
[65] Data source: DOWRAM, Kratie Province

Figure 4.2: Mean Monthly Temperature (1991-2015)[66] – Kratie

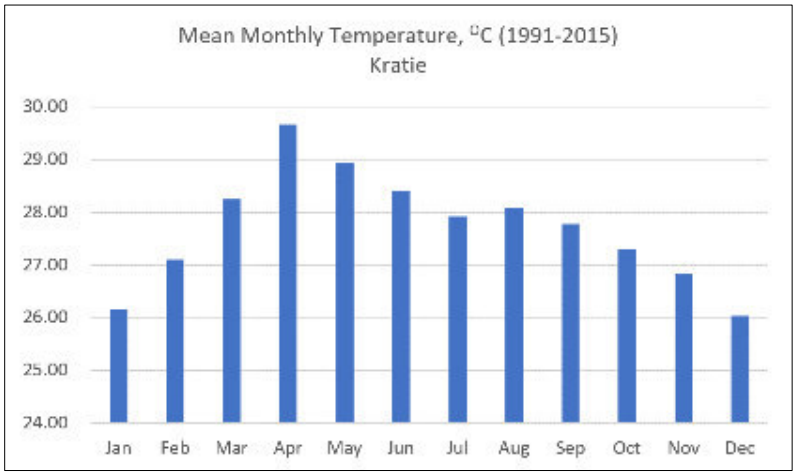


Figure 4.3: Total Annual Rainfall (1998-2016)[67] – Kratie

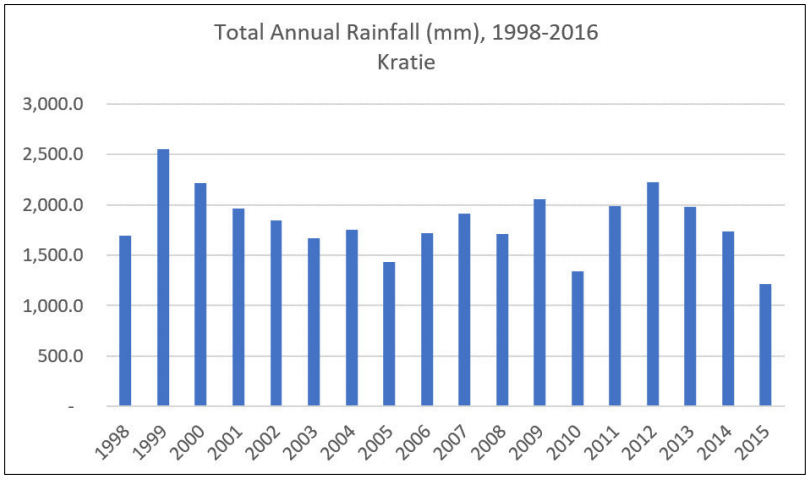
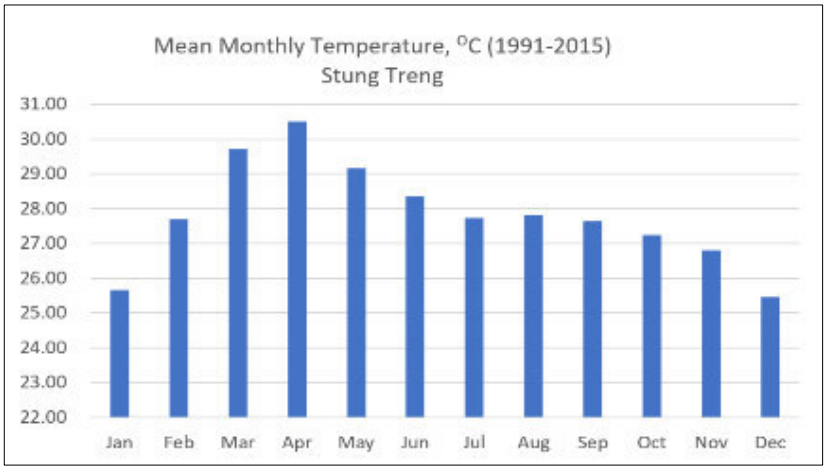
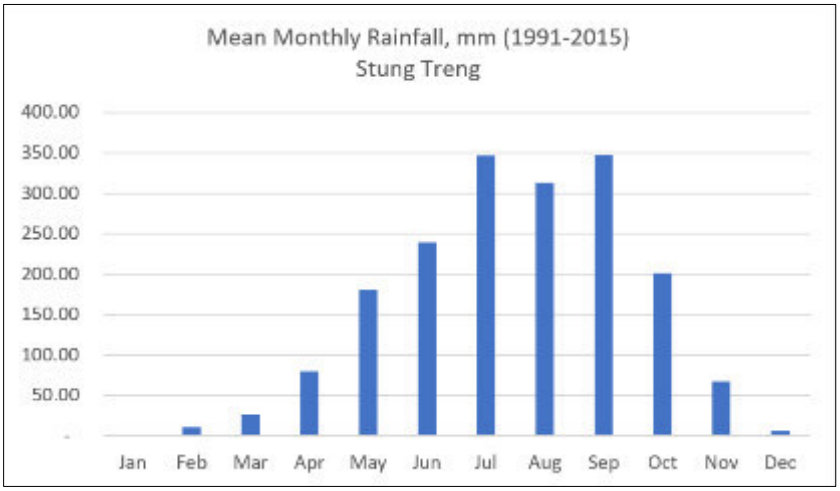


Figure 4.4: Mean Monthly Temperature (1991-2015)[16] - Stung Treng



[66] Data source: World Bank Climate Change Knowledge Portal. http://sdwebx.worldbank.org
[67] Data source: DOWRAM, Kratie Province

Figure 4.5: Mean Monthly Rainfall (1991-2015)[68] - Stung Treng



3. Climate Change and Natural Disaster

79. The Project was screened using the AWARE for Projects tool, an online tool used by ADB to screen projects for climate risks. The result of the screening indicated that the Project was at medium risk from climate change impacts, and at low risk from geological hazards. The Project was at high risk for flood; and at medium risk for precipitation and water availability. The climate risk and vulnerability assessment (CRVA) for the Project included a review of studies on the future trends of climate in Cambodia and the Mekong River Basin. The projected changes in mean annual temperature and precipitation from selected studies/sources were applied to the historical climate data, to estimate future mean annual temperature and precipitation in the three project towns.[69] The key findings of the CRVA are as follows:

- In Cambodia, floods affect the lowland areas while the geographical distribution of droughts is widespread. Storms occur more frequently between August and November, with the highest frequency in October. The country is rarely exposed to the full force of tropical cyclones and typhoons as it is surrounded by mountain chains, which dissipate a typhoon's force;
- Increased rainfall intensity during extreme events from 2030-2090 is projected for Cambodia but the rainfall intensity will not vary too much from town to town across the country. By 2030, during a 1 in 10-year event, the country will experience a 4% increase in 1-hour rainfall; and by 2050, 7%. By 2030, during a 1 in 100-year event, the country will experience a 7% increase in 1-hour rainfall; by 2050, 12%. The increase of a 1-day rainfall could be between 6-8% by 2030; 9-10% by 2050; and 28-34% by 2070. The increase of a 5-day rainfall could be between 9-14% by 2030; 16-20% by 2050; and 29-38% by 2090;
- Over the period 1985-2000 to 2042-2050, the mean annual high flow season discharge along the entire length of the Mekong River is projected to increase by

[68] Data source: World Bank Climate Change Knowledge Portal. http://sdwebx.worldbank.org

[69] The studies/sources used include (i) C. McSweeney, et.al., UNDP Climate Change Country Profiles: Cambodia; (ii) J. Mpelasoka, et.al., (2008). Mekong River Basic Water Resources Assessment: Impacts of Climate Change; (iii) USAID (2016). Mekong Adaptation and Resilience to Climate Change, Final Report; and (iv) Exploring Climate and Development Links: The World Bank. They are discussed in detail in the CRVA report prepared under the ADB PPTA.

10-15%. This will result in the project towns experiencing more annual "flood days";[70]

- A comparison of the extent of flooding between that in the 2000 flood event and that of a large flood event in 2048 under a projected climate change state revealed an 8.8% increase in the extent of flooding (that is, for flood depths above 0.0 m) in the 2048 event. For depths over 1.5 m, the projected increase would be 30-60%; and
- The project infrastructure, therefore, would be most at risk from increased precipitation frequency and intensity, and associated flooding.

80. **Kampong Cham.** Between 2050 and 2060, Kampong Cham could have a mean annual temperature range of 29.1 to 31.4 ^{O}C and a mean annual rainfall range of 1,560 to 1,750 mm. Between 2090 and 2100, the town could have a mean annual temperature range of 32.4 to 32.7 ^{O}C and a mean annual rainfall range of 1,600 to 1,750 mm.

81. Recurrent flooding occurs in Kampong Chan due to increasing rainfall intensity, which increases the water levels in the Mekong River and its tributaries. Flooding typically occurs from July to September. It causes damages to businesses, residential properties, agricultural land and crops. It also endangers the lives of thousands of households. Drainage, roads and some houses could get buried in mud. Flooding affects people's health, especially those of the children and the elderly. There is increased incidence of waterborne diseases such as diarrhea during and immediately after flooding. Kampong Cham experiences flooding of as high as four meters. Flooding of one-meter height that stays for one hour occurs more regularly. During the PPTA, it was reported that for long term flooding, people move to higher grounds to stay with their family or friends.

82. According to the Commune Database 2009-2014, for every 1,000 families in 2014, there were 28 that were seriously affected by floods. None were seriously affected by drought. From the socio-economic survey (SES) results, 32.5% of respondents had experienced flooding in various years (2004 to 2017). 74% indicated that flooding was caused by normal rains or monsoon; while 26% indicated that flooding was caused by extended monsoons, leading to the most serious flooding in terms of losses and damages. About 54% experienced flooding in 2017.

83. **Kratie.** Flooding in the town occurs during the rainy season. When there is heavy rainfall, water accumulates in the low lying and catchment areas. The existing drainage system cannot accommodate the volume of water. Uncollected solid waste of various kinds thrown into canals clogs the waterways. In addition, due to the heavy rain, the Mekong River rises. When flooding occurs, peoples' livelihoods as well as civic and business operations in the town are disrupted. Stagnant water causes ill health and poor sanitation and hygiene. Flooding also results in heavy traffic along highways.

84. Although the existing drainage system is still functional, it dates back to the colonial period and is largely dilapidated and unable to accommodate the volume of flow. The three outlets enter a channel that convey to a wetland area. However, the channel is blocked and there is no alternative drainage system. Solid waste collection services are not functioning to a desired level. Both poor drainage and solid waste exacerbate town flooding issues. The proposed site for the WWTP is waterlogged during the rainy season.

85. **Stung Treng.** Stung Treng experiences flooding every rainy season, usually after a heavy

[70] Flood days are days with discharges greater than mean annual high flow season discharge.

rainfall. The water that accumulates in the town because of a heavy downpour flows to the Mekong River through four canals. However, the same rain causes the water level in the Mekong and Sekong Rivers to rise, which prompts the town government to close the four sluice gates installed in the canals so that the water from the Mekong River and Sekong River combined will not enter the town. With no water outlets, the flood water gets trapped in the town, resulting the flooding of residential and business areas, particularly in the lower-lying areas. Flooding in the town has become a recurring phenomenon.

86. After the rain stops, the water remains in the town. It takes several days to drain due to the town's small drainage. The situation is exacerbated by accumulated household solid wastes, carelessly thrown in the canals causing blockage to the drainage system. There is no systematic collection and disposal of solid waste. Moreover, not all areas have solid waste collection. The people burn waste or dispose of them onto empty land. There is lack of knowledge of the environmental and health risks of burning plastics. The private companies contracted by the municipality have not been able to efficiently manage the operation of the landfill and waste collection services.

87. Water scarcity, which people attribute to drought, is a grave concern in the town from November to June. Only 40% of the water requirement is being met by the water authority. The remaining 60% comes from wells, extracted from the ground. For drinking water, people buy at \$1 per 6 m^3 from the city, and at US\$8 for the same quantity if bought from outside suppliers.

4. Air Quality and Noise

88. **Kampong Cham.** Data on ambient air quality and noise level in Kampong Cham are not available. The proposed combined sewer works will be implemented in the main urban area, where the major source of air pollution is traffic emissions. The trunk sewers will be close to a new development area which is predominantly residential. The sources of ambient noise are the road vehicles, construction activities, small-scale industry involving metal forming, and equipment maintenance and repairs. At the WWTP site, the nearest noise receptors will be the residents within 200 m from the northwest edge of site, and farmers of the farm plots close to the site.

89. **Kratie.** The combined sewer and town center enhancement works will be in the main urban area, where there are sensitive receptors, such as hospitals and schools. In these areas, the major source of air pollution and noise is traffic emissions. Near the WWTP and controlled landfill, the closest sensitive receptors are the farmers and agricultural land. At the controlled landfill site, the closest receptors to noise will be the farmers of farm plots within the area of influence. This community will also be affected by the noise generated by the movements of construction-associated vehicles and equipment along the access road. At the dumpsite, which will be closed under the subproject, the nearest receptors to noise are the residents just across the access road. Data on ambient air quality and noise levels in Kratie were not available.

90. **Stung Treng.** Data on ambient air quality and noise levels in Stung Treng were also not available. The major source of air pollution in the town is traffic emissions. Combined sewer and town center enhancement works will be in the main urban area, where the population concentration is highest and where there are noise and air quality sensitive institutions, such as hospitals, schools and temples.

5. Surface Water

91. **Kampong Cham.** The Mekong River will be within the area of influence of the proposed

combined sewer network. According to the 2014 Lower Mekong Regional Water Quality Monitoring Report of the Mekong River Commission, water samples taken at the Kampong Cham station a rating score of "A" or "high quality" for the protection of aquatic life and human health and for agricultural use. The results of more recent Mekong River water quality monitoring by MOWRAM at the Kampong Cham Station were not accessible. Mekong River water quality data obtained from the Department of Laboratory of MOE, for 03 February, 20 March and 24 April 2017, and from the Kampong Cham Water Treatment Plant, for raw water quality, on 30 June 2017 – showed no exceedances of the few parameters monitored over national standard limits and international target values. The parameters monitored were pH, TSS, BOD_5, COD, CR^{+6}, TN, TP, temperature, turbidity, TDS, alkalinity and electrical conductivity (**Appendix D**).

92. Boeng Bassac, the site for the proposed WWTP, is linked to the Mekong River through a stream with a width of 10-15 m. According to the DPWT, the stream reverses direction seasonally. Roughly, the stream flows from the southeastern edge of the lagoon to the Mekong River for a distance of at least 800-900 m. Data on the water quality of this stream is not available. A stream on the western edge of Boeng Bassac connects to Boeng Smuos in the west. The shortest distance between the two lagoons is about 1 km. The WWTP will discharge onto Boeng Bassac.

93. There is an intermittent stream at least 70m from the western boundary of the landfill site. This stream leads the surface runoffs in the rainy season from the areas across NR7 and along its course to Boeng Thum, a large lagoon south of the landfill site.

94. **Kratie.** The Mekong River is within the areas of influence of the combined sewer and town center enhancement works. According to the 2014 Lower Mekong Regional Water Quality Monitoring Report of the Mekong River Commission, water samples taken at the Kratie station had rating scores of "A" or "high quality" for the protection of human health and for agricultural use, and "B" or "good quality" for the protection of aquatic life.[71]

95. Data on water quality of the stream close to the eastern boundary of the landfill site was not available.

96. The property within which the controlled landfill will be developed has a stream close to the eastern boundary of the site. This stream leads to a small lagoon. The site for the WWTP is close to a large lagoon, south of the main urban area. This area is waterlogged in the rainy season.

97. **Stung Treng.** The Mekong River and the Sekong River will be within the area of influence of the combined sewer component. Moreover, three creeks draining to the Sekong River will be subject to works for the automation of, and installation of pump stations at, the existing flood gates. One creek draining to the Mekong River will be subject to the installation of an automated flood gate and pump station. The Mekong River is linked to the WWTP site by a stream that serves as the natural drainage course not only of the immediate vicinity of the site but also of areas upstream and east of the site (largely open, about five houses, some forested areas, some agricultural areas, with a gasoline station and a depot at the northeast corner). At the landfill site, there are two perennial streams that flow southwest toward the road and flow further southwest.

98. According to the 2014 Lower Mekong Regional Water Quality Monitoring Report of the Mekong River Commission, the water samples taken at the Stung Treng station had rating scores

[71] "A" for "high quality" class indicates all measurements as within objectives virtually all of the time. "B" for "good quality" class indicates conditions rarely depart from desirable values.

(in 2014) of "A" or "high quality" for the protection of human health and for agricultural use, and "B" or "good quality" for the protection of aquatic life.[48] The results of more recent Mekong River water quality monitoring by MOWRAM at the Stung Treng Station were not made available. Data on water quality of the Sekong River and the stream traversing through the identified WWTP site were also reportedly not available.

6. Groundwater

99. **Kampong Cham.** Data on groundwater quality in Kampong Cham District are not available. In the Mien Commune of Prey Chor District, the site of the proposed landfill, groundwater quality analysis was conducted in 2008. The groundwater quality rating for Mien is 100F, that is, the general safety of deep aquifer groundwater was excellent, although the aesthetic quality of the water was poor, according to the contaminants measured and samples collected. No health-impacting contaminants of concern were observed within this commune, except elevated concentrations of iron. The estimated probability of encountering potentially unacceptable concentrations of iron (>1 mg/L) in tube wells is 91%, based on the observed data.[49]

100. **Kratie**. Arsenic was detected in Cambodia through the National Drinking Water Quality Assessment in 2001, conducted jointly by the Ministry of Rural Development (MRD) and the Ministry of Industry, Mines and Energy (Figure 4.6). The arsenic risk map prepared under this assessment shows Kratie District partly "at risk". Three villages in Kratie District had arsenic levels of 10 and 75 µg/L in their groundwater. The limit set by WHO Guidelines for Drinking Water is 10 µg/L. Cambodia's Drinking Water Quality Standards, 2004, prescribes a maximum value of 50 µg/L. The villages of Smabok in Sambok Commune and Thma Kreae Leu in Thma Kreae Commune registered contamination of 75 µg/L in their groundwater; while Kakot Village in Sambok Commune had 10 µg/L[50]. Specific data on groundwater quality at the WWTP and landfill sites were not available but will be assessed during geotechnical studies carried out prior to detailed engineering design.

101. **Stung Treng**. The above arsenic risk map shows Stung Treng Province with "very low" arsenic risk. Two villages in Stung Treng District were with arsenic levels of 10 µg/L however, the villages of DaBa Chang in Preah Bat Commune, and Phomrachea Rukol in Stung Treng Commune[51].

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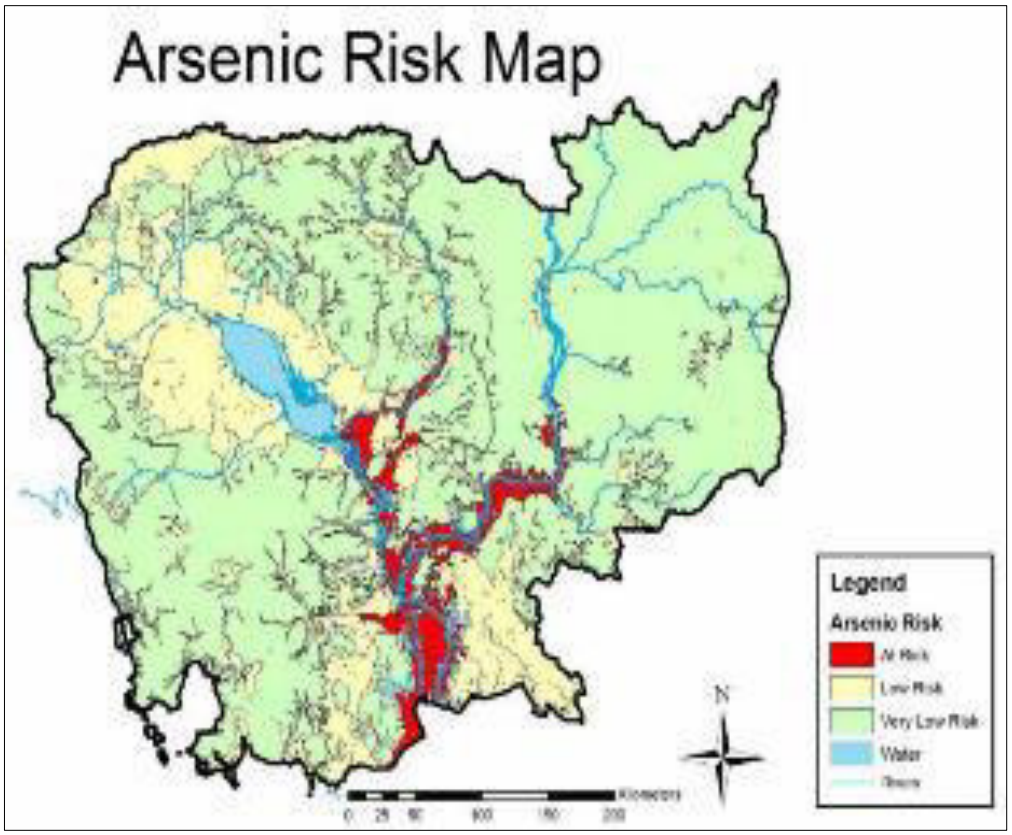
[48] "A" for "high quality" indicates all measurements as within objectives virtually all of the time. "B" for "good quality" indicates conditions rarely depart from desirable values.

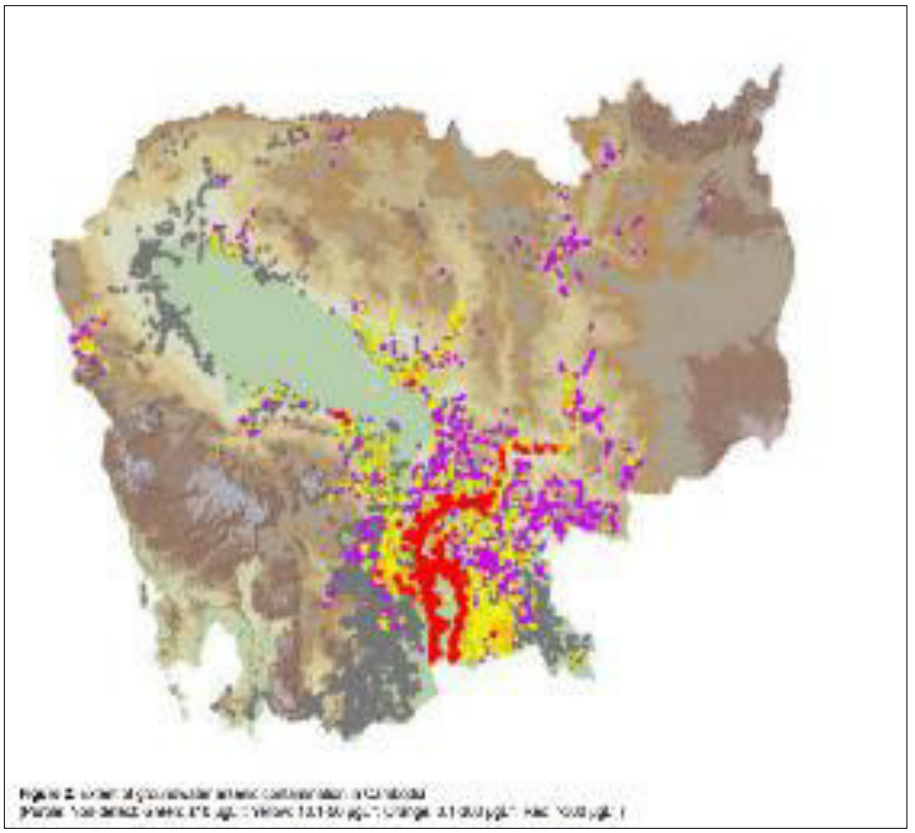
[49] Groundwater Quality Analysis Report Kampong Cham - Prey Chhor - Mien (100F). Resource Development International – Cambodia (www.rdic.org) – April 2009.

[50] Source: Arsenic Contamination by Well. Water and Sanitation Program. http://cambodiawellmap.com/worldbank/maps/44789/arsenic-contamination-by-well#

[51] Source: Arsenic Contamination by Well. Water and Sanitation Program. http://cambodiawellmap.com/worldbank/maps/44789/arsenic-contamination-by-well#

Figure 4.6: Arsenic Risk Map in Cambodia and Extent of Groundwater Arsenic Contamination in Cambodia





B. Biological Environment

102. **Kampong Cham.** There is no protected area, RAMSAR site or important bird area (IBA) in Kampong Cham Province. Vegetation within and around the subproject footprints generally include common trees, shrubs and grasses. The WWTP will be developed on Boeng Bassac, a lagoon that is surrounded by farm plots, forested lands, scrub and grassland. The area of Boeng Bassac is waterlogged for almost the entire rainy season. The trunk sewers will be laid alongside Boeng Snay, a lagoon which has been filled for new urban development. Remaining vegetation are mainly shrubs and grasses. From the meeting with the DOE and the municipality, no special fauna species have been reported in or close to the town.

103. **Kratie.** The proposed controlled landfill will be developed in an area of shrub and grassland. A portion of the land is currently used for the dumping of wastes from the town. This dumpsite replaced the old dumpsite, although dumping operations at the old dumpsite have continued, especially when access to the existing dumpsite is difficult during the rainy season. The vicinity of the property is shrub and grassland, with active agricultural plots. The area around the WWTP site is mixed agricultural, shrub and grassland. A large lagoon, south of the main urban area lies to the west. The combined sewer and town enhancement works will be implemented in the main urban area.

104. The Land Cover Map 2015 (Figure 4.7) of the European Space Agency Climate Change Initiative shows that land cover in Kratie Municipality is largely “cropland, rainfed” with some “cropland irrigated or post-flooding”.

Figure 4.7: Land Cover Map 2015 – Kratie

Source:European Space Agency Climate Change Initiative. http://maps.elie.ucl.ac.be/CCI/viewer/index.php

105. Kratie Municipality is bordered by an important bird area IBA to the west, the Mekong IBA. The approximate location of the IBA is shown on Figure 4.8. According to BirdLife International, the IBA includes the stretch of the Mekong River and associated riverine vegetation, from Kratie town to the international border with Laos. This is described as follows: “Although much of the fringing riverine forest is degraded, some areas of good condition mixed deciduous/semi-

evergreen forest remain around the Kratie-Stung Treng provincial border."[52] The habitats of the IBA within the influence area of Kratie Municipality have however been altered due to uncontrolled urban development and the granting of land concessions.

106. The IBA supports a large proportion of the global population of Mekong Wagtail *Motacilla samveasnae*, a recently described species, which is thought to be endemic to the Mekong River and its major tributaries. In addition, the IBA supports significant populations of a suite of riverine species that have declined severely throughout mainland South-east Asia, including River Lapwing *Vanellus duvaucelii*, Great Thick Knee *Esacus recurvirostris* and River Tern *Sterna aurantia*. Furthermore, a number of globally threatened and near-threatened species have been recorded in small numbers, including the White-rumped Vulture *Gyps bengalensis*, Red-headed Vulture *Sarcogyps calvus* and Darter Anhinga melanogaster. Small, but significant numbers of White-shouldered Ibis *Pseudibis davisoni* have been recorded along forested parts of the river. Finally, the IBA may be one of the last remaining sites in Indochina to support Black-bellied Tern *Sterna acuticauda*, although there have been few recent records and no recent confirmation of breeding. Historically the area supported a breeding population of Indian Skimmer *Rhynchops albicollis*, however, the last record on this stretch of the river was of "several pairs" in 1932, and the failure to find the species on recent surveys indicate that it is probably now extinct on the Mekong River (an extract from datazone.birdlife.org).

107. The conservation status and population trends for the above species are shown on Table 4.1.

Table 4.1: IUCN Conservation Status and Population Trend Kratie

Name of Specie	Status	Population Trend
Pseudibis davisoni (White-shouldered Ibis)	Critically Endangered	decreasing
Vanellus duvaucelii (River Lapwing)	Near Threatened	decreasing
Esacus recurvirostris (Great Thick-knee)	Near Threatened	decreasing
Motacilla samveasnae (Mekong Wagtail)	Near Threatened	decreasing
Sterna aurantia (River Tern)	Near Threatened	decreasing
Gyps bengalensis (White-rumped Vulture)	Near Threatened	decreasing
Sarcogyps calvus (Red-headed Vulture)	Critically Endangered	decreasing
Anhinga melanogaster (Oriental Darter)	Near Threatened	decreasing
Sterna acuticauda (Black-bellied Tern)	Endangered	decreasing
Rynchops albicollis (Indian Skimmer)	Vulnerable	decreasing

Source: http://www.iucnredlist.org/

108. **Stung Treng.** The controlled landfill will be developed in an area of scrub, grassland and scattered trees. The area was previously under Forestry Administration but is now degraded, there were no mature trees of particular significance observed during the site visit. The WWTP will be located on scrub and forest land. The site is bordered on the north, east, south, and west with a road. The combined sewer, floodgate and town center enhancement works will be implemented in the main urban area, which lies along the southern bank of the Sekong IBA and eastern bank of the Mekong IBA from Kratie to the Lao border.

109. The Land Cover Map 2015 (Figure 4.9) of the European Space Agency Climate Change Initiative shows that land cover from the confluence of Mekong and Sekong River to farther east of the confluence of Sekong and Sesan Rivers are largely "cropland, rainfed". The red arrow on the map shows the designation of cropland rainfed land cover at the location of the town.

[52] http://datazone.birdlife.org/country/cambodia

Figure 4.8: Mekong River IBA

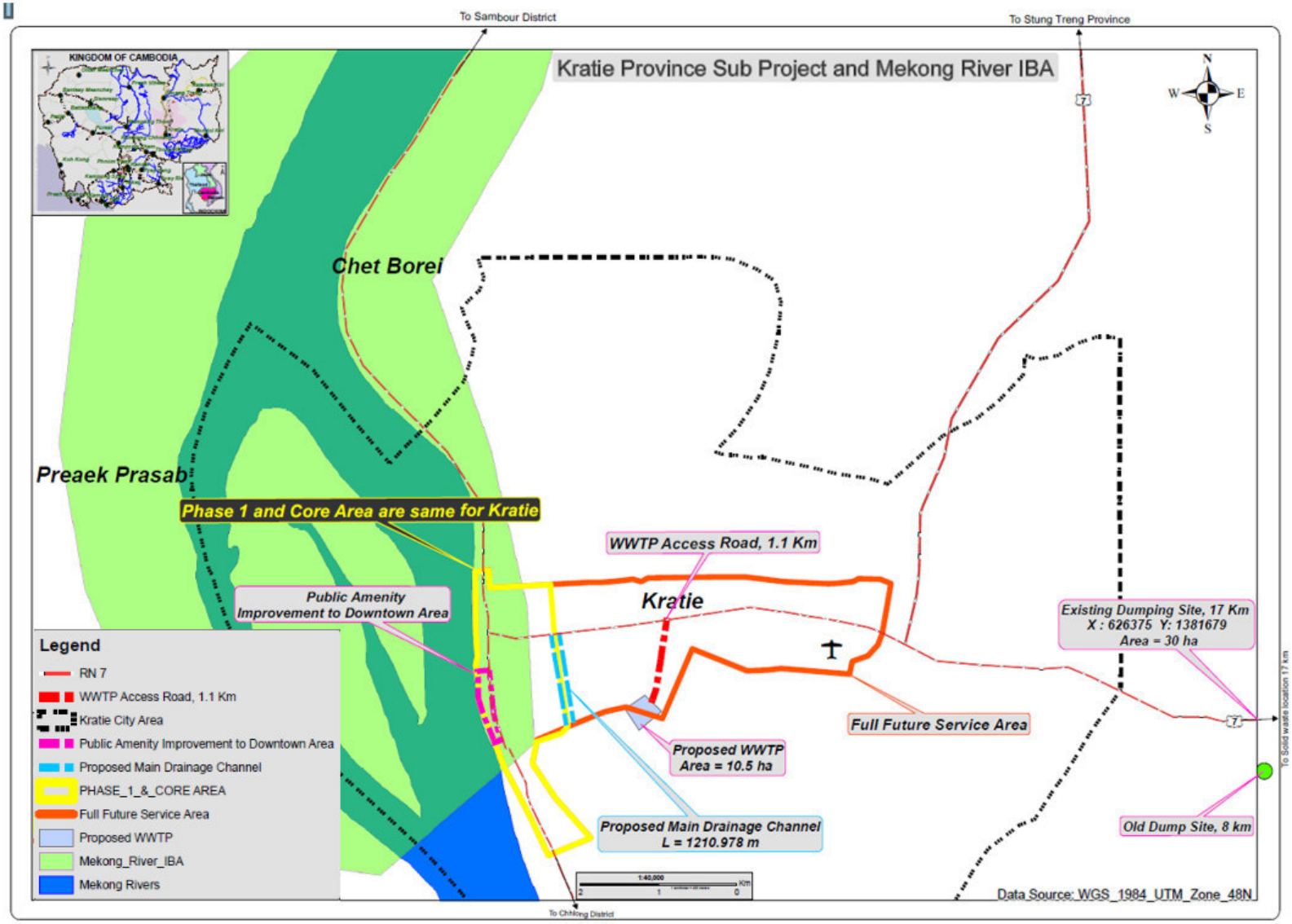
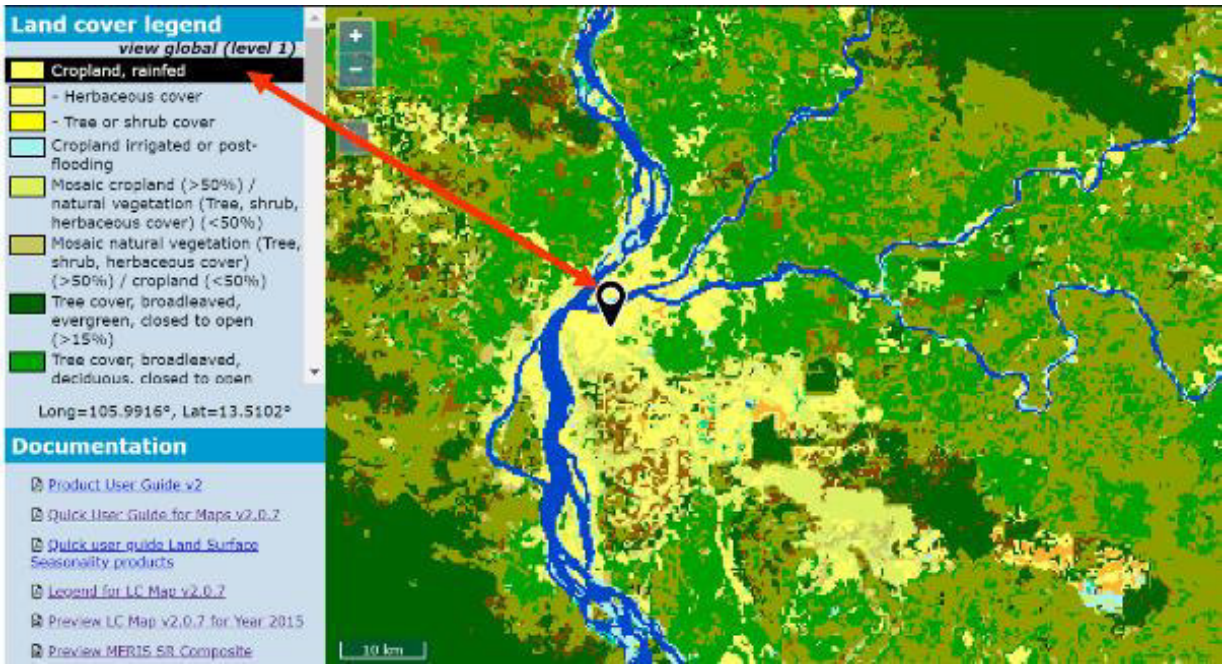


Figure 4.9: Land Cover Map 2015 – Stung Treng



Source:European Space Agency Climate Chang Initiative. http://maps.elie.ucl.ac.be/CCI/viewer/index.php
Note: The red arrow indicates that the yelow colored area pointed on the map (the Stung Treng town) is cropland, rainfed.

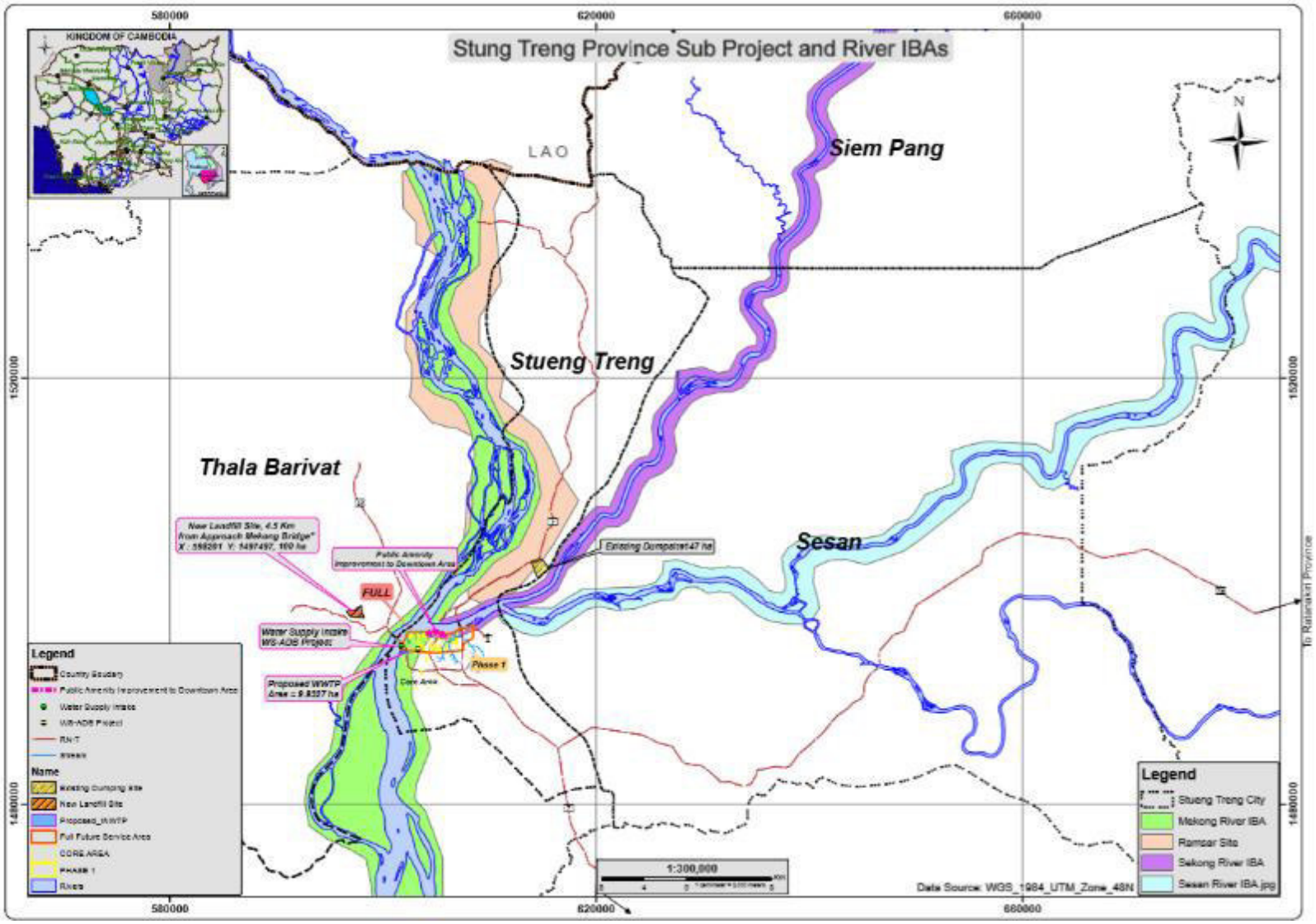
110. Stung Treng Municipality is bordered by or relatively close to four important biodiversity areas of international significance.[53] These are shown on Figure 4.10, and summarized as follows:

- **Ramsar Site - Middle Stretches of the Mekong River North of Stung Treng.** This is one of four designated Ramsar sites in Cambodia. It lies about 5 km from the town of Stung Treng where the Sekong river joins the Mekong river, and 4 km south from the border with Lao PDR. The existing dumpsite property is partly within the RAMSAR boundary. Among the components under the subproject, the closure of the dumpsite will be implemented.

  The RAMSAR site is home to a breeding population of the critically endangered White-shouldered Ibis (*Pseudibis davisoni*). It is also an important refuge and a food source for fish species during times of high flows; and a refuge for aquatic species, including the critically endangered Giant Mekong Catfish (*Pangasianodon gigas*) and the vulnerable Irrawaddy Dolphin (*Orcaella brevirostris*). The site faces a number of significant threats, such as an expanding infrastructure network, a market-driven agricultural increase of cash crop and logging activities that are reducing the forest, and the omnipresent threat of dams, particularly those upstream, including a proposed hydropower dam on the Laos side of the border with Cambodia.[54]

[53] Information herein were extracted directly from the ramsar.org or datazone.birdlife.org.
[54] Extracted from: https://www.ramsar.org/wetland/cambodia

Figure 4.10: Locations of the RAMSAR Site and IBAs in Relation to Stung Treng Town and Proposed Subproject Components



According to a recent report of WWF-Cambodia, dated 10 November 2015, the population of the Mekong Irrawaddy Dolphin was estimated at no more than 200 individuals in 1997. Their numbers fell to 127 in 2005, to 93 in 2007 and to 85 in 2010. The same report revealed that based on a recent survey, the rate of decline of the population of dolphins is slowing owing to the conservation program to protect the dolphins. The survey showed that from a 'zero recruitment' rate in 2013, the recruitment of new individuals (juveniles who survived to adulthood) was recently estimated at 0.8% per year. A large part of Sameakki Commune of Stung Treng District is within the Ramsar boundary. The full extent of the Ramsar site is shown on Figure 4.11.

Figure 4.11: Ramsar Site Middle Stretches of the Mekong River North of Stung Treng

Source: https://protectedplanet.net

- **Sekong River IBA.** The stretch of the Sekong River from the international border with Laos to its confluence with Mekong River is an IBA. The IBA supports a suite of bird species restricted to wide, lowland rivers, including River Lapwing (*Vanellus duvaucelii)*, Small Pratincole (*Glareola lacteal)*, Great Thick-knee (*Esacus recurvirostris)* and River Tern (*Sterna aurantia)*. In addition, the IBA supports Mekong Wagtail (*Motacilla samveasnae)*, a recently described species, which is thought to be endemic to the Mekong River and its major tributaries. Furthermore, at certain times of the year, the IBA may be important for other large waterbirds, including Giant Ibis (*Pseudibis gigantean)*.[55]

  Along this stretch of the river, there are many different habitats. For much of its length, the Sekong River is fringed by a belt of gallery forest, about 100 m wide, which is significantly taller than the adjacent deciduous dipterocarp forest and contains a high proportion of broadleaf evergreen trees. However, this has been degraded or cleared for cultivation in many areas. The main urban area is bordered on the north by the Sekong River, and since the Sekong Bridge opened in 2007, it has drawn development east from the town to either side of the Sekong River at

[55] Lifted from: datazone.birdlife.org

this point. The bridge development has encouraged uncontrolled development on the opposite bank of the Sekong River (across the main urban area). Figure 4.12 shows the full extent of the IBA.

Figure 4.12: Sekong River IBA

Source: http://datazone.birdlife.org/site/factsheet/16660

- **Sesan River IBA.** The entire Cambodian stretch of the Sesan River and associated riverine vegetation, from its confluence with the Sekong River to the international border with Vietnam, is also an IBA. The confluence of the Sesan and Sekong rivers borders Sameakki Commune and Srah Ruessei Commune of Stung Treng District on the southeast and northeast, respectively. The confluence is about 4 km from the Sekong Bridge.

  The IBA supports one of the best remaining examples of the riverine bird community that was once widespread along wide, lowland rivers in Indochina. This community includes River Lapwing *(Vanellus duvaucelii)*, Small Pratincole (*Glareola lacteal)*, Great Thick-knee (*Esacus recurvirostris)* and River Tern (Sterna aurantia), of which the IBA supports over 1% of the Asian biogeographic population of the former two. In addition, the IBA supports Mekong Wagtail (*Motacilla samveasnae)*, a recently described species, which is thought to be endemic to the Mekong River and its major tributaries. Furthermore, the IBA may be one of the last remaining sites in Indochina to support a breeding population of Black-bellied Tern (*Sterna acuticauda)*, although this is probably now limited to one or two pairs, and with changes in flow regime following the development of hydropower schemes upstream, on the verge of extinction. The full extent of the IBA is shown on Figure 4.13.

  The nearest subproject component to the Sesan IBA is the installation of the pump station at the stream nearest to the west side of the Sekong Bridge, about 4 km away from the confluence of the Sesan River with Sekong River.

Figure 4.13: Sesan River IBA

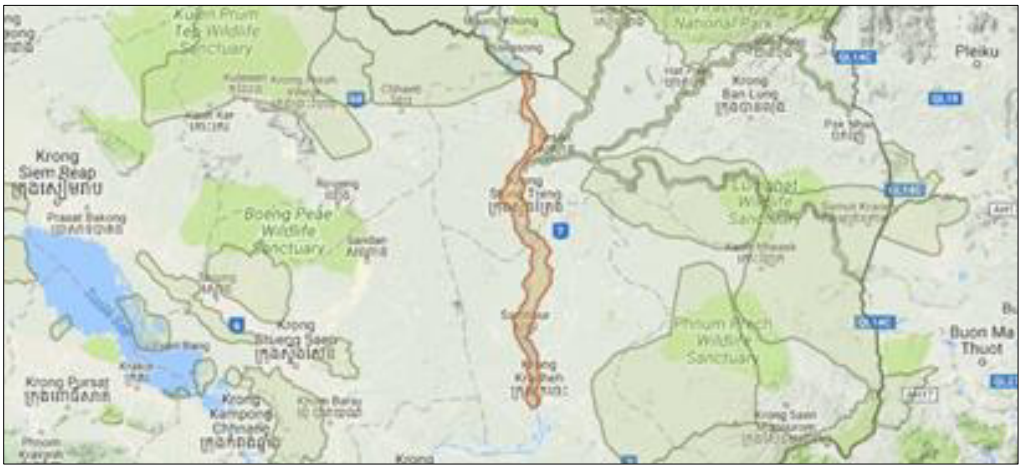
Source: http://datazone.birdlife.org/site/factsheet/16662

- **Mekong River IBA.** The Mekong River and associated riverine vegetation, from Kratie town to the international border with Lao PDR is also an IBA. Preah Bat Commune of Stung Treng District is bordered on the west by this IBA. The development of the Mekong Bridge has encouraged growth on either side of the Mekong at this point and is expected to continue in the future.

  The IBA supports a large proportion of the global population of Mekong Wagtail (*Motacilla samveasnae)*, a recently described species, which is thought to be endemic to the Mekong River and its major tributaries. In addition, the IBA supports significant populations of a suite of riverine species that have declined severely throughout mainland South-east Asia, including River Lapwing (*Vanellus duvaucelii)*, Great Thick Knee (Esacus *recurvirostris)* and River Tern (*Sterna aurantia)*. Furthermore, a number of globally threatened and near-threatened species have been recorded in the IBA in small numbers, including White-rumped Vulture (*Gyps bengalensis)*, Red-headed Vulture (*Sarcogyps calvus)* and Darter (*Anhinga melanogaster)*. Small, but significant numbers of White-shouldered Ibis (*Pseudibis davisoni)* have been recorded along forested parts of the river. Finally, the IBA may be one of the last remaining sites in Indochina to support Black-bellied Tern (*Sterna acuticauda)*, although there have been few recent records and no recent confirmation of breeding. Historically the area supported a breeding population of Indian Skimmer (*Rhynchops albicollis)*, however, the failure to find the species on recent surveys indicate that it is probably now extinct on the Mekong River. The full extent of the IBA is shown on Figure 4.14.

  Among the subproject components, the installation of a flood gate and pump station at one of the streams along the Mekong River and the outfall works of the combined sewer system will potentially have direct impacts on the Mekong River. The WWTP works will have indirect impacts on the Mekong River through the stream that traverses the WWTP site.

Figure 4.14: Mekong River IBA



Source: http://datazone.birdlife.org/site/factsheet/16674

111. The conservation status and population trends for the above species is shown on Table 4.2.

Table 4.2: IUCN Conservation Status and Population Trend

Name of Specie	Status	Population Trend
Pseudibis davisoni (White-shouldered Ibis)	Critically Endangered	decreasing
Pangasianodon gigas (Mekong Giant Catfish)	Critically Endangered	decreasing
Orcaella brevirostris (Irrawaddy Dolphin)	Endangered	decreasing
Vanellus duvaucelii (River Lapwing)	Near Threatened	decreasing
Glareola lactea (Little Pratincole)	Least Concern	unknown
Esacus recurvirostris (Great Thick-knee)	Near Threatened	decreasing
Motacilla samveasnae (Mekong Wagtail)	Near Threatened	decreasing
Thaumatibis gigantea (Giant Ibis)	Critically Endangered	decreasing
Esacus recurvirostris (Great Thick-knee)	Near Threatened	decreasing
Sterna aurantia (River Tern)	Near Threatened	decreasing
Sterna acuticauda (Black-bellied Tern)	Endangered	decreasing
Gyps bengalensis (White-rumped Vulture)	Near Threatened	decreasing
Sarcogyps calvus (Red-headed Vulture)	Critically Endangered	decreasing
Anhinga melanogaster (Oriental Darter)	Near Threatened	decreasing
Rynchops albicollis (Indian Skimmer)	Vulnerable	decreasing

Source: http://www.iucnredlist.org/

C. Physical Cultural Environment

112. There are no UNESCO world heritage sites recorded in the three provinces of the Project. At the local level, there could however be temples/religious structures in the areas of influence of the combined sewer works (see Table 3.1 for details of identified sensitive environmental receptors).

D. Socio-economic Environment

1. Population

113. **Kampong Cham.** Kampong Cham Municipality had a total population of 44,528 in 2013.

This is projected to have reached 47,945 (9,988 households or HHs) in 2017 and to reach 50,714 (10,565 HHs) in 2020 and 74,899 (15,604 HHs) in 2040.[56]

114. Of the 283 respondents in the socio-economic survey (SES) conducted by the PPTA Team, 98.9% were Khmer and 1.1% were Islam. In 2014, the ratio of vulnerable persons per 1,000 people was 4.4. The majority included disabled persons aged 18 years and above that were able to earn income, followed by disabled persons aged 18 years and above unable to earn income.

115. The combined sewer works will be in the main urban area, where the population is the highest and urban activities are concentrated. The sangkats that will be fully or partially covered in Phase 1 (of the service area) include Kampong Cham, Veal Vong and Sambuor Meas. As of 2014: (i) there were no houses with thatched roof and zinc roof using less than 20 sheets in Sangkat Kampong Cham; (ii) there were no houses with thatched roof and there were 0.6% of houses with zinc roof using less than 20 sheets in Sangkat Veal Vong; and (iii) there were 0.2% of houses with thatched roof and 1.7% of houses with zinc roof using less than 20 sheets in Sangkat Sambuor Meas. There are houses within 200 m distance from the northwest edge of the WWTP site. Residences along NR7 are within 500 m from the approximate center of the controlled landfill site.

116. **Kratie.** Kratie town has a total population of 32,002 and total households of 7,049 (2016).[57] Of the 286 respondents in the SES conducted, 100% were Khmer. In 2014, the ratio of vulnerable persons per 1,000 people was 6.8. The majority included disabled persons aged 18 years and above that were able to earn income, followed by disabled persons below 18 years old.[58]

117. The combined sewer and town center works will be in the main urban area, where the population is the highest and urban activities are concentrated. There are no houses within 1 km from the landfill and WWTP sites.

118. **Stung Treng.** Stung Treng Municipality had a total population of 25,158 in 2013, including Sameakki Commune. Sameakki Commune is north of the Sekong River and is not included in the service area of the proposed combined sewer system and wastewater treatment system. The population, including Sameakki, is projected to have reached 32,303 in 2017 and to reach 35,528 in 2020 and 68,511 in 2040. Excluding Sameakki, the population would have been 25,029 (5,214 HHs) in 2017 and would be 27,098 (5,645 HHs) in 2020 and 46,023 (9,588 HHs) in 2040.

119. Of the 276 respondents in the socio-economic survey conducted during the PPTA, 98.6% were Khmer, 1.1% were Lao and 0.4% was Vietnamese. In 2014, the ratio of vulnerable persons per 1,000 people was 2.6. The majority included disabled persons aged 18 years and above that were able to earn income, followed by disabled persons aged 18 years and above unable to earn income.

120. The combined sewer, flood control gate works, and town center enhancement works will be in the main urban area, largely within Stung Treng Commune. This is where the population is the highest and urban activities are concentrated. According to the District Profile of 2015 (based

[56] Source: PPTA population projections for estimation of scope of infrastructure components.
[57] Sangkat data for 2016 for Commune Database.
[58] Profile on Economic and Social in Year 2015. Municipality of Kratie. Province of Kratie. Provincial Department of Planning. March 2015.

on the commune database 2014), Stung Treng Commune had 6.7% of total families living in houses with thatched roofs and 11.7% in houses with zinc roofs using less than 20 sheets. At the existing dumpsite, there is only one house, which belongs to the caretaker of the dumpsite. No informal housing is in the area. The nearest residence is part of a housing subdivision along NR7. The WWTP site is within an area block that is bordered on all side by roads. Houses exist to the south of the WWTP site, and a low-density residential development exists to the west. Types of residences vary from small, all wooden houses but with galvanized iron roofing sheets, to several larger mixed wooden and concrete residences.

2. Employment

121. **Kampong Cham.** In 2014, the primary occupations of 18 years old and older were agriculture, 20.3%; handicraft 2.3%; and services, 77,4%. The percentage of women with primary occupations in agriculture was 10%, in handicraft was 0.3%, and in services 33.5%.

122. **Kratie.** In 2014, 78.7% of people 18-60 years old had a primary occupation. Of this, 46.5% were in agriculture, 3.3% in handicraft, and 50.2% were in the services sectors. The percentages of women with their primary occupation in agriculture was 22.2%, in handicraft was 0.7%, and in services 21.5%.

123. **Stung Treng.** In 2014, the primary occupation of 18 years old and older were agriculture, 38.9%; handicraft 2.2%; and services, 58.9%. The percentage of women with primary occupations in agriculture was 20.4%, in handicraft was 0.5%, and in services 25.5.5%.

3. Water Supply

124. **Kampong Cham.** Almost 96% of families in 2014 had access to clean water, of which 91% used water from the piped water supply system. The remaining 4% sourced water from rivers, streams and dug wells. From the SES results:

- 96% had access to piped water supply.
- For drinking, 85.5% used water from the public water supply; 58.3% buy water; 3.2% used water from their own well; 0.4% fetch water from the river/stream; 0.7% sourced water from the neighborhood; and 34.3% used rainwater.[59]
- 23% of respondents considered poor quality of drinking water, and 12% considered difficult access to drinking water, as the most serious problems in their households or establishments.

125. **Kratie**. About 94% of families in 2014 had access to clean water, of which 78% used water from the piped water supply system, 21% from pump wells, and the rest from either dug wells or by using rainwater. From the SES results:

- 76% had access to piped water supply.
- For drinking, 65.4% used water from the public water supply; 60.5% buy water; 11.9% used water from their own well; 2.4% fetch water from rivers and streams; and 45.1% used rainwater.[60]
- 27% of respondents considered poor quality of drinking water and 11% considered difficult access to drinking water as the most serious problems in their households or

[59] Respondents were allowed to give multiple answers.
[60] Respondents were allowed to give multiple answers.

establishments.

126. **Stung Treng.** About 75% of families in 2014 had access to clean water, of which 63.5% used water from the piped water supply system. The remaining 36.5% sourced water from pump wells, dug wells and rain water. From the social-economic survey results:

- 66% had access to piped water supply
- For drinking, 47.1% used water from the public water supply; 64.1% buy water; 3.3% used water from their own well; 3.3% fetched water from the river/stream; 0.4% sourced water from the neighborhood; 5.4% tonle (large river); and 42.4% used rainwater. (Respondents were allowed to give multiple answers.)
- 34.1% of respondents considered poor quality of drinking water, and 10.1% considered difficult access to drinking water, as the most serious problems in their households or establishments.

4. Sanitation

127. **Kampong Cham**. There is no reticulated wastewater collection and treatment in Kampong Cham. There are no records kept of numbers, volumes or condition of septic tanks in the town. Private septage trucks and septage disposal are unregulated. There is no building code, stipulating requirements for urban on-site sanitation. Wastewater treatment is limited to septic tanks in the more modern houses, hotels and restaurants. The majority of households use an unsealed soak away pit formed with locally available concrete ring sections.

128. From the SES results, of the respondents:

- 98% had toilets in their houses, of which 75% had flush toilets and 25% had latrines.
- Among those without toilets (6 respondents), 5 used their neighbor's toilets for defecation and 1 goes to the open field.
- 80.9% dispose of their wastewater to their own septic tank; 4.2% dispose of their wastewater near or behind their houses; 1.8% had soak pits; 12.7% to public sewer pipe and 0.4% into the farm near house.
- Only 9% had their septic tanks emptied, between 2008 and 2017. Sewer pumping service was by private company (78.3%), through individual pumping (8.7%); through hired labor (8.7%), or by DPWT (4.3%).
- 31.4% of respondents considered inadequate disposal of residential wastewater, and 1.4% considered inadequate disposal of human excreta, as the most serious problems in their households or establishments.
- About 85% considered that wastewater disposal problems were very serious.

129. **Kratie.** There is no reticulated wastewater collection and treatment in Kratie. There are no records kept of numbers, volumes or the condition of septic tanks in the town. Private septage trucks and septage disposal are unregulated. There is no building code, stipulating requirements for urban on-site sanitation. Wastewater treatment is limited to septic tanks in the more modern houses, hotels and restaurants. Most households use unsealed soakway pits formed with locally available concrete ring sections. From the SES results, of the respondents:

- 88% had toilets in their houses, of which 83% had flush toilets and 17% had latrines.
- Among those without toilets (34 respondents), 17 used their neighbor's toilets for defecation, 13 go to the open field, while the rest go to the forest, the pagoda toilet,

their mother's house, and dig land.

- 71.7% dispose of their wastewater to their own septic tank; 7.3% disposed of their wastewater near or behind their houses; 2.1% had soak pits; 5.9% to public sewer pipe; 11.9% into open channel drains; and 0.6% in front or behind the house with a water hole.
- Only 10% had their septic tanks emptied, between 2008 and 2016. Sewer pumping services was by private company (89.7%), and individual pumping (10.3%).
- 28.3% of respondents considered inadequate disposal of residential wastewater, and 11.2% considered inadequate disposal of human excreta, as the most serious problems in their households or establishments.
- About 86% considered wastewater disposal problems to be very serious.

130. **Stung Treng.** There is no reticulated wastewater collection and treatment in Stung Treng. There are no records kept of numbers, volumes or condition of septic tanks in the town. Private septage trucks and septage disposal are unregulated. There is no building code, stipulating requirements for urban on-site sanitation. Wastewater treatment is limited to septic tanks in the more modern houses, hotels and restaurants. The majority of households use an unsealed soakway pit formed with locally available concrete ring sections.

131. As of 2014, about 65% of families were using latrine.[61] From the socio-economic survey (SES) results:

- 91% had toilets in their houses, of which 82.5% had flush toilets and 17.5% had latrines.
- Among those without toilets (25 respondents), 10 used their neighbor's toilets for defecation, 14 go to the open field and 1 goes the forest.
- 57.6% would dispose of their wastewater to their own septic tank; 7% disposed of their wastewater near or behind their houses; 7.6% had soak pits; 17.8% to public sewer pipe, into the tonle, 0.4%, open channel drain, 9.4% and 0.4% into the farm near house.
- 29% had their septic tanks emptied, between 2002 and 2017. Sewer pumping service was by private company (86%), through individual pumping (9%); and through hired labor (5%).
- 21% of respondents considered in adequate disposal of residential wastewater, and 15.6% considered inadequate disposal of human excreta – as the most serious problems in their households or establishments.
- About 91% considered wastewater disposal problem very serious.

5. Drainage

132. **Kampong Cham.** The drainage system in Kampong Cham was installed during three main periods: (i) the older colonial era drains around the market area in the 1930s, (ii) open canals laid through a program led by the provincial governor in 1997, and (iii) most significantly a program paid for under the government's "Social Fund" in 1990. All the canals constructed in 1997 were reported to have been infilled for development, with no alternative provision for drainage provided. The condition of most (particularly colonial era) existing drains is largely unknown. The existing drainage systems could be deemed as no longer adequate to cope with the pressure of climate change, i.e., increasing runoff. From the SES results:

[61] Commune Database 2009-2013. Ministry of Planning.

- 27% had access to drainage; 2.8% to open canals.
- 50% had public drainage system in their area.
- 41% said their houses/buildings were connected to the road drains.
- 19.4% of respondents considered flooding and inadequate drainage of stormwater as the most serious problem in their households or establishments.
- About 85.5% considered drainage problem very serious.

133. **Kratie.** All of the main town center area has some form of drainage, dating from the colonial era onwards, although few records of size or condition have been kept. In general, town center surface water drains away from the Mekong River to the east through three outlets where it, until recently, entered a channel that conveyed it to the wetland to the south. This channel has now been infilled for development, and no alternate drainage arrangements made. The existing old system is deemed no longer adequate for the increasing runoff and pressures of climate change. From the SES results:

- 10.5% had access to drainage; 3.8% to open canals.
- 29% had a public drainage system in their area.
- 51% said their houses/buildings were connected to the road drains.
- 16.8% of respondents considered flooding and inadequate drainage of stormwater as the most serious problem in their households or establishments.
- About 86.7% considered the drainage problem to be very serious.

134. **Stung Treng.** Stung Treng town is not completely served with drainage. The most significant drainage works in recent times was a JICA funded project in 2006 that installed 1,900 m of reinforced concrete pipe drains of 600 mm diameter from the market area to a pond to the west. A 2009, the ADB PPTA "Mekong Water Supply and Sanitation Project" produced a series of drawings showing existing drainage at that time based on a physical survey but no physical works followed. Drainage works to relieve ponding in one area have been ongoing and were now complete as of December 2017 but have not been tested with a wet season as yet. The following are from the SES results:

- 21.4% had access to drainage; 1.8% to open canals;
- 47% had public drainage system in their area;
- 46% said their houses/buildings were connected to the road drains;
- 10.5% of respondents considered flooding and inadequate drainage as the most serious problem in their households or establishments; and
- About 88% considered drainage problem very serious.

6. Solid Waste Management

135. **Kampong Cham.** Solid waste services in Kampong Cham is contracted to CINTRI.[62] The method of final disposal of solid waste in Kampong Cham is open dumping. The existing solid waste dump site is on approximately 10 ha of land located 18 km from the town center on NR7 towards Phnom Penh. The site is 3.5 km along an access road from NR7. The site is owned and operated by the private company CINTRI. The municipality wants to terminate the contract with CINTRI and manage solid waste collection and disposal themselves and has identified the site for development of a managed landfill.

[62] Recognized by Prakas No 634 of the Krong Kampong Cham Authority dated 24 June 2014.

136. Nearly 30% of families in 2014 were covered by the solid waste collection services; by 2017, 57%. All four sangkats were covered in 2017; but only Krong Kampong Cham had all households served. Veal Vong had 75%, Boeng Kok had 50%, and Sambour Meas had 30% of their households served. From the SES results:

- 68% had access to solid waste collection services.
- 36% were collected every two days; 18%, daily; 18% every 5 days, among others.
- 67.5% were received waste collection service by – private company, 99%; self-employed waste collector, 8.5%; informal waste collector, 0.5% (respondents allowed to give multiple answers).
- Waste collection fees ranged from KR 5,000 to 38,000.
- 97% indicated that sorting of waste was important.
- 78% indicated that they sorted waste before disposing.
- 65% used their organic waste as animal feed; 5% throw the organic waste in their backyard; 15% dispose it with other waste, 15% throw it to open space; 0.7% compost the organic waste.
- 76% indicated that there was a solid waste-associated problem in their area – bad smell, 67%; scattered on the road, 21%; waste not collected properly, 12%.
- 93% indicated that the solid waste problem could cause impacts on the environment or health – water pollution, 1.5%; infectious diseases, 2.3%; air pollution, 23.5%; respiratory disease, 6.4%; bad smell, 67.4%.
- 10.6% of respondents considered inadequate solid waste collection service, 1.1% considered nuisance form solid waste disposal sites, and 0.7% considered nuisance from solid waste transfer points, as the most serious problems in their households or establishments.
- About 82% considered solid waste collection problem very serious.

137. **Kratie.** Solid waste collection service currently extends to the 4 communes that make up the urban and peri-urban area. However, only 50% of the total households in 2017 were served. The method of final disposal is open dumping on a portion of a 30-ha public land located 20 km east of Kratie town center. It is operated by a private operator,[63] who operates two collection trucks that haul the collected wastes to the open dumpsite, where some informal sorting is carried out by waste pickers. Each truck has 7m^3 capacity and makes 2 trips per day. The contract between the province and the operator is set out under Prakas No 24 dated 10 March 2015, and Prakas No 049/17 dated 20 March 2017. From the SES results:

- 51% had access to solid waste collection services.
- 62% were collected every two days; 21%, daily; 14% every 3 days, among others.
- 67.5% received waste collection service by—private company, 82%; self-employed waste collector, 17%; informal waste collector, 4%; province department, 2%; and district department, 0.7%.[64]
- Waste collection fees ranged from KR 4,000 to 15,000.
- 97% indicated that sorting of waste was important.
- 80% indicated that they sorted waste before disposing.
- 60% used their organic waste as animal feed; 13% throw the organic waste in their backyard; 12% dispose it with other waste, 14% throw it to open space; and 1% compost the organic waste.

[63] Mr. Tok Kun
[64] Respondents were allowed to give multiple answers.

- 72% indicated that there were solid waste-associated problems in their area—bad smell, 66%; scattered on the road, 33.5%; waste not collected properly, 0.5%.
- 92% said the solid waste problems could cause impacts on the environment or health—water pollution, 4.6%; infectious diseases, 4.6%; air pollution, 20.2%; respiratory disease, 3.8%; bad smell, 66.8%.
- 2.4% of respondents considered inadequate solid waste collection service, 0.3% considered nuisance form solid waste disposal sites, and 0% considered nuisance from solid waste transfer points—as the most serious problem in their households or establishments.
- About 80% considered solid waste collection problem to be very serious.

138. **Stung Treng.** Solid waste collection service currently extends to the 3 sangkats that make up the urban and peri-urban areas. Sameakki sangkat, being across the Sekong bridge and being spread over a large area, is not served. As of 2017, 43% of the households are served by solid waste collection services. In 2014, 22% of families availed of solid waste collection services.[65] From the social-economic survey results:

- 52% had access to solid waste collection services.
- 37.5% were collected every two days; 30.5%, every three days; 29%, daily, among others.
- 52% were received waste collection service by --- private company, 81%; self-employed waste collector, 7.6%; informal waste collector, 14%; province department, 1.4% (respondents allowed to give multiple answers).
- Waste collection fees ranged from KR 4,000 to 40,000.
- 94% said sorting of waste was important.
- 71% said they sorted waste before disposing.
- 51% used their organic waste as animal feed; 12.7% throw the organic waste in their backyard; 16.3% dispose of it with other waste, 20% throw it to open space.
- 84% said there was solid waste-associated problem in their area --- bad smell, 76%; scattered on the road, 18%; waste not collected properly, 6.5%.
- 97% said solid waste problem could cause impacts on the environment or health --- water pollution, 8.2%; infectious diseases, 6.7%; air pollution, 11.2%; respiratory disease, 9.4%; bad smell, 64.4%.
- 5.1% of respondents considered inadequate solid waste collection service, 1.4% considered nuisance form solid waste disposal sites, and 1.4% considered nuisance from solid waste transfer points --- as the most serious problem in their households or establishments.
- About 91.3% considered solid waste collection problem very serious.

139. Currently, there is one donated truck for collection, and in addition a rural “toktok” or agricultural hand tractor is used to tow a trailer to deliver waste to the site. Between the two vehicles 30-32 tonnes/day is collected and delivered to the disposal site. The method of final disposal is open dumping. The dumpsite is 147-ha, about 10km across the Sekong Bridge. The site is along NR7. The dump site is operated by the municipality. No waste pickers were seen during two site visits made.

[65] Commune Database 2009-2013. Ministry of Planning.

7. Power Supply

140. **Kampong Cham.** Based on information provided during the PPTA Interim Field Mission in August 2017, all households in Kampong Cham were connected to the grid electricity supply. From the SES results, 1 of the 283 respondents indicated that he/she had no access to grid electricity supply and 1 of 283 respondents considered unreliable electricity supply as the most serious problem in their households or establishments.

141. **Kratie.** In 2014, nearly 80% of houses were connected to the power grid.[66] From the SES results, 10 of the 286 respondents said they had no access to grid electricity supply and 9 of 286 respondents considered unreliable electricity supply as the most serious problem in their households or establishments.

142. **Stung Treng.** All households are connected to the power grid.

8. Health

143. **Kampong Cham.** According to the Municipal Government, there is a health center in every commune; while secondary and tertiary health care facilities are available at the district level or in the town center. As of 2014, there were: (i) 3 health centers and ratio of beds of health centers per 100,000 people was 22.5; and (ii) 79 private hospitals with a ratio of bed per 100,000 people of 397.3. The ratio of staff of health centers per 100,000 people was 87.4.

144. **Kratie.** According to the Municipal Government, of the 5 communes that make up Kratie Municipality, only one (Kaoh Trong) has no health center. This commune avails of the services in the closest commune. The Department of Health had planned to put one in Kaoh Trong, especially as the people had requested for it. In 2014, the average distances from village to heath center ranged from 1 - 1.8 km in the 4 communes with 1 heath center each. The average distance of a village in Kaoh Trong to the nearest health center was 6 km. Kratie had 1 referral hospital with 150-bed capacity. There was no private hospital.[67]

145. **Stung Treng.** As of 2014, there were 2 health centers with 4 beds, and 1 referral hospital with 90 beds. The ratio of beds per 100,000 people was 288. The distance from a village to the health center ranged from 2.5 km (Stung Treng Commune) to 7.8 km (Sameakki Commune), or an average distance of 5.6 km. [68]

9. Education

146. **Kampong Cham.** Kampong Cham has an elementary and secondary school in every commune. As of 2014, there were 8 state pre-schools, 11 private primary schools, 5 state secondary schools and 3 state high schools. Student to teacher ratios were: (i) in state pre-schools, 34:1; (ii) in private pre-schools, 22:1; (iii) in primary schools, 38:1; (iv) in secondary schools, 15:1; and (v) in high schools, 41:1. Of the total 6-11-year old population, 88.5% attended primary school. Of the 12-14-year old population, 43% attended secondary school.

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[66] Profile on Economic and Social in Year 2015. Municipality of Kratie. Province of Kratie. Provincial Department of Planning. March 2015.

[67] Profile on Economic and Social in Year 2015. Municipality of Kratie. Province of Kratie. Provincial Department of Planning. March 2015.

[68] Profile on Economic and Social in Year 2015. Municipality Stung Treng Code 1904. Province Stung Treng. Provincial Department of Planning. March 2015.

147. The literacy rate of the 15-17-year old population was 99.7%; that of the 18-45-year old population was 99.2%. Of the male SES respondents, the majority finished secondary (32.5%) and high school (38.9%); of the females, majority finished secondary (33.6%) and high school (26.5%). There were also male respondents who completed university/master's degrees (9.9%), and female respondents who completed university/master's degrees (9.9%). There were also a few respondents who had never attended school or had no answer.

148. **Kratie.** As of 2014, there were 13 state primary schools with 129 classrooms and 126 classes, 6 state secondary schools with 45 classrooms and 39 classes, and 2 state high schools with 55 classrooms and 55 classes. Average distances from village center to schools were: (i) 0.3 km to primary school; (ii) 0.8 km to secondary school; and (iii) 2.1 km to high school. The ratios of student to a teacher in state schools were: (i) 28 in primary schools; (ii) 18.5 in secondary schools; and (iii) 18.1 in high schools.[69]

149. Of the total 6-11-year old population, almost 94% attended primary school. Of the 12-14-year old population, 97.6% attended secondary (51%) and primary (46.6%) schools. Of the total 18-35-year old population, nearly 7% attended vocational training. Literacy rates were as follows: (i) 98.1% for 15-17 years of age; and (ii) 98.6% for 18-45 years of age.[70]

150. Of the male SES respondents, the majority finished secondary (29.7%) and high school (33.9%); of the females, majority finished secondary (29.7%) and high school (31.1%). There were also male respondents who completed university/master's degrees (9%), and female respondents who completed university/master/doctorate degrees (7.6%). There were also a few respondents who had never attended school or had no answer.

151. **Stung Treng.** As of 2014, there were 13 state primary schools with 129 classrooms and 126 classes, 6 state secondary schools with 45 classrooms and 39 classes, and 2 state high schools with 55 classrooms and 55 classes. Average distances from village center to schools were: (i) 0.3 km to primary school; (ii) 0.8 km to secondary school; and (iii) 2.1 km to high school. The ratios of student to a teacher in state schools were: (i) 28 in primary schools; (ii) 18.5 in secondary schools; and (iii) 18.1 in high schools.[71]

152. Of the total 6-11-year old population, almost 94% attended primary school. Of the 12-14-year old population, 97.6% attended secondary (51%) and primary (46.6%) schools. Of the total 18-35-year old population, nearly 7% attended vocational training. Literacy rates were as follows: (i) 98.1% for 15-17 years of age; and (ii) 98.6% for 18-45 years of age.[72]

153. Of the male SES respondents, the majority finished secondary (29.7%) and high school (33.9%); of the females, majority finished secondary (29.7%) and high school (31.1%). There were also male respondents who completed university/master's degrees (9%), and female respondents who completed university/master/doctorate degrees (7.6%). There were also a few respondents who had never attended school or had no answer.

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[69] Ibid.
[70] Ibid.
[71] Ibid.
[72] Ibid.

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Environmental Benefits, Positive Impacts and Results

159. The Project is expected to improve the urban environment in the three towns, reduce their vulnerability to environmental and climate risks, and improve their climate resilience level and quality of life. It will provide them with improved stormwater, wastewater and solid waste management services, and in all three, formulate a provincial development strategy and strengthen institutional capacities in resilience town planning. The Project also includes town center enhancements in Kratie and Stung Treng. Cumulatively, the positive impacts of such benefits are, but not limited to: (i) reduced flood risk, (ii) reduced risk of human contact with raw sewage during flooding, (iii) reduced health risks from and incidence of diseases caused by inadequate stormwater, (iv) improved environmental sanitation, (v) controlled GHG emissions from solid waste disposal, (vi) reduced pollution discharges and improved water quality, (vii) reduced air and land pollution, and(viii) improved social equity from access by all to recreational amenity. Table 5.1 presents the environmental benefits, positive impacts and expected results from each component of the subproject.

Table 5.1: Environmental Benefits, Positive Impacts and Outcomes

Subproject Component	Benefits, Positive Impacts and Outcomes	
Lagoon-based wastewater treatment system	Benefit	• Improved stormwater and wastewater management
	Positive impacts	• Reduced flood risks • Reduced health risks and incidence of diseases • Reduced pollution discharges • Improved water quality • Improved environmental sanitation • Reduced risks of human contact with sewage from drainage during flooding
Controlled landfill	Benefit	• Improved solid waste management
	Positive impacts	• Improved environmental sanitation • Reduced impacts on groundwater and surface water • Reduced air, and land pollution • Controlled and managed GHG emissions from SW disposal operations
Town center enhancement	Benefit	. Safe and pleasant environment in the town . Enhanced public recreational amenity
	Positive impacts	. Improved pedestrian safety . Improved environmental sanitation . Improved public health . Improved social equity, ensuring access by all to recreational amenity
Institutional capacities for regional economic connectivity enhanced	Benefit	• Strengthened institutional capacities
	Positive impacts	• More sustainable urban growth. • Reduced infilling of wetlands
Results (environmental)		• Reduced vulnerability to environmental risks • Improved climate resilience • Enhanced quality of life and livability

B. Anticipated Impacts/Issues/Concerns of Each Subproject

154. **Kampong Cham Subproject.** The proposed combined sewer system in Kampong Cham will be built in the main urban area to serve four communes, namely, (i) Krong Kampong Cham (100%), (ii) Veal Vong (100%), (iii) Sambor Meas (50%), and (iv) Boeng Kok (10%). The sewer lines will be laid along roads in the main urban area and will affect at least eleven schools, businesses, one hospital, an orphanage, two temples, two mosques, and one church along the roads in Boeng Snay and Boeng Bassac. The impacts of the combined sewer will primarily occur during the construction phase. The impacts will be temporary but will potentially affect community health and safety, cause road traffic and blocking of accesses to properties. These impacts will be addressed by implementing good construction practices as outlined in the environmental management plan.

155. The proposed wastewater treatment plant will be located in Boeng Bassac area in Sambor Meas commune. The area is bordered on all sides by roads and is dominated by shrub/grassland and agricultural land but during the rainy season the entire area is waterlogged for about 4 – 5 months. Traffic is low and there are few houses in the vicinity. Flooding and the assimilative capacity of the Boeng Bassac lagoon will be further evaluated during detailed design. The design will also take into consideration the intended use of the lagoon, the presence of sensitive receptors that are dependent on the lagoon, and the expected effluent quality of the treatment plant. This will also include the design of an emergency response plan for the project.

156. The proposed controlled landfill in Kampong Cham will be located in Preuk Village, Mean commune, Prey Chhor District. The site is about 17 – 18 km away from the town center. The proposed site is dominated by grassland with scattered shrubs and trees, surrounded by rice fields and upland areas. The nearest residential house is about 500 meters away. There is an intermittent stream located along the western edge of the property while a transmission line is located along the northern boundary adjacent to the access road. Issues that need to be considered in the detailed design of the controlled landfill of Kampong Cham are the impacts of leachate on the intermittent stream, groundwater and surrounding agricultural land, cutting of trees and safety clearance from transmission lines.

157. **Kratie Subproject.** The combined sewer in Kratie will be installed in the main urban center and will serve the sangkats of (i) Krong Kratcheh (100%), (ii) Krakor (25%), (iii) Ou Russei (50%), and Roka Kandal (10%). Adverse impacts during the construction can be mitigated through implementation of best practices to manage community health and safety. Sensitive receptors along the alignment of the sewer lines include at least four schools, the Kratie Referral Hospital, three temples, one mosque, a public library, existing utility lines, businesses, and residential establishments along the roads.

158. The vicinity of the proposed wastewater treatment plant is mainly agricultural. The nearest residential area is about 1.5 km west of the proposed site. The access to the proposed wastewater treatment plant will affect a commercial establishment, a school, agricultural lands, and residences along Road 377. The impacts will primarily occur during laying of the main trunk to the wastewater treatment plant. However, during the operational phase, the anticipated adverse impacts will not be significant since the area is far from residential communities. The operational phase impacts are primarily positive since wastewater treatment will help improve health and sanitation of the community. During detailed design, the capacity of the receiving lagoon will be evaluated further to ensure that the receiving water can accommodate discharged effluent without causing flooding in the surrounding areas. In addition, the level of treatment and effluent quality for discharge into the lagoon will take into consideration the assimilative capacity

and the intended use of the lagoon.

159. The proposed controlled landfill in Kratie will be developed within the existing dumpsite which is about 17 km east of the town center. The site is flat and is surrounded by shrub/grassland with agricultural lands to the west. The nearest agricultural land is about 500 m west of the existing dumpsite while a stream can be found at the eastern boundary of the property. There are no houses in the immediate vicinity of the proposed controlled landfill since the nearest house is about 1.75 km away. However, farmers work in the nearby agricultural lands to grow crops. The issues that should be considered in the detailed design include the proper closure of the existing dumpsite, management of leachate to protect the adjacent stream and groundwater and protection of waste pickers from hazards of exposure to mixed wastes. The detailed design will evaluate air and odor pollution control measures, buffer/fence, and other methods to ensure safety of communities in the vicinity.

160. The town center enhancement in Kratie will be along the riverfront walkway in Preah Soramarith Quay. The impacts are anticipated to occur only during the construction phase. Sensitive receptors that were identified include one temple, at least four schools, a market and businesses and residential establishments. Once the town center enhancement project becomes operational, the impacts are expected to be mostly beneficial to the community and the environment.

161. **Stung Treng Subproject.** The combined sewer and floodgate will be located in the main urban area of Stung Treng and will serve the communes of (i) Krong Stung Treng (75%), (ii) Srah Ruessei (10%), and (iii) Preah Bat (90%). Temporary disturbances are expected to occur during the laying of the sewer lines. Identified sensitive receptors include at least seven schools, the First Region Hospital, Stung Treng Health Center, at least five temples, one mosque, one church, existing utility lines, and residential and business establishments along the roads. The floodgate and four pump stations will be located near Mekong River and Sekong River. The impacts to trees and vegetation as well as to adjacent residential and business establishments and a pagoda will occur during the construction phase. Once the floodgate and pump stations become operational, the communities in Stung Treng will be protected against floods caused by rising waters from Mekong River and Sekong River.

162. The location of the proposed wastewater treatment plant will be within an area that is bordered by roads. The wastewater treatment plant is not expected to cause significant adverse impacts to communities since the vicinity is largely agricultural. However, measures are necessary during detailed design to ensure that the stream within the site can adequately accommodate the discharge from the wastewater treatment plant and that the effluent meets the standards for discharge into Mekong River which is just about 200 m away from the site.

163. The proposed controlled landfill of Stung Treng will be developed in a 100-ha public land about 10 km from the town center. There are no residential communities in the immediate vicinity. The nearest house is about 1 km away from the site. The site is degraded forest with two perennial streams in the south. During detailed design, the potential impacts on ecology and leachate on water resources needs to be evaluated further.

C. Anticipated Impacts/Issues/Concerns – Pre-Construction Phase

160. Pre-construction issues and concerns primarily relate to (i) ensuring that subproject component designs fully incorporate environmental protection, sustainability and climate resilience measures, and (ii) promoting the preparation and readiness of key subproject

stakeholders and affected communities. Mitigation of impacts from these issues includes the following:

(i) **Engaging qualified environmental personnel.** These include (i) a full-time national Environmental Safeguards Officer in the Project Management Unit (PMU-ESO), over the five-year subproject implementation period,[73] and (ii) the engagement of an international Environmental Specialist (4 months,) and national Environmental Specialist (20 months), based in the PMCS.

(ii) **Environmental training and capacity building:** The PMCS will provide training for environmental personnel of the PMU/PMU-ESO, PIU, contractors and the DOE. Training modules will include environmental management and technical strengthening in EMP implementation, grievance redress mechanism (GRM) implementation, climate adaptation, disaster risk resilience, public consultation, and monitoring and reporting. The participation of the PMU and PIU in the conduct of the dumpsite environmental compliance audits (ECA) will also be a training opportunity. Funds for environmental seminars, workshops and training are also allocated.

(iii) **Mine and Unexploded Ordnance Clearances.** As indicated by the Cambodia Mine Action and Victim Assistance Authority (CMAA), the region of the three subproject towns contain cluster munition contaminated areas. Impacts will be mitigated as follows: (i) all subproject sites and their areas of influence will have been cleared by the CMAA at least two weeks prior to construction mobilization, (ii) In collaboration with the CMAA, PMU and PIU, a workers' preconstruction workshop will be held to orientate workers on health and safety requirements, and particularly the procedures to follow when mines or unexploded ordnances are encountered during construction, and (iii) information and key contacts will be incorporated in an emergency response plan.

(iv) **Grievance Redress Mechanism:** Established by the MPWT and with oversight from the PMU, the PIU will ensure implementation of the GRM at the subproject level. The GRM provides the mechanism to receive and facilitate the resolution of affected peoples' environmental and other concerns and grievances at the project level, accommodating informally and formally lodged grievances. Section VIII describes the GRM.

(v) **IEE and EMP Updates.** Mitigation measures defined in this IEE and associated EMPs will be modified and updated as necessary, based on the final design of subproject components. The detailed design of the subproject components and the updated IEEs will consider the assimilative capacity of receiving water bodies, intended use of receiving water bodies, presence of sensitive receptors, and impacts on ecology such as Important Bird Areas in Mekong River and Sekong River. Further site assessment, ecological surveys, environmental sampling (surface and groundwater quality, air quality, noise, and leachate quality), geological survey, hydrological and hydrogeological assessment, and environmental compliance audit of existing dumpsites will be conducted. These activities will be conducted during detailed design as part of the domestic IEIA/EIAs and the updates to the IEE/EMP. In accordance with ADB and government protocol, the revised documents will be submitted to ADB and government for review and approval, for subsequent disclosure on the ADB's website.

[73] The PMU-ESO will oversee the implementation of environmental safeguard requirements for the Project.

(vi) **Inclusion of EMPs in Bidding Documents.** The updated EMPs will be included in the respective bidding and contract documents. The civil works contracts will include provisions to ensure that contractors prepare site-specific contractor EMPs (CEMPs) that fully respond to the EMPs.

(vii) **Consultations and Disclosures.** Consultation and disclosure activities will be ongoing with affected people and other involved stakeholders to ensure implementation schedule, details of construction activities and particularly activities that result in nuisances and disturbances, the status of claims and compensation and other aspects are shared in advance with persons in the project area of influence.

(viii) **Environmental Site Parameter Evaluation.** Supplementary baseline assessments will be conducted during the final design phase to further refine component designs and inform any necessary IEE and EMP modifications. These include for example, the sampling and analysis of biodiversity, air quality, surface waters, groundwater, soils (vadose zone), noise, wastewater influents, and existing dumpsite effluents and leachate quality.

(ix) **Environmental Compliance Audits (ECAs).** In accordance with SPS 2009, ECAs will be completed for existing dumpsites to assess compliance with existing environmental requirements, identify deficiencies, evaluate impacts, and propose remedial recommendations for dumpsite closure and post closure monitoring and maintenance. They will also provide additional technical and operational information in order to guide the final dumpsite closure designs. Post-closure monitoring plan will also be designed to ensure effectiveness of the dumpsite closure. The monitoring plan will include monitoring of surface and groundwater, landfill gas, erosion control, and leachate collection. The post-closure monitoring plan will be included in the updated IEE. **Appendix E** provides a draft terms of reference template for the conduct of the ECAs.

D. Anticipated Impacts/Issues/Concerns – Construction Phase

161. **Air Quality.** Temporary, moderate air quality impacts are anticipated during the construction phase, due to both fugitive dust generation associated with earthworks and construction works, and to the movement and disturbance of solid wastes at the existing dumpsites. These waste movements relate to (i) the currently dumped wastes at the existing Kratie dumpsite, which will be carefully transported to the new, adjacent controlled landfill, and (ii) potentially to the dumpsites in the three towns that are to be closed and remediated.[74] The receptors of these air quality impacts are residents, businesses, and other affected persons residing nearby, and particularly downwind of construction activities, as well as formal and informal waste workers at the dumpsites. Dust will also be generated during pipe network installation excavations in urban areas which are by their nature, densely populated. Sources of air quality impacts during construction therefore include the following:

(i) Construction machinery and equipment leading to minor increases in levels of nitrogen oxides (NOx) and sulfur oxides (SOx).

(ii) Asphalt for any road pavement reinstatement for pipelines and other excavations that will generate emissions containing small quantities of toxic and hazardous chemicals such as volatile organic compounds (VOC) and poly-aromatic hydrocarbons (PAH).

[74] For example, currently deposited waste may be disturbed during the grading and covering of exposed waste surfaces at these facilities.

(iii) Fugitive dust from (i) the loading, unloading and haulage of construction materials. (ii) borrow pits and other excavations, and (iii) batching plants.
(iv) Fugitive dust, bioaerosols and potentially hazardous chemicals from the movement or disturbance of waste within the existing dumpsites.
(v) Fugitive dust from wind action on stockpiles of cement, fine natural aggregates and dry residual wastes.

162. The following mitigation measures are proposed to protect sensitive receptors from air quality issues:

(i) The spraying of water at borrow pits, construction sites and material handling areas where fugitive dust is generated.
(ii) Ensuring dust suppression systems are included in asphalt and concrete batching facilities, and that they are located at least 500 m downwind from the nearest receptors.
(iii) Covering trucks to encapsulate dry construction materials.
(iv) Ensuring that vehicles and machinery are maintained to a high standard to minimize emissions.
(v) Ensuring suitable advanced notice is provided for pipeline and other excavation works.
(vi) Ensuring that formal and informal waste workers at the dumpsites, and receptors within 500 m of these facilities, are suitably informed in advance of when these activities are planned.
(vii) Ensuring that appropriate environmental and occupational health and safety provisions are followed during the disturbances and movement of solid wastes at the dumpsites, as to be defined during the final designs of the dumpsite closure and remediation plans.

163. **Noise.** Noise impacts will be caused by the operation and movement of construction vehicles as well as works involving the use of excavators, electric saws, pumps, generators, drilling rigs, and other equipment. These noise impacts will however be temporary and localized, as the machinery and vehicles only generate noise as they operate. It is anticipated that construction machinery may generate noise levels of up 90 dB(A), and, that receptors within an approximate 250 m influence area could be affected temporarily by intermittent noise impacts above the WHO limit of One Hour LAeq 55 dBA. Although noise will therefore be periodically endured by nearby receptors, particularly during pipeline laying activities, it is anticipated that only construction site workers will be subjected to noise impacts for an extended period of time.

164. Potential noise impacts will be mitigated through the following measures:

(i) Utilizing low-noise, well maintained vehicles and equipment, and ensuring that exhaust systems are in good working order.
(ii) Establishing noise barriers such as temporary fences around active work areas, and barriers to be as close to the source or to the receptor location as possible.
(iii) Installing sound-absorbing enclosures around generators and other equipment.
(iv) Restricting heavy and noisy machinery operations to between 8am-5pm.
(v) Providing construction workers with and enforcing the use of personnel protective equipment (PPE).
(vi) Enforcing the non-use of vehicle horns unless absolutely necessary.
(vii) Maintaining close coordination with affected persons and communities, to ensure

that advanced warning is provided, considerations are given, and the GRM widely understood so that grievances and complaints are handled expeditiously.

(viii) Monitoring noise levels, particularly of nearby sensitive receptors.

165. **Surface Water**. The controlled landfills proposed for the three towns are to be located on stable, well drained sites. Responding to localized drainage requirements, the final designs of these facilities will incorporate surface drainage features, such as perimeter drains and the diversion of existing streams to mitigate adverse drainage impacts. Regarding the proposed dumpsite remediation initiatives, the dumpsite closure plans will also prioritize the installation of key features to minimize impacts to surface water resources. These include (i) surface grading and covering of exposed waste cell surfaces to provide for controlled runoff and reduced erosion, and (ii) site perimeter drains to control surface water run-on and runoff. The dumpsite closure final designs will be guided by the ECAs.

166. The available sites for the lagoon-based WWTPs are at low elevations, comprising of shrub and grasslands, interspersed with agricultural lands. Due to their relatively low elevations, all three sites are subject to extensive flooding. While the Stung Treng and Kratie sites are intermittently waterlogged, reportedly for up to five months per year, the proposed Kampong Cham site is waterlogged almost continually, being proposed within an existing lagoonal area.[75] Hydrologically, the potential environmental impacts to surface water resources from WWTP construction are: (i) changes to natural surface hydrology and drainage pathways due to WWTP construction, and (ii) potential flooding of the facilities by surface waters. These impacts will be addressed at final design phase through (i) detailed hydrological assessment to ensure that the final designs fully accommodate and mitigate impacts on natural hydrology, and (ii) incorporating bunds and raising the elevations of the WWTPs above potential flood levels.

167. Other mitigation measures to be adopted that are common to the construction of both the WWTPs, controlled landfills and dumpsite closures include the following:

(i) Adequate management of sediments, soils, stockpiles and aggregate materials utilized in facility construction.
(ii) Monitoring of upgradient and downgradient surface water quality.
(iii) Management of solid and hazardous wastes.[76]
(iv) Siltation and sedimentation runoff control by (i) minimizing excavation exposure, (ii) stockpiling soils away from water bodies and flood-prone areas, (iii) utilizing sediment detention basins and other control features, and (iv) avoiding rainy season excavation where possible.
(v) Avoidance of vegetation removal or damage beyond site boundaries.
(vi) Reporting of wildlife and rare animal species sightings, and prohibition of poaching.

168. Regarding the combined sewerage system, the construction of the outfalls will need to ensure that Mekong River habitats are not impacted. Although these are not major works, they will be implemented close to the Mekong River. Measures to mitigate these impacts include the following:

[75] While the actual facility boundaries of the Stung Treng site have been confirmed, only the general locations of the sites for Kratie and Kampong Cham have currently been identified. The actual locations of these sites will be confirmed during the final design phase.

[76] Including (i) provision of adequate waste storage facilities; (ii) enforced sorting and disposal; (iii) separate storage for hazardous and non-hazardous wastes; and (iv) prompt disposal.

(i) Minimizing riparian vegetation removals.
(ii) Installation of erosion and sediment controls prior to construction commencement.[77]
(iii) Limiting soil stripping to the dry season.
(iv) Ensuring workers observe proper sanitation and good hygiene.
(v) Ensuring where possible works close to the river are conducted in the dry season.
(vi) Ensuring the management of hazardous materials, and the containment of spills.
(vii) Ensuring that sites close to waterbodies are stabilized prior to the removal of erosion and sediment control measures following construction.
(viii) Monitoring water quality during and after construction.

169. **Wastewater**. During the construction works, wastewater will be generated by (i) on site sanitation facilities, campsites and other facilities, (ii) equipment maintenance and repairs, (ii) vehicle and equipment washing, (iii) construction site surface runoff, (iv) discarded drainage pipes, and (v) borings and excavation works. Inadequate wastewater management will impact on the health and safety of construction workers and communities. It will pollute surface water resources, groundwater and soils within the areas of influence. These impacts will be mitigated by:

(i) Maintaining sanitation facilities onsite and at workers' campsites.
(ii) Strictly enforcing hygiene and sanitation practices.
(iii) Incorporating sediment controls, silt traps and wastewater collection.
(iv) Maintaining equipment washdown areas, complete with sediment control devices.
(v) Providing retention control for material stockpile areas.
(vi) Designating specific areas for repair and maintenance.
(vii) Ensuring regular wastewater collection by a recognized service provider.
(viii) Ensuring wastewater from boring and excavation works is properly managed and disposed of.

170. During construction, any existing septic tanks or soakways connected to existing drains will need to be disconnected. Owners will then need to construct temporary soakway pits as required for effluent if they don't already have a septic tank.

171. **Groundwater.** There is a potential that boreholes drilled during the design and construction phases are not properly sealed after completion, creating a direct contaminant pathway from the surface to the groundwater table. This will be mitigated through the inclusion of detailed borehole construction specifications in the contractor's overall method statements for the drilling works to assure correct borehole construction. Other than this, groundwater impacts during construction are not anticipated.

172. **Fauna, Flora and Potential Habitat Loss.** Although the initial baseline has not revealed specific impacts to fauna and flora at the proposed subproject sites, the precise sites of the proposed WWTPs in Kratie and Kampong Chamare yet to be identified. For this reason, and due to the waterlogged and lagoonal nature of these sites and the proposed Stung Treng WWTP site, it is recommended that further site assessment, including site specific ecological surveys, be conducted at the final design stage to identify, evaluate and where necessary mitigate ecological impacts caused by the siting of these facilities.

173. **Physical Cultural Environment.** Although subproject sites within the three towns are not

[77] For example, sediment control fences supplemented with sandbag barriers.

within the close vicinity of historical and archaeological sites, the pipelines to be constructed for the combined sewer network could be located close to pagodas, other religious monuments and other facilities. In adherence with cultural heritage protection laws, measures to mitigate any associated impacts are as follows:

(i) Ensure pre-construction coordination with temple authorities.
(ii) Cease construction works on discovery.
(iii) Declare to the police, who will transmit the declaration to the Governor.
(iv) The Governor will then inform the appropriate authority, which will implement the necessary measures to protect both the discovered items and the site.

174. Chance finds procedures are set out in the EMP and will be followed.

175. **Community Health and Safety.** Communities will be exposed to health and safety hazards from dust, noise, access restrictions, local flooding, utility service disruptions, construction vehicle and equipment movements, and potential social conflicts and diseases (communicable and transmittable) from outside workers. Mitigation measures include:[78]

(i) Access restrictions:
   a. Manage material stockpiles to prevent blockages.
   b. Provide access restriction information in advance.
   c. Ensure vehicles park at previously agreed locations.
   d. Provide temporary, alternative access where possible.
(ii) Localized flooding:
   a. Divert main surface drainage routes when obstructions are unavoidable.
   b. Dispose of spoils and debris promptly.
(iii) Utility service disruptions:
   a. Repair service disruptions expeditiously.
   b. Provide alternative power and water supplies.
(iv) Worker social conflicts:
   a. Prioritize local employment.
   b. Provide health and safety training.

176. **Traffic.** Traffic impacts caused by the subproject relate primarily to pipeline construction within urban areas, particularly during peak hours. Contractors will be required to mitigate traffic impacts by:

(i) Developing traffic management schemes in conjunction with local traffic authorities and affected community leaders.
(ii) Scheduling materials delivery and other traffic-causing activities outside of peak hours.
(iii) Assigning traffic staff during periods of peak disruption and peak hours.
(iv) Ensuring stockpiles and construction equipment and vehicles least impede traffic flow.
(v) Providing adequate prior information on road and lane closures, and traffic diversions.
(vi) Providing safe access to pedestrians, motorbikes and bicycles.
(vii) Ensuring affected persons are aware of the GRM.
(viii) Ensuring contractors repair damages at their expense.

[78] Air quality, dust and noise mitigation is provided earlier in this section.

177. **Construction workers' health and safety.** Construction workers will be exposed to air emissions, noise, vibration, construction-generated wastes and wastewater, hazardous substances, social conflicts with communities, communicable and transmittable diseases in the community, chance finds of unexploded ordnances, large moving and operating construction vehicles and equipment, and pits and excavations. These impacts will be mitigated through:

(i) Contractor compliance with environmental and occupational health and safety guidelines.
(ii) Contractor's CEMPs will include health and safety plans.
(iii) Provision of personal protective equipment (PPE) for workers.
(iv) Adequate work site lighting, water supply, sanitation facilities and safe access
(v) Establishment of a first-response team comprising of trained staff, equipment, tools, supplies, and an adequate office/clinic. The first response team will be linked to ultimate responders.
(vi) Appointment of an Environmental, Health and Safety Officer.[79]

E. Anticipated Impacts/Issues/Concerns – Operation Phase

178. It is estimated that the largest environmental risks caused by the subprojects occur in the operation phase, and that these primarily relate to the operation of the WWTPs, controlled landfills and the closed dumpsites. This is largely due to the risks of uncontrolled atmospheric, surface and subsurface emissions arising from (i) leachate, landfill gas and odor emissions from the controlled landfills and closed dumpsites, and (ii) untreated/poorly treated effluents and odor from the WWTPs. These and other anticipated impacts are discussed in this section.

179. **Air Quality.** During their operation, both the controlled landfills and the closed dumpsites will generate landfill gas (LFG), which includes the primary greenhouse gases (GHGs) of carbon dioxide, methane and nitrous oxide. These gases are formed through organic decomposition processes within waste masses, with decomposition being accelerated through the saturation of waste due to the ingress of precipitation and surface waters into the waste. The subproject transition from uncontrolled open dumping to controlled landfilling will however reduce the impacts of LFG generation and emission to some extent, due to a reduction of LFG generation within the waste (by reducing surface water inundation due to encapsulation by its surface cover (capping) system), and through the controlled venting of LFG from the facility, which will reduce fire and explosion risks.[80] Similar benefits will accrue at the closed dumpsites, where LFG emissions should also be reduced (due to waste encapsulation) and venting controlled to also reduce fire and explosion risks.

180. The WWTPs, controlled landfills and closed dumpsites will also generate odor, which in each case can be mitigated through design. The WWTPs will be sited in relatively remote locations, away from major receptors, and odor reduction measures such as berms and tree lines can be incorporated into the designs to reduce odor impacts. Following the completion of closure operations, the waste within the closed dumpsites will be completely encapsulated, thereby significantly reducing odor emissions. Likewise, the operations of the controlled dumpsites will include the provision of daily cover, resulting in the complete covering of all waste at the end of

[79] To maintain worker's health records and ensure national labor code compliance regarding the recommended minimum vaccinations and physical examinations for construction workers.

[80] In the future, it may be feasible to install LFG flaring systems at the controlled landfill facilities, however at the present time, such as installation would be difficult due to the challenges in capture such small quantities of generated LFG, and the excessive cost of the system.

each day. Even during hours of operation, the waste tipping areas in the controlled landfills will be minimized as much as possible, to limit odor emissions. Significant air quality and odor issues are not anticipated at other subproject facilities.

181. **Surface Water.** As discussed previously, the WWTPs will be raised to an elevation that is above the conventional flood levels within their respective sites, therefore ensuring separation between effluents within the WWTPs and surrounding surface waters. These facilities will also be designed to meet appropriate regulatory standards for effluent discharge. There are conditions however where combined sewer systems may discharge excess wastewater directly to water bodies. Although these overflows can contain raw sewage, other waste, toxic materials and debris, they are estimated to contain about 95% rainwater[81] and therefore pose less risk when compared with the current situation in the towns, where practically all the town's untreated wastewater is discharged directly to the environment. Mitigation to improve system efficiency and reduce overflow events include:

(i) Specify maintenance procedures in the WWTP operations manual.
(ii) Ensure adequate budget and equipment for routine maintenance activities.
(iii) Remove flow obstructions in the sewer system prior to the onset of the rainy season to maximize the use of the network and the flow to the WWTP.
(iv) Conduct operator training for WWTP operations and maintenance (O&M)
(v) Monitor water quality of the overflow-receiving water bodies following an overflow event.

182. Potential surface water impacts at the controlled landfills (during operations) and closed dumpsites (once closed) include: (i) surface water run-on,[82] (ii) site water runoff, (iii) waste mass inundation, and (iv) leachate emissions. Surface water run-on and runoff will be mitigated through the provision of perimeter drains, and possibly additional collector drains within the site area: these will be a key design feature. As discussed earlier, the potential for waste mass inundation from precipitation will be mitigated through the provision of cover materials over waste mass surfaces, coupled with the drainage of these covered areas through the contouring of surfaces and installation of surface drains to encourage flow. Completed waste mass surfaces can also be vegetated to reduce cover material erosion.

183. There is also a potential for leachate generated within waste masses to migrate through the sidewalls and bases of landfills and dumpsites: this will be mitigated to some extent in the controlled landfills through (i) a reduction in leachate generation, as discussed earlier, (ii) the provision of base liners to capture leachate, and (iii) a rudimentary leachate collection and disposal system that will allow leachate to be collected and stored, for disposal back onto and into the controlled landfill. Although these systems will not be installed in the closed dumpsites, at least the proposed cover systems will reduce the generation of leachate within these facilities, and therefore possibly the escape volume.

184. **Vadose Zone and Groundwater.** There is always a possibility that there could be a failure in the integrity of the sewer pipes within the combined sewer system, or a failure of the lagoons in the WWTPs, that would result in leakage of untreated or partially treated wastewater effluents percolating into and contaminating the underlying vadose zone and groundwater. Similarly, there could be a failure in the integrity of the liner or leachate collection system of the controlled landfill, resulting in similar groundwater contamination. These impacts should be

[81] PPTA engineering team estimate.
[82] Surface water run-on is the movement of surface water onto the site.

mitigated however through both the design of the facilities (that provides for sustainable systems), and through facility O&M procedures, which are supported by training, monitoring and evaluation. As the closed dumpsites will not be lined however, leachate emissions will most likely continue to escape through the bases of the dumpsites, however at least the covers over the waste placed as an integral part of closure activities will reduce the amount of leachate being generated to some extent.

185. **Water logging in WWTP sites.** The sites of the proposed wastewater treatment plant sites in Stung Treng and Kratie are intermittently waterlogged for up to five months per year while the site in Kamping Cham is waterlogged almost continually. These impacts will be addressed during the final design phase through detailed hydrological assessments so that appropriate measures can be designed to counter the effects of flooding on the operation of the wastewater treatment plant. In addition, during the operational phase, an emergency response plan will be designed to ensure that the wastewater treatment plant will not impact on the surrounding areas in case of emergency. Flood risk areas will be identified along with location of designated evacuation sites and routes. Community-based flood warning system, information dissemination campaign of the community evacuation plan, and drills will be identified through consultation with communities.

186. **Disposal of sludge from WWTP.** The wastewater treatment plant will be designed with anaerobic lagoons to treat wastewater delivered from the sewer lines. Based on the conceptual plan of the wastewater treatment plant, sludge will be removed annually or every two years. Sludge from anaerobic treatment is largely inert, can be dried and landfilled or applied to agricultural land. During the first two years of operation of the wastewater treatment plants, sludge that will be collected will be analyzed in terms of bacterial content before these are applied to agricultural land. If the results show consistent absence of bacterial contamination, only then can this be applied to agricultural land, otherwise, sludge will only be dried and landfilled.

187. **Impacts on Access Roads due to Waste Transportation.** During the operational phase of the controlled landfill, the collection and transport of solid wastes will become regular activities that will use existing roads and infrastructure. The lack of proper maintenance of roads being traversed by waste collection vehicles may lead to damage, unnecessary delays in solid waste collection and disposal, and community hazards. In Kampong Cham, NR7 will be utilized to access the landfill through a direct haul route of about 17 – 18 km which is paved with asphalt-concrete. In Kratie and Stung Treng, access to the controlled landfill sites will be through laterite roads which could be easily damaged from regular movement of haulers. On a continuous basis, the DPWT should maintain the access roads to the controlled landfill sites. Typical repairs include cleaning, adding or grading of soil and gravel, filling holes and cleaning of drainage ditches.

188. In addition, without any measure to manage and regulate vehicle movement in and out of the controlled landfill site, lining up of haulers may happen particularly at the entrance gate of the landfill site. Delays in waste unloading procedures may happen which could affect traffic at access roads. An operations system that will include fast weighing, recording and unloading of wastes should be developed to facilitate quick and systematic movement of waste hauling vehicles at the site.

189. **Health and Safety Aspects.** The combined sewer networks will have several open channels, and as a result, there is a possibility that human receptors could come into contact with wastewater. Also, as the channels are open, they attract litter and waste, which often results in

channel blockages and vector breeding. This can be mitigated through community outreach initiatives, such as consultations, meetings and information campaigns.

190. Operations and maintenance (O&M) activities pose risks to the health and safety of workers. These risks will be mitigated through preparation of an operations manual for combined sewers and WWTP, which shall include an occupational health and safety plan (OHSP).[83] A similar operations manual will be prepared for the controlled dumpsites.

F. Cumulative Impacts of the Subproject

191. The changes in population for the GMS4 provinces indicate that population in Stung Treng and Kratie had above average increases in 2011. Kampong Cham's population in 2011 has significantly reduced in relative importance during the period 1998-2013. In general, the level of urbanization is still relatively low for the region but is at an early stage of demographic and economic transformation from an agrarian to a mixed industrial/agricultural economy and society. Each of the towns have treated water supply serving the urban center, a solid waste dumpsite, and some stormwater drainage. There are no trunk sewers and centralized wastewater treatment systems in the subproject towns and wastewater treatment is limited to soakway pits with a small percentage of houses with septic tanks. Drainage has been typically constructed at the same time as new roads and has not been designed in towns as a single, cohesive system, addressing sub-catchments as a whole. In Kampong Cham, the nearest wetland has been infilled for development and drainage is becoming a problem in some parts of the town.

192. Drainage and wastewater disposal is considered a serious problem by 87% of households in the three towns and 33–40% have had their residences affected by flooding in the last five years (Household survey, 2017). Seasonal flooding destroys infrastructure, block road access, affect's women's and men's livelihoods, obstructs children from going to school and causes diseases. Solid waste collection service is inadequate with 54% of households presently served.

193. The GMS CTDP4 will bring about long-term positive benefits of improved stormwater and wastewater management, solid waste management, and enhanced recreational amenities for the subproject towns. The provincial five-year development plans for the three towns will support regional cooperation and resilient provincial and town planning. Collectively the subprojects will significantly improve environmental sanitation, reduce the vulnerability to environmental risks and flooding. The cumulative impacts during operation will be more positive than adverse. The cumulative impacts of the proposed subprojects and development plans on the sensitive river habitats associated with the Mekong and Sekong River will be evaluated further during detailed design and during plan development. At this stage, initial estimates show that the controlled landfills in the three subproject towns are expected to reduce disposal into open fields and waterways by as much as 1,624,500 cubic meters. The wastewater treatment plants are expected to reduce the organic load into waterways which eventually lead to Mekong River by about 4,928 kg BOD per day[84].

[83] Based on the Environmental, Health and Safety Guidelines for Water and Sanitation of the International Finance Corporation, dated 10 December 2007.

[84] The computed BOD load reduction was based on the preliminary engineering design of the waste stabilization ponds, average flows, per capita BOD load, and the expected effluent BOD load. Design criteria has an Influent BOD load for Kampong Cham, 2302 kg/day; for Kratie, 2302 kg/day, and Stung Treng, 1619 kg/day. Effluent BOD in each town varies according size of lagoons.

VI. ANALYSIS OF ALTERNATIVES

A. Kampong Cham

1. Combined Sewer

187. **Without project.** Drains in Kampong Cham have been laid over a period spanning 50 years or more. In common with all urban drainage in Cambodian provincial towns, the drains have often been laid without considering the connectivity with the rest of the drainage assets, and are often laid without a consistent, calculated grade. As previously discussed, the drains serving Kampong Cham were installed during three main periods: (i) the older colonial era drains around the market area in the 1930s, (ii) open canals laid through a program led by the provincial governor in 1997, and (iii) most significantly, a program funded by the government's 'Social Fund' in 1990. All the canals constructed in 1997 were reported to have been infilled for development, with no alternative provision for drainage provided. The condition of most (particularly colonial era) existing drains is unknown.

188. There used to be two natural ponds (wetlands) to the immediate west of the town, Boeng Snay and Boeng Bassac. The former, of area 88-ha, which was until recently the main receiving area for stormwater and wastewater, has been filled in for development without any alternative provision for drainage or wastewater retention. This has caused stormwater to flow and be stored around the edges, particularly the northern edge. There are three main low points in the town, all of which suffer from flooding, reportedly up to 800 mm deep for up to 4 hours following heavy rainfall events.

189. In general, the town drainage system has been constructed with road construction at various stages over the previous few decades. It has not been designed as a single, coherent system based on sub-catchments and rainfall data. The old systems are deemed to no longer be adequate for the increasing runoff and pressures of climate change. Without the project, Kampong Cham flooding will worsen.

190. **With project.** Three main technical solutions for drainage have been considered.

191. Option 1 involves addressing locally known drainage and flooding problem areas as initially identified by the Municipality and DPWT. This would consist of:

- A drain and outfall to the Mekong for the market area.
- Two main drains around the south and north of what was Boeng Snay, to the location of an existing pump station at the western end of Boeng Snay, immediately adjacent to the elevated road that divides the two wetlands.

192. Option 2 would better address drainage for the entire town now and into the future. It includes the collection of wastewater through domestic connections, and more closely aligns with the objectives of MPWT for addressing drainage in provincial towns. It includes:

- A completely new combined drainage system for the town.
- A new lagoon-based WWTP on the 10-ha site identified.
- Household and commercial connections for wastewater.
- Combined sewer overflows for wet season flows.
- Septage to be co-treated in the WWTP.

193. Option 3 consists of separate systems for the entire urban area, comprising (i) large and small diameter reinforced concrete pipe and channels where appropriate for stormwater, and (ii) a network of smaller diameter high density polyethylene (HDPE) pipe and domestic connections for wastewater. Pumps may be required to attain self-cleaning velocities for the separated wastewater pipe network.

194. A multi-criteria assessment of the drainage/combined sewer options has been performed for the IEE. The results show that Option 2 ranks more favorably than the other two options. (Table 6.1).

195. In terms of pipe size for the subproject towns, there were three alternatives:

- Option 1 is the current way of providing drainage, one that is not calculated and not part of a larger and studied system. This option faces risk of not being able to cope with the pressures of climate change.
- Option 2, uses a rain event that comes once every two years to calculate the pipe sizes. This is the option adopted by the PPTA Team, which led them to know that the largest pipe size available in the local market is still large enough to handle the extreme rain event that would come every two years.
- Option 3 uses a higher return period, say 5-10 years, which will result in much bigger pipes. In most cases, pipes that are much bigger than needed will have lower flow velocities. This will allow sediment to remain in the pipes and in effect, will not work well. Moreover, this option will be more expensive. Larger sized pipes need to be imported and transport by land.

Table 6.1: Multi-Criteria Analysis of Drainage/Combined Sewer Options

Criteria	Option 1 Addressing immediate drainage and flooding only	Option 2 Combined sewer	Option 3 Separate stormwater and sewer
Technical			
Service coverage	A minimal option, only solves localized drainage problems.	Aims to resolve drainage concerns of main urban area and residential areas of significance in the periphery.	Aims to resolve drainage concerns of main urban area and residential areas of significance in the periphery.
Managed waters	Stormwater only	Stormwater and wastewater	Stormwater and wastewater
Pumping requirements	Requires upgrade of existing pump		Requires separate pumping for wastewater. Existing may be upgraded for more effective stormwater management
Economic			
Construction cost	Least construction cost.	Lower construction cost	Higher construction cost.
Pumping cost	Least pumping cost.	Lower pumping costs	Higher pumping costs
O&M costs	Least O&M costs	Low O&M costs	High O&M costs
Environmental and social			
Will reduce vulnerability of town to climate change	No replacement of existing systems. Lesser new pipes will be installed. If to interface new with old pipes, stormwater management in covered areas may not be effective.	Install new, upgrade or replace existing systems, considering the effects of climate change.	Install new, upgrade or replace existing systems, taking into account the effects of climate change.

Criteria	Option 1 Addressing immediate drainage and flooding only	Option 2 Combined sewer	Option 3 Separate stormwater and sewer
	Old system deemed no longer adequate to cope with increasing runoffs.		
Land (surface area) disturbed or converted	Least new land disturbed and least surface area required	Higher new land disturbed and higher surface area required.	Less land disturbed, less surface area required than that with Option 2.
Pollution to environment	Lower pollutant load (from relatively little polluted surface runoff). Surface runoffs over un-serviced larger part of town and wastewater of town, not managed.	Higher pollutant loads due to mixed stormwater and wastewater. CSOs during heavy rains are untreated wastewater.	No mixing of storm- and wastewater. Lower pollutant load, only from surface runoff, discharged without treatment.
GHG emissions	None (if using all underground pipes, since wastewater in underground pipes is not believed to be a significant source of CH_4).	With few open channels in areas needing pipes >1500mm. Mixed stormwater and wastewater in open channels will be subject to heating from the sun and may be stagnant, allowing anaerobic conditions, emitting CH_4.	Wastewater in closed underground sewers is not believed to be a significant source of CH_4.
Access by households to wastewater collection	None.	Includes individual household connections.	Domestic connections for wastewater.
Impacts on health and safety	Risk of contact with contaminated stormwater during flooding.	The few open channels pose risk of human contact with raw sewage; open to pest/mosquito breeding; and risk of people falling into them.	Risk of contact with contaminated stormwater during flooding.

Most favorable, 1
2
3
4
Least favorable, 5

2. Wastewater Treatment

196. **Without project.** There is no reticulated wastewater collection and treatment in Kampong Cham. There are no records kept of numbers, volumes or condition of septic tanks in the town. Private septage trucks and septage disposal are unregulated. There is no building code, stipulating requirements for urban on-site sanitation. Wastewater treatment is limited to septic tanks in the more modern houses, hotels and restaurants. The majority of households use an unsealed soakway pit formed with locally available concrete ring sections. These do not allow for any significant treatment. Liquid waste soaks into the ground if the water table is low enough (which varies with season and proximity to the river). Solids remain in the pit.

197. There are currently three private and no government septage trucks operating in Kampong Cham, with septage typically being sold as fertilizer and discharged directly to agricultural land without treatment. There is presently no septage treatment facility for Kampong Cham. Inadequate management of sewage/wastewater discharge can cause significant surface water and groundwater pollution, resulting in the spread of disease and destruction of aquatic life, among other impacts. During flooding, there is a risk of human contact with raw sewage. Health

problems and diseases have often been caused by the discharge of untreated, or inadequately treated wastewater. Public health and environmental sanitation are key drivers of livability. The 'without-wastewater-management-and-treatment' scenario would therefore seriously undermine the livability and competitiveness of the town.

198. **With project.** Three wastewater treatment improvement options have been evaluated, (i) a standard lagoon system, (ii) an aerated lagoon system, and (iii) trickling filter preceded by settlement.

199. Option 1, the standard lagoon system, comprises of lagoons, or shallow constructed basins into which wastewater flows and from which, after a retention time of several days (rather than several hours in conventional treatment process), a treated effluent is discharged. It comprises a series of ponds for three key processes: anaerobic, facultative and maturation.

200. Option 2 is the aerated lagoon system. With the ambient temperatures experienced in Cambodia, aeration by mixing the upper layers of the lagoons has the potential to increase the capacity of the WWTP by between two and two and a half times. If insufficient land is available for an unaerated lagoon system, this represents the most technically simple option for ease of operation and maintenance (O&M) from a staff base of limited capacity and experience.

201. Appropriate mixers would be of a 'floating surface' design, as opposed to submersible, so that the depth of mixing can be better controlled in the lagoons. In the facultative lagoons the objective would only to be to aerate the upper layers, while leaving the deeper anaerobic layers undisturbed.

202. Solar-powered mixers have the obvious advantage of reducing power costs, taking advantage of the long hours of sunlight in Cambodia. Mixers are available for specific lagoon types, including a very shallow surface water mixer designed for odor reduction in the anaerobic lagoons, which provides the added advantage of removing surface scum and aiding methane release, and improving the digestion of wastewater. These mixers are specifically designed to stop the escape of aerosols. Another mixer type designed for the facultative and maturation lagoons mixes water to a deeper level and this depth can be controlled.

203. Option 3 is a trickling filter. This option, preceded by a settling pond to avoid the filter becoming easily blocked, has recently been considered for Battambang City, where there is insufficient land for a lagoon system. Trickling filters are designed primarily for biological oxygen demand (BOD) removal. They are basically a form of biological filter as opposed to a physical filter in that solids are not removed. An underdrain system collects treated wastewater, which then usually requires further treatment and settlement in an oxidation pond prior to release into receiving waters. The filter is usually above ground, and is usually a cylinder 1-3m deep, filled with large surface area media, to which micro-organisms attach. Sloughing of the micro-organisms from the media into the effluent can occur which requires further settlement downstream of the filter. Pumps are required to feed the wastewater to the top of the filter unit, so a constant power supply is required. A standard low-rate trickling filter can remove 80-85% of BOD when operated correctly.

204. A multi-criteria assessment of the wastewater treatment options was performed for the IEE. The results, shown on Table 6.2, indicate that Option 1 ranked more favorably than the other two options.

Table 6.2: Multi-Criteria Analysis of Wastewater Treatment Options

Criteria	Option 1 Standard lagoon	Option 2 Aerated lagoon	Option 3 Trickling filter
Technical	.		
Efficiency in wet season treatment	Less effective wet season treatment.	Less effective wet season treatment.	Better wet season treatment
Availability of important parts	Low requirement	Replacement parts are available to prevent extended downtimes.	Not all parts and materials are available locally
Suitability to developing countries	Most appropriate technology for countries with limited financial or trained operational staff resource.	Most technically simple O&M. Can be handled by staff with limited capacity and experience.	More suited to fully developed countries. Requires skilled staff for construction and operation.
Economical			
Capital cost	Low capital cost where land prices are low.	Moderate to high	High capital cost.
Operation and maintenance costs	Least operation cost	low operation costs	High operation cost
Environmental and social			
Land disturbed or converted	Higher new land disturbed and higher surface area requirement	Less land requirement than the standard lagoon system.	Requires far less land than standard lagoon system.
Energy consumption	Low	High.	High.
Pollution to environment	Not for direct recharge in surface waters. Discharge only after passing through chlorine contact basin.	Effluents of completely mixed ponds require a post-treatment in a sedimentation pond.	Additional treatment may be needed to meet more stringent discharge standards
Waste to manage (sludge, etc.)	Sludge requires proper removal and treatment. Anaerobic ponds need to be desludged once every 2-5 years,	Settled sludge needs to be dug out regularly and requires a further treatment or correct disposal.	The sludge that accumulates on the filter must be periodically washed away once in five to seven years or more.
Flies/mosquitoes and odors	No real problems with flies or odors if designed and maintained correctly. Mosquito control required.	No real problems with insects or odors if designed and maintained correctly.	Odor and fly problems require that trickling filter be built away from homes
Reuse of effluent	Effluent contains nutrients (e.g. N and P) and is therefore appropriate for reuse in agriculture. But not for direct recharge in surface waters.	The effluent of aerated ponds may be reused or used for recharge, The treated water can be reused or discharged if a secondary maturation/settling pond follows the aerated lagoon/completely mixed aerated pond	Should be clarified prior to discharge

Most favorable, 1
2
3
4
Least favorable, 5

3. Solid Waste Disposal

205. **Without Project.** Currently, the method of final disposal of solid waste in Kampong Cham is open dumping. The existing solid waste dump site is on approximately 10-ha of land and is 18 km from town center on NR7 towards Phnom Penh. The site is located 3.5 km along an access

road from NR7. The site is owned and operated by a private company. CINTRI.[85] The municipality wants to terminate the contract with CINTRI and manage solid waste collection and disposal themselves and has identified the site for the development of a managed landfill. Only 57.3% of the total households in 2017 were served by SWM services. Environmental sanitation is a key driver of livability. Hence, inadequate solid waste management would undermine the competitiveness of Kampong Cham.

206. **With Project.** The options for basic solid waste management disposal improvements relate primarily to how advanced the proposed disposal facility will be, ranging from basic improvements to the existing open dumping practices (current situation across Cambodia) at one end of the scale, to a controlled landfill that includes certain basic engineered systems, through to full sanitary landfill development. A multi-criteria assessment of these three waste disposal options was completed for the IEE, as shown on Table 6.3. The results indicate that Option 2 (controlled landfill) ranked more favorably than the other two options, given the relative development level of the town, funding level, and overall planning and implementation capacity of involved institutions.

Table 6.3: Multi-Criteria Analysis of Solid Waste Disposal Options

Criteria	Option 1 Open dump	Option 2 Controlled landfill	Option 3 Sanitary landfill
Technical	.		
Management of waste at the site	Waste dumped as collected	Waste dumped into lined cells	Waste dumped into lined cells
Materials recovery	Some sorting and recycling by informal pickers at dumpsite, often operating in dangerous conditions	Organized sorting and recycling at landfill	Sorting and recycling prior to collection and potentially also at landfill
Final disposal method	Limited compaction, no cover	Compaction and soil cover in layers (daily or periodic)	Compaction and soil cover daily
Hazardous waste management	No separate hazardous waste treatment	Incinerator or separate cell for hazardous waste	Incinerator or separate cell for hazardous waste
Onsite energy generation	None	None	Possible landfill gas recovery
Appropriateness for improving solid waste disposal in developing countries	Will not improve solid waste disposal.	Staged improvement and often more appropriate for operational capacity limitations	Improvements meet international standards, and require a high level of operational capacity
Economic			
Capital cost	Least	Moderate	High
Operation and maintenance costs	Least	Moderate	High
Environmental and social			
Risks to biodiversity	High	Low	Least
Waste burning	High	None	None
GHG emissions	Uncontrolled	Controlled, and possibly collected and flared	Controlled, collected and flared or converted to energy
Odor	High	Low	Least
Leachate	High, as exposed to rainfall	Lower, collected and reduced risk	Low, collected and least risk

[85] Recognized by Prakas No 634 of the Krong Kampong Cham Authority dated 24 June 2014.

Criteria	Option 1 Open dump	Option 2 Controlled landfill	Option 3 Sanitary landfill
Groundwater and soil pollution risks	High risk	Lower risk	Lowest risk
Risk of surface water pollution	High risk	Reduced risk	Least risk
Flies, mosquitoes, other disease vectors	High	Low	Low
Vulnerability to climate change effects	High	Low	Least
Health and safety hazards	High	Low	Low
Reuse of landfill gas	None	Potential flaring	Flaring or energy recovery

Most favorable, 1
2
3
4
Least favorable, 5

B. Kratie

1. Drainage/Combined Sewer

207. **Without project.** All the main town center area has some form of drainage dating from the colonial era onwards, although few records of size or condition have been kept. In general, town center surface water drains away from the Mekong river to the east through three outlets where, until recently, it entered a channel that conveyed it to a wetland to the south. This channel has now been infilled for development, and no alternate drainage arrangements made.

208. There is a large movement of flood water during the wet season that runs behind the main town, north to south. Floodwaters pass under the bridge on Rd 377 and pass into an 80-m wide constructed channel which has been partly defined with embankments, also running in a north-south alignment. All areas not currently built up in the area east of the main center and south of Rd 377 are flooded in the wet season and are up to 7 m below the average road level in the urban center. All drainage ultimately enters the wetland to the south and not the Mekong, as the river banks are higher than the interior wetland.

209. This old system is deemed to no longer be adequate for the increasing runoff and pressures of climate change. Without the project, Kratie will continue to suffer from flooding, or from worsened flooding during extreme wet weather.

210. **With project.** Three main technical solutions for drainage have been considered.

211. Option 1 is a basic proposal, which aims to address immediate drainage and flooding problems. The proposal was originally put forward by DPWT under a previous 2013 ADB project. The proposal is threefold:

- To redirect floodwaters from the town center that once drained to the canal to the east of the Mekong river (now filled) into a piped drain, which feeds to the pond south of the town.
- Serving the north and south of the town center area with a new drain running north-south. The area north of the town center will drain through this canal to the southern pond, and the area south of the town center will drain to a creek further south of the pond.

- Additionally, a large 80 m wide bunded channel is proposed to the east of the main town center, to drain the whole area behind the town to the southern wetland. Currently, this area is largely undeveloped, but the town plan has identified this area for future development.

212. Option 2 better addresses drainage for the entire town now and into the future. It includes the collection of wastewater through domestic connections, and more closely aligns with the objectives of MPWT for addressing drainage in provincial towns. It includes

- A completely new combined drainage system for the town.
- A new lagoon-based WWTP on a 10-ha site identified.
- Household and commercial connections for wastewater.
- Combined sewer overflows for wet season flows.
- Septage to be co-treated in the WWTP.

213. This option would address drainage for the town as a whole in an integrated and cohesive way and would take advantage of the available public land at the northern end of the wetland, securing it for the future for wastewater treatment. This approach of designing an integrated combined system for the whole urban area follows the approach taken by MPWT in recent years, as included in their "Sector Analysis, Development Roadmap and 20-year Investment Roadmap for Urban Sanitation".[86]

214. Option 3 consists of a separate sewer system for the entire urban area, utilizing (i) large and small diameter reinforced concrete pipe and channels where appropriate for stormwater, and (ii) a network of smaller diameter HDPE pipe and domestic connections for wastewater. Pumps may be required to attain self-cleaning velocities for the separated wastewater pipe network.

215. A multi-criteria assessment of the drainage/combined sewer options was attempted for the IEE. The results showed that Option 2 ranked more favorably than the other two options. (Table 6.4).

Table 6.4: Multi-Criteria Analysis of Drainage/Combined Sewer Options

Criteria	Option 1 Addressing immediate drainage and flooding only	Option 2 Combined sewer	Option 3 Separated sewer
Technical			
Service coverage	A minimal option. May solve localized drainage problems.	Aims to resolve drainage concerns of main urban area and residential areas of significance in the periphery.	Aims to resolve drainage concerns of main urban area and residential areas of significance in the periphery.
Managed waters	Stormwater only.	Stormwater and wastewater.	Stormwater and wastewater.
Pumping requirement	Requires upgrade of existing pump		Requires separate pumping for wastewater. Existing may be upgraded for more effective stormwater management.

[86] TA8556-REG: Pre-feasibility studies and preliminary engineering – Provincial Water & Sanitation Sector Project.

Criteria	Option 1 Addressing immediate drainage and flooding only	Option 2 Combined sewer	Option 3 Separated sewer
Economic			
Construction cost	Least construction cost.	Lower construction cost	Higher construction cost.
Pumping cost	Least pumping cost.	Lower pumping costs	Higher pumping costs
O&M costs	Least O&M costs	Low O&M costs	High O&M costs
Environmental and Social			
Will reduce vulnerability of town to climate change	No replacement of existing systems. Lesser new pipes will be installed. If to interface new with old pipes, stormwater management in covered areas may not be effective. Old system deemed no longer adequate to cope with increasing runoffs.	Install new, upgrade or replace existing systems, taking into account the effects of climate change.	Install new, upgrade or replace existing systems, taking into account the effects of climate change.
Land (surface area) disturbed or converted	Least new land disturbed and least surface area required.	Higher new land disturbed and higher surface area required.	Less land disturbed, less surface area required than that with Option 2.
Pollution to environment	Lower pollutant load (from relatively little polluted surface runoff). Surface runoffs over un-serviced larger part of town and wastewater of town, not managed.	Higher pollutant loads due to mixed storm- and wastewater. CSOs during heavy rains are untreated wastewater.	No mixing of stormwater and wastewater. Lower pollutant load, only from surface runoff, discharged without treatment.
GHG emissions	None (if using all underground pipes, since wastewater in underground pipes is not believed to be a significant source of CH^4).	With few open channels in areas needing pipes >1500mm. Mixed stormwater and wastewater in open channels will be subject to heating from the sun and may be stagnant, allowing anaerobic conditions, emitting CH^4.	Wastewater in closed underground sewers is not believed to be a significant source of CH^4.
Access by households to wastewater collection	None.	Includes individual household connections.	Domestic connections for wastewater.
Impacts on health and safety	Risk of contact with contaminated stormwater during flooding.	The few open channels pose risk of human contact with raw sewage; open to pest/mosquito breeding; and risk of people falling into them.	Risk of contact with contaminated stormwater during flooding.

Most favorable, 1
2
3
4
Least favorable, 5

2. Wastewater Treatment

216. There is no reticulated wastewater collection and treatment in Kratie. There are no records kept of numbers, volumes or condition of septic tanks in the town. Private septage trucks and septage disposal are unregulated. There is no building code, stipulating requirements for urban on-site sanitation. Wastewater treatment is limited to septic tanks in the more modern houses,

hotels and restaurants. The majority of households use an unsealed soakway pit formed with locally available concrete ring sections. These do not allow for any significant treatment. Liquid waste soaks into the ground if the water table is low enough. Solids remain in the pit. There are currently three private and no government septage trucks operating in Kratie with septage typically being sold as fertilizer and discharged directly to agricultural land without treatment. There is presently no septage treatment facility for Kratie.

217. Inadequate management of sewage/wastewater discharge can cause surface water and groundwater pollution, resulting in the spread of disease and destruction of aquatic life, among others. During flooding, there is a risk of human contact with raw sewage. Health problems and diseases have often been caused by discharging untreated, inadequately treated wastewater. Public health and environmental sanitation are key drivers of livability. Hence, a scenario without wastewater management would undermine the livability and competitiveness of Kratie.

218. **With project.** Similar to Kampong Cham, three wastewater treatment options have been evaluated, (i) standard lagoon system, (ii) aerated lagoon system, and (iii) a trickling filter preceded by settlement. A technical explanation of these options is provided in the Analysis of Alternatives for Kampong Cham. Also, a multi-criteria assessment of these wastewater treatment options has been completed for the IEE, the results of which are summarized on Table 6.5. The results indicate that Option 1 ranked more favorably than the other two options.

Table 6.5: Multi-Criteria Analysis of Wastewater Treatment Options

Criteria	Option 1 Standard lagoon	Option 2 Aerated lagoon	Option 3 Trickling filter
Technical	.		
Efficiency in wet season treatment	Less effective wet season treatment.	Less effective wet season treatment.	Better wet season treatment
Availability of important parts	Low requirement	Replacement parts are available to prevent extended downtimes.	Not all parts and materials are available locally
Suitability to developing countries	Most appropriate technology for countries with limited financial or trained operational staff resource.	Most technically simple O&M. Can be handled by staff with limited capacity and experience.	More suited to fully developed countries. Requires skilled staff for construction and operation.
Economical			
Capital cost	Low capital cost where land prices are low.	Moderate to high	High capital cost.
Operation and maintenance costs	Least operation cost	low operation costs	High operation cost
Environmental and social			
Land disturbed or converted	Higher new land disturbed and higher surface area requirement	Less land requirement than the standard lagoon system.	Requires far less land than standard lagoon system.
Energy consumption	Low	High.	High.
Pollution to environment	Not for direct recharge in surface waters. Discharge only after passing through chlorine contact basin.	Effluents of completely mixed ponds require a post-treatment in a sedimentation pond.	Additional treatment may be needed to meet more stringent discharge standards
Waste to manage (sludge, etc.)	Sludge requires proper removal and treatment. Anaerobic ponds need to be desludged once every 2-5 years,	Settled sludge needs to be dug out regularly and requires a further treatment or correct disposal.	The sludge that accumulates on the filter must be periodically washed away once in five to seven years or more.

Criteria	Option 1 Standard lagoon	Option 2 Aerated lagoon	Option 3 Trickling filter
Flies/mosquitoes and odors	No real problems with flies or odors if designed and maintained correctly. Mosquito control required.	No real problems with insects or odors if designed and maintained correctly.	Odor and fly problems require that trickling filter be built away from home
Reuse of effluent	Effluent contains nutrients (e.g. N and P) and is therefore appropriate for reuse in agriculture. But not for direct recharge in surface waters.	The effluent of aerated ponds may be reused or used for recharge, The treated water can be reused or discharged if a secondary maturation/settling pond follows the aerated lagoon/completely mixed aerated pond	Should be clarified prior to discharge

Most favorable, 1
2
3
4
Least favorable, 5

3. Solid Waste Disposal

219. **Without Project.** The method of final disposal of solid waste in Kratie is open dumping. The existing solid waste dump site is located on a 10.5-ha public land parcel, some 17 km to the east from the town center. The site is along NR7 and has a 1.75 km unpaved access road. Close to the site's eastern boundary is a stream that flows southward to a lagoon. There are no residents along the stream and around the lagoon. Only 50% of the total households in 2017 were served by SWM services.

220. **With Project.** Similar to the appropriate options for the other two towns, basic solid waste management disposal improvements relate primarily to how advanced the proposed disposal facility will be, ranging from basic improvements to the existing open dumping practices (current situation across Cambodia) at one end of the scale, to a controlled landfill that includes certain basic engineered systems, through to full sanitary landfill development. A multi-criteria assessment of these three waste disposal options was completed for the IEE, as shown on Table 6.6. The results indicate that Option 2 (controlled landfill) ranked more favorably than the other two options, given the relative development level of the town, funding level, and overall planning and implementation capacity of involved institutions.

Table 6.6: Multi-Criteria Analysis of Solid Waste Disposal Options

Criteria	Option 1 Open dump	Option 2 Controlled landfill	Option 3 Sanitary landfill
Technical	.		
Management of waste at the site	Waste dumped as collected	Waste dumped into lined cells	Waste dumped into lined cells
Materials recovery	Some sorting and recycling by informal pickers at dumpsite, often operating in dangerous conditions	Organized sorting and recycling at landfill	Sorting and recycling prior to collection and potentially also at landfill
Final disposal method	Limited compaction, no cover	Compaction and soil cover in layers (daily or periodic)	Compaction and soil cover daily
Hazardous waste management	No separate hazardous waste treatment	Incinerator or separate cell for hazardous waste	Incinerator or separate cell for hazardous waste

Criteria	Option 1 Open dump	Option 2 Controlled landfill	Option 3 Sanitary landfill
Onsite energy generation	None	None	Possible landfill gas recovery
Appropriateness for improving solid waste disposal in developing countries	Will not improve solid waste disposal.	Staged improvement and often more appropriate for operational capacity limitations	Improvements meet international standards, and require a high level of operational capacity
Economic			
Capital cost	Least	Moderate	High
Operation and maintenance costs	Least	Moderate	High
Environmental and social			
Risks to biodiversity	High	Low	Least
Waste burning	High	None	None
GHG emissions	Uncontrolled	Controlled, and possibly collected and flared	Controlled, collected and flared or converted to energy
Odor	High	Low	Least
Leachate	High, as exposed to rainfall	Lower, collected and reduced risk	Low, collected and least risk
Groundwater and soil pollution risks	High risk	Lower risk	Lowest risk
Risk of surface water pollution	High risk	Reduced risk	Least risk
Flies, mosquitoes, other disease vectors	High	Low	Low
Vulnerability to climate change effects	High	Low	Least
Health and safety hazards	High	Low	Low
Reuse of landfill gas	None	Potential flaring	Flaring or energy recovery

Most favorable, 1
2
3
4
Least favorable, 5

C. Stung Treng

1. Combined Sewer

221. **Without project.** The topography of the town is flat along the riverfront, and is divided into 5 sub-catchments by 4 natural creeks that run through the town, approximately perpendicular to and into the Sekong and Mekong rivers. The three largest creeks have flood control gates installed which are closed in the wet season to prevent river water from flowing up the creeks into the town. Currently, these gates are manually operated with a gear mechanism and key, which is reportedly problematic for DPWT. The remaining creek, which flows into Mekong River, does not have a floodgate.

222. Periodic flooding in Stung Treng is caused by overland flow from the south of the town running towards the rivers. The flow cannot enter the rivers when the outfall gates are closed during high water levels in the Sekong River. The creeks then back up and flood surrounding areas.

223. Stung Treng town is partly served with drainage. The most significant drainage works in recent times was a JICA funded project in 2006 that installed 1,900 m of RC pipe drains of 600

mm diameter from the market area to a pond to the west. A 2009 ADB PPTA, the Mekong Water Supply and Sanitation Project, produced a series of drawings showing existing drainage at that time based on a physical survey but no physical works followed. Drainage works to relieve ponding in one area were completed in December 2017 but have not been tested with a wet season as yet. The old drainage systems are deemed to no longer be adequate for the increasing runoff and pressures of climate change. Without the project, Stung Treng will continue to suffer from flooding, or from worsened flooding during extreme wet weather.

224. **With project.** Three main technical solutions for drainage have been considered.

225. Option 1 is a basic proposal from DPWT, which aims to address immediate drainage and flooding problems only. The option 1 proposal is twofold:

- Provide new drains along the riverbank road and Roads #12 and #14, which both run parallel to and behind the riverbank. These three new main drains will flow into the four existing creeks that discharge to the Sekong and Mekong rivers.
- Provide a gate for the fourth creek, and for all four, provide automation for opening and closing the gates, and a pump station at each for wet season discharge to the river when the gates are closed.
- Option 1 does not consider wastewater collection or treatment.

226. An alternative Option 2 proposal, which better addresses drainage for the entire town now and into the future, includes the collection of wastewater through domestic connections, and more closely aligns with the objectives of MPWT for addressing drainage in provincial towns. It includes;

- A completely new combined drainage system for the town.
- A new lagoon-based WWTP.
- Household and commercial connections for wastewater.
- Combined sewer overflows for wet season flows.
- Septage to be co-treated in the WWTP.
- Provision of a fourth flood gate.
- Provision of automation and pump stations for each of the four flood gates.

227. Option 3 consists of a separate sewer system for the entire urban area utilizing (i) large and small diameter reinforced concrete pipe and channels where appropriate for stormwater, and (ii) a network of smaller diameter HDPE pipe and domestic connections for wastewater. Pumps may be required to attain self-cleaning velocities for the separated wastewater pipe network.

228. A multi-criteria assessment of the drainage/combined sewer options was completed for the IEE. The results showed Option 2 to rank more favorably than the other two options. (Table 6.7)

Table 6.7: Multi-Criteria Analysis of Drainage/Combined Sewer Options

Criteria	Option 1 Addressing immediate drainage and flooding only	Option 2 Combined sewer	Option 3 Separated sewer
Technical			
Service coverage	A minimal option. May solve localized drainage problems.	Aims to resolve drainage concerns of main urban area and residential areas of significance in the periphery.	Aims to resolve drainage concerns of main urban area and residential areas of significance in the periphery.
Managed waters	Stormwater only.	Storm- and wastewater.	Storm- and wastewater.
Pumping requirement	Requires upgrade of existing pump		Requires separate pumping for wastewater. Existing may be upgraded for more effective stormwater management.
Economic			
Construction cost	Least construction cost.	Lower construction cost	Higher construction cost.
Pumping cost	Least pumping cost.	Lower pumping costs	Higher pumping costs
O&M costs	Least O&M costs	Low O&M costs	High O&M costs
Environmental and social			
Will reduce vulnerability of town to climate change	No replacement of existing systems. Lesser new pipes will be installed. If to interface new with old pipes, stormwater management in covered areas may not be effective. Old system deemed no longer adequate to cope with increasing runoffs.	Install new, upgrade or replace existing systems, taking into account the effects of climate change.	Install new, upgrade or replace existing systems, taking into account the effects of climate change.
Land (surface area) disturbed or converted	Least new land disturbed and least surface area required.	Higher new land disturbed and higher surface area required.	Less land disturbed, less surface area required than that with Option 2.
Pollution to environment	Lower pollutant load (from relatively little polluted surface runoff). Without treatment involved. Surface runoffs over un-serviced larger part of town and wastewater of town, not managed.	Higher pollutant loads due to mixed storm- and wastewater. CSOs during heavy rains are untreated wastewater.	No mixing of storm- and wastewater. Lower pollutant load, only from surface runoff, discharged without treatment.
GHG emissions	None (if using all underground pipes, since wastewater in underground pipes is not believed to be a significant source of CH4).	With few open channels in areas needing pipes >1500mm. Mixed storm- & wastewater in open channels will be subject to heating from the sun & may be stagnant, allowing anaerobic conditions, emitting CH4.	Wastewater in closed underground sewers is not believed to be a significant source of CH4.
Access by households to wastewater collection	None.	Includes individual household connections.	Domestic connections for wastewater.
Impacts on health and safety	Risk of contact with contaminated stormwater during flooding.	The few open channels pose risk of human contact with raw sewage; open to pest/mosquito breeding; and risk of people falling into them.	Risk of contact with contaminated stormwater during flooding.

Criteria	Option 1 Addressing immediate drainage and flooding only	Option 2 Combined sewer	Option 3 Separated sewer

Most favorable, 1
2
3
4
Least favorable, 5

2. Wastewater Treatment

229. **Without project.** As with the other two towns of the Project, there is no reticulated wastewater collection and treatment system in Stung Treng. There are no records kept of numbers, volumes or condition of septic tanks in the town, and private septage collection and disposal operations are unregulated. There is no building code, stipulating requirements for urban on-site sanitation. Wastewater treatment is limited to septic tanks in the more modern houses, hotels and restaurants. The majority of households use an unsealed soakway pit formed with locally available concrete ring sections. These do not allow for any significant treatment. Liquid waste soaks into the ground if the water table is low enough. Solids remain in the pit.

230. There are currently two private and no government septage trucks operating in Stung Treng, with septage typically being sold as fertilizer and discharged directly to agricultural land without treatment. Currently, there is no septage treatment facility for the town. Inadequate management of sewage/wastewater discharge can cause surface water and groundwater pollution, resulting in the spread of disease and destruction of aquatic life, among others. During flooding, there is a risk of human contact with raw sewage. Health problems and diseases have often been caused by discharging untreated, inadequately treated wastewater. Public health and environmental sanitation are key drivers of livability. Hence, a scenario without wastewater management and treatment would undermine the competitiveness and livability of the town.

231. **With project.** Similar to Kampong Cham, three wastewater treatment options have been evaluated, (i) standard lagoon system, (ii) aerated lagoon system, and (iii) a trickling filter preceded by settlement. A technical explanation of these options is provided in the Analysis of Alternatives for Kampong Cham. Also, a multi-criteria assessment of these wastewater treatment options has been completed for the IEE, the results of which are summarized on Table 6.8. The results indicate that Option 1 ranked more favorably than the other two options.

Table 6.8: Multi-Criteria Analysis of Wastewater Treatment Options

Criteria	Option 1 Standard lagoon	Option 2 Aerated lagoon	Option 3 Trickling filter
Technical	.		
Efficiency in wet season treatment	Less effective wet season treatment.	Less effective wet season treatment.	Better wet season treatment
Availability of important parts	Low requirement	Replacement parts are available to prevent extended downtimes.	Not all parts and materials are available locally
Suitability to developing countries	Most appropriate technology for countries with limited financial or trained operational staff resource.	Most technically simple O&M. Can be handled by staff with limited capacity and experience.	More suited to fully developed countries. Requires skilled staff for construction and operation.

Criteria	Option 1 Standard lagoon	Option 2 Aerated lagoon	Option 3 Trickling filter
Economical			
Capital cost	Low capital cost where land prices are low.	Moderate to high	High capital cost.
Operation and maintenance costs	Least operation cost	low operation costs	High operation cost
Environmental and social			
Land disturbed or converted	Higher new land disturbed and higher surface area requirement	Less land requirement than the standard lagoon system.	Requires far less land than standard lagoon system.
Energy consumption	Low	High.	High.
Pollution to environment	Not for direct recharge in surface waters. Discharge only after passing through chlorine contact basin.	Effluents of completely mixed ponds require a post-treatment in a sedimentation pond.	Additional treatment may be needed to meet more stringent discharge standards
Waste to manage (sludge, etc.)	Sludge requires proper removal and treatment. Anaerobic ponds need to be desludged once every 2-5 years,	Settled sludge needs to be dug out regularly and requires a further treatment or correct disposal.	The sludge that accumulates on the filter must be periodically washed away once in five to seven years or more.
Flies/mosquitoes and odors	No real problems with flies or odors if designed and maintained correctly. Mosquito control required.	No real problems with insects or odors if designed and maintained correctly.	Odor and fly problems require that trickling filter be built away from home
Reuse of effluent	Effluent contains nutrients (e.g. N and P) and is therefore appropriate for reuse in agriculture. But not for direct recharge in surface waters.	The effluent of aerated ponds may be reused or used for recharge, The treated water can be reused or discharged if a secondary maturation/settling pond follows the aerated lagoon/completely mixed aerated pond	Should be clarified prior to discharge

Most favorable, 1
2
3
4
Least favorable, 5

3. Solid Waste Disposal

232. **Without Project.** As with the other two towns, the method of final disposal of solid waste in Stung Treng is open dumping. The existing solid waste dumpsite is on a 147-ha public land parcel, located approximately 10 km from the foot of the Sekong Bridge across the town. It is along NR7 and has an unpaved access road. The site is partly within the boundary of one of four RAMSAR sites in Cambodia, and less than 2 km away from the Sekong River, an IBA. A no-project option of continuing with this current method of solid waste disposal in this location would therefore result in continued and significant negative impacts to adjacent environments.

233. **With Project.** For these reasons, the site will be closed and remediated, and another disposal facility developed. Regarding the technical options for this proposed facility, and similar to the appropriate options for the other two towns, basic solid waste management disposal improvements relate primarily to how advanced the proposed disposal facility will be, ranging from basic improvements to the existing open dumping practices (current situation across Cambodia)

at one end of the scale, to a controlled landfill that includes certain basic engineered systems, through to full sanitary landfill development. A multi-criteria assessment of these three waste disposal options was completed for the IEE, as shown on Table 6.9. The results indicate that Option 2 (controlled landfill) ranked more favorably than the other two options, given the relative development level of the town, funding level, and overall planning and implementation capacity of involved institutions.

Table 6.9: Multi-Criteria Analysis of Solid Waste Disposal Options

Criteria	Option 1 Open dump	Option 2 Controlled landfill	Option 3 Sanitary landfill
Technical	.		
Management of waste at the site	Waste dumped as collected	Waste dumped into lined cells	Waste dumped into lined cells
Materials recovery	Some sorting and recycling by informal pickers at dumpsite, often operating in dangerous conditions	Organized sorting and recycling at landfill	Sorting and recycling prior to collection and potentially also at landfill
Final disposal method	Limited compaction, no cover	Compaction and soil cover in layers (daily or periodic)	Compaction and soil cover daily
Hazardous waste management	No separate hazardous waste treatment	Incinerator or separate cell for hazardous waste	Incinerator or separate cell for hazardous waste
Onsite energy generation	None	None	Possible landfill gas recovery
Appropriateness for improving solid waste disposal in developing countries	Will not improve solid waste disposal.	Staged improvement and often more appropriate for operational capacity limitations	Improvements meet international standards, and require a high level of operational capacity
Economic			
Capital cost	Least	Moderate	High
Operation and maintenance costs	Least	Moderate	High
Environmental and social			
Risks to biodiversity	High	Low	Least
Waste burning	High	None	None
GHG emissions	Uncontrolled	Controlled, and possibly collected and flared	Controlled, collected and flared or converted to energy
Odor	High	Low	Least
Leachate	High, as exposed to rainfall	Lower, collected and reduced risk	Low, collected and least risk
Groundwater and soil pollution risks	High risk	Lower risk	Lowest risk
Risk of surface water pollution	High risk	Reduced risk	Least risk
Flies, mosquitoes, other disease vectors	High	Low	Low
Vulnerability to climate change effects	High	Low	Least
Health and safety hazards	High	Low	Low
Reuse of landfill gas	None	Potential flaring	Flaring or energy recovery

Most favorable, 1
2
3
4
Least favorable, 5

4. Town Center Enhancement

234. **Without Project**. Although not as popular as Kratie, Stung Treng derives some income from tourism as a riverside town with colonial buildings, excursions to view rare river dolphins, and as a transit stop over en route to and from Lao PDR. However, the riverside and market square areas, and some key urban center roads are in poor condition and the riverside walkway is dilapidated and lacks lighting or public amenities. There are fairly simple measures that could be taken to enhance the town center and rehabilitate the river side as a recreational space.

235. **With Project.** With the project, the downtown area in the town will have an improved recreational value accessed by all, both residents and visitors.

VII. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

236. Stakeholder consultation and participation was an essential process in project preparation. These included: (i) meetings with Government agencies and key informant interviews, (ii) an inception workshop held in Phnom Penh in June 2017, attended by DPWT and town and provincial government officials to present the overall work plan and obtain feedback and comments on key issues; (iii) consultations at the interim stage to hold key informant interviews, meetings, discussions and random interviews; and (iv) a socio-economic survey in September 2017; and (v) a joint Laos-Cambodia workshop, attended by the officials and representatives of the Project provinces in November 2017, which included disaster risk reduction (DRR) as one of the topics. The meetings with Government agencies such as the MOE, MOWRAM, DPWT, DOE, and DOWRAM were held 31July – 08 August to gather information about the Government's regulatory requirements and to gather information on the environmental conditions in the subproject sites. The socio-economic survey, which covered 283 households, included key questions on environmental issues and concerns. Relevant findings from the survey are presented in Section IV. Details of environmental safeguard-specific consultations are presented in Appendix F.

237. During the inception workshop in June 2017, a total of 50 participants attended the workshop. The participants were composed of representatives from MPWT, other ministries, provincial/project town offices, ADB, and PPTA consultant team. The meeting was held at the Cambodiana Hotel in Phnom Penh. The workshop was chaired by the Deputy Director, General Directorate of Public Works of MPWT. The following key points on environmental and social issues were discussed:

- The three towns have seen little development and there needs to be organized land use plans in the cities for residential development, economic development, industrial zoning, road network, flood prevention, drainage system, wastewater treatment and solid waste management.
- The benefits of the proposed project will be felt by the people who are living in the cities and immigrants who move from the countryside to live in the cities.
- Infrastructure improvement priorities that were identified during the workshop are:
  - Kampong Cham: solid waste management, riverbank protection, drainage, wastewater treatment
  - Kratie: solid waste management, drainage and ring road
  - Stung Treng: solid waste management, drainage new wastewater treatment plant, riverbank protection.

- Environmental and social benefits of the project that were mentioned by the participants are:
    - Reduction of pollution in Mekong River
    - Reduction of flooding from rainwater
    - People will live in a better environment
    - Increase in the number of tourists
    - Improvement of the health condition of the people
    - Reduction of difficulties for women, children, and elderly people
    - Reduction of conflicts or arguments between citizens
    - Reduction of damage to infrastructure
    - Improvement of people's livelihood and quality of life.

238. Follow-up workshop was held on 13 October 2017 to present the results of the assessment and to obtain feedback and comments. The meeting was attended by representatives from MPWT, other government agencies, provincial officials from the project towns, ADB, and the consultant team. The following help points arose from the workshop in relation to environment and social issues:

- Resettlement:
    - There should be 2 or 3 options for site selection based on the comment from the General Department of Resettlement (GDR), Ministry of Economy and Finance (MEF).
    - There has been a meeting with GDR and inventory of losses (IOL) survey in cooperation with GDR.
    - Stung Treng will work closely with affected persons (AP) for resettlement issues for the wastewater treatment plant.
- Landfill sites:
    - The MOE will assess and give approval for the landfill sites.
    - The present dumping site in Stung Treng has been evaluated by a Manila-based NGO in 2010-2011 and it was concluded that there would be no impact. The said site was approved by DOE and has been used for several years. However, considering ADB's criteria, Stung Treng will look for an alternative site but this may require higher O&M budget than the present site.
    - An alternative site for the landfill in Kampong Cham will be confirmed by MPWT.
    - The proposed landfill site at Kratie is located in another district. Solid waste is currently collected by a private partner company with two trucks.
- Riverbank protection:
    - The riverbank protection at Kampong Cham needs 3-5 years of hydrological study and river flow monitoring. MPWT does not want ADB to invest in works which have not been properly studied to avoid failure.
- Roads:
    - The proposed ring road/bypass at Kratie will take traffic from the town center and reduce accidents.
    -

239. Key informant interviews (KII)/consultations and focus group discussions (FGDs) were held from 5 – 8 September 2017. A total of five FGDs were held. Participants comprised of the following: representative of communities or affected communities, village chiefs/deputy village chiefs, commune chiefs/deputy commune chiefs and commune council members. The FGDs

conducted were as follows:

FGD	Venue	Date of FGD
Stung Treng and Preah Bat Sangkat, Stung Treng	Barchong Pagoda, Preah Bat Commune	5 September 2017
Srach Russei Sangkat, Stung Treng	Commune Office	5 September 2017
Kratie and Rokar Kandal Sangkats, Kratie	Commune Office	6 September 2017
Krakor and Ou Russei Sangkats, Kratie	Krakor commune office	7 September 2017
Beong Kok and Kampong Cham Sangkats, Kampong Cham	Beong Kok commune office	8 September 2017

240. The FGDs elicited the following comments from the stakeholders:

- **Kampong Cham**
  - Almost every year during the rainy season, village areas in Kampong Cham and Boeng Kok communes are flooded.
  - Women worry mostly about decrease in local business or income during flooding (flooded roadway and lack of clients)
  - Women also consider the negative impacts on community sanitation and public health, especially for their children
  - Women are mostly responsible for household work during floods
  - Flooding is caused by the lack of culverts and drainage system in the town. Some parts of drainage are destroyed and some areas are not connected to public drainage system or with no drainage
  - Some households have installed and use own drainage (but have low capacity and standards)
  - Flooding impacts the quality of life of the community through poor sanitation, increase in waterborne diseases, bad smell, polluted water, and bringing solid wastes from upstream area through runoff
  - Some schools are flooded during heavy rain affecting travel time to school (delayed and reduced learning time).
  - Environmental problems that were associated with drainage and the WWTP construction such as dust, noise, air, etc. are considered small and temporary during construction stage. The local people are not concerned about the environmental issues during construction. The people said that they need the culvert/drainage system and WWTP in their town.

- **Kratie**
  - Flooding is an issue in Kratie town during the rainy season; there is flash flooding on some roads and in village areas.
  - A respondent said that the village always floods and there is bad smell. Absence of flow for two or three days causes more mosquitoes and flies which then results to spread of diseases.
  - Lack of culverts/drainage system
  - All the wastewater discharges to low-lying lands and then flows directly to the Mekong River without any treatment. In Kratie town, the situation is the same as in Krakor, Ou Russei, Kratie, and Rokar Kandal communes.

- There is shallow river water in villages.
- Floods could impact water use, community sanitation, and increase waterborne diseases.
- The participants said that the project should improve sanitation, public health, and environmental quality as well as Mekong River quality.

- **Stung Treng**
  - Flood from runoff is a problem in Stung Treng commune during the rainy season because of lack of drainage. Some culverts/drainage are too old and are damaged.
  - Mothers worry about sending children to school, diseases, and sometimes babies drown in flood waters.
  - Agricultural products, poultry and livestock are also negatively affected.
  - Men worry about their daily livelihood because flooding destroys infrastructure.
  - All the wastewater in discharged to Mekong River without treatment.
  - Flood affects road structures, fruit trees/vegetables, and education (school time is delayed) and local business activities.
  - The participants said that the improvement of the drainage system including the WWTP and solid waste disposal in Stung Treng are important for the environment, Mekong River and for community health.
  - The FGD participants are not concerned too much about the impacts from project construction activities on natural and social environment because the components are located in existing sites. The participants added that noise and air pollution during construction are temporary and are no big issues.

241. Household survey was also conducted in each of the three towns. The questionnaire was designed with inputs from the environmental, financial, and engineering specialists on the team. A sample of 271 households in each town was determined. To ensure that all areas of the towns were covered in the survey, the sample was spread over all villages that will be covered and serviced with the proposed components.

242. The household survey confirms that drainage and wastewater collection service coverage is low in all three towns: 27% of households in Kampong Cham, 10% in Kratie, and 21% in Stung Treng have access to drainage (sewerage is not yet established). Service with solid waste collection among the sample household ranges from 67% in Kampong Cham, and to around 52% in the two other towns. Almost no households in the sample have access to open canal drains.

243. The survey identified the following main problems in the subproject towns:

- Inadequate disposal of residential wastewater
- Inadequate disposal of human excreta
- Flooding and inadequate stormwater (mostly by households in Kampong Cham and Kratie)
- Poor quality of drinking water
- Difficult access to drinking water.

244. Stakeholder consultations will continue through subproject implementation and operation, following the Project Stakeholder Participation Plan. All stakeholders must be invited and encouraged to participate in community consultations. To facilitate the engagement of stakeholders, the PMU and PIU will maintain good communication and collaboration with

Commune Councils and Village Leaders. The PMU, PIU Contractors and/or Operators will be open to contact by the public on matters concerning the progress of the subprojects, adverse impacts, mitigation measures and environmental monitoring and grievances. Future stakeholder consultations will include the following:

- During detailed design, if update of the IEE is warranted, it would be appropriate to disclose the updated IEE to the affected communities and solicit feedback.
- Prior to construction, the PMU will conduct an intensive information, education and communication campaign to ensure sufficient level of awareness/information among the affected communities regarding the upcoming construction, its anticipated impacts, the grievance redress mechanism, contact details and location of the PMU, and status of compliance with Government's environmental safeguard requirements, among others, are attained/provided. Billboards about the subproject, implementation schedule and contact details of the executing agency, PMU, PIU and Contractors will have been set up at strategic locations within the subprojects' main areas of influence. The grievance redress procedure and details will have been posted at the offices of the PMU, PIU, Municipality and concerned Commune Councils and provided to concerned Village Leaders.

245. No formal information disclosure of the overall Subproject has been made to date, except on a general description of the components during onsite interviews, FGDs, and workshops.

246. The IEE (in English) and the EMP (in English and Khmer), as well as the MOE-approved IEIA/EIA Reports (in Khmer), will be available at the offices of the PMU and PIU for interested parties. Copies may be made available upon formal request. The IEE and EMP and semi-annual environmental monitoring reports will be disclosed on the ADB's website.

VIII. GRIEVANCE REDRESS MECHANISM

A. Purpose of the Mechanism

247. 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 project level.

B. Proposed Set-Up

248. The MPWT, as executing agency of the GMS-CTDP-4 will establish and manage the GRM. The PMU's environmental safeguards officer (ESO) will oversee the implementation/ observance of the GRM for the Project. The ESO's counterparts in the PIUs (environmental focal points) will ensure the implementation of the GRM at the Subproject level and will be responsible for keeping the PMU informed as prescribed in the GRM. Access points will be set up with the Commune Council and Municipality. Contractors and Operators will be required to designate their respective counterpart GRM staff.

249. The GRM will accommodate both informally and formally lodged, but eligible, grievances. Informally lodged grievances are those received by the Contractor during construction or Operator during operation. Formally lodged grievances are those received at the offices of the PIU, Municipality and Commune Council. The PIU evaluates complaints for eligibility. The PIU and PMU maintains record of all grievances, informally and formally lodged, eligible and ineligible.

The PMU will inform the ADB, as necessary, and report on the observance/implementation of the GRM in the quarterly project progress reports and in the semi-annual Environmental Monitoring Reports that will be submitted to ADB.

250. Sufficient support system, including well GRM-oriented staff in the access points of the Commune Council and Municipality, communication facilities, documentation/recording, and reporting system, funds, posters declaring contact details and displayed at strategic locations, among others, will be in place to sustain the effective implementation of the mechanism.

C. Access to the Mechanism

251. Any person who has environmental concerns/issues pertaining to the subprojects during detailed design, construction and operation phases will have access to the mechanism free of charge. The PMU, through its ESO and his/her counterparts in the PIUs, will ensure that:

- the mechanism is understandable, transparent, gender-responsive, culturally appropriate, and readily accessible to all segments of the affected people at no cost and without retribution;
- the GRM is displayed in the offices of the PMU, PIU, Municipality and Commune Council and at strategic places.

D. GRM Steps and Timeframe

252. Grievances raised on environmental impacts are critical to the health, wellness and safety of affected persons (APs). Hence, the proposed mechanism intends to be easily accessible and promptly responsive to APs' complaints.

1. Informal Approach

253. Informally, APs can lodge complaints directly to the Contractor during construction or Operator during operation. Contractor/Operator shall document and assess the complaint immediately. If assessment validates the complaint as within the scope of the GRM/eligible, the Contractor/Operator shall act on the complaint within 3 days from receipt of complaint. If assessment invalidates the complaint (i.e., reveals the complaint as ineligible or not associated with the Subproject's environmental performance), the Contractor/Operator shall direct the AP to the Municipality. The Contractor/Operator shall report to the PIU the complaints received, eligible or ineligible, actions to be taken, ineligible complaints directed to the Municipality within 2 days from receipt of complaint. The PIU shall obtain a written confirmation of satisfaction from the AP after 7 days from completion of resolution by Contractor/Operator.

2. Formal Approach

254. If complaint is eligible but is not acted on within three days from receipt of complaint, or if AP is not satisfied with the resolution undertaken by the Contractor/Operator, he/she can access the formal mechanism, as follows:

Step 1 Lodging a Complaint (Day 1)
AP lodges complaint, by him/herself or with assistance from the Village Leader, at the access points of the PIU, PMU, Municipality or Commune Council.

Step 2 Documentation & Registration of Complaint (Day 1)

In coordination with the PMU, PIU/Municipality/Commune Council documents/registers lodged complaint, makes sure these are duly referenced and provides AP with a copy of referenced complaint. The Municipality forwards documented complaint to the PIU; the Commune Council, through the Municipality.

Step 3 Assessment and Discussion (Day1/Day 2/Day 3)

AP shall be informed if the grievance is eligible or ineligible. If it is ineligible, AP shall be directed to the Municipality. If complaint is eligible, AP shall be informed of the expected action timelines as set out in the established mechanism.

If both of the AP and Contractor/Operator are available, the complaint shall be immediately reviewed, investigated and discussed. If not, both parties should agree to undertake the review, investigation and discussion within 3 days. The discussion will be on the cause and action/measure to implement based on the review and investigation. Agreement on actions and measures and time involved shall be made with the AP. Agreement shall be properly documented and filed; PIU, Municipality, Commune Council and AP shall have copies.

Step 4 Implementing the Agreed-on Resolution

(Day 3/Day 4) If complaint is minor, i.e., not requiring further investigation and would be easy to resolve, the Contractor/Operator shall immediately implement agreed on action/resolution.

(Day 3/Day 4 to Day 7/Day 8) If further investigation and/or procurement of supplies/parts would be necessary, the Contractor/Operator shall: (i) immediately provide the most suitable interim measure to reduce the magnitude of the impact; and (ii) start work on the final measure within 5 days from the day discussion meeting is held.

Step 5 Acceptance of Resolution (1 week after completion of action/measure taken)

If, according to the AP, the impact has been resolved satisfactorily, PIU shall obtain a written confirmation of satisfaction from the AP. This confirmation will signify closure of grievance and will form part of the grievance documentation. The Municipality, Commune Council and AP shall retain their copies of the confirmation.

Step 6 Monitoring and Evaluation (for 1 week after closure of grievance)

The PMU shall monitor the effectiveness of the resolution for at least a week after closure of grievance (that is, when action implemented has been satisfactorily confirmed in writing by the complainant). Monitoring and evaluation shall be properly documented and included in the Environmental Monitoring Report.

Step 7 Appeal for Dissatisfied AP

When dissatisfied (or, in the event the issue/impact persists despite actions undertaken), AP can appeal for assistance from the Municipality in the elevation of his/her complaint to the Province. The Province shall call all parties concerned

to review the history of the grievance and resolution process taken and assess the validity of the appeal.

If appeal is found not valid, the Province shall write the AP and declare the grievance closed.

If appeal is assessed to be valid, Province and the parties discuss and agree on the quick resolution of the issue. PMU requires Contractor and Operator to implement the agreed resolution. Should the issue continue to persist despite the second action, dissatisfied AP can raise an appeal to the Provincial Court.
In the event of an appeal, the PIU shall immediately report to the PMU. The PMU shall ensure that the ADB is immediately informed.

255. The PMU will be the overall manager of GRM and should document and report on all complaints that have been raised in respect of the Project. All grievances and their resolution should be reported in quarterly project progress reports and semi-annual environmental monitoring reports.

256. Adversely affected persons can also raise their grievances to the Accountability Mechanism of the ADB. Alleged noncompliance of ADB projects may also be reported to this Accountability Mechanism.

IX. ENVIRONMENTAL MANAGEMENT PLAN

250. The EMP will serve as the framework for the environmental management of the subprojects, commencing from the detailed design phase through to operation and if applicable, decommissioning. The EMP addresses the potential impacts and risks identified in the IEE. It includes: (i) mitigation measures; (ii) monitoring measures; (iii) implementation arrangements and responsibilities; and (iv) preliminary costs for EMP implementation. The EMP will be updated by the PMU based on the detailed design, with technical assistance from the Environmental Specialists of the Project Management and Construction Supervision (PMCS) Consultant.

251. Environmental management of the Project during implementation will be a joint responsibility of the: (i) Ministry of Public Works and Transport through its Project Management Unit; (ii) Department of Public Works and Transport through its Project Implementation Unit; (iii) Project Steering Committee; (iv) Design Team/Consultant; (v) Civil Works Contractors; (vi) Operators of completed components; (vii) Project Management and Construction Supervision; and (viii) Asian Development Bank (ADB). As Executing Agency, the MPWT will be responsible for overseeing the implementation of EMPs through its Project Management Unit (PMU). The Social and Environment Office (SEO) of MPWT will support the PMU with review of environment reports. The implementing agencies, the DPWTs of each province will supervise component activities carried out prior to construction, during construction and during operation through their respective Project Implementation Units (PIUs). The PIUs will be responsible for providing assistance to the PMU in environmental management at the subproject level.

Entity	Overall Role
Project Steering Committee (PSC)	strategic guidance and support to the MPWT and PMU and facilitate inter-agency coordination
Project Management Unit (PMU)	Management of the day-to-day activities of the Project
PMU Environment Safeguards Officer (PMU-	Supervise EMP implementation/ compliance

ESO)	
Project Implementation Unit (PIU)	Oversee subproject implementation
PIU environment focal point	Responsible for subproject environmental monitoring
Design Team of DB Contactor and Design Consultant for standard contract component	Ensure detailed designs incorporate environmental and climate considerations
DB Contractor and Standard Contractor	Prepare Contractor EMP (CEMP) full addressing the ADB-cleared EMP. Implement the CEMP.
Operators of completed components	Responsible for EMP implementation during operation.
Project Management and Construction Supervision Consultant (PMCS)	provide technical support and capacity building to the PMU and PIU
International and national Environmental Specialists (ES)	Provide environmental safeguards management support during design and implementation
Asian Development Bank (ADB)	Review project performance against the commitments in the covenants and advise on corrective actions and review relevant documents.

A. Institutional Capacity in Environmental Management

252. The MPWT has a Social and Environment Office (SEO) to manage environment and social aspects of foreign-funded projects. SEO will support the PMU to review environment reports and will be invited to join training and field visits during implementation. The current institutions at the DPWT in Kampong Cham, Kratie and Stung Treng lack the skills and resources to implement environment safeguards, hence, assistance and guidance from the SEO, ES and the PMCS will be crucial.

253. Based on experience of other projects in Cambodia, the PMU and PIU will not assign adequate or suitably qualified staff resources to project implementation. The loan will finance recruitment of a qualified person to be assigned as PMU-ESO to work with the municipal officers in Kampong Cham, Kratie, and Stung Treng to support implementation of the EMP in coordination with the PMU and the PMCS. The PMU-ESO will work with the provincial/municipal and sub-municipal administrative levels, community-based organizations (CBO), local business community, and residents to ensure that the project impacts are managed in line with the EMP, and if unidentified impacts are found, the EMP will be updated.

X. CONCLUSION

254. This IEE was prepared to identify the environmental issues and risks associated with the proposed subprojects. The proposed EMP and operations and maintenance requirements for facilities will mitigate subproject impacts on the natural environment and affected people to an acceptable level, if implemented effectively. The assessment confirms that the project is classified as Category B for environment.

255. The most significant environmental risks will arise from poor facility operation and maintenance and future uncontrolled urban development. The main urban areas in Stung Treng and Kratie are bordered by protected riverine habitats, Sekong River to north and Mekong River to west. The riverine habitats within the project area of influence of the urban areas have been altered through years of uncontrolled development and granting of land concessions. The project presents an opportunity to reduce polluted discharges, through closure of the existing dumpsites in Stung Treng and Kratie, establishment of controlled landfills and collection and treatment of wastewater prior to discharge, significantly improving the current situation. However, the design of the wastewater treatment plants and sewer network should take into consideration the assimilative capacity of the receiving water bodies, their intended uses, and the presence of

sensitive receptors. Further to hydrological assessments, flood mitigation and emergency response measures will be developed to be incorporated into the plant operations and maintenance manual.

256. The EMP includes measures to minimize potential impacts on water quality and biodiversity associated with the Sekong and Mekong Rivers. Additional baseline surveys (ecology, air, surface water and groundwater quality and noise) will be carried out as part of the domestic IEIA/EIA during detailed design and will inform the update of the IEE/EMP. The provincial development strategy consulting services include Environment and Climate Change Specialists to ensure integration of environment and climate change considerations in future development plans for project towns. There is a comprehensive training and capacity building component which will include development of operation manuals and procedures. Improving capacity of operators is essential to achieve the anticipated environmental benefits and project outcome.[87]

257. Project sites, except the controlled landfills, experience flooding each year, either fully or partly. The proposed subprojects will be designed to ensure resilience to climate risks. The WWTPs have been raised by an additional 1 m and access roads will be paved with concrete instead of DBST. Additional measures will be considered during detailed engineering design, as set out in the Project Climate Risk Management Report and as presented in summary in this IEE.

258. The key parties involved in implementing the proposed mitigation measures are the construction contractors and operators. They will be supported by national and international environmental consultants within the Project Management and Construction Supervision Consultant team and the loan will finance a full-time Environment Safeguards Officer to support the PMU with implementation. The project stakeholders will closely monitor, and report on the implementation of the EMP.

259. Overall, the Project is expected to improve the urban environment in the three towns, reduce pollution impacts, reduce vulnerability to environmental and climate risks, improve health and support a more sustainable development path for the future.

[87] Anticipated project outcome is improved urban services for enhancing regional economic connectivity in participating towns

Appendix A

Environmental Management Plan

May 2018

Cambodia: Fourth Greater Mekong Subregion Corridor Towns Development Project

Kampong Cham Subproject
Kratie Subproject
Stung Treng Subproject

Prepared by the Ministry of Public Works and Transport for the Asian Development Bank.

Appendix A

This environmental management plan is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgments as to the legal or other status of any territory or area.

I. INTRODUCTION

1. This draft environmental management plan (EMP) is for the Fourth Greater Mekong Subregion Corridor Towns Development Project (the project). The EMP summarizes the potential impacts of the project, as identified in the initial environmental examination (IEE) and defines mitigation measures and monitoring requirements to reduce these impacts to acceptable levels.

2. The EMP also defines the institutional arrangements in terms of the roles and responsibilities of involved institutions, and procedures and budgets for EMP implementation. It seeks to ensure effective implementation of environmental protection activities during preconstruction, construction, and operation phases to prevent, reduce, and/or mitigate adverse impacts and risks. The EMP draws on the findings of the project IEE, the project preparatory technical assistance (PPTA), as well as discussions and agreements with relevant agencies of the Government of Cambodia (the government) and the Asian Development Bank (ADB).

3. The draft EMP is based on the proposed project designs as of February 2018. It will subsequently be modified and finalized by the Project Management Unit (PMU) based on the detailed designs and results of further environmental baseline quality surveys. Technical support will be provided by the Environmental Specialist (ES) of the Project Management Consulting Service team (PMCS). The final IEE/EMP will be disclosed on the ADB website in accordance with ADB's Public Communications Policy. The final EMP will also be included in all bidding and contract documents. Environmental monitoring results will be used to evaluate (i) the extent and severity of actual environmental impacts against the predicted impacts, (ii) the performance of the environmental protection measures and compliance with regulations, (iii) overall effectiveness of the project EMP, and (iv) any requirements to adjust the EMP.

II. INSTITUTIONAL ARRANGEMENTS AND RESPONSIBILITIES FOR EMP IMPLEMENTATION

4. Environmental management of the project during implementation will be the joint responsibility of:

(i) Ministry of Public Works and Transport (MPWT) through its PMU;
(ii) Department of Public Works and Transport (DPWT) through its Project Implementation Unit (PIU);
(iii) Project Steering Committee (PSC);
(iv) Design consultants;
(v) Civil works contractors;
(vi) Operators of completed components;
(vii) PMCS team; and
(viii) ADB.

5. Primary responsibilities are defined below and detailed in Table 1.

6. **Executing agency.** The MPWT, the project's executing agency, will be responsible for overseeing the implementation of, and compliance with, covenants and the EMP. It will ensure the project's compliance with the environmental safeguard requirements identified in the EMP, and that environmental approvals from the Ministry of Environment (MOE) are obtained prior to contract awards.

7. **Project Management Unit.** The MPWT will establish the PMU, which will be responsible for managing day-to-day activities. Prior to the commencement of the preparation of detailed engineering design (DED), the PMU will recruit a qualified Environmental Safeguard Officer which will be a full-time position financed through the loan.

8. **Implementing agency.** The provincial Department of Public Works and Transport (DPWT) will be the implementing agency for the Project and will supervise activities carried out prior to construction, during construction, and during operation. The DPWT will coordinate and collaborate with the provincial Department of Environment.

9. A PIU for the Project will be established within the provincial DPWTs. Prior to commencement of the preparation of DED, the PIU will appoint an environmental focal point for environmental safeguard management and grievance redress mechanism (GRM) at the provincial subproject level.

10. A PSC will be established to provide strategic guidance and support to the MPWT and PMU, and to facilitate inter-agency coordination. The MOE is among the proposed members of the PSC.

11. The civil works contractors will be responsible for implementing mitigation measures during construction. Design-build contractors will engage an environmental management specialist during the design stage. The specialist will ensure compliance with environmental requirements and obligations during the design and construction phases. Each contractor will also appoint environmental, health and safety officers.

12. The design consultants for town center enhancement components will incorporate environmental and climate considerations into designs, procurement and contact documents.

13. The operators will comprise of (i) the DPWT for the combined sewer and wastewater treatment plants (WWTPs), and (ii) provincial and municipal governments for the controlled landfills and town enhancement components. For EMP implementation during operations, operators will appoint an environmental focal person. Through these officers, operators will (i) ensure effective implementation of both the EMP and the environmental management sections of operations manuals, (ii) submit the required environmental monitoring reports to the PIU, and (iii) monitor the GRM.

14. The PMCS consultant will include environmental specialists (one international and one national), who will provide (i) PMU, PIU and contractor training, (ii) technical support during IEE and EMP updates, and (iii) EMP implementation, monitoring and reporting.

15. ADB will: (i) review and supervise project performance against executing agency and implementation agency commitments, as described in the legal agreements, (ii) undertake reviews of relevant documents, such as the updated IEE and EMP, for clearance purposes, and (iii) conduct periodic review missions to review, among others, EMP implementation.

Table 1: Environmental Responsibility

Responsible Entity	Project Stage and Environmental Responsibility					
	Project Preparation	**Post-Loan Approval & Prior to DED**	**Detailed Engineering Design**	**Tendering and/or Pre-Construction**	**Construction**	**Operation**
MPWT	As the executing agency (EA) for the Project, will be responsible for overseeing the implementation of and compliances with loan assurances and the EMP.					
		- Ensure environment approvals from MOE are obtained prior to contract awards. - Establish the necessary collaboration with the MOE for environmental impact monitoring. - Ensure the PMU is staffed with a qualified ESO. - Ensure PIUs have appointed their environmental focal points.		Clear CEMP.		
PMU	Established by the EA to be responsible for managing day-to-day activities of the Project. Has overall responsibility, delegated by the EA, for supervising the implementation of environmental mitigation measures, coordinating the Project level GRM and reporting to ADB.					
		<u>For works under DB contracts</u>. - Incorporate the mitigation measures and EMP clauses (environmental conditions) in the bidding documents and contracts for DB works. - Incorporate environmental criteria in the evaluation of bids for DB works.	- Obtain the results of baseline survey from the national IEIA/EIA Consultant to inform design and update of IEE/EMP. - Update the IEE and EMP based on the detailed designs and results of the baseline environmental surveys. - Provide updated EMP to the Design Consultant. - Conduct follow up consultations and information, education & communication (IEC) activities to prepare the affected communities. - Ensure readiness of the subproject for construction, especially with respect to environmental approvals/clearances and mine and UXO clearances.	<u>For works under standard contracts</u> - Ensure mitigation measures and EMP clauses (environmental conditions) are incorporated in the bidding documents and civil works contracts and environmental criteria are incorporated in bid evaluation. <u>For works under DB and standard contracts</u> - Review CEMP. - Clear CEMP.	- Coordinate GRM; supervise EMP implementation; conduct regular site inspections; prepare monthly (periodic) progress reports; collaborate with the PMCS-ES in the preparation of annual EMP monitoring & progress reports.	- Conduct compliance review; instruct PIUs on environmental management requirements; prepare semi-annual environmental monitoring reports and summary for quarterly Project progress reports until PCR is issued.
DPWT	As the implementing agency (IA) of the subproject, will supervise component activities carried out prior to construction, during construction and during operation. Will ensure that the EMP is implemented proactively and will respond to any adverse impact beyond those foreseen in the IEE and ensure that if there are any changes in scope, inform the PMU for the IEE/EMP to be updated, as needed.					

Responsible Entity	Project Stage and Environmental Responsibility					
	Project Preparation	**Post-Loan Approval & Prior to DED**	**Detailed Engineering Design**	**Tendering and/or Pre-Construction**	**Construction**	**Operation**
		- Tie up with the DOE for collaborative environmental impact monitoring. - Ensure PIU has appointed with an environmental focal point.	-			
PIU	Established by the IA, will be responsible for providing assistance to the PMU in environmental management at the subproject level.					
		- Support the PMU in ensuring the incorporation of the mitigation measures and EMP clauses (environmental conditions) in the bidding documents and contracts for DB works.	- Support the PMU in carrying out its responsibilities during DED phase.	- Support the PMU in ensuring that mitigation measures and EMP clauses (environmental conditions) are incorporated in the bidding documents and civil works contracts and environmental criteria are incorporated in bid evaluation.	- Monitor EMP implementation at component level and report to PMU.	- Support the PMU in the environmental management of the subproject.
PPTA Team	- Provide technical assistance in project preparation. - Prepare FSR, IEEs/EMPs, RPs/CPs. - Conduct public consultations.	-	-	-	-	-
PSC	Established to provide strategic guidance and support to the MPWT and PMU and facilitate inter-agency coordination. The Ministry of Environment is among the proposed members of the PSC.					
DB Contractor			- Engage an EMS to: (i) ensure compliance with environmental requirements and obligations in designs; (ii) prior construction prepare the CEMP based on the ADB cleared updated IEE/EMP and reviewed and cleared by the PMU; and (iii) during construction, to monitor adherence to CEMP and need for any corrective actions. - Engage the EMS or an environmental officer and health and safety officer for construction phase, and conduct workers' orientation on health and	(Phase not applicable to works under DB Contracts)	- Implement mitigation measures and conduct internal monitoring and supervision of environmental management during construction.	-

Responsible Entity	Project Stage and Environmental Responsibility					
	Project Preparation	**Post-Loan Approval & Prior to DED**	**Detailed Engineering Design**	**Tendering and/or Pre-Construction**	**Construction**	**Operation**
			safety and CEMP requirements. - Ensure its design team incorporates: (i) mitigation measures in detailed designs and bidding documents; (ii) climate change adaptation measures in detailed designs; (iii) the results of baseline groundwater and soil quality surveys in the detailed designs of controlled landfills and WWTP; & (iv) environmental management and climate change adaptation measures during operation in Operations Manuals.			
Design Consultant for standard civil works contracts			- Incorporate key EMP clauses (or updated EMP or simplified matrix of mitigation measures for major impacts) in the tender documents and environmental conditions in standard civil works contracts. - Incorporate environmental criteria in bid evaluation		-	-
Standard Contractor				- Prepare and submit Contractor's CEMP that is fully responsive to the ADB-cleared updated EMP. - Engage an environmental officer and health and safety officer. - Conduct workers' orientation on health & safety & pertinent EMP matters.	- Implement mitigation measures and conduct internal monitoring and supervision of environmental management during construction.	-
Licensed Institute					- Conduct quarterly environmental quality monitoring & prepare monitoring report.	- Conduct environmental quality monitoring following approved monitoring plan and prepare corresponding reports.

6 Appendix A

Responsible Entity	Project Stage and Environmental Responsibility					
	Project Preparation	**Post-Loan Approval & Prior to DED**	**Detailed Engineering Design**	**Tendering and/or Pre-Construction**	**Construction**	**Operation**
Operator						- Implement mitigation measures as defined in the EMP
PMCS			- Provide TA and support to PMU in carrying out its responsibilities during DED phase.	- Provide TA and support to PMU in ensuring that the mitigation measures and EMP clauses (environmental conditions) are incorporated in the bidding documents and civil works contracts and environmental criteria are incorporated in bid evaluation. - Review tender documents and assess subproject's readiness. - Review bid evaluation (environmental safeguards aspect) - Review CEMP.	- Advise on the mitigation measures; provide comprehensive TA and support to the PMU and PIUs in environmental management, conduct or facilitate lectures/training; conduct annual EMP compliance review; prepare annual EMP monitoring & progress reports.	- If ES is engaged to provide TA & support in the first year/or first few years of operation, advise on mitigation measures during operation. - Support the PMU in its task in environmental management in operation.
ADB	- Engaged a PPTA Team. - Review and clear the draft IEEs/EMPs.	-	- Review and clear the updated IEEs/EMPs. - Disclose the updated IEEs/EMPs on ADB project website.	- Review and clear tender documents. - Review and concur on bid evaluation.	- Conduct review missions; review and approve semiannual monitoring reports and disclose on ADB project website.	- Review and approve annual monitoring reports and project completion report and disclose on ADB project website.

III. SUMMARY OF POTENTIAL IMPACTS AND MITIGATION

16. Table 2 summarizes potential environmental impacts and mitigation measures that are designed to avoid and/or minimize identified impacts to acceptable levels. Mitigation measures that will become part of the permanent infrastructure (such as landscaping) and temporary construction mitigation measures (such as dust suppression) should be included within the bills of quantities for the civil works.

17. The mitigation measures defined in the EMP will be (i) reviewed, and where necessary updated during detailed design by the Environmental Safeguard Officer (ESO) of the PMU, with technical support from the PMCS-ES, (ii) incorporated into procurement documentation, construction contracts, and operation and maintenance (O&M) manuals, and (iii) implemented by contractors, under the supervision of the PMU/PIU and PMCS. The effectiveness of these measures will be evaluated based on both the results of environmental quality monitoring, and through EMP compliance verification monitoring, conducted by the PIU environmental focal person, PMU-ESO and PMCS-ES.

Table 2. Environmental Mitigation Plan

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
A. PRE-CONSTRUCTION PHASE						
Design	Existing environmental conditions	Lack of baseline data on environmental quality	• Obtain results of baseline studies carried out as part of the national IEIA/EIA to inform the detailed engineering design and the update to ADB IEE/EMP. • Conduct further site assessment and baseline surveys (ecology, air, surface water, groundwater quality and noise) as part of the domestic IEIA/EIA during detailed design once siting of project components confirmed.	PMU	PMCS-ES	Included in PMCS cost
	WWTPs	Impact of the WWTPs on hydrology, water logging, receiving water bodies, and sensitive receptors	• Undertake hydrological studies, determine assimilative capacity, intended uses, and presence of sensitive receptors dependent on receiving water bodies of the WWTPs • Ensure that the final effluent of the WWTPs conforms to the prescribed standards of Sub-decree on Water Pollution Control and the MRC target values • Undertake ecology baseline survey of lagoon sites associated with WWTPs • Design an emergency response plan based on the results of the hydrological studies in coordination with stakeholders	PMU	PMCS-ES	Included in PMCS cost
	Controlled landfills	Impact on trees, sensitive receptors, leachate, groundwater, surface water	• Conduct an inventory of trees and other vegetation that will be affected prior to site clearing in Kampong Cham and Stung Treng • Design a tree replacement plan • Undertake assessment of geological condition, groundwater levels and surface water bodies that will be affected by possible leaching based on detailed design • Design a leachate collection and treatment system to avoid percolation into groundwater or discharge into streams • Ensure appropriate safety clearance of the transmission lines in Kampong Cham from the controlled landfill site and access entrance. • Design measures to control air and odor pollution • Provide buffer/fence surrounding the controlled landfill	PMU	PMCS-ES	Included in PMCS cost
	Closure of existing dumpsites	Impacts of leachate, landfill gas, and erosion to surface water, groundwater and sensitive receptors	• Conduct an environmental compliance audit (ECA) of the dumpsites and incorporate corrective actions and post closure requirements in detailed design and operations and maintenance requirements (TOR for ECA in IEE Appendix E) • Design a post-closure monitoring plan that includes monitoring of surface and groundwater quality, landfill gas, erosion control, and leachate collection.	PMU	PMCS-ES	Included in PMCS cost
		Informal waste pickers	• Undertake consultations and identify opportunities to formalize roles of waste pickers and to provide a safer working environment: • Detailed design to consider options for permanent or mobile shed/shelter to enable access to recyclables whilst reducing exposure to hazardous	PMU	PMCS-ES	Included in PMCS cost

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
			conditions; • Detailed design to incorporate welfare facilities including potable water, separate toilets and showers for male and female workers and changing areas; • Establish registration system and only permit registered adult waste pickers access to the site.			
Environmentally responsible readiness	Preparation & readiness of key subproject stakeholders and affected communities	Engaging qualified environmental personnel	• Engage a full-time national Environmental Safeguards Officer in the Project Management Unit (PMU-ESO), over the Project's five-year implementation period; and	PMU	PMCS-ES	Recurrent cost
			• Engagement of an international and national Environmental Specialist through PMCS.	ADB	-	-
		Environmental training and capacity building	• The PMCS will provide training for environmental personnel of the PMU, PIU, contractors and the DOE in environmental management and technical strengthening in EMP implementation, grievance redress mechanism (GRM) implementation, climate adaptation, disaster risk resilience, public consultation, and monitoring and reporting. • The participation of the PMU and PIU in the conduct of the dumpsite environmental compliance audits (ECA) will also be a training opportunity.	PMCS	ADB	Included in PMCS cost
		Grievance redress mechanism	• Ensure establishment of the GRM at the subproject level.	PMU, PIU	PMCS-ES	Included in PMCS cost
		Obtain MOE approvals for subprojects	• MOE registered firm to undertake domestic IEIA/EIA (including baseline surveys) and obtain all necessary approvals prior to civil works contract awards.	PMU, PIU	PMCS-ES	$150,000 included for domestic IEIA/EIAs
		IEE and EMP updates	• Update IEE/EMP based on the final design of subproject components and baseline surveys. Have this reviewed and cleared by ADB.	PMCS-ES, PMU	ADB	Included in PMCS cost
		Inclusion of EMPs in bidding documents	• Include the ADB-cleared EMP in bidding and contract documents. • Ensure contracts require Contractors to prepare site-specific CEMPs that fully respond to the ADB-cleared EMPs.	PMU PMCS-ES	ADB	Included in PMCS cost
		Consultations and disclosures	• Maintain consultation and disclosure activities with affected people and other involved stakeholders to ensure continued communication regarding for example, overall subproject implementation schedule, details of construction activities and particularly activities that result in nuisances and disturbances, the status of claims and compensation, and other aspects.	PMU, PIU	PMCS-ES	Included in PMCS cost
Estimated cost for Pre-construction phase: Included in the recurrent cost, PMCS cost.						
B. CONSTRUCTION PHASE						

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
Construction site good practice	Air quality	Dust & suspended particles in air, and gas emissions/fumes	• The spraying of water at borrow pits, construction sites and material handling areas where fugitive dust is generated. • Ensuring dust suppression systems are included in asphalt and concrete batching facilities, and that they are located at least 500 m downwind from the nearest receptors. • Covering trucks to encapsulate dry construction materials. • Ensuring that vehicles and machinery are maintained to a high standard to minimize emissions. • Ensuring suitable advanced notice is provided for pipeline and other excavation works. • Ensuring that formal and informal waste workers at the dumpsites, and receptors within 500 m of these facilities, are suitably informed in advance when these activities are planned. • Ensuring that appropriate environmental and occupational health and safety provisions are followed during the disturbance and movement of solid waste at the dumpsites, to be defined during the final designs of the dumpsite closure and remediation plans.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
	Noise and vibration	Operation/movement of construction vehicles/ equipment, drilling, excavations	• Utilizing low-noise, well maintained vehicles and equipment, and ensuring that exhaust systems are in good working order. • Establishing noise barriers such as temporary fences around active work areas, and barriers to be as close to the source or to the receptor location as possible. • Installing sound-absorbing enclosures around generators and other equipment. • Restricting heavy and noisy machinery operations to between 8am-5pm. • Providing construction workers with and enforcing the use of personnel protective equipment (PPE). • Enforcing the non-use of vehicle horns unless absolutely necessary. • Maintaining close coordination with affected persons and communities, to ensure that advanced warning is provided, considerations are given, and the GRM widely understood so that grievances and complaints are handled expeditiously. • Monitoring noise levels, particularly of nearby sensitive receptors.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
	Surface Water		<u>For WWTP, controlled landfill, closure of dumpsite works:</u> • Adequate management of sediments, soils, stockpiles and aggregate materials utilized in facility construction. ○ Use of sediment detention basins, silt fences, sediment sandbag barriers, along main surface drainage routes and around stockpiles of excavated soils and natural aggregates.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
			○ Prohibit stockpiling of excavated materials, spoils and natural aggregates on the riverside (where water body is in the area of influence). Stockpiles/storage of construction materials should be located sufficiently away from water bodies (not less than 50 m away) and main surface drainage routes; and installed with effective diversion drains. ○ Avoid excavation in the rainy season, as practicable. ○ Stockpile natural construction aggregates only in amounts necessary for the short-term. ○ Dispose of residual soils/spoils promptly and properly if no longer reusable. • Monitoring of upgradient and downgradient surface water quality. • Have adequate sanitation facilities at active work sites • Management of solid and hazardous wastes. ○ Provide adequate storage facilities for solid wastes. ○ Enforce proper sorting and disposal of solid wastes. ○ Separate storage for hazardous and non-hazardous wastes ○ Ensure hazardous substances and wastes have safe storage that can contain spillage, raised at least 1 foot (or higher as may be advised during detailed design) above ground & sited at areas not vulnerable to water impoundment. ○ Manage the amount of hazardous substances brought on site, ensuring not more than what would be needed in two weeks are brought to or stored on site. ○ Protect storage areas for solid wastes and hazardous materials and wastes from stormwater, placed under a shed as much as possible, with peripheral channels to lead runoffs away from the storage area. ○ Dispose of wastes regularly. ○ Link with junkshops and itinerant buyers of recyclables for reusable and recyclable materials. • For works close to or at riverbanks ○ Install filters on pumps. ○ Minimize riparian vegetation removals. ○ Install effective erosion and sediment controls, e.g., sediment fence supplemented with sandbag barriers – prior to start of construction ○ soil stripping should be done in the dry season ○ Use designated refueling areas away from rivers. ○ Ensure site and all areas to waterbody are stabilized prior to removal of erosion and sediment control measures following construction. ○ Reporting of wildlife and rare animal species sightings, and prohibition of			

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
			poaching. o Avoid damage and removal of vegetation beyond component footprints. Physically mark the limits of construction footprints, including work easements, and ensuring limits ae observed. Replant and reinstate disturbed areas, as possible. o For works at the edge of or on the lagoon, apart from waste, wastewater, materials and sediment management - Ensure the temporary earth berm (an integral component of site preparation for lagoon works) is constructed well, not eroding, especially during heavy rains and is properly maintained during its service life to effectively serve the purpose and mitigate impacts on the lagoon. • - Pump out the water in the confined space created by the berm by a vacuum truck for reuse in construction washing or in agricultural lands close by or in watering plants along the streets, as appropriate.			
			<u>For combined sewer works:</u> • Minimizing riparian vegetation removals. • Installation of erosion and sediment controls prior to construction commencement.1 • Limiting soil stripping to the dry season. • Ensuring workers observe proper sanitation and good hygiene. • Ensuring where possible works close to the river are conducted in the dry season. • Ensuring the management of hazardous materials, and the containment of spills. • Ensuring that sites close to waterbodies are stabilized prior to the removal of erosion and sediment control measures following construction. • Monitoring water quality during and after construction.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
	Wastewater.		• Maintaining sanitation facilities onsite and at workers' campsites. • Strictly enforcing hygiene and sanitation practices. • Incorporating sediment controls, silt traps and wastewater collection. • Maintaining equipment washdown areas, complete with sediment control devices. • Providing retention control for material stockpile areas. • Designating specific areas for repair and maintenance. • Ensuring regular wastewater collection by a recognized service provider. • Ensuring wastewater from boring and excavation works is properly managed	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract

[1] For example, sediment control fences supplemented with sandbag barriers.

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
			and disposed of.			
	Groundwater.	Improper sealing of boreholes after completion of construction	• Include of detailed borehole construction specifications in the contractor's overall method statements for the drilling works to assure correct borehole construction.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
	Biodiversity	Fauna, Flora and Potential Habitat Loss	• Further site assessment, including site specific ecological surveys, be conducted at the final design stage to identify, evaluate and where necessary mitigate ecological impacts caused by the siting of these facilities.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
	Damage to items of cultural/ historical / archaeological significance	Potential chance find of items of cultural/historical/ archaeological significance	<u>For WWTP, controlled landfill works, closure of dumpsite works:</u> • In case of chance find, stop construction work and make a declaration to the local police, who shall transmit the declaration to the Provincial Governor.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
		Religious structures within the area of influence	<u>For combined sewer works:</u> • Coordinate with concerned village leader and temple/church authorities for the measures to protect temple/church structure and parts along the road.			
	Community health and safety	Communities exposed to health and safety hazards	• Access restrictions: o Manage material stockpiles to prevent blockages. o Provide access restriction information in advance. o Ensure vehicles park at previously agreed locations. o Provide temporary, alternative access where possible. • Localized flooding: o Divert main surface drainage routes when obstructions are unavoidable. o Dispose of spoils and debris promptly. • Utility service disruptions: o Repair service disruptions expeditiously. o Provide alternative power and water supplies. • Worker social conflicts: o Prioritize local employment. o Provide health and safety training. o Ensure informal waste pickers made aware of construction activities and potential risks are managed.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
	Traffic		• Developing traffic management schemes in conjunction with local traffic authorities and affected community leaders. • Scheduling materials delivery and other traffic-causing activities outside of peak hours. • Assigning traffic staff during periods of peak disruption and peak hours. • Ensuring stockpiles and construction equipment and vehicles least impede traffic flow.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
			• Providing adequate prior information on road and lane closures, and traffic diversions. • Providing safe access to pedestrians, motorbikes and bicycles. • Ensuring affected persons are aware of the GRM. • Ensuring contractors repair damages at their expense.			
	Construction workers' health and safety – risks	air emissions, noise and vibration, construction wastes and wastewater, hazardous substances, potential social conflicts with surrounding communities, potential communicable and transmittable diseases in the community, chance finds of unexploded ordnances (UXO), large moving and operating construction vehicles and equipment pits and excavations	• Contractor compliance with environmental and occupational health and safety guidelines. • Contractor's CEMPs will include health and safety plans. • Provision of personal protective equipment (PPE) for workers. • Adequate work site lighting, water supply, sanitation facilities and safe access • Establishment of a first-response team comprising of trained staff, equipment, tools, supplies, and an adequate office/clinic. The first response team will be linked to ultimate responders. • Appointment of an Environmental, Health and Safety Officer.	Contractor	PIU, PMU, PMCS-ES	Included in Contractor's Contract
Estimated cost for Construction phase: Included in Contractor's Contract						
C. OPERATION PHASE						
Preparing for operation	Air quality	Landfill gas, odor	• The landfill is receiving less than 100 tons of waste per day therefore will be a relatively small landfill gas producer, the immediate approach is for passive release of gas through minor cracks in the soil cover. • As the landfill develops, the type of landfill gas management system will be decided, e.g., vertical gravel wicks that can be retrofitted once the landfill is near capacity. • Odor from WWTP and closed dumpsites • Application of soil cover • Berms and tree line	Operator	MPWT	Included in the Operator's budget
	Surface water quality	Water contamination from CSOs	• Specify maintenance procedures in the WWTP operations manual. • Ensure adequate budget and equipment for routine maintenance activities. • Remove flow obstructions in the sewer system prior to the onset of the rainy season to maximize the use of the network and the flow to the WWTP. • Conduct operator training for WWTP operations and maintenance (O&M) • Monitor water quality of the overflow-receiving water bodies following an	Operator	MPWT	Included in the Operator's budget

Item	Impact Factor	Potential impact, concerns and/or Issues	Mitigation Measures	Implementing Entity	Supervising Entity	Source of funds
			overflow event.			
	Vadose zone & groundwater	Leachate contamination due to failure in the integrity of WWTP liner, CSS, controlled landfill liner and leachate collection system	• Provision of surface cover systems for controlled landfills and closed dumpsites. • Provision of liner and leachate collection system for controlled landfills. • Provision of liners for WWTP ponds. • Strengthened O&M procedures, which are supported by training in monitoring and evaluation	Operator	MPWT	Included in the Operator's budget
	Water logging in WWTP sites	Flooding of adjacent communities	• Identify flood risk areas along with evacuation sites and routes • Implement the emergency response plan in case of flooding that includes a community-based flood warning system and information dissemination	Operator	MPWT	Included in Operator's budget
	Effluent quality	Discharge of effluent above the prescribed standards	• Monitor the quality of resulting effluent on a monthly basis to check compliance with the prescribed discharge standards. • Report the results of monitoring to the PMU	Operator	MPWT	Included in Operator's budget
	Sludge from the WWTPs	Disposal of sludge	• Implement sludge management through sludge drying and landfilling • Analyze the bacterial content during the first two years of operation to check if appropriate for application to agricultural land.	Operator	MPWT	Included in Operator's budget
	Health and safety		• Community outreach initiatives, such as consultations, meetings and information campaigns. • Preparation of an operations manual for combined sewers, WWTP and controlled landfills that shall include an occupational health and safety plan (OHSP).	Operator	MPWT	Included in the Operator's budget

IV. ENVIRONMENTAL MONITORING AND REPORTING

A. Environmental Monitoring

18. Environmental monitoring will consist of:

(i) Subproject readiness monitoring, to be implemented by the PMU, with technical assistance from the PMCS-ES.
(ii) Environmental effects monitoring, to be undertaken by a licensed institute engaged by the PMU.
(iii) EMP compliance monitoring or verification, to be undertaken by the PMU and PIU, with technical assistance from the PMCS-ES.

19. ADB will oversee project compliance on the basis of the annual environmental monitoring reports provided by the project management office, and site visits (generally once or twice a year). Monitoring and reporting arrangements for this project are described below.

20. **Project readiness monitoring.** Prior to construction, the PMCS will assess the Project's environmental management readiness based on the indicators presented in Table 3 and report the findings to ADB and the PMU. This assessment will confirm that environmental commitments are being carried out and environmental management systems are in place prior to construction commencement, or recommend corrective actions to ensure that all requirements will be met.

Table 3: Project Readiness Assessment Indicators

Indicator	Criteria	Assessment	
Compliance with loan covenants	• Borrower has complied with loan covenants relative to detailed design and environmental	Yes	No
EMP update	• EMP updated after approval by ADB of detailed designs and environmental management.	Yes	No
HHs affected by land or ROW acquisition	• Affected HHs compensated at the latest one month prior to construction mobilization.	Yes	No
MOE approval	• Secured at the latest one month prior to contract award.	Yes	No
Mine/UXO clearance	• Secured at the latest one month prior to contract ward.	Yes	No
CEMP cleared	•	Yes	No
Contractors' needed pre-construction coordination	• Contractor has coordinated with proper authorities on: - Waste and wastewater disposal - Steps to take in case of discovery of items of cultural/historical significance - Steps to take in case of discovery of UXO/mine - Religious items of temples exposed to risk of accidental damaged during construction - Traffic management	 Yes Yes Yes Yes Yes	 No No No No No
PMU/PIU prepared	• PMU ESO recruited. • PIU environmental focal point appointed • PMU and PIU oriented on the IEE/EMP • Monitoring and reporting systems in place.	Yes	No
Relevant communities preparation	• Meaningful consultations completed. • GRM established with entry points formally at commune, district, PIU, PMU and informally, contractor and operator. • Posters on health and safety strategically assigned. • Posters on GRM assigned at PMU, PIU, commune and district offices) • Posters and billboards with subproject details and contact numbers assigned/installed.	Yes	No

Indicator	Criteria	Assessment	
Waste haulers and waste pickers prepared	• Decision on waste picking activities during construction during detailed design stage to inform design for physical measures for safety of waste haulers and, if applicable, waste pickers. • Orientation on these groups regarding health and safety measures during construction completed.	Yes	No
Construction workers prepared	• Orientation of workers on health and safety and CEMP completed. • Environmental management officer to oversee CEMP implementation and reporting in place.	Yes	No
Bidding documents and contracts with environmental safeguards	• Bidding documents and contracts incorporating the environmental activities and safeguards listed as loan assurances • Bidding documents and contracts incorporating the environmental contract clauses.	Yes	No
EMP financial support	• Funds for EMP implementation has been set aside.	Yes	No

21. Environmental effects monitoring will be undertaken by a licensed institute engaged by the PMU. It will include the following:

For the controlled landfill:

a) Baseline: ambient air quality, noise, surface water quality, groundwater quality, soil quality during pre-construction
b) Semi-annually: ambient air quality, noise, surface water quality and groundwater quality during construction.
c) Semi-annually: ambient air quality, groundwater quality, and leachate/effluent quality during operation.
d) Annually: surface water quality, landfill gas, and soil quality during operation.

For the closure of existing dumpsites:

a) Baseline: ambient air quality, noise, surface water quality, groundwater quality, soil quality and leachate during pre-construction
b) Semi-annually: ambient air quality, noise, surface water quality and groundwater quality during construction.
c) Post-closure: ambient air quality, groundwater quality, landfill gas, leachate, surface water quality and soil quality.

For the WWTPs and combined sewer network:

a) Baseline: surface water quality, groundwater quality, hydrology[2] and ecological survey during pre-construction
b) Semi-annually: ambient air quality, noise, and surface water quality during construction.
c) Semi-annually: effluent quality, surface water quality, groundwater quality, soil quality, and hydrology[3] during operation.

22. Environmental effects and quality monitoring results will be evaluated against both the national and international standards shown in Table 4. The more stringent limits will apply (reference: Appendix C of the IEE). In the event that preconstruction levels or pre-operation levels of certain parameters have exceeded standard levels, the target results should be not exceeding

[2] Evaluate hydrological flow regimes at receiving waterbodies, intended water uses and presence of sensitive receptors relying on the water bodies
[3] Evaluate changes in hydrological flow regimes at receiving waterbodies, flood/water logging instances and conditions

pre-construction or pre-operation levels. Performance will therefore be assessed on the exceedance over the stringent standard levels, or the pre-construction/pre-operation levels if these have exceeded standard levels.

Table 4: Key Standards to Apply in the EMP

Particular	National Standard	International Standards[4]
Ambient air quality	Annex 1, Ambient Air Quality Standard, of Sub-decree on Control of Air Pollution and Noise Disturbance, 2000	WHO Air Quality Guidelines, global update 2005
Noise	Annex 6, Max. Standard of Noise Level Allowable in the Public and Residential Areas, of Sub-decree on Control of Air Pollution and Noise Disturbance, 2000	WHO Guidelines for Community Noise, 1999
Groundwater quality	Drinking water Quality Standards, 2004	WHO Guidelines for Drinking-water Quality, Fourth Edition, 2011
Surface water quality	Annex 4, Water Quality Standards for Public Waters for the Purpose of Biodiversity Conservation, and Annex 5, Water Quality Standards for Public Waters and Health, of Sub-decree on Water Pollution Control, 1999	US EPA National Recommended Water Quality Criteria MRC Technical Guidelines for the Protection of Aquatic Life MRC Technical guidelines for the Protection of Human Health
Effluent quality (from landfill & WWTP)	Annex 2, Effluent standard (Discharged wastewater to public water areas or sewers), of Sub-decree on Water Pollution Control, 1999	EHS General Guidelines and Guidelines for Water and Sanitation
Soil Quality[5]	-	Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health[2]

23. EMP compliance during construction will be verified by the PMU-ESO, with support from the PIU and PMCS-ESs. The PMU will report on environmental safeguard performance of the contractors and their environmental compliance through the quarterly Project progress reports, and the semi-annual environmental monitoring reports. The PMU will monitor environmental compliance during operations until loan closure or as agreed.

24. The environmental monitoring plan is presented as Table 5.

B. Reporting

25. Environmental monitoring activities and findings shall be documented for purposes of reporting, recording, verifying, referring on and evaluating the environmental performance of the Project. The documentation shall also be used as a basis to correct and enhance further environmental mitigation and monitoring. A suggested outline for the environmental monitoring report is presented as Annex B.

26. Environmental monitoring reports will be prepared as follows:

(i) Monthly: by contractors during construction, submitted to the PMU.
(ii) Quarterly: a progress report, prepared by the PMU for submission to ADB, which will cover safeguard matters.
(iii) Semi-annually: a safeguards report prepared by the PMU for submission to ADB.

[4] Featured or recommended in the Environmental, Health, and Safety Guidelines. IFC. WBG. April 30, 2007.
[5] As a national standard for soil quality has not been identified, it is recommended soil quality results be evaluated against the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (Agriculture).

(iv) Semi-annually: by the PMU during operation until loan closure or as agreed, to be submitted to the ADB.

Table 5: Environmental Monitoring Plan for Each Subproject

A. Environmental Effects Monitoring *

Monitoring Location	Item	Monitoring Parameter	Monitoring Frequency & Duration	Implementing Entity	Estimated Cost		
					Kampong Cham	Kratie	Stung Treng
LAGOON-BASED WASTEWATER TREATMENT SYSTEM							
Pre-Construction Phase							
WWTP receiving waterbody							
○ At two locations, i.e. upstream and downstream	Surface water quality	See A below	Once	Licensed Lab (for PMU)	2,400	2,400	2,400
○ At two locations, one upgradient and one downgradient	Groundwater quality	See B below	Once	Licensed Lab (for PMU)	2,000	2,000	2,000
○ At receiving waterbody and surrounding areas	Hydrological survey		Once	PMU, PMCS-ES	c/o PMSC cost	c/o PMSC cost	c/o PMSC cost
○ At proposed WWTP site	Ecological survey		Once	PMU, PMCS-ES	c/o PMSC cost	c/o PMSC cost	c/o PMSC cost
Sub-total – WWTP receiving waterbodies					**4,400**	**4,400**	**4,400**
Construction Phase **Combined sewer** ○ At three locations in the area of influence (one in the mid, one in the northern fringe and one in the south fringe)	Air quality	See F below	Semi-annual	Licensed Lab (for PMU)	3,570	3,570	3,570
○ At five locations in the area of influence (one in the mid, one each in the northern, southern, eastern, and western fringes of the site)	Noise	L_{Aeq}	Semi-annual		500	500	500
○ 2 locations, one upstream and one downstream	Surface water quality	See A below.	Semi-annual		4,800	4,800	4,800
Sub-total – combined sewer					**8,870**	**8,870**	**8,870**
WWTP ○ At two locations, one in the community NW of the site,	Air quality	See F below	Semi-annual	Licensed Lab (for PMU)	2,380	2,380	2,380

Monitoring Location	Item	Monitoring Parameter	Monitoring Frequency & Duration	Implementing Entity	Estimated Cost		
					Kampong Cham	Kratie	Stung Treng
and one at WWTP site							
○ At five locations, four stations in the periphery of the site and one at WWTP site	Noise	L_{Aeq}	Quarterly		500	500	500
○ At two locations (upstream and downstream)	Surface water quality	See A below.	Semi-annual		4,800[6]	4,800[7]	4,800
				Sub-total – WWTP	**7,680**	**7,680**	**7,680**
				Total Construction	**16,550**	**16,550**	**16,550**
Operation Phase WWTP							
○ Upstream and downstream of receiving waterbody	Surface water quality	See A below.	Semi-annually	Licensed Lab (for PMU)	9,600[8]	4,800	4,800
○ One upgradient, two downgradient	Groundwater quality	See B below.	Semi-annually		4,000	4,000	4,000
○ One upgradient, two downgradient	Soil quality	See C below.	Semi-annually		3,600	3,600	3,600
○ Final effluent discharge	Effluent	See D below.	Semi-annually		2,000	2,000	2,000
○ At receiving waterbody and surrounding areas	Hydrological survey		Once	PMU, PMCS-ES	c/o PMSC cost	c/o PMSC cost	c/o PMSC cost
				Total Operation (annually)	**19,200**	**14,400**	**14,400**
CONTROLLED LANDFILL							
Pre-Construction Phase							
○ At two locations, one close to the work site, one at access road	Air quality	See F below	Once	Licensed Lab (for PMU)	1,190	1,190	1,190
○ At two locations, one at the nearest residence north of the site ; and one at the nearest building of the Regional National Police School in the east.	Noise	L_{Aeq}	Once		100	100	100
○ One upstream and one downstream (in	Surface water quality	See A below	Once	Licensed Lab (for PMU)	2,400	2,400	2,400

[6] Surface water quality sampling in Kampong Cham will be at two locations (upstream and downstream) of two streams.
[7] Surface water quality sampling in Kratie will be at two locations (upstream and downstream) of the lagoon.
[8] Same sampling location as footnote 6

Monitoring Location	Item	Monitoring Parameter	Monitoring Frequency & Duration	Implementing Entity	Estimated Cost		
					Kampong Cham	Kratie	Stung Treng
the rainy season when stream has water)							
○ At two locations, one upgradient and one downgradient	Groundwater quality	See B below	Once		2,000	2,000	2,000
○ At three locations at controlled landfill : one upgradient and two downgradient	Soil quality		Once		1,800	1,800	1,800
○ At controlled landfill site	Ecological survey		Once	PMU, PMCS-ES	c/o PMSC cost	c/o PMSC cost	c/o PMSC cost
				Total - Pre-Construction	**7,490**	**7,490**	**7,490**
Construction Phase							
○ At two locations, one close to the work site, one at access road	Air quality	See F below	Semi-annual	Licensed Lab (for PMU)	2,380	2,380	2,380
○ At two locations at nearest sensitive receptors and one at site	Noise	L_{Aeq}	Semi-annual		200[9]	200	200
○ One upstream and one downstream (in the rainy season when stream has water)	Surface water quality	See A below	Annual		2,400	2,400	2,400
○ At three locations: one upgradient and two downgradient	Groundwater quality	See B below	Semi-annual		6,000	6,000	6,000
				Total Construction	**10,980**	**10,980**	**10.980**
Operation Phase							
○ Three, one at active waste cell, and two at nearest residences / sensitive receptors	Air quality	See F below	Semi-annually	Licensed Lab (for PMU)	3,570	3,570	3,570
○ One upgradient, 2 downgradient	Groundwater quality	See B below.	Semi-annually		6,000	6,000	6,000
○ One upstream and one downstream (in	Surface water quality	See A below	Annually		2,400	2,400	2,400

[9] Noise sampling will be at two locations: (i) nearest residence north of site and (ii) nearest building of the Regional National Police School in the east

Monitoring Location	Item	Monitoring Parameter	Monitoring Frequency & Duration	Implementing Entity	Estimated Cost		
					Kampong Cham	Kratie	Stung Treng
the rainy season when stream has water)							
○ One upgradient, 2 downgradient	Soil quality	See C below.	Annually		1,800	1,800	1,800
○ At sump at lower end of the waste cell (where leachate gathers at pump area)	Leachate	See E below	Semi-annually		2,000	2,000	2,000
○ One at middle of waste cell	Landfill gas	See F below	Annually		595	595	595
			Total Operation (annually)		**16,365**	**16,365**	**16,365**
CLOSURE OF EXISTING DUMPSITES							
Pre-Construction Phase							
○ At two locations, one close to the work site, one at access road	Air quality	See F below	Once	Licensed Lab (for PMU)	-	1,190	1,190
○ At two locations, one at the nearest residence of the site and one near the entrance to dumpsite	Noise	L_{Aeq}	Once		-	100	100
○ One upstream and one downstream (in the rainy season when stream has water)	Surface water quality	See A below	Once		-	2,400	2,400
○ At three locations, one upgradient and one downgradient	Groundwater quality	See B below	Once		-	2,400	2,400
○ At two locations at dumpsite	Soil quality		Once		-	1,200	1,200
○ At three locations : one at center of site and two at at downgradient	Leachate	See E below	Once		-	3,000	3,000
			Total - Pre-Construction		**-**	**10,890**	**10,890**
Construction Phase							
○ At two locations, one close to the work site, one at access road	Air quality	See F below	Semi-annual	Licensed Lab (for PMU)	-	2,380	2,380
○ At two locations, one at the nearest residence to the site and one near	Noise	L_{Aeq}	Semi-annual		-	200	200

Monitoring Location	Item	Monitoring Parameter	Monitoring Frequency & Duration	Implementing Entity	Estimated Cost		
					Kampong Cham	Kratie	Stung Treng
the entrance to the dumpsite							
o One upstream and one downstream	Surface water quality	See A below	Semi-annual		-	4,800	4,800
o One upgradient and one downgradient	Groundwater quality	See B below	Semi-annual		-	6,000	6,000
				Total Construction	**-**	**13,380**	**13,380**
Post-Closure Phase[10]							
o At two locations, one close to the center of site, one at access road-	Air quality	See F below	Once	Licensed Lab (for PMU)	-	1,190	1,190
o One at center of site	Landfill gas	See F below	Once	Licensed Lab (for PMU)	-	595	595
o One upgradient, 2 downgradient	Groundwater quality	See B below.	Once		-	3,000	3,000
o One upgradient, 2 downgradient	Soil quality	See C below.	Once		-	1,800	1,800
o At three locations : one at center of site and two at downgradient	Leachate	See E below	Once		-	3,000	3,000
o One upstream and one downstream station	Surface water quality	See E below	Once		-	4,800	4,800
				Total Post-Closure	**-**	**14,385**	**14,385**

* **Results should not exceed: (i) standard levels, if the pre-construction or pre-operation levels are equal or below standard levels; or (II) pre-construction or pre-operation levels, if the pre-construction or pre-operation levels have exceeded standard levels.**

Suggested parameters to monitor.

A. Surface water quality – pH, BOD, SS, DO, Faecal Coliform, Total Coliform, Temperature, Total NO2+NO3, Total P, COD, NH3 as N, As, Cd, Pb, CN, Total Hg, Se, Cr+6, oil & grease, phenol, total organochlorine pesticide. These includes all the parameters for the protection of human health and aquatic life in the MRC Technical Guidelines for the Implementation of Water Quality, approved in the Meeting of the MRC Council on 22 November 2016, in Pakse, Lao DR. Added a few parameters from the national standards for biodiversity conservation and for public health.

B. Groundwater quality – Faecal coliform, e-coli, total coliform, As, Cd, Cr+6, Cr-3, CN, F Pb, Hg, Ni, NO2, NO3, odor, color, turbidity, conductivity, pH, temperature, TDS, hardness, Cu, Cl, Fe, Mn, SO4, Zn, Al, H2S. Selected from the National Drinking Water Quality Standards 2004.

C. Soil quality – pH, As, Cu, Zn, Cr, Pb, Hg, Fe, Cd, electrical conductivity, WHC, soil moisture, Cl, alkalinity, K, Na, Organic C, organic matter, Ca, Ng, NO3, soil salinity.

D. Effluent (WWTP) – TDS, electrical conductivity, temperature, color, hardness, COD, BOD, TSS, pH, PO4, K, Chlorides, DO, NO3, SO4, Mg, Ca, Na, Carbonate, Faecal coliform, Eoli.

E. Recirculated leachate – Temperature, color, odor, turbidity, pH, conductivity, COD, BOD, TSS, Total organic carbon, TVS, TDS, ammonia-N, PO4, Chloride, faecal coliform, phenols, SO4, NO3, Ca, Mg As, CN, Pb, Cu, Ni, Cr, Zn, Cd, Mn, Hg, grease oil, Fe, DO.

F. Ambient air quality and Landfill gas – CO, NO_2, SO_2, $PM_{2.5}$, O_3, Pb, Ch_4

[10] Applicable to closure of existing dumpsites in Kratie and Stung Treng.

V. CAPACITY DEVELOPMENT

26. **Initial capacity assessment.** Each government ministry has a Social and Environment Office (SEO) to manage environment and social aspects of foreign-funded projects. The MPWT has a SEO to manage environment and social aspects of foreign-funded projects. From discussions, it has been agreed that the SEO will support the PMUs in reviewing environmental reports and be invited to join training activities and field visits during Project implementation.

27. Discussions have been held with senior DPWT representatives in the three towns to assess the capacity of the PIUs in project environmental management.[11] At that stage, the PIUs had not been established, and they do not have environmental management units or assigned staff that are responsible for environmental matters or requirements. The officials emphasized the need for capacity building and technical support during subproject implementation. Identified priority needs include (i) knowledge of the country's safeguard system and ADB's Safeguard Policy Statement, (ii) familiarization with IEEs, EMPs and associated CEMPs, (iii) monitoring and reporting, and (iv) information management. Preferred capacity development methods include hands-on training, field visits, the exchange of experiences with other GMS-CTDP-4 towns, lectures/seminars, and opportunities to attend short courses.

28. Based on experience of other projects in Cambodia, the PMU and PIU will not assign adequate or suitably qualified staff resources to project implementation. The loan will finance recruitment of a qualified person to be assigned as PMU-ESO to work with the municipal officers in Kampong Cham, Kratie, and Stung Treng to support implementation of the EMP in coordination with the PMU and the PMCS. The PMU-ESO will work with the provincial/municipal and sub-municipal administrative levels, community-based organizations (CBO), local business community, and residents to ensure that the project impacts are managed in line with the EMP, and if unidentified impacts are found, the EMP will be updated.

29. **Capacity development under the Environmental Specialists (ESs) of the PMCS.** The PMSC ES will provide "hands-on" training for the PMU ESO and PIU environmental focal points. Among the responsibilities specified in the outline terms of reference for the Environmental Specialists of the PMCS, the following relate to capacity development: (Appendix D)

- Provide close technical supervision and guidance to PMU ESO and PIU environmental focal points.
- At the onset of DED, and in collaboration with the MOE/DOE, conduct an orientation regarding the environmental requirements of the Royal Government of Cambodia, SPS 2009, and the ADB-cleared draft EMP to the PMU, PIUs and, if any, environment specialists of the Design Consultant.
- Finalize the training needs.
- In collaboration with the PMU and PIUs, develop training plans for incorporation in the overall capacity building program of the Project.
- Present the ECA findings/report to the PMU and PIU. The participation of the PIU in site investigations and consultations during the conduct of environmental compliance audits will be encouraged for learning purposes.

30. **Capacity Building Program.** The proposed *Activity 3: Project Management of the Draft Capacity Building Program* will prepare the PIUs to assume their responsibilities to support the

[11] The representatives include the Administration Chief of the Kampong Cham DPWT, Deputy Director of DPWT of Kratie, and the Director of DPWT of Stung Treng. These consultations were held in August 2017.

PMU and provide other relevant agencies an understanding of the basic principles of project management, including social and environmental safeguards, through training sessions and local workshops. Target participants include the PMU, PIUs, nominated staff from Provincial and Municipal Governors offices, provincial and municipal procurement committee members, and other relevant staff of DPWTs, DOEs, DOWRAMs, DLMCUP, DEF, DPI, DIH (waterworks).

31. The topics recommended for Activity 3 through the training sessions, lectures and/or workshops include (i) those relevant to the environmental management responsibilities of the PMU and PIUs under the Project, such as the EMP requirements, monitoring and reporting, carrying out consultations, and GRM, and (ii) those that the interviewed officers have expressed their interests in, such as climate change, climate risks/vulnerabilities/resilience, disaster risk management, project environmental management, best practices in mitigating environmental impacts during construction and during operation and climate change adaptation for infrastructure. The active participation of the PMU and PIU in the conduct of the environmental compliance audits of the existing dumpsites by the PMCS-ES would also be a hands-on training opportunity.

32. Funds for seminars, workshops and training are allocated under the PMCS cost.

Table 6: Capacity Building Plan

Training	Attendees	Contents	Time	Days	Persons	Unit Cost/ person	Total Cost
Orientation Training	PMU, PIUs, contractors, DOE, DWPT, District, Province	Cambodia's environmental safeguard system, ADB SPS EMP (mitigation measures, monitoring measures, roles and responsibilities, reporting, GRM, carrying out consultations)	Pre-construction	1	25	LS	* 1,500 (held in 1 town)
Assessment after one year	PMU, PIUs, contractors, DOE, DWPT, District, Province	An evaluation of the 1st year of environmental management – sharing of the three towns.	One year after start of construction	1	25	LS	1,500 (held in 1 town)
Project environmental management	PMU, PIUs, contractors, DOE, DWPT, District, Province	Environmental management practices in improvement and maintenance of basic urban services (drainage, wwtp, solid waste management) Sharing of experiences with other GMS projects (as suggested by 2 towns.)		1	25	LS	1,500 (held in 1 town)
Climate change and risks, adaptation and disaster management	PMU, PIUs, contractors, DOE, DWPT, District, Province	Relative to infrastructure (suggested by one of the towns).	2nd year	1	25	LS	1,500 (held in 1 town)
1 other seminar	PMU, PIUs, contractors, DOE, DWPT, District, Province	For suggested topic by PMU and PIUs later.			25 (PNH)	LS	4,000 (held in Phnom Penh)
							10,000
						Engagement of a total of 6 invited lecturers, all national	1,800
						TOTAL	11,800

Notes: Lump sum (LS) estimate: (i) USD1,500 for a workshop/seminar held in the town, 25 participants; and (ii) USD4,000 for a workshop in the capital city, 25 persons.

VI. PUBLIC CONSULTATIONS

33. Public participation and consultation will be an essential process in project preparation and that this will continue through to subproject implementation and operation. As shown on Table 7, this will include:

(i) Pre-construction: discussions on (i) subproject environmental benefits, positive impacts and results, (ii) anticipated impacts and health and safety hazards during construction, (iii) grievance redress mechanism, (iv) opportunity for participating in monitoring. and (v) subproject contact details.

(ii) Construction and operations: discussions and soliciting feedback on (i) environmental impacts and the effectiveness of mitigation measures implemented by the contractors and operators, and (ii) the efficiency of the GRM.

Table 7: Public Consultation Plan

A. Kampong Cham

Organizer	Format	No. of Times	Subject	Attendees	Budget
Prior construction PMU	Public consultation	1 time, prior to mobilization	Environmental impacts during construction, health and safety risks, GRM, persons to contact in case of concerns, among others	Residents in the immediate influence areas of components	$300
During construction PMU	Public consultation	1st and 2nd years of construction	Solicit feedback on environmental impacts and mitigation measures implemented by contractors	Residents in the immediate influence areas of components	$600
During operation PMU	Public consultation	Once each in the 1st, 3rd and 5th year	Solicit feedback on environmental impacts and mitigation measures implemented by operators	Residents in the immediate influence areas of components	$900
				Sub-Total	$1,800
				10% contingency	$180
				Total	$1,980

Notes: unit cost of snack is estimated at $1.88/participant; 160 estimated participants in Kampong Cham; and consultations are estimated at: prior construction – 1, during construction – 2, and during operation – 3.

B. Kratie

Organizer	Format	No. of Times	Subject	Attendees	Budget
Prior construction PMU	Public consultation	1 time, prior to mobilization	Environmental impacts during construction, health and safety risks, GRM, persons to contact in case of concerns, among others	Residents in the immediate influence areas of components	$244
During construction PMU	Public consultation	1st and 2nd years of construction	Solicit feedback on environmental impacts and mitigation measures implemented by contractors	Residents in the immediate influence areas of components	$488
During operation PMU	Public consultation	Once each in the 1st, 3rd and 5th year	Solicit feedback on environmental impacts and mitigation measures implemented by operators	Residents in the immediate influence areas of components	$731
				Sub-Total	$1,463
				10% contingency	$146
				Total	$1,609

Notes: unit cost of snack is estimated at $1.88/participant; 130 estimated participants in Kratie; and consultations are estimated at: prior construction – 1, during construction – 2, and during operation – 3.

C. Stung Treng

Organizer	Format	No. of Times	Subject	Attendees	Budget
Prior construction PMU	Public consultation	1 time, prior to mobilization	Environmental impacts during construction, health and safety risks, GRM, persons to contact in case of concerns, among others	Residents in the immediate influence areas of components	$225
During construction					
PMU	Public consultation	1st and 2nd years of construction	Solicit feedback on environmental impacts and mitigation measures	Residents in the immediate influence areas of components	$450

			implemented by contractors		
During operation PMU	Public consultation	Once each in the 1st, 3rd and 5th year	Solicit feedback on environmental impacts and mitigation measures implemented by operators	Residents in the immediate influence areas of components	$675
				Sub-Total	$1,350
				10% contingency	$135
				Total	$1,485

Notes: unit cost of snack is estimated at $1.88/participant; 120 estimated participants in Stung Treng; and consultations are estimated at: prior construction – 1, during construction – 2, and during operation – 3.

VII. PRELIMINARY COST

36. The preliminary costs for EMP implementation are estimated to include:

- USD 685,644 of fixed costs.
- USD 97,095 annually for environmental monitoring during operation.
- USD 28,770 annually for post-closure environmental monitoring of the dumpsites in Stung Treng and Kratie.

37. The estimated costs exclude: (i) taxes and inflation, (ii) salaries of the environmental focal points of the PIUs assuming existing DPWT staff will be appointed, (iii) costs for securing mine and unexploded ordnance clearances, and (iv) travel and out-of-pocket expenses of the international and national PMCS environmental specialists.

Table 8: Preliminary Cost for EMP Implementation

EMP Item	Estimated Cost		
	Fixed Cost	Annual Cost	Fund source
Environmental mitigation *			
Environmental effects monitoring			
A. Kampong Cham			
Prior to construction	11,890		PMCS cost
During construction	27,530		PMCS cost
During operation **		35,565	Operator's annual budge
B. Kratie			
Prior to construction	22,780		PMCS cost
During construction	40,910		PMCS cost
During operation **		30,765	Operator's annual budget
Post-closure of existing dumpsite	14,385		PMCS cost
C. Stung Treng			
Prior to construction	22,780		PMCS cost
During construction	40,910		PMCS cost

During operation **		30,765	Operator's annual budget
Post-closure of existing dumpsite	14,385		PMCS cost
PMCS Environmental Specialists (fees only)	179,200		PMCS cost
PMU Environmental Safeguard Officer (5years)	144,000		Recurrent cost
Preparation of Borrower IEIAs/EIAs and obtaining MOE approvals.	150,000		PMCS cost
Consultations			
A. Kampong Cham	1,980		PMCS cost
B. Kratie	1,609		PMCS cost
C. Stung Treng	1,485		PMCS cost
Training (inclusive all 3 towns)	11,800		PMCS cost
Total fixed cost	**685,644**		

* During construction, included in the Contractors' contracts; during operation, included in the Operators' annual budgets.

** For an agreed period.

VII. MECHANISM FOR FEEDBACK

38. The EMP will be reviewed when there are changes in design, construction methods and program, unfavorable environmental monitoring results or inappropriate monitoring locations, and ineffective or inadequate mitigation measures. Based on environmental monitoring and reporting systems in place, the PMU, with the technical guidance and support of the PMCS-ES shall assess whether further mitigation measures are required as corrective action, or improvement in environmental management practices are required. The PMU will inform ADB promptly on any changes to the Project and necessary adjustments to the EMP. The updated EMP will be submitted to ADB for review and approval; and will be disclosed on the ADB project website.

VIII. ENVIRONMENTAL CONTRACT CLAUSES

39. The following environmental contract clauses shall be incorporated into tender documents and works contracts.

40. Siting of construction facilities:
- (i) Locations of asphalt/concrete mixing stations shall be at least 300 m downwind of the nearest air quality and noise protection target.
- (ii) Locations of borrow areas shall be at least 300 m from residential areas.
- (iii) Borrow areas and spoil disposal sites with long, steep slopes, susceptible to erosion shall be avoided.

41. Construction time
- (i) There shall be no night time (between 22:00H and 06:00H) construction on new road sections and new bridges.
- (ii) If night time construction is necessary, no noisy equipment shall be used.

42. Protection of air quality
- (i) Watering of access road and stockpiles shall be undertaken at least two times each day during the dry season.
- (ii) Vehicle speed in access road and construction sites shall be limited to 30kph. Speed limit signs shall be posted in these areas.

(iii) Wheel washing equipment shall be installed, or wheel washing shall be conducted manually at each exit of the works area and asphalt/concrete mixing station to prevent trucks from carrying muddy or dusty substances onto public roads.
(iv) Dust prone materials shall be stored in areas with shelters enclosed on four sides and on top. If such materials have to be stored in open area, durable tarpaulin must be used to cover to fully cover the materials.
(v) Vehicles with an open load-carrying case, which transport potentially dust-producing materials, shall have proper fitting sides and tail boards. Dust-prone materials shall not be loaded to a level higher than the side and tail boards and shall always be covered with s strong tarpaulin.
(vi) Unauthorized burning of construction and demolition waste materials and refuse is prohibited and shall be subject to penalties and withholding of payment.
(vii) Asphalt, hot mix and batching plants shall be equipped with fabric filters and/or wet scrubbers to reduce the level of dust emissions.

43. Protection of the acoustic environment
(i) Machinery shall be maintained and repaired regularly and properly to keep them in good working condition and to minimize noise.
(ii) Low noise machinery or equipment with sound insulation shall be deployed when working within 100 m from villages or townships.
(iii) Temporary hoardings or hoardings shall be erected around the equipment to shield the noise from equipment when there are residences, schools, health clinics or mosques within 80 m from the noise source.
(iv) Suitable hearing protection (such as ear muffs) shall be provided to construction workers.
(v) The use of horns is forbidden unless absolutely necessary. The use of whistles shall be minimized.

44. Protection of water quality
(i) Portable toilets and small package wastewater treatment plants shall be provided on construction sites and construction camps for the workers. If there are nearby public sewers, interim storage tanks and pipelines shall be installed to convey wastewater to public sewers. Runoff from construction sites and construction camps shall be collected and treated with drainage provisions.
(ii) Sedimentation tanks shall be installed and operated on construction sites, asphalt /concrete mixing stations and pre-casting yards to treat process water and muddy runoff with high concentrations of suspended solids. If necessary, flocculants such as polyacryl amide (PAM) shall be used to facilitate sedimentation.
(iii) Mitigation measures such as placement of sandbags or berms shall be deployed during construction of river works or works close to rivers and lagoons.
(iv) Storage and fueling facilities for fuels, oil, and other hazardous materials shall be located within secured areas on impermeable surfaces/non-flood prone areas, at least 300 m away from water bodies, raised on platform, and provided with bunds and cleanup kits, roofed and with perimeter stormwater diversion drains.
(v) Material stockpiles shall be protected against wind and runoff waters which might transport them to surface waters. There shall be no storage of materials and equipment in or close to water bodies. Temporary storage of materials and equipment on river banks, if necessary, shall be short-term and protected to prevent run-off polluting river water.
(vi) Any chemical spills into water bodies shall be cleaned up according to standards.

45. Protection of biological resources and wildlife
    (i) Construction workers are prohibited from capturing any wildlife during construction.
    (ii) Existing trees and grassland shall be protected during construction. Trees and shrubs shall only be removed as a last resort if they impinge directly on the permanent works or necessary temporary works.
    (iii) Where a tree has to be removed or an area of grassland disturbed, trees shall be replanted, and the area revegetated after construction. Tree planting shall use local species with local provenance. Planting of exotic of invasive species shall be prohibited.
    (iv) No construction staging area, borrow area, spoil disposal site and haul road shall be established within a local, provincial or national protected area.

46. Solid waste management, earth works and soil erosion
    (i) The reuse of earth cut materials and construction and demolition waste shall be maximized, including the reuse of old asphalt or concrete road pavement for subgrade materials.
    (ii) All refuse and construction and demolition waste generated on construction sites and construction staging areas shall be stored in designated areas and regularly removed from these locations for disposal or reuse.

47. Construction site sanitation
    (i) The contractor shall provide adequate and functional systems for sanitary conditions, toilet facilities, waste management, labor dormitories and cooking facilities.
    (ii) The site shall be effectively cleaned and disinfected. During site formation, the site shall be sprayed with phenolated water for disinfection. Toilets and refuse bins shall be disinfected and timely removal of solid waste shall be ensured.
    (iii) Rodents on site shall be exterminated at least once every 3 months. Mosquitoes and flies shall be exterminated at least twice each year.
    (iv) Public toilets shall be provided in accordance with the requirements of labor management and sanitation departments in the living areas on construction site, and designated staff responsible for cleaning and disinfection shall be appointed.
    (v) Work camp wastewater shall be discharged into the municipal sewer system or treated on-site using portable systems or septic tanks.

48. Occupational safety
    (i) At least one environment, health and safety (EHS) officer shall be appointed to manage the occupational health and safety risks in the construction sites.
    (ii) Personal protective equipment (PPE) shall be provided to all workers and wearing them must be strictly enforced.

49. Food safety
    (i) Food hygiene in the canteens on site shall be inspected and supervised regularly. Canteen workers must have valid health permits.
    (ii) If food poisoning is discovered, effective control measures shall be implemented immediately to prevent it from spreading.

50. Disease prevention and health services
    (i) All construction workers shall undergo a physical examination before they start working on site. If infectious disease is found, the patient must be isolated for

treatment to prevent the disease from spreading. Physical examination shall be conducted on 20% of the workers every year, from the second year onwards.

(ii) Workers' orientation prior to mobilization on health and safety shall be coordinated with the local health department; it should include the prevention and management of communicable diseases.

51. Social conflict prevention. The following shall be prioritized: (i) employment of local people for works, (ii) ensuring equal opportunities for women and men, (iii) paying equal wages for work of equal value, (iv) paying women's their wages directly; and (v) the banning of child or forced labor in all work premises.

52. Community health and safety

(i) A traffic control and operation plan shall be prepared together with the local traffic authorities prior to any construction.

(ii) Residents and businesses shall be informed in advance of utility disruption, access blocking, hazardous activities and activities that would emit higher noise level and vibration. They shall be made aware of the project GRM.

(iii) Clear signs shall be placed in the construction sites in full view of the public and they should warn people of potential dangers such as moving vehicles, hazardous materials, excavations, etc. and raising awareness on safety issues.

(iv) Local communities and residents shall be alerted if night time construction work shall occur nearby; there will be no night time construction within 500 m of the nearest households.

(v) The contractor shall liaise with schools during examination periods and scale down construction activities during such periods, if necessary.

(vi) All construction sites shall be made secure and access to them by the public shall be discouraged through appropriate fencing, signage and/or security personnel, as appropriate.

53. Utility interruption

(i) Contractors shall assess construction locations in advance and identify potential for disruption to services and risks before starting construction. Any damage or hindrance/disadvantage to local businesses caused by the premature removal or insufficient replacement of public utilities shall be subject to full compensation, at the expense of the contractor causing the problem.

(ii) If temporary disruption is unavoidable, the contractor shall, in collaboration with relevant local authorities such as the power company, water supply company and communication company, develop a plan to minimize the disruption and communicate the dates and duration in advance to affected persons.

54. Grievance redress mechanism

(i) The contractor shall establish a GRM for receiving and handling complaints. In case of a complaint, the contractor shall notify the project management office within one week and subsequently advise them of the agreed solution.

(ii) The contractor shall disclose the GRM to affected people at the main entrance of each site before construction begins

(iii) The contractor shall maintain and update a complaint register to document all complaints, and report to the PMU/PIU on every grievance filed promptly.

Annex A

Draft Sample Terms of Reference for Environmental Quality Study (Monitoring)

A. Introduction

1. The Asian Development Bank (ADB), is supporting the Government of Cambodia to enhance the competitiveness of the town of (name of town), which is located along the Central Mekong Economic Development Corridor in the Greater Mekong Subregion. This is expected to be achieved through improved integrated regional and local planning and through investment in basic urban infrastructure under the Fourth Greater Mekong Subregion Corridor Towns Development Project (Project). Among the infrastructure that are proposed under the Project is the development of the (subproject component) at (location of subproject component).

2. The Ministry of Public Works and Transport (MPWT), as executing agency for the Project, intends to secure the services of a qualified and Government-accredited entity to undertake (groundwater, surface water, soil, ambient air quality or noise) study in the vicinity of the (Subproject component). This Terms of Reference will serve as basis for the study and for a Request for Quote for the study. The cost for undertaking the study shall include sampling, measurements/tests/ analyses (on site and in laboratory) and reporting, field allowances and accommodation, and travel/ transportation.

B. Objective

3. The objective of the study is to:

A. For baseline study: To determine the current quality of (groundwater, surface water, soil, ambient air quality or noise) at the site of the (subproject component) and vicinity, the results of which shall serve as baseline data for (groundwater, surface water, soil, ambient air quality or noise) quality. The results of the study shall be shared with the design consultant for use as a basis for incorporating measures in the design to safeguard the (groundwater, surface water, soil, ambient air quality or noise) in the vicinity from the adverse impacts of the (subproject component.

B. For environmental effects monitoring (say during construction): (i) to assess the effects of the construction of (subproject component) on (groundwater, surface water, soil, ambient air quality or noise) in the subproject's area of influence; and (ii) to comply with the requirement of the Environmental Management Plan (EMP).

C. Scope of Work

For groundwater quality study

C.1 General

The study will include the following tasks:

- Coordinate with the PMU, PIU and the Environmental Specialist of the Project Management and Construction Supervision (PMCS) team prior to commencement of the study.
- Undertake sampling, measurements/tests/analyses and reporting of the groundwater conditions (depth and quality) in the vicinities or areas of influence of the (subproject component). (See Subsections C.2 Field Sampling and C.3

Parameters to Measure/Test/Analyze for details.)

- Conduct standard field sampling and onsite measurements/tests/analyses, using appropriate equipment.
- Use appropriate containers and seals and follow standard sample container filling procedures.
- Follow storage and holding time requirements of accepted international procedures (e.g., AWWA)[12] and promptly deliver the samples that require laboratory test/analysis to an accredited laboratory in Phnom Penh.
- Follow appropriate quality assurance/quality control procedures.
- Assess the resulting data against the standard values prescribed in the Drinking Water Quality Standards, 2004, of Cambodia and the WHO Guidelines for Drinking-water Quality (fourth edition incorporating the first addendum), 2017.
- Prepare a report on the groundwater quality study.

C.2 Field Sampling

Groundwater sampling locations will be determined in collaboration with the PMU, PIU and Environmental Specialist of the PMCS team. These could be any combination of:

- existing wells (at least 1 upgradient and 1 down-gradient);
- developed groundwater wells from among the boreholes drilled for geologic and soil site investigations during detailed design; and/or
- bore hole drilled intentionally for the study (at least 1 upgradient and 1 down-gradient).

The appropriate number of samples to take must meet the study objectives and standard data quality.

C.3 Parameters to Measure/Test/Analyze

The parameters to measure, test and analyze are listed in the table below.

Groundwater Parameter	Location of Measurement/Test/Analysis
Depth of water table	At well site
Temperature (^{O}C)	At well site with meter
pH	At well site with meter
Dissolved Oxygen (mg/L)	At well site with meter
Conductivity	At well site with meter
COD (mg/L)	In laboratory
Total dissolved solids (mg/L)	In laboratory
Heavy metals: As, Cd, Pb, Fe, Z, Cu, Cr^{+6} (mg/L)	In laboratory
Oil and grease (mg/L)	In laboratory
Total and faecal coliform (MPN)	In laboratory
Nitrogen: TN, NH_3, NO_3, NO_2 (mg/L)	In laboratory
Phosphorous (TP, PO_4 (mg/L)	In laboratory
Hydrogen sulphide (mg/L)	In laboratory
Surfactants (detergents) (Mg/L)	In laboratory
Quality Assurance & Quality Control Samples	
2 field sampling blanks with distilled water.	
2 laboratory analysis blanks	

[12] American Water Works Association, AWWA. 2013. Standard Methods for Examination of Water and Wastewater: Water Wells.

C.4 Reporting Requirements

The groundwater quality study report will include the following:

- Description of the sampling and analytical methods;
- Maps showing the sampling locations relative to the (subproject component location) and the respective latitude and longitude coordinates of the sampling locations.
- Results of the groundwater quality investigations in a table format to include columns for the:
  - parameters investigated,
  - locations of measurement/test/ analysis (on site or in laboratory),
  - results or measurements and their respective units,
  - standard values for each parameter as prescribed in the Drinking Water Quality Standards, 2004, of Cambodia and the WHO Guidelines for Drinking-water Quality (fourth edition incorporating the first addendum), 2017,
  - Assessment of each parameter whether compliant or non-compliant with the standard value,
  - QA/QC samples for all variables.
- Summary of assessment/findings.
- To append in the report:
  - notes of collaboration/coordination meetings with the PMU, PIU, Environmental Specialist of the PMCS and the Department of Environment prior to commencement of the study.
  - certificates of laboratory analyses;
  - photos of field sampling and measurements/tests/analyses and of other relevant activities; and
  - other relevant document that the entity will deem it necessary and/or appropriate to append.

For surface water quality study

C.1 General

The study will include the following tasks:

- Coordinate with the PMU, PIU and Environmental Specialist of the PMCS prior to commencement of the study.
- Undertake sampling, measurements/tests/analyses and reporting of the water quality of the surface body closest to or within the areas of influence of the (subproject component). (See Sub-sections C.2 Field Sampling and C.3 Parameters to Measure/Test/Analyze for details.)
- Conduct standard field sampling and some onsite measurements/tests/ analyses, using appropriate equipment.
- Use appropriate containers and seals and follow standard sample container filling procedures.
- Follow storage and holding time requirements of accepted international procedures (e.g., AWWA)[13] and promptly deliver the samples that require laboratory test/analysis to an accredited laboratory in Phnom Penh.
- Follow appropriate quality assurance/quality control procedures.
- Assess the resulting data against the standard values prescribed in the relevant annex/es of Sub-decree on Water Pollution Control, 1999.
- Prepare a report on the surface water quality study.

[13] American Water Works Association, AWWA. 2013. Standard Methods for Examination of Water and Wastewater: Water Wells.

C.2 Field Sampling

Surface water sampling locations, upstream and downstream of the Subproject, will be determined in collaboration with the PMU, PIU and Environmental Specialist of the PMCS.

C.3 Parameters to Measure/Test/Analyze

The parameters to measure, test and analyze are listed in the table below. Parameters below are a combination of selected parameters from the applicable annexes in Sub-decree on Water Pollution Control, 1999, and from the Technical Guidelines on the Implementation of the Procedures for Water Quality of the Mekong River Commission[14].

Surface Water Parameter	Location of Measurement/Test/Analysis
Temperature (^{O}C)	At well site
pH	At well site with meter
Dissolved Oxygen (mg/L)	At well site with meter
Conductivity	At well site with meter
COD (mg/L)	At well site with meter
BOD5	In laboratory
TSS (mg/L)	In laboratory
Heavy metals: As, Cd, Pb, Cu, CN, Total Hg, Cr^{+6}, Se, (mg/L)	In laboratory
Total and faecal coliform (MPN)	In laboratory
Nitrogen: TN, NH_3, NO_3, NO_2 (mg/L)	In laboratory
Phosphorous: TP, PO_4 (mg/L)	In laboratory
Oil & grease (mg/L)	In laboratory
Phenol (mg/L)	In laboratory
Total Organochlorine Pesticide	In laboratory
Quality Assurance & Quality Control Samples	
2 field sampling blanks with distilled water.	
2 laboratory analysis blanks	

C.4 Reporting Requirements

The surface water quality study report will include the following:

- Description of the sampling and analytical methods;
- Maps showing the sampling locations relative to the (subproject component location), and the respective latitude and longitude coordinates of the sampling locations.
- Results of the surface water quality investigations in a table format to include columns for the:
  - parameters investigated,
  - locations of measurement/test/ analysis (on site or in laboratory),
  - results or measurements and their respective units,
  - standard/target values for each parameter as prescribed in the Sub-decree on Water Pollution Control, 1999, and from the Technical Guidelines on the Implementation of the Procedures for Water Quality of the Mekong River Commission.
  - Assessment of each parameter whether compliant or non-compliant with the standard value,
  - QA/QC samples for all variables.

[14] Approved in the 23rd Meeting of the MRC Council on 22 November 2016.

- Summary of assessment/findings.
- To append in the report:
  - certificates of laboratory analyses;
  - photos of field sampling and measurements/tests/analyses and of other relevant activities; and
  - other relevant document that the entity will deem it necessary and/or appropriate to append.

For soil quality study

C.1 General

The study will include the following tasks:

- Coordinate with the PMU, PIU and Environmental Specialist of the PMCS prior to commencement of the study.
- Undertake sampling, measurements/tests/analyses and reporting of the soil quality within the areas of influence of the (subproject component) (See Sub-sections C.2 Field Sampling and C.3 Parameters to Measure/Test/Analyze for details.)
- Follow accepted international standard procedures[15] in obtaining, containing/storing and holding on to and delivering of samples.
- Follow appropriate quality assurance/quality control procedures.
- Assess the resulting data against the standard guidelines recommended in the Environmental, Health and Safety Guidelines (General and for Waste Management Facilities). IFC. WBG. 2007.
- Prepare a report on the soil quality study.

C.2 Field Sampling

Soil sampling locations will be determined in collaboration with the PMU, PIU, Environmental Specialist of the PMCS and Department of Environment. Soil samples could be acquired through:

- boreholes constructed for geotechnical investigations; and/or
- boreholes drilled intentionally for the soil quality study.

It is recommended that the conduct of the soil quality study be coordinated with the geotechnical investigations, particularly in the aspect of taking soil samples and the parameters to analyze to avoid duplication. The appropriate number of samples to take must meet the study objectives and standard data quality.

C.3 Parameters to Measure/Test/Analyze

The parameters to measure, test and analyze would include: pH, As, Cu, Zn, Pb, Cr, Hg, Fe, Cd, Conductivity, Cl, Alkalinity, Na, K, Organic C, Organic matter, Ca, Mg, NO3, P, particle size, soil color, soil salinity, water holding capacity, soil moisture. No set of national soil standard guidelines has been encountered. The results will be assessed against the Environmental, Health and Safety Guidelines (General and for Waste Management Facilities). IFC. WBG. 2007.

C.4 Reporting Requirements

The soil quality study report will include the following:

[15] As specified in the Environmental, Health and Safety Guidelines (General and for Waste Management Facilities).

- Description of the sampling and analytical methods;
- Maps showing the sampling locations relative to the (subproject component location), and the respective latitude and longitude coordinates of the sampling locations.
- Results of the soil quality analyses in a table format to include columns for the:
  - parameters investigated, locations of measurement/test/analyses
  - results or measurements and their respective units,
  - standard/target values specified in the guidelines based on
- Assessment of each parameter whether compliant or non-compliant with the standard value,
- QA/QC samples for all variables.
- Summary of assessment/findings.
- To append in the report:
  - notes of collaboration/coordination meetings with the PMU, PIU, Environmental Specialist of the PMCS and the Department of Environment prior to commencement of the study.
  - certificates of laboratory analyses;
  - photos of field sampling and measurements/tests/analyses and of other relevant activities; and
  - other relevant document that the entity will deem it necessary and/or appropriate to append.

For ambient air quality and noise study

C.1 General

The study will include the following tasks:

- Coordinate with the PMU, PIU and Environmental Specialist of the PMCS prior to commencement of the study.
- Undertake measurements and analyses of, and reporting on, the ambient air quality and noise. (See Sub-sections C.2 Field Sampling and C.3 Parameters to Measure/Test/Analyze for details.)
- Use of standard equipment.
- Follow appropriate quality assurance/quality control procedures.
- Assess the resulting data against the standard values prescribed in the Sub-decree on Control of Air Pollution and Noise Disturbance, 2000, and the WHO Air Quality Guidelines Global Update 2005.
- Prepare a report on the ambient air quality and noise study

C.2 Field Sampling

It is recommended that two sampling stations be identified at the controlled landfill site. This will be finally agreed on with the PMU, PIU and Environmental Specialist of the PMCS. The appropriate number of measurements to take must meet the study objectives and standard data quality.

The appropriate number of samples to take must meet the study objectives and standard data quality.

C.3 Parameters to Measure/Test/Analyze

The parameters to measure and analyze, which must be finalized with the ESS-PMCS, are:

During construction

- For ambient air quality, PM2.5, PM10, NO2, SO2, (at 1-hr and 24-hr averaging

period), the results of which will serve as baseline data for ambient air quality.[16]
    - For noise, the L_{max}, L_{min} La_{ve}, but prior to the start of the day's construction work, noise must be measured for reference.
- During operation of controlled landfill:
    - For ambient air quality, PM2.5, PM10, NO2, SO2, CH4, NMOC, H2S, O3 (at 1-hr and 24-hr averaging period).
- During operation of WWTP:
    - For ambient air quality: NO2, SO2, CH4, N2O

C.4 Reporting Requirements

The ambient air quality and noise study report will include the following:

- Description of the sampling and analytical methods;
- Maps showing the sampling locations relative to the (subproject component location), and the respective latitude and longitude coordinates of the sampling locations.
- Results of the ambient air quality analysis in a table format to include columns for the:
    - parameters investigated,
    - locations of measurement/test/analysis,
    - results or measurements and their respective units,
    - standard/target values for each parameter as prescribed in the Sub-decree on Control of Air Pollution and Noise Disturbance, 2000, and the WHO Air Quality Guidelines Global Update 2005.
    - Assessment of each parameter whether compliant or non-compliant with the standard value.
- Summary of assessment/findings.
- To append in the report:
    - notes of collaboration/coordination meetings with the PMU, PIU, Environmental Specialist of the PMCS and the Department of Environment prior to commencement of the study.
    - photos of field sampling and measurements/tests/analyses and of other relevant activities; and
    - other relevant document that the entity will deem it necessary and/or appropriate to append.

For effluent quality study

C.1 General

The study will include the following tasks:

- Coordinate with the PMU, PIU and Environmental Specialist of the PMCS prior to commencement of the study. The opinion of the Department of Environment must be solicited.
- Undertake sampling, measurements/tests/analyses and reporting of the quality of the effluent from the (subproject component) (See Sub-sections C.2 Field Sampling and C.3 Parameters to Measure/Test/Analyze).
- Follow accepted international standard procedures in obtaining, containing/storing and holding on to and delivering of samples.
- Follow appropriate quality assurance/quality control procedures.

[16] Seek the opinion of the Department of Environment, PMU, PIU and Environmental Specialist of the Project Management and Construction Supervision on the parameters to measure during operation. (Suggested additional parameters to monitor during operation would be CH_4, O_3, H_2S, NMOC)

- Assess the resulting data against the standard guidelines recommended in the Annex 2 of the Sub-decree on Water Pollution Control, 1999 Environmental, Health and Safety Guidelines (General and for Waste Management Facilities). IFC. WBG. 2007.
- Prepare a report on the effluent quality study.

C.2 Field Sampling

Coordinate with Operator of the (subproject component) and the Provincial Department of Environment prior to the conduct of the study.

C.3 Parameters to Measure/Test/Analyze

The parameters to measure, test and analyze specified herein are suggested. Coordinate with the Operator and Department of Environment for the final set of parameters. The suggested parameters are:

- For effluent from the WWTP:
  - Temperature, color, odor, transparency, pH, COD, BOD, TSS, TDS, NH3, Total P, Total N, PO4, Chloride, faecal coliform, e-coli, DO, Cl residuals, NO3, SO4.
- For the effluent from the controlled landfill:
  - Temperature, turbidity, pH, Conductivity, COD, BOD, TSS, Total organic carbon, DO, TDS, ammonia-N, PO4, Chloride, faecal coliform, phenols, NO3, SO4, Mg, As, C, Pb, Se, Cu, Ni, Mn, Hg, Fe oil and grease.

C.4 Reporting Requirements

The effluent quality study report will include the following:

- Description of the sampling and analytical methods;
- Results of the effluent quality analyses in a table format to include columns for the:
  - parameters investigated
  - results or measurements and their respective units,
  - standard/target values specified in the guidelines based on
- Assessment of each parameter whether compliant or non-compliant with the standard value,
- QA/QC samples for all variables.
- Summary of assessment/findings.
- To append in the report:
  - notes of collaboration/coordination meetings with the Operator and the Provincial Department of Environment prior to commencement of the study.
  - certificates of laboratory analyses;
  - photos of field sampling and measurements/tests/analyses and of other relevant activities; and
  - other relevant document that the entity will deem it necessary and/or appropriate to append.

Annex B
Template for Integrated Safeguards Monitoring Report

Safeguards Monitoring Report

Semiannual Report
xxx {month} 20xx

Country: xxx {Project name}, xxx {sub-project name, if report covers only one sub-project}

Prepared by the Project Management Unit of {complete name of Implementing Agency} for the {complete name of the borrower} and the Asian Development Bank.

NOTE

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

This safeguards monitoring report is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgments as to the legal or other status of any territory or area.

Executive Summary

{Read and delete: Provide short summary of the following items:

- **Summary of EMP/RP Implementation**
- **Description of monitoring activities** carried out (e.g. field visits, environment effect monitoring, survey questionnaire, public consultation meetings, focus group discussions, etc.)
- **Key issues**, any **corrective actions** already taken, and any **grievances**
- Key activities planned in the next reporting period
- Recommendations

Use the paragraph numbering format provided below throughout the report}

1. xxx

2. xxx

Project Overview, General safeguard matters

1. Project Overview

{Read and delete: Briefly describe project objectives, scope and components – can be taken from PAM or other relevant document}

3. xxx

4. xxx

2. Project Progress

{Read and delete: Using most recent project progress report, describe status of project implementation, including full list of contracts, status of contract awarding and implementation, name of contractor, Engineer, Project Supervision Consultant.}

5. xxx

6. xxx

Table 1: Project Overview, Snapshot of Project Progress

Project Number and Title:		
Safeguards Category	Environment	
	Indigenous Peoples	
	Involuntary Resettlement	
Reporting period:		
Last report date:		

Key sub-project activities since last report:	*{Read and delete: This section should include, among others, the following:}* • Contract awarding • Progress of Work (% physical completion) • Status of Safeguard Approvals / Permits / Consents
Report prepared by:	

3. Safeguard Plans Implementation Arrangements

{Read and delete: Describe institutional arrangements and responsibilities for EMP and RP implementation, internal and external monitoring, and reporting, defining roles of PMU, Engineer, Implementation Consultant, Contractors. (Table format as needed)}

7. xxx

8. xxx

4. Updated EMPs and RPs, Incorporation of Safeguards Requirements into Project Contractual Arrangements

{Read and delete: Define manner by which EMP and RP requirements are incorporated into bidding documents, contracts.
Indicate when updated EMPs and RPs were submitted for approval to ADB (Table format appropriate).}

9. xxx

10. xxx

Environmental Performance Monitoring

1. Status of EMP implementation (Mitigation Measures)

{Read and delete: Summarize main mitigation/protection measures implemented in the reporting period (narrative section). Structure in accordance to phases (detailed design, construction preparation, construction, and operation).}

11. xxx

12. xxx

{Read and delete: Include EMP table or updated EMP table if applicable. Assess compliance of environmental management activities with the original or updated EMP. For that purpose, include additional columns entitled "Compliance Status", "Comment or Reasons for Non-Compliance", and "Issues for Further Action". Example is provided below.}

Table 2: Compliance with EMP Requirements (Environmental Performance)

EMP Requirements	Compliance Status (Yes, No, Partial)	Comment or Reasons for Non-Compliance	Issues for Further Action
Use environmental impact as main heading and EMP	Use EMP list as basis for rating/evaluating		

as listing (see example below)	compliance (see example below)		
Rise of employment opportunities: • Job openings of the project should give priority to local communities. • Recruitment of local laborers should be stipulated in the contract for construction	• Field inspections and interviews with communities - DONE • Note each complaint case in the field – 3 COMPLAINTS RECEIVED • Set up grievance centre and report as part of monitoring action plan – NOT DONE		

Table 3: Issues for Further Action

Issue	Required Action	Responsibility and Timing	Resolution
Old Issues from Previous Reports			
List of EMP measures or activities not completed (last column of previous table)			
New Issues from This Report			

2. Health and Safety

{Read and delete: Provide narrative of occupational and community health and safety issues that occurred during the reporting period. Any accident involving injury or death of workers or community members must be reported. Include investigation report of DOLISA as attachment to the report. Provide details in the Table below}.

13. xxx

14. xxx

Table 4: Health and Safety Issues

Issue	Required Action	Responsibility and Timing	Resolution
Old Issues from Previous Reports			

New Issues from This Report			

3. Environment Effect Monitoring

15. **Monitoring plan.** xxx *{Read and delete: Present the environment effect monitoring plan as defined in the EMP or the updated monitoring plan. Refer to Table 4. Describe monitoring responsibilities}*

16. **Monitoring activities in the reporting period.** Xxx *{Read and delete: Describe the environment effect monitoring activities in the reporting period, including number of monitoring campaigns, number of samples, etc. Confirm compliance with the monitoring plan, or justify any deviation from the plan}*

Table 4: Environment Effect Monitoring Results in the Reporting Period
{Read and delete: Present monitoring result in a Table (see example below, adjust as needed). Any non-compliance should be highlighted for attention and follow-up.}

Location	Parameter	Date	Monitoring value	Relevant government standard, standard value

17. **Assessment.** *Xxx {Read and delete: Compare monitoring results with baseline conditions (if baseline data is available) and relevant government standards in qualitative terms. Additional explanatory comments should be provided as necessary. Possible reasons for non-compliance should be identified.}*

Involuntary Resettlement Performance Monitoring

{Read and delete: Provide narrative of status of implementation of the RP(s), including but not limited to: status of RP or Resettlement Framework updating; number of households relocated during the reporting period; outstanding resettlement activities; etc.}.

18. xxx

19. xxx

Table 6: Summary of Compliance with RP Requirements

RP Requirements	Compliance status Yes/No/Partial	Comment or Reasons for Compliance, Partial Compliance/Non-Compliance	Issues for Further Action[17]
Establishment of personnel in PMU/PIU			
Public consultation and socialization process		*Provide information on:* • *Public consultation, participation activities carried out* • *Inclusive dates of these activities* *To be elaborated on in Item 5*	
Land area to be acquired is identified and finalized			
Resettlement plan(s) updated after detailed design			
Land acquisition completed			
Establishment of Resettlement Site(s)		*Please state:* • *Number of AHs to be relocated as per agreed RP* • *Number of AHs already relocated* • *Number of houses built* • *Status of installation of community facilities to be provided as per agreed RP*	
Compensation payments for affected assets is completed		*Please state:* • *Total Number of Eligible AHs and APs (as per agreed RP)* • *Number of AHs and APs compensated as of this monitoring period* • *Total Budget allocation as per agreed RP* • *Total budget disbursed to AHs as of this monitoring period*	

[17] To be elaborated further in table 3.b (Issues for Further Action)

Transport assistance for relocating affected households		*As above*	
Additional assistance to vulnerable affected household		*Please state:* • *Total Number of vulnerable AHs and APs (as per agreed RP)* • *Agreed forms of assistance as per RP* • *Number of AHs and APs assisted as of this monitoring period*	
Income Restoration Program		*Please state progress per income restoration feature/activity and actual period of implementation*	
Temporary impacts have been addressed (affected properties restored to at least pre-project conditions)		*Please state:* • *Total Number of AHs affected by temporary impacts as per agreed RP* • *Actual Number of AHs and total area affected by temporary impacts (if this differs from the projected number, such as in cases of unforeseen project impacts)* • *Status of restoring affected property*	
Capacity building activities			

Table 7: Issues for Further Action

Issue	**Required Action**	**Responsibility and Timing**	**Resolution**
Old Issues from Previous Reports			
List of RP activities not completed (last column of previous table)			
New Issues from This Report			

Compliance with safeguards related project covenants

{Read and delete: List all environment and resettlement related loan covenants, and assess project's compliance with the covenants (Table format is appropriate, with concluding statement on compliance, partial compliance or non-compliance, and corrective actions as needed)

Schedule	Para No.	Covenant	Remarks/Issues (Status of Compliance)
Schedule 5	xxx		Complied with / Partially complied with / Not complied with. *{Identify reason for partial or non-compliance}*

Public consultation, Information Disclosure, Capability Building

{Read and delete: Describe public consultation activities during the reporting period. Confirm compliance with consultation plan defined in the IEE/EMP and the RP(s) or justify deviation from these plans. Present planned consultation activities in next reporting period. Use Tables as appropriate.}

- Field Visits (sites visited, dates, persons met)
- Public Consultations and meetings (Date; time; location; agenda; number of participants disaggregated by sex and ethnic group, not including project staff; Issues raised by participants and how these were addressed by the project team)
- Training (Nature of training, number of participants disaggregated by gender and ethnicity, date, location, etc.)
- Press/Media Releases
- Material development/production (e.g., brochure, leaflet, posters)
- Information disclosure

Grievance Redress Mechanism

{Read and delete: Describe mechanisms established to address and redress public complaints and grievances related to social and environment safeguards. Summarize grievances received, if any, and measures implemented to redress them.}

- Number of new grievances, if any, since last monitoring period: ____
- Number of grievances resolved: _____
- Number of outstanding grievances: _____

Type of Grievance	Details (Date, person, address, contact details, etc.)	Required Action, Responsibility and Timing	Resolution
Old Issues from Previous Reports			

New Issues from This Report			

Conclusion

{Read and delete: Highlight important results from the implementation of EMP and RP monitoring; recommendations to improve EMP and RP management, implementation, and monitoring; key activities planned in next reporting period}.

20. xxx

21. xxx

Attachments

- Consents / permits
- Monitoring data (water quality, air quality, etc.)
- Inspection checklists
- Photographs
- Others

Environmental Relevance of Other Laws, Regulations and Guidelines to the Project

Chance find of cultural heritage items.

Law on the Protection of Cultural Heritage 1996. In case of chance find of cultural heritage item/s during construction: (i) works must immediately stop; (ii) construction team must immediately declare the find to the local police; and (iii) as may be announced by the competent authority, temporary works suspension must be observed and the recommended measures to safeguard the found item/s must be taken.

Law on Land Management, Urban Planning and Constructions 1994. In case of discovery of any object with archeological or historical value, the supervisor of the construction shall be obliged to report to competent authorities. After receiving the report, the competent authority must immediately stop such construction.

Conservation of Protected Areas

Protected Areas Law 2008 Protected areas shall have four (4) zones namely, core zone, conservation zone, sustainable use zone & community zone. All types of public infrastructure are prohibited in the Core Zone & Conservation Zone. Development of public infrastructure are allowed in the Sustainable Use Zone & Community Zone with approval from the Royal Government at MoE's request. Destructive/harmful practices are prohibited in protected areas, e.g., destroying water quality, poisoning, using of chemical substances, disposing of solid and liquid wastes into water or on land.

Law on Land Management, Urban Planning and Constructions 1994. All construction activities are required construction permit. Permit shall be denied if the environment, a property which have archeological/historical/ cultural/aesthetic value, or natural resources will be affected by construction.

Labor health and safety.

Labor Law 1997. Work places are to be: (i) kept clean and maintained to standards of hygiene and sanitation to protect the health of workers; and (ii) set up to standards that guarantee workers' safety. Machines, tools and equipment are to be installed and maintained to standards that guarantee workers' safety.

Discharges, disposal or deposits of polluting substances.

Law on Water Resources Management 2007. The discharge, disposal or deposit of polluting substances that are likely to deteriorate the quality of water and to endanger human, animal and plant health shall be subject to water license or authorization.

Sub-decree No. 27 on Water Pollution Control 1999. The following activities are required MOE permit before discharging or transporting their wastewater: (i) wastewater treatment plant discharging more than 10 m^3 of effluent daily; (ii) macadam (crushed stone) and gravel quarrying activities discharging more than 10 m^3 of effluent daily; (iii) all solid waste landfill operations; and (v) all waste recycling plant operations.

Solid waste management (SWM).

Sub-decree No. 36 on Solid Waste Management 1999. Provincial and city authorities are responsible for the collection, transport, recycling, minimizing and disposal of household waste in the provinces and cities, respectively. Prior MOE approval is required for investment in landfill, incinerator, waste storage sites or recycling plant for household wastes.

Sub-decree No.113 on Garbage and Solid Waste Management in Urban Areas 2015. Transferred the SWM responsibility from the MOE to the municipality/town/district administrations.

Guidelines on Urban Solid Waste Management, MOE 2016. A landfill site should be at least: (i) 10 km from the town ; (ii) 1 km from a national road, residence and public drainage; (iii) 3 km from school, hospital, natural water resource; (iv) 5 km from natural eco-tourism site, cultural site and natural conservation area; (v) 15 km from archaeological and historical (natural and cultural) site; and (vi) 8 km from an airport. Site should not be flood prone, should have good surface drainage all season. Site should be of low economic value or infertile land.
Air emissions from immovable sources. Sub-decree No. 42 on the Control of Air Pollution and Noise Disturbance 2000. MOE authorization for emissions from immovable sources is required from solid waste landfills and wastewater treatment plants. Monitoring of air pollutant emissions and noise from immovable sources is an MOE responsibility. However, owners of air pollution and noise sources may request to have their samples tested at other public or private laboratories formally recognized as applying the same analytical methods used by MOE. Owners of air pollution sources have the responsibility to install the necessary equipment to meet standard air emission, noise and vibration levels.
Quarrying/extraction of construction aggregates. Law on Mineral Resource Management and Exploitation 2001. A Pits and Quarries Mining License is required for conducting exploration and exploitation of any construction and industrial minerals such as, but not limited to, sand, gravel, crushed stone, clay and cement clay. Law on Water Resources Management 2007. The extraction of sand, soil, stones and gravels from the beds and banks of watercourses, lakes, canals and reservoirs are subject to licensing.

Environmental Quality Standards Applied in the IEE

Ambient Air Quality Standards

Parameter	Averaging Period	Cambodia's Ambient Air Quality Standard (mg/m^3) *	WHO Air Quality Guidelines (mg/m^3)	
			Global Update 2005 **	2000 ***
CO	8-hour	20	-	10
	1-hour	40	-	30
	30-minute	-	-	60
	15-minute	-	-	100
NO_2	1-year	-	0.04	-
	24-hour	0.1		-
	1-hour	0.3	0.2	-
SO_2	1-year	0.1	-	
	24-hour	0.3	0.02	-
	1-hour	0.5	0.35	-
	10-minute	-	0.5	-
TSP	1-year	0.1	-	-
	24-hour	0.33	-	-
PM_{10}	1-year	-	0.02	-
	24-hour	-	0.05	-
$PM_{2.5}$	1-year	-	0.01	-
	24-hour	-	0.025	-
O_3	8-hour daily max.	-	0.1	-
	1-hour	0.2	0.15 - 0.2	-
Pb	1-year	-	-	0.0005
	24-hour	0.005	-	-

WHO guideline value more stringent. To apply in the 4th GMS Corridor Towns Development Project.

* Annex 1. Sub-decree on Control of Air Pollution and Noise Disturbance (No. 42/ANK/BK). 2000.

** Environmental, Health, and Safety General Guidelines. IFC. April 30, 2007.

*** Air Quality Guidelines for Europe. Second Edition. WHO Regional Publication, European Series, No. 91. 2000.

Noise & Vibration Level Guidelines

Receptor	Cambodia's Max. Standard of Noise Level Allowable in Public and Residential Areas (dB(A)) *		WHO Guidelines for Community Noise 1999 ** (dB(A))	
Quiet areas: (hospital, library, school, kindergarten)	06:00 - 18:00	45	07:00 - 22:00	55
	18:00 - 22:00	40		
	22:00 - 06:00	35	22:00 - 07:00	45
Residential areas: (hotel, administrative office, villa, flat)	06:00 - 18:00	60	07:00 - 22:00	55 ^
	18:00 - 22:00	50		
	22:00 - 06:00	45	22:00 - 07:00	45
Commercial/service areas & areas of multiple business	06:00 - 18:00	70	07:00 - 22:00	70
	18:00 - 22:00	65		
	22:00 - 06:00	50	22:00 - 07:00	70
Small industrial factories in residential residential area	06:00 - 18:00	75	07:00 - 22:00	70 ^
	18:00 - 22:00	70		
	22:00 - 06:00	50	22:00 - 07:00	70

^ WHO guideline value more stringent. To apply in the 4th GMS Corridor Towns Development Project between 06:00 - 18:00.

* Annex 6. Sub-decree on Control of Air Pollution and Noise Disturbance (No. 42/ANK/BK). 2000.

** Environmental, Health, and Safety General Guidelines. IFC. April 30, 2007.

Surface Water Quality Standards

A. For Biodiversity Conservation

Parameter	Unit	Cambodia's Standard Value [1]		US EPA [3]		MRC Target Values [4]
		River	Lake & Reservoir [2]	Aquatic Life Criteria Table		for the Protection of Aquatic Life (Direct Impact)
				CMC (acute)	CCC (chronic)	
pH	-	6.5 - 8.5	6.5 - 8.5	-	6.5 - 9	6 - 9
BOD_5	mg/l	1 - 10	-	-	-	3 [5]
SS	mg/l	25 - 100	1 - 15	-	-	-
DO	mg/l	2.0 - 7.5	2.0 - 7.5	-	-	> 5
Coliform	MPN/100 ml	< 5000	< 1000	-	-	-
COD	mg/l	-	1 - 8	-	-	-
Total N	mg/l	-	0.1 - 0.6	-	-	-
Total P	mg/l	-	0.005 - 0.05	-	-	-

B. For Public Protection

Parameter	Unit	Cambodia's Standard Value [6]	US EPA [3] Human Health Criteria Table For the consumption of		MRC Target Values [4] for the Protection of Human Health	
			water+organism	organism only	Direct Impact	Indirect Impact
Carbon Tetrachloride	µg/l	< 12	0.4	5	-	-
Hexachlorobenzene	µg/l	< 0.03	0.000079	0.000079	-	-
DDT	µg/l	< 10	0.000030	0.000030	-	-
Endrin	µg/l	< 0.01	0.03	0.03	-	-
Dieldrin	µg/l	< 0.01	0.0000012	0.0000012	-	-
Aldrin	µg/l	< 0.005	0.00000077	0.00000077	-	-
Isodrin	µg/l	< 0.005	-	-	-	-
Perchloroethylene	µg/l	< 10	-	-	-	-
Hexachlorobutadiene	µg/l	< 0.1	0.01	0.01	-	-
Chloroform	µg/l	< 12	60	2,000	-	-
1.2 Trichloroethylene	µg/l	< 10	-	-	-	-
Trichloroethylene	µg/l	< 10	0.6	7	-	-
Trichlorobenzene	µg/l	0.4	-	-	-	-
Hexachloroethylene	µg/l	< 0.05	-	-	-	-
Benzene	µg/l	< 10	0.58 - 2.1	16 - 58	-	-
Tetrachloroethylene	µg/l	< 10	10	29	-	-
Cd	µg/l	< 1	-	-	5 µg/l	-
Total Hg	µg/l	< 0.5	-	-	2 µg/l	-
Organic Hg	µg/l	0	-	-	-	-
Pb	µg/l	< 10	-	-	50 µg/l	-
Cr^{6+}	µg/l	< 50	Total	-	50 µg/l	-
As	µg/l	< 10	0.018	0.14	-	-
Se	µg/l	< 10	170	4,200	-	-
Polychlorobiphenyl	µg/l	0	0.000064	0.000064	-	-
CN	µg/l	< 0.005	4	400	10 µg/l	-

International guideline value more stringent. To apply in the 4th GMS Corridor Towns Development Project.

[1] Annex 4. Water Quality Standard in Public Water Areas for Biodiversity Conservation. Sub-decree on Water Pollution Control. (No. 27/ANRK/BK). 1999.

[2] Assumed applicable to natural lagoons.

[3] National Recommended Water Quality Criteria. US EPA.

[4] Technical Guidelines on the Implementation of the Procedures for Water Quality. Mekong River Commission. Approved in the 23rd Meeting of the
MRC Council on 22 November 2016.

[5] An interim target value requiring further review by the MRC Technical Body on Water Quality.

[6] Annex 5. Water Quality Standard in Public Water Areas for Public Health Protection. Sub-decree on Water Pollution Control. (No. 27/ANRK/BK). 1999.

Groundwater Quality Standards (mg/l)

Parameter	Cambodia's Drinking Water Quality Standards, 2004		WHO Guidelines for Drinking Water Quality *
	Unit	Maximum Value	Guideline Value
Bacteriological			
Thermotolerant (Fecal Coliform or E. Coli)	MPN/100 ml	0	Must not be detectable in any 100 ml sample.
Total coliform	MPN/100 ml	0	
Inorganic constituents			
As	mg/l	0.05	0.01
Ba	mg/l	0.7	1.3
Cd	mg/l	0.003	0.003
Cr	mg/l	0.05	0.05
CN	mg/l	0.07	None established
F	mg/l	1.5	1.5
Pb	mg/l	0.01	0.01
Hg	mg/l	0.001	0.006
Ni	mg/l	0.02	0.07
NO_3	mg/l	50	50
NO_2	mg/l	3	3
Se	mg/l	0.01	0.04
Organic constituents			
Polychlorinated biphenyls	µg/l	0.5	-
Benzene	µg/l	10	10
Disinfection by-product			
Trihalomethanes	µg/l	250	300 (chloroform) **
Pesticides			
2,4 D	µg/l	30	30
Aldrin and Dieldrin	µg/l	0.3	0.03
Carbofuran	µg/l	10	7
Chlordane	µg/l	0.2	0.2
DDT	µg/l	20	1
Dichlorvos	µg/l	l	None established
Dimethoate	µg/l	6	6
Endosulfan	µg/l	30	None established
Endrin	µg/l	0.6	0.6
Glyphosate	µg/l	10	None established
Heptachlor	µg/l	0.3	None established
Hexachlorobenzene	µg/l	l	None established
Methyl parathion	µg/l	0.3	None established
Mevinphos	µg/l	5	-
Monocrotophos	µg/l	l	-
Paraquat	µg/l	30	-
Parathion	µg/l	10	None established
Permethrin	µg/l	20	-
Physical/chemical			
Taste	-	Acceptable	-
Odor	-	Acceptable	None established
Color	TCU	5	None established
Turbidity	NTU	5	None established
Residual Cl	mg/l	0.2 - 0.5	5
pH	-	6.5 - 8.5	None established
Al	mg/l	0.2	None established
NH_3	mg/l	1.5	None established
Chloride	mg/l	250	None established
Cu	mg/l	1	2

Parameter	Cambodia's Drinking Water Quality Standards, 2004		WHO Guidelines for Drinking Water Quality *
	Unit	Maximum Value	Guideline Value
Hardness ($CaCO_3$)	mg/l	300	None established
H_2S	mg/l	0.05	None established
Fe	mg/l	0.3	None established
Mn	mg/l	0.1	None established
Na	mg/l	200	None established
SO_4	mg/l	250	None established
TDS ^	mg/l	800	None established
Zn	mg/l	3	None established

WHO guideline value more stringent. To apply in the 4th GMS Corridor Towns Development Project.

* Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization; 2017. Licence: CC BY-NC-SA 3.0 IGO.

** Most common THM.

^ Conductivity (µS/cm) can also be measured and is roughly equivalent to twice the TDS value.

Effluent Quality Standards

Parameter	Unit	Cambodia's Allowable Limits for Pollutant Substance Discharge to	
		Protected Public Water Area	Public Water Area & Sewer
Temperature	ºC	< 45	< 45
pH	-	6 - 9	5 - 9
BOD_5 (at 200 ºC)	mg/l	< 30	< 80
COD	mg/l	< 50	< 100
TSS	mg/l	< 50	< 80
TDS	mg/l	< 1000	< 2000
Grease and Oil	mg/l	< 5.0	< 15
Detergents	mg/l	< 5.0	< 15
Phenols	mg/l	< 0.1	< 1.2
NO_3	mg/l	< 10	< 20
Cl (free)	mg/l	< 1.0	< 2.0
Cl^- (ion)	mg/l	< 500	< 700
SO_4	mg/l	< 300	< 500
Sulphide (as Sulphur)	mg/l	< 0.2	< 1.0
PO_4	mg/l	< 3.0	< 6.0
CN	mg/l	< 0.2	< 1.5
Ba	mg/l	< 4.0	< 7.0
As	mg/l	< 0.10	< 1.0
Sn	mg/l	< 2.0	< 8.0
Fe	mg/l	< 1.0	< 20
B	mg/l	< 1.0	< 5.0
Mn	mg/l	< 1.0	< 5.0
Cd	mg/l	< 0.1	< 0.5
Cr^{-3}	mg/l	< 0.2	< 1.0
Cr^{+6}	mg/l	< 0.05	< 0.5
Cu	mg/l	< 0.2	< 1.0
Pb	mg/l	< 0.1	< 1.0
Hg	mg/l	< 0.002	< 0.05
Ni	mg/l	< 0.2	< 1.0
Se	mg/l	< 0.05	< 0.5
Ag	mg/l	< 0.1	< 0.5
Zn	mg/l	< 1.0	< 3.0
Mo	mg/l	< 0.1	< 1.0

NH_3	mg/l	< 5.0	< 7.0
DO	mg/l	> 2.0	> 1.0
Polychlorinated Biphenyl	mg/l	< 0.003	< 0.003
Ca	mg/l	< 150	< 200
Mg	mg/l	< 150	< 200
Carbon tetrachloride	mg/l	< 3	< 3
Hexachlorobenzene	mg/l	< 2	< 2
DTT	mg/l	< 1.3	< 1.3
Endrin	mg/l	< 0.01	< 0.01
Dieldrin	mg/l	< 0.01	< 0.01
Aldrin	mg/l	< 0.01	< 0.01
Isodrin	mg/l	< 0.01	< 0.01
Perchloroethylene	mg/l	< 2.5	< 2.5
Hexachlorobutadiene	mg/l	< 3	< 3
Chloroform	mg/l	< 1	< 1
1.2 Dichloroethylene	mg/l	< 2.5	< 2.5
Trichloroethylene	mg/l	< 1	< 1
Trichlorobenzene	mg/l	< 2	< 2
Hexachlorocyclohexene	mg/l	< 2	< 2

* Annex 2. Sub-decree on Water Pollution Control (No. 27/ANRK/BK). 1999.

Notes:

a) "Discharges of process wastewater, sanitary wastewater, wastewater from utility operations or stormwater to surface water **should not result in contaminant concentrations in excess of local ambient water quality criteria** or in the absence of local criteria other sources sources of ambient water quality." (General Effluent Quality. Discharges to Surface Water. Environmental, Heath, and Safety Guidelines. General Guidelines. April 30, 2007.)

b) "The selected approach **should achieve effluent water quality consistent with applicable national requirements** or internationally accepted standards and with effluent water quality goals based on the assimilative capacity and the most sensitive end use of the receiving water." (Chapter 2.1 of Environmental, Health and Safety Guidelines, Water and Sanitation. December 10, 2007. IFC. WBG.)

Soil Quality Standards

PPTA Environment Team could not obtain a national standard for soil quality. Instead obtained a copy of the IEIA for 2D Seismic Survey of Block XVII, in Kampong Thom, Siem Reap, and Preah Vihear Province, Cambodia, dated December 2011, which evaluated the results of soil quality study against the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (Agriculture).

Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health

	Variables	Units	Agricultural Coarse	Agricultural Fine
1	Arsenic (inorganic)	mg/kg	12	12
2	Barium	mg/kg	750	750
3	Benzene	mg/kg	0.0095/0.01	0.0068/0.0068
4	Benzo[a]pyrene	mg/kg	0.1	0.1
5	Cadmium	mg/kg	1.4	1.4
6	Total chromium	mg/kg	64	64
7	Hexavalent chromium (VI)	mg/kg	0.4	0.4
8	Copper	mg/kg	63	63
9	Cyanide (free)	mg/kg	0.9	0.9
10	DDT (total)	mg/kg	0.7	0.7
11	Diisopropanolamine	mg/kg	180	180
12	Ethylbenzene	mg/kg	0.082/0.082	0.018/0.018
13	Ethylene glycol	mg/kg	960	960
14	Lead	mg/kg	70	70
15	Mercury (inorganic)	mg/kg	6.6	6.6

	Variables	Units	Agricultural Coarse	Agricultural Fine
16	Naphthalene	mg/kg	0.1	0.1
17	Nickel	mg/kg	50	50
18	Nonylphenol (and its ethoxylates)	mg/kg	5.7	5.7
19	Pentachlorophenol	mg/kg	7.6	7.6
20	Petroleum Hydrocarbons F1 (C6 to C10)	mg/kg	130/200	180/180
21	Petroleum Hydrocarbons F2 (C>10 to C16)	mg/kg	150/150	250/250
22	Petroleum Hydrocarbons F3 (C>16 to C34)	mg/kg	400/2500	800/3500
23	Petroleum Hydrocarbons F4 (C>34 to C50+)	mg/kg	2800/10000	5600/10000
24	Phenol	mg/kg	3.8	3.8
25	Polychlorinated biphenyls (PCBs)	mg/kg	0.5	0.5
26	Polychlorinated dibenzo-p-dioxins/ dibenzofurans (PCDD/Fs)	ng TEQ/kg	4	4
27	Selenium	mg/kg	1	1
28	Sulfolane	mg/kg	0.8	0.8
29	Tetrachloroethylene	mg/kg	0.1	0.1
30	Thallium	mg/kg	1	1
31	Toluene	mg/kg	0.37/0.37	0.08/0.08
32	Trichloroethylene	mg/kg	0.01	0.01
33	Vanadium	mg/kg	130	130
34	Xylene	mg/kg	11/11	2.4/2.4
35	Zinc	mg/kg	200	200
36	Conductivity	dS/m	2	2
37	pH		6-8	6-8
38	Sodium adsorption ratio	mg/kg	5	5
39	Antimony	mg/kg	20	20
40	Beryllium	mg/kg	4	4
41	Boron (hot water soluble)	mg/kg	2	0
42	Cobalt	mg/kg	40	50
43	Fluoride (total)	mg/kg	200	400
44	Molybdenum	mg/kg	5	10
45	Silver	mg/kg	20	20
46	Sulphur (elemental)	mg/kg	500	0
47	Tin	mg/kg	5	50
48	Chlorobenzene	mg/kg	0.1	1
49	1,2-Dichlorobenzene	mg/kg	0.1	1
50	1,3-Dichlorobenzene	mg/kg	0.1	1
51	1,4-Dichlorobenzene	mg/kg	0.1	1
52	Styrene	mg/kg	0.1	5
53	Chlorophenols (each)	mg/kg	0.05	0.5
54	Nonchlorinated Phenols (each)	mg/kg	0.1	1
55	Benzo[a]anthracene	mg/kg	0.1	1
56	Benzo[b]fluoranthene	mg/kg	0.1	1
57	Benzo[k]fluoranthene	mg/kg	0.1	1
58	Dibenz[a,h]anthracene	mg/kg	0.1	1
59	Indeno[1,2,3-c,d]pyrene	mg/kg	0.1	1
60	Phenanthrene	mg/kg	0.1	5
61	Pyrene	mg/kg	0.1	10
62	Chlorinated aliphatics (each)	mg/kg	0.1	5
63	Chlorobenzenes (each)	mg/kg	0.05	2
64	Hexachlorobenzene	mg/kg	0.05	2
65	Hexachlorocyclohexane	mg/kg	0.01	0
66	Nonchlorinated aliphatics (each)	mg/kg	0.3	0
67	Phthalic acid esters (each)	mg/kg	30	0
68	Quinoline	mg/kg	0.1	0
69	Thiophene	mg/kg	0.1	0

Estimating GHG Emissions

A. Wastewater Treatment Plant

The formula used in estimating came from **"**Greenhouse Gas Emissions Estimation Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal Wastewater Treatment Ethanol Fermentation", 2010, December 14, RTI International (Research Triangle Institute).

3.2.1 Estimating CH_4 and CO_2 Emissions from Wastewater and Sludge Treatment Units

Aerobic wastewater treatment systems produce primarily CO_2, whereas anaerobic systems produce a mixture of CH_4 and CO_2. Equations 3-1 and 3-2 provide a general means of estimating the CO_2 and CH_4 emissions directly from any type of wastewater treatment process assuming all organic carbon removed from the wastewater is converted to either CO_2, CH_4, or new biomass.

$$CO_2 = 10^{-6} \times Q_{WW} \times OD \times Eff_{OD} \times CF_{CO2} \times \left[(1 - MCF_{WW} \times BG_{CH4})(1 - \lambda)\right] \quad (3\text{-}1)$$

$$CH_4 = 10^{-6} \times Q_{WW} \times OD \times Eff_{OD} \times CF_{CH4} \times \left[(MCF_{WW} \times BG_{CH4})(1 - \lambda)\right] \quad (3\text{-}2)$$

where:

CO_2 = CO_2 emission rate (Mg CO_2/hr)
CH_4 = CH_4 emission rate (Mg CH_4/hr)
10^{-6} = Units conversion factor (Mg/g)
Q_{WW} = Wastewater influent flow rate (m^3/hr)
OD = Oxygen demand of influent wastewater to the biological treatment unit determined as either BOD5 or COD (mg/L = g/m^3)
Eff_{OD} = Oxygen demand removal efficiency of the biological treatment unit
CF_{CO2} = Conversion factor for maximum CO_2 generation per unit of oxygen demand
= 44/32 = 1.375 g CO_2/ g oxygen demand
CF_{CH4} = Conversion factor for maximum CH_4 generation per unit of oxygen demand
= 16/32 = 0.5 g CH_4/ g oxygen demand
MCF_{WW} = methane correction factor for wastewater treatment unit, indicating the fraction of the influent oxygen demand that is converted anaerobically in the wastewater treatment unit (see **Table 3-1**)
BG_{CH4} = Fraction of carbon as CH_4 in generated biogas (default is 0.65)
λ = Biomass yield (g C converted to biomass/g C consumed in the wastewater treatment process).

The biomass yield, λ, in Equations 3-1 and 3-2 should be determined based on the net sludge generation from the process. For example, for an activated sludge tank, the sludge wastage rate would be used. Commonly, the mixed liquor volatile suspended solids (MLVSS) value is used as a measure of the biomass concentration. The flow rate of the sludge waste stream multiplied by the MLVSS concentration of the sludge waste stream provides a mass generation rate of biomass. Using the general cell composition from **Figure 3-2**, carbon accounts for 53% of the biomass weight (dry basis). The carbon consumed in the wastewater treatment process is estimated based on the BOD removal rate. Thus, the biomass yield, λ, can be calculated using Equation 3-3. When the biomass generation rate cannot be assessed, default values for the biomass yield provided in **Table 3-1** should be used.

$$\lambda = \frac{Q_S \times MLVSS_S \times CF_S}{Q_{WW} \times OD \times Eff_{OD} \times CF_C} \quad (3\text{-}3)$$

where:

λ = Biomass yield (g C converted to biomass/g C consumed in the wastewater treatment process)
Q_S = Waste sludge stream flow rate (m^3/hr)
Q_{WW} = Wastewater influent flow rate (m^3/hr)
$MLVSS_S$ = Mixed liquor volatile suspended solids concentration of the waste sludge stream (mg/L = g/m^3)

OD = Oxygen demand of influent wastewater to the biological treatment unit determined as either BOD5 or COD (mg/L = g/m^3)
Eff_{OD} = Oxygen demand removal efficiency of the biological treatment unit
CF_S = Correction factor for carbon content of the biomass (i.e., $MLVSS_S$)
= 0.53 g C/g MLVSS (default)
CF_C = Conversion factor for maximum C consumption per unit of oxygen demand
= 12/32 = 0.375 g C/ g oxygen demand.

Table 3-1. Default Values for Methane Correction Factor and Biomass Yield

Treatment System	MCF[a]	λ
Wastewater Treatment Processes		
Aerated treatment process (e.g., activated sludge system), well managed	0	0.65 [b]
Aerated treatment process, overloaded (anoxic areas)	0.3	0.45 [b,c]
Anaerobic treatment process (e.g., anaerobic reactor)	0.8	0.1 [c,d]
Facultative lagoon, shallow (< 2 m deep)	0.2	0
Facultative lagoon, deep (≥ 2 m deep)	0.8	0
Sludge Treatment Processes		
Aerobic sludge digestion	0	Use λ from wastewater treatment process
Anaerobic sludge digestion	0.8	

[a] Source: IPCC (2006).
[b] Source: Choubert et al. (2009), Muller et al. (2003), and Munz (2008); λ reported in g-COD in produced biomass/g-COD consumed; equivalent to λ in g-C in produced biomass/g-C consumed when using default CF_c in Equation 3-3.
[c] Source: Ammary (2004); λ reported in g-VSS produced/g-COD degraded; converted to λ in g-C in produced biomass/g-C consumed using default CF_s and CF_c in Equation 3-3 as λ = λreported × (CF_s / CF_c).
[d] Source: Low and Chase (1999); λ reported in g-VSS produced/g-COD degraded; converted to λ in g-C in produced biomass/g-C consumed using default CF_s and CF_c in Equation 3-3 as λ = λreported × (CF_s / CF_c).

Equation 3-8 presents a methodology to estimate N_2O emissions for both aerobic and anaerobic processes using an average value for the percent of influent TKN emitted as N_2O from Chandran (2010):

$$N_2O_{WWTP} = Q_i \times TKN_i \times EF_{N2O} \times \frac{44}{28} \times 10^{-6} \quad (3\text{-}8)$$

where:

N_2O_{WWTP} = N_2O emissions generated from WWTP process (Mg N_2O/hr)
Q_i = Wastewater influent flow rate (m^3/hr)
TKN_i = Amount of TKN in the influent (mg/L = g/m^3)
EF_{N2O} = N_2O emission factor (g N emitted as N_2O per g TKN in influent),
= 0.0050 g N emitted as N_2O/g TKN (Chandran, 2010)
44/28 = Molecular weight conversion, g N_2O per g N emitted as N_2O
10^{-6} = Units conversion factor (Mg/g).

Inputted data:

		KC	K	ST
Households served		43,221	,45,410	29,890
Total WWtr generation		7,700	6,953	4,892
BOD removal from anaerobic pond	60%			
BOD contribution per capita	5 gal/cap/day			

Results:

Town/Activity	GHG Emissions (Mg CO_2/hr)			Total
	CO_2	CH_4	N_2O	(tpy CO_2)
Kampong Cham				
Anaerobic	0.0202	0.1676	-	1,810.36
Facultative	0.0190	0.0217	-	392.48
Maturation	-	-	0.0273	263.55
Total				**2,466.39**

Procedures used in calculating emissions were obtained from:
Research Training Institute International. 2010. Greenhouse Gas Emissions Estimation. Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal, Wastewater Treatment, Ethanol Submitted to US Environmental Protection Agency.

Town/Activity	GHG Emissions (Mg CO_2/hr)			Total
	CO_2	CH_4	N_2O	(tpy CO_2)
Kratie				
Anaerobic	0.0212	0.1754	-	1,894.89
Facultative	0.0199	0.0227	-	411.20
Maturation	-	-	0.0247	237.99
Total				**2,544.08**

Procedures used in calculating emissions were obtained from:
Research Training Institute International. 2010. Greenhouse Gas Emissions Estimation. Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal, Wastewater Treatment, Ethanol Fermentations. Submitted to US Environmental Protection Agency.

Stung Treng				
Anaerobic	0.0139	0.1153	-	1,245.85
Facultative	0.0131	0.0150	-	270.35
Maturation	-	-	0.0174	167.44
Total				**1,683.65**

Procedures used in calculating emissions were obtained from:
Research Training Institute International. 2010. Greenhouse Gas Emissions Estimation. Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal, Wastewater Treatment, Ethanol Fermentation. Submitted to US Environmental Protection Agency.

B. Controlled Landfill

The tool used was “Estimation Tool for Greenhouse Gas (GHG) Emissions from Municipal Solid Waste (MSW) Management in Life Cycle Perspective”. Nirmala Menikpura. Janya Sang-Arun. Institute for Global Environmental Strategies (IGES).

Inputted data:

	KC	K	ST
Solid waste generated (tonnes per month)	1,663	1,514	1,017
Collection vehicle capacity (m3)	15	15	15
Diesel consumption per trip including collection	12L round	12L round	8L round
Diesel consumption of landfill equipment, per month	25% of that of collection truck	25% of that of collection truck	25% of that of collection truck
Waste composition	(See Table 1)		
Recyclable at the landfill	(See Table 2)		

Table 1: Adopted Waste Composition of Battambang

Please enter the compostion of landfilling waste	
Component	**Percentage (%)**
Food waste	71.88
Garden waste	0.00
Plastics	8.61
Paper	2.72
Textile	2.88
Leather/rubber	0.00
Glass	5.40
Metal	1.06
Hazardous waste	0.00
Others	7.45
Total	**100.00**

Source: JICA. 2004. The Study on Solid Waste Management in the Municipality of Phnom Penh. Kokosai Kogyo Co. Ltd.

Table 2: Composition of Recyclables at Dumpsite*

Type of recyclable	Percentage (%)
Paper	15.58
Plastic	74.13
Aluminium	1.90
Steel	0.00
Glass	8.40
Total	**100.00**

* Based on: The Composition of Municipal Waste at Dumpsite
Waste Management and Activities of Cambodia in the Application of Basel Convention.
A presentation prepared by: Mr. Chin Sothun of the Department of Environmental Pollution Control, MoE, Cambodia, for the Workshop 2010 of Asian Network of Prevention of Illegal Transboundary Movement of Hazardous Waste. 29 November-02 December 2010.

Results: GHG Emissions from Controlled Landfill Operations

Kampong Cham

Activity	Direct GHG Emissions	Indirect GHG Savings	Net GHG Emissions	Unit
Transportation	1.84	0.00	1.84	kg of CO2-eq/tonne of waste
Landfilling of mix MSW	747.85	0.00	747.85	kg of CO2-eq/tonne of mix waste
Composting	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Anaerobic digestion	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Mechanical Biological Treatment (MBT)	0.00	0.00	0.00	kg of CO2-eq/tonne of waste
Recycling	1844.79	2252.79	-408.00	kg of CO2-eq/tonne of mixed recyclables
Incineration	0.00	0.00	0.00	kg of CO2-eq/tonne of incinerated waste
Open burning	0.00	0.00	0.00	kg of CO2-eq/tonne of open burned waste
GHG emission from whole system	**948.61**	**408.51**	**540.10**	**kg of CO2-eq/tonne of collected waste**
Total GHG emissions per month	**1,926,279.25**	**829,826.45**	**1,096,452.80**	**kg of CO2-eq/monthly managed waste**

Mitigation Calculations

Results: Simulation of GHG Emissions from Controlled Landfill Operations with Mitigation Measures in Place

Activity	Direct GHG Emissions	Indirect GHG Savings	Net GHG Emissions	Unit
Transportation	3.23	0.00	3.23	kg of CO2-eq/tonne of waste
Landfilling of mix MSW	748.20	0.00	748.20	kg of CO2-eq/tonne of mix waste
Composting	177.00	892.50	-715.50	kg of CO2-eq/tonne of organic waste
Anaerobic digestion	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Mechanical Biological Treatment (MBT)	0.00	0.00	0.00	kg of CO2-eq/tonne of waste
Recycling	1844.79	2252.79	-408.00	kg of CO2-eq/tonne of mixed recyclables
Incineration	0.00	0.00	0.00	kg of CO2-eq/tonne of incinerated waste
Open burning	0.00	0.00	0.00	kg of CO2-eq/tonne of open burned waste
GHG emission from whole system	**798.45**	**503.94**	**294.51**	**kg of CO2-eq/tonne of collected waste**
Total GHG emissions per month	**1,213,156.99**	**766,743.65**	**446,413.34**	**kg of CO2-eq/monthly managed waste**

Results: Estimated GHG Emissions from the Without Mitigation Kratie

Activity	Direct GHG Emissions	Indirect GHG Savings	Net GHG Emissions	Unit
Transportation	1.79	0.00	1.79	kg of CO2-eq/tonne of waste
Landfilling of mix MSW	747.84	0.00	747.84	kg of CO2-eq/tonne of mix waste
Composting	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Anaerobic digestion	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Mechanical Biological Treatment (MBT)	0.00	0.00	0.00	kg of CO2-eq/tonne of waste
Recycling	1844.79	2252.79	-408.00	kg of CO2-eq/tonne of mixed recyclables
Incineration	0.00	0.00	0.00	kg of CO2-eq/tonne of incinerated waste
Open burning	0.00	0.00	0.00	kg of CO2-eq/tonne of open burned waste
GHG emission from whole system	**948.54**	**408.51**	**540.03**	**kg of CO2-eq/tonne of collected waste**
Total GHG emissions per month	**1,753,583.97**	**755,476.39**	**998,107.58**	**kg of CO2-eq/monthly managed waste**

Climate Mitigation Calculations

Results: Simulation of GHG Emissions from Controlled Landfill Operations with Mitigation Measures in Place

Mitigation Measures:

- Waste to be collected is reduced by 15% due to active recycling at source.
- Waste collection frequency is every other day except for market waste.
- Composting of about 20% of the waste collected (about 200- 300 tonnes per month at the landfill site.

Kratie

Estimated GHG Emissions with Mitigation

Activity	Direct GHG Emissions	Indirect GHG Savings	Net GHG Emissions	Unit
Transportation	3.23	0.00	3.23	kg of CO2-eq/tonne of waste
Landfilling of mix MSW	748.20	0.00	748.20	kg of CO2-eq/tonne of mix waste
Composting	177.00	892.50	-715.50	kg of CO2-eq/tonne of organic waste
Anaerobic digestion	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Mechanical Biological Treatment (MBT)	0.00	0.00	0.00	kg of CO2-eq/tonne of waste
Recycling	1844.79	2252.79	-408.00	kg of CO2-eq/tonne of mixed recyclables
Incineration	0.00	0.00	0.00	kg of CO2-eq/tonne of incinerated waste
Open burning	0.00	0.00	0.00	kg of CO2-eq/tonne of open burned waste
GHG emission from whole system	**785.20**	**512.27**	**272.93**	**kg of CO2-eq/tonne of collected waste**
Total GHG emissions per month	**1,097,151.29**	**716,844.29**	**380,307.00**	**kg of CO2-eq/monthly managed waste**

Results: GHG Emissions from Controlled Landfill Operations
Stung Treng

Activity	Direct GHG Emissions	Indirect GHG Savings	Net GHG Emissions	Unit
Transportation	2.12	0.00	2.12	kg of CO2-eq/tonne of waste
Landfilling of mix MSW	747.92	0.00	747.92	kg of CO2-eq/tonne of mix waste
Composting	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Anaerobic digestion	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Mechanical Biological Treatment (MBT)	0.00	0.00	0.00	kg of CO2-eq/tonne of waste
Recycling	1844.79	2252.79	-408.00	kg of CO2-eq/tonne of mixed recyclables
Incineration	0.00	0.00	0.00	kg of CO2-eq/tonne of incinerated waste
Open burning	0.00	0.00	0.00	kg of CO2-eq/tonne of open burned waste
GHG emission from whole system	**948.94**	**408.51**	**540.43**	**kg of CO2-eq/tonne of collected waste**
Total GHG emissions per month	1,178,257.27	507,431.64	670,825.63	kg of CO2-eq/monthly managed waste

Climate Mitigation Calculations

Results: Simulation of GHG Emissions from Controlled Landfill Operations with Mitigation Measures in Place

Mitigation Measures:

- Waste to be collected is reduced by 15% due to active recycling at source.
- Waste collection frequency is every other day except for market waste.
- Composting of about 20% of the waste collected (about 200- 300 tonnes per month at the landfill site.

Stung Treng

Activity	Direct GHG Emissions	Indirect GHG Savings	Net GHG Emissions	Unit
Transportation	2.12	0.00	2.12	kg of CO2-eq/tonne of waste
Landfilling of mix MSW	747.92	0.00	747.92	kg of CO2-eq/tonne of mix waste
Composting	177.00	892.50	-715.50	kg of CO2-eq/tonne of organic waste
Anaerobic digestion	0.00	0.00	0.00	kg of CO2-eq/tonne of organic waste
Mechanical Biological Treatment (MBT)	0.00	0.00	0.00	kg of CO2-eq/tonne of waste
Recycling	1844.79	2252.79	-408.00	kg of CO2-eq/tonne of mixed recyclables
Incineration	0.00	0.00	0.00	kg of CO2-eq/tonne of incinerated waste
Open burning	0.00	0.00	0.00	kg of CO2-eq/tonne of open burned waste
GHG emission from whole system	**786.04**	**510.93**	**275.11**	**kg of CO2-eq/tonne of collected waste**
Total GHG emissions per month	742,185.58	482,886.13	259,299.45	kg of CO2-eq/monthly managed waste

ENVIRONMENTAL COMPLIANCE AUDIT
CLOSURE OF EXISTING SOLID WASTE MANAGEMENT FACILITIES
(_____ Subproject)

A. Introduction

The Asian Development Bank (ADB) is supporting the Government of Cambodia (Government) in enhancing the competitiveness of (name of town), which is located along the Central Mekong Economic Development Corridor in the Greater Mekong Subregion. The Project is expected to be achieved both through integrated regional and local planning, together with investments in basic urban infrastructure. Among the infrastructure components proposed is the development of a controlled landfill to improve the towns solid waste management services, in conjunction with the closure of the town's existing dumpsite. The objective of the dumpsite closure is to address environmental and social impacts and safeguard compliance issues.

B. Objective of the Environmental Compliance Audit

The dumpsites in Kratie and Stung Treng are an Existing Facility of the project which necessitates Environmental Compliance Audit (ECA) to be conducted pursuant to the SPS (2009), para 10 of Appendix 1 and para 12 of Appendix 4. Specifically, para 12 of Appendix 4 of SPS (2009) states:

……for projects involving facilities and/or business activities that already exist or are under construction, the borrower/client will undertake an environment and/or social compliance audit, including on-site assessment, to identify past or present concerns related to impacts on the environment, involuntary resettlement, and Indigenous Peoples. The objective of the compliance audit is to determine whether actions were in accordance with ADB's safeguard principles and requirements for borrowers/clients and to identify and plan appropriate measures to address outstanding compliance issues. Where noncompliance is identified, a corrective action plan agreed on by ADB and the borrower/client will be prepared. The plan will define necessary remedial actions, the budget for such actions, and the time frame for resolution of noncompliance. The audit report (including corrective action plan, if any) will be made available to the public in accordance with the information disclosure requirements of the SPS (2009).

Because the subproject involves upgrading an existing dumpsite [the existing facility], the SPS (2009) calls for the preparation of an environmental assessment and a compliance audit of the existing dumpsite. However, in this case the ECA along with the IEE of the subproject will suffice as the environmental assessment and will be disclosed together following detailed engineering design.

C. Detailed Tasks and/or Expected Output

a. Environmental Desk Review

1. Collate and review relevant reports, publications and other relevant information regarding environmental assessment and environmental management planning for the Project, including:
   a. Government policies and requirements for environmental safeguards such as regulations, decrees, design standards, and technical parameters and guidelines for the sector.
   b. Environmental safeguard documents (e.g. EIA, IEE, EMP) and other reports such as the feasibility study and any technical reports relating to the existing facility.

c. Environmental approvals obtained by the Project, and any Government requirements and conditions imposed on the existing dumpsite.
d. Civil works contract documents (environment-related provisions).

2. Determine the Government's environmental impact assessment requirements relating to dumpsites, its review processes to secure environmental approvals, and its requirements regarding public consultations, monitoring and reporting.
3. Identify specific Government environmental clearances and approvals required for facility operation and closure. Assess procedural compliance with these clearances (such as environmental clearance certificates and approval letters), indicating which approvals have been obtained. For approvals that are yet to be issued, indicate the timeframe for securing these and reasons for the delay in obtaining the approval (if applicable).
4. Complete an environmental desk review of the facility, in accordance with the checklist shown in Attachment 1.

b. Environmental Field Reconnaissance

1. In conjunction with site personnel wherever possible, conduct field reconnaissance of the facility, in accordance with the checklist shown in Attachment 2.
2. Following initial site reconnaissance, develop and implement detailed field sampling and testing programs for surface water, groundwater, soils, ambient air, noise and leachate in accordance with the environmental sampling and testing protocol in Attachment 3.
3. Consult with project-affected households and people, and local officials, in order to determine issues and concerns with the operation and planned closure of the existing dumpsite, and any consultations and social development programs being implemented by the facility operator.

c. Environmental Assessment and Reporting

1. Utilizing information from the desk review, field reconnaissance and consultation meetings and discussions, evaluate existing conditions at the dumpsite.
2. Assess existing facility compliance in accordance with (i) government requirements, (ii) ADB SPS 2009, and (iii) IFC environmental health and safety guidelines (IFC EHS) for waste management facilities and highlight key areas of environmental deficiency.[1]
3. In conjunction with the engineering team responsible for the final design of the dumpsite closure program, identify facility closure design options, evaluate the options, and propose a preferred option/s in order to achieve facility closure and ensure environmental compliance with government, SPS 2009 and IFC EHS standards. Key factors in the analysis include environmental impact severity and likelihood, funding and institutional capacity constraints, the potential to phase closure operations, and other parameters.
4. Assess the original environmental mitigation measures and monitoring requirements detailed in the IEE and EMP and refine as necessary in order to ensure compliance.
5. Assess whether adequate budget and qualified personnel are allocated to implement mitigation measures and the monitoring plan relating to the dumpsite closure.

[1] IFC/World Bank 2007. Environmental Health and Safety Guidelines: Waste Management Facilities; Municipal Solid Waste.

Attachment 1: Environmental Desk Review Checklist

The following information should be collated and analyzed as a minimum, where available:

A. General:

1. Site name and location.
2. Geographic coordinates.
3. Contact personnel.
4. Facility size (hectares).
5. Surrounding land use.
6. Surrounding surface features.
7. Principal access routes.
8. Geologic setting.
9. Hydrologic setting.
10. Hydrogeologic setting.
11. Nearby groundwater well data.
12. Landowners (previous and current).
13. Site operators (previous and current).

B. Site Operations

1. Commencement date.
2. Operation records.
3. Previous site surveys, investigations.
4. Types of wastes accepted.
5. Approximate daily volume.
6. Estimated total waste volume.
7. Compliance/violation records.
8. Monitoring records.

C. Site Closure and Post Closure (as applicable)

1. Closure date.
2. Facility closure records.
3. Facility post-closure use.
4. Facility post closure records.

Maps and Figures

1. Site location and site access plan.
2. Geologic map.
3. Hydrogeologic map.
4. Map of known groundwater wells in the vicinity.
5. Site surface layout.

Attachment 2: Environmental Field Reconnaissance Checklist

The following information should be collated and analyzed as a minimum, where possible:

A. General:
1. Contact personnel (SWM Department and at the facility).
2. Date of site survey.

B. Site Location and Access:
1. Distance from major highway.
2. Access road suitability (width, condition, adjacent developments).
3. Average drive time from major highway.
4. Site access procedures.

C. Key Site Features:
1. Site area (total).
2. Site area (waste piles).
3. Facility design and construction records.
4. Site boundary protection: condition, adequacy.
5. Waste pile plan dimensions.
6. Waste pile depth: maximum, average (where known).
7. Waste pile height.
8. Sideslope configuration.
9. Waste pile volume remaining.
10. Surface drainage features.
11. Site substrate.
12. Adjacent land use.
13. Any topographically notable features.

D. Site Operations:
1. Facility equipment and working practices.
2. Estimates of incoming waste volumes.
3. Waste types.
4. Daily vehicles: number and types.
5. Daily, intermediate and final covers.
6. Any environmentally engineered components.
7. Operation methodology.
8. Waste checking and screening procedures.
9. Operations personnel and functions.
10. Personnel health and safety procedures.
11. Personnel protective equipment.
12. Fire protection equipment and procedures.
13. Restricted working area procedures.
14. Emergency response planning.
15. Visible surface leachate.
16. Visible indications of the presence of landfill gas.
17. Exposed waste.
18. Litter and litter control procedures.
19. Odor and odor control procedures.
20. Animals, disease vectors.
21. Site operations documents.

E. Interview questionnaires of site personnel.

F. Photographic Record.

Attachment 3: Environmental Sampling and Testing Protocol

A. Groundwater Sampling and Analysis

Groundwater sampling locations will be at either:

- existing wells (at least 2 up-gradient and 5 down-gradient of the dumpsite);
- developed groundwater wells from among the investigative boreholes drilled for geologic and soil site investigations during detailed design; and/or
- boreholes drilled intentionally for the study (at least 1 up-gradient and 3 down-gradient).

The groundwater sampling plan will be determined in collaboration with the PMU, PIU and Environmental Specialist of the Project Management and Construction Supervision (PMCS) team. The groundwater quality parameters to measure, test and analyze are listed in the following table. The results will be compared with the Drinking Water Quality Standards of Cambodia and WHO Guidelines for Drinking Water Quality, 2017.

Groundwater Parameter	**Location of Measurement/Test/Analysis**
Depth of water table	Well site
Temperature (^{O}C)	Well site with portable meter
pH	Well site with portable meter
Dissolved Oxygen (mg/L)	Well site with portable meter
Conductivity	Well site with portable meter
COD (mg/L)	Laboratory
Total dissolved solids (mg/L)	Laboratory
Heavy metals: As, Cd, Pb, Hg, Fe, Z, Cu, Cr^{+6} (mg/L)	Laboratory
Oil and grease (mg/L)	Laboratory
Total and faecal coliform (MPN)	Laboratory
Nitrogen: TN, NH_3, NO_3, NO_2 (mg/L)	Laboratory
Phosphorous (TP, PO_4 (mg/L)	Laboratory
Hydrogen sulphide (mg/L)	Laboratory
Surfactants (detergents) (Mg/L)	Laboratory
Cyanide (CN) (mg/l)	Laboratory

B. Surface Water Sampling and Analysis

Surface water sampling locations will be taken upstream and downstream in the nearest surface waters (river, creek, lake). This will be determined in collaboration with the PMU, PIU and Environmental Specialist of the PMCS team. The surface water parameters to measure, test and analyze are listed in the following table. These parameters are a combination of selected parameters from the applicable annexes in the Sub-decree on Water Pollution Control, 1999, and from the Technical Guidelines on the Implementation of the Procedures for Water Quality of the Mekong River Commission[2].

[2] Approved in the 23rd Meeting of the MRC Council on 22 November 2016.

Surface Water Parameter	Location of Measurement/Test/Analysis
Temperature (^{O}C)	In situ
pH	In situ
Dissolved Oxygen (mg/L)	In situ
Conductivity	In situ
COD (mg/L)	Laboratory
BOD5	Laboratory
TSS (mg/L)	Laboratory
Heavy metals: As, Cd, Pb, Cu, CN, Total Hg, Cr^{+6}, (mg/L)	Laboratory
Total and faecal coliform (MPN)	Laboratory
Nitrogen: TN, NH_3, NO_3, NO_2 (mg/L)	Laboratory
Phosphorous: TP, PO_4 (mg/L)	Laboratory
Oil & grease (mg/L)	Laboratory
Phenol (mg/L)	Laboratory
Total Organochlorine Pesticide	Laboratory
Cyanide	Laboratory

C. Soil Quality Sampling and Analysis

Soil sampling locations will be determined in collaboration with the PMU, PIU, the Environmental Specialist of the PMCS team, and the Department of Environment. Soil samples will be acquired through either boreholes constructed for geotechnical investigations, and/or boreholes drilled intentionally for soil quality study. It is recommended that the study be coordinated with the geotechnical investigations, particularly with respect to soil sampling and the parameters to analyze to avoid duplication. The number of samples must meet the study objectives and standard data quality.

D. Ambient Air Quality Sampling and Analysis

Four sampling stations will be identified, comprising of two at community areas, and based on wind direction, one upwind of the dumpsite and one downwind of the dumpsite. The final locations of the sampling stations will be agreed between the PMU, PIU and Environmental Specialist of the PMCS team. The appropriate number of measurements to take must meet the study objectives and standard data quality. The parameters to measure and analyze are CO, PM2.5, PM10, CH4, H2S, NO_2, and SO_2, (at 1-hr and 24-hr averaging periods).

E. Noise Sampling and Analysis

Six sampling stations will be identified, comprising of two at community areas, two at the access road to the dumpsite, one upwind of the dumpsite, and one downwind of the dumpsite. The final locations of the sampling stations will be agreed between the PMU, PIU and the Environmental Specialist of the PMCS team. The measurements must meet the study objectives and WHO Guidelines for Community Noise, 1999.

F. Leachate Sampling and Analysis

Where leachate is present within or around the site, leachate quality will be analyzed at up to three sampling stations, with the final locations being agreed between the PMU, PIU and Environmental Specialist of the PMCS team. The parameters to measure, test and analyze will be based on Annex 2 of the Sub-Decree on Water Pollution Control, 1999 that include temperature, turbidity, pH, Conductivity, COD, BOD, TSS, Total organic carbon, DO, TDS, ammonia-N, PO4, Chloride, faecal coliform, phenols, NO3, SO4, Mg, As, Cd, Pb, Se, Cu, Ni, Mn, Hg, Fe, oil and grease.

Stakeholders Consultations in August 2017

PLACE Date/Time	Organization	Person/s Met	Highlights
Phnom Penh 31 Jul 2017 2:30 PM	MOE	Mr. Duong Samkeat Deputy Director, EIA Department Mr. Chea Leng Deputy Director, EIA Department Ms. Srun Im Deputy Director, WQ Department Mr. Chek Roth Deputy Director, Laboratory Department Ms. Delfa Uy Environmental Specialist, ADB-PPTA Mr. Yim Chamnan Environmental Specialist, ADB-PPTA	- The new Environment and Natural Resources Code not yet finalized. Once approved, existing sub-decrees will be revised accordingly. - Government environmental assessment requirements will be necessary for the Project: - All Project IEIAs to be submitted to the MOE. Copies of such document/s will be sent DOEs and relevant ministries for their review. If MPWT will not submit IEIA report, the project/subprojects will not be allowed to start. - One IEIA report per town (with the components) is acceptable to the MOE. - IEIA report must follow format and basic contents of an IEIA/EIA report. - The conduct IEIA/EIA study and preparation of IEIA/EIA report must be done by an entity or individual that is registered/permitted in the country to provide technical services on environmental assessment. - The project owner will prepare EA or IEIA or EIA report in accordance to EIA sub-decree and submit to MoE for review, comments, and approval. - standards for water quality, soil quality, air and noise. To date, there is no update on the standards.
01 Aug 2017 9:00 am	Laboratory Building, Hydrology and River works Department, MOWRAM,	Mr. Chin Savuth Director Department Hydrology and River works Ms. Ms. Nhim Sophea Deputy Director Hydrology and River works Ms. Delfa Uy Environmental Specialist MPWT-ADB, PPTA Team Mr. Yim Chamnan Environmental Specialist MPWT-ADB, PPTA Team	- MRC had not conducted monitoring of Mekong River since 2015. The responsibility of monitoring was handed over to the GMS countries. - MOWRAM conducts monthly monitoring of the water quality of Mekong River. PPTA may write the MOWRAM Minister for request of data. - Based on the monitoring data, BOD and chlorophyll are low. - MOWRAM can also collect samplings, conduct tests and analyses when requested for such services. Quotations for such services will be provided upon request which should include details such number and location of samplings; and parameters to analyze. - MOWRAM is responsible/ has the capacity for the monitoring surface water (lake river, and stream). The ground water samples may be taken to Ministry of Rural Development (MRD). - The department of hydrology and river works of MOWRAM collaborated with MRC for the monitoring of water quality, water flow, water level of a few locations in main Mekong River in Stung Treng, Kratie, Kampong Cham, Kandal, Phnom Peng, and Prey Veng Province. Such monitoring activities are being implemented by MOWRAM.
07 August 2017 8:00 am	Meeting room of the Department Public Works and Transport, Stung Treng	Mr. Sar Kimnath Director of DPWT, Stung Treng Mr. Khan RA DTL, MPWT-ADB, PPTA Ms. Delfa Uy Environmental specialist MPWT-ADB, PPTA Mr. Yim Chamnan Environmental specialist MPWT-ADB, PPTA Mr. Michael Alcazaren Social safeguards specialist MPWT-ADB, PPTA Mr. Mel Sophanna Social safeguards specialist	- The DPWT welcomes the consultant team for study Kratie Town. We recommend GMS project on roads, WWTP-drainage and Solid waste dumping site. - The proposed roads should be constructed in the existing road alignment so land acquisition is minimal. But I think the local people are happy and will cooperate with the project. There are no complaints from the local people considering the potential positive impact of the project on the social and environments. The people asked for the commencement of the project. - The proposed WWTP site is located in an area (small stream) which is below Mekong River water level. The land is public land. We will collaborate with town governor for assistance on the project. - The proposed component for improve dumping site for solid waste is far from town about 11 km and we have big site which is about 147 ha. This proposed dumping site is a public land. - I think, there are potential subprojects for Stung Treng Town, due to population and economic increasing and for environmental protection, especially Mekong River. If you have questions concerning other departments you can consult with them, I will endorse you.

PLACE Date/Time	Organization	Person/s Met	Highlights
		MPWT-ADB, PPTA Mr. Jens Sjorslen Social-Gender specialist MPWT-ADB, PPTA Mr. Pen Thay Social-Gender specialist MPWT-ADB, PPTA	
04 August 2017 10:00 am	Meeting room of the Department of Environment, Stung Treng	Mr. Yin Run Deputy Director of DoE PDoE, Stung Treng Mr. Noy Phahavisoth Chief office PDoE, Stung Treng Ms. Delfa Uy Environmental specialist MPWT-ADB, PPTA Mr. Yim Chamnan Environmental specialist MPWT-ADB, PPTA	- In Stung Treng, the main environmental problems in some areas are: Solid Water Management and waste water (sewage). This is because it is unclear whose agency is responsible for waste management. Following the government policy, the waste management is divided into 2 options: (i) public waste (public areas) and Stung Treng Market which is managed by subcontractor (private), the management cost is provided by MoE; and (ii)The household waste is managed by government (town. The households pay for waste collection fee every month. - Some households are not willing to pay for waste collection fee, they bring the waste and dispose in the public areas and market area or dispose anywhere. The waste collector/ subcontractor is complaining to this situation because it doesn't have enough truck and capacity for the collection and transportation of this volume of wastes. - Some villages in the Stung Treng Town doesn't have access roads for the waste trucks to pass and collect. Further, they also don't want to pay for solid waste collection fee. I flagged this issue in the meeting with MoE and Kratie Town. - All the waste water from public drainage and private drainage is discharged to Mekong River without treatment. There is no WWTP in Stung Treng Town. - There are no sensitive areas, protected areas, sensitive resources and endangered species in the proposed sites (dumping site and WWTP site). - The DoE has no laboratory, so we don't have the water quality data of Mekong River. I think MOWRAM is responsible for Mekong Water Quality Monitoring. - I think these proposed subprojects for solid waste dumping site and WWTP are very good for Stung Treng Town to help mitigate negative impacts to the Mekong River.
04 August 2017 3:00 pm	In the meeting room of the Stung Treng Town	Mr. Ly Mina Deputy Governor Stung Treng Town Mr. Suong Hy Deputy Governor Stung Treng Town Ms. Delfa Uy Environmental specialist MPWT-ADB, PPTA Mr. Yim Chamnan Environmental specialist MPWT-ADB, PPTA	- I think the proposed subprojects are very important for Stung Treng Town. These subprojects we discussed with DPWT and relevant departments and we accepted these selected subprojects for GMS project. - The population increased and solid waste will increase too. The proposed landfill (dumping site) is located in Samaky Commune with the size of 145 ha and is about 11 km from Stung Treng Tow. The land is public land. I think this site is suitable for a landfill. There are people living near and in this site, only 1 subcontractor's house is there to guard the site equipment. There are no sensitive sites and protected areas located near the proposed landfill site. I think the impact to environment is minor. - According to the government declaration, the SWM is divided into 2 options: (i) public waste (public areas and Stung Treng Market is managed by subcontractor (private). the management cost is provided by MoE; and (ii)The household waste is managed by government (town). The households pay for waste collection fee every month. - We discussed and approved the selection of WWTP site. The proposed site is Tang Memay Village, Preah Bat Commune, Stung Treng. The site is lowland area of Ta Eng Tream and near to Mekong River. The land is public land but there are a few families that cultivated portion of the land. There are areas which are privately owned which is located on both sides of the stream. I think this is not a big issue. The DPWT should collaborate with local governors, DLMUPC, and communities in conducting RAP. - Grievance Redress Mechanism (GRM) is an existing mechanism for our people complaint to: Village, Commune, District, and Province. The people are very much aware of this complaining process

PLACE Date/Time	Organization	Person/s Met	Highlights
04 August 2017 4: 30 pm	In the meeting room of the DOWRAM, Stung Treng Province	Mr. Pang Peng Director of DOWRAM DOWRAM Stung Treng Ms. Delfa Uy Environmental specialist MPWT-ADB, PPTA Mr. Yim Chamnan Environmental specialist MPWT-ADB, PPTA	- The DOWRAM is responsible for Mekong Water, Rainfall, and Temperature monitoring in Stung Treng Town, I will provide some hydrology-meteorology data for you. Department does not have laboratory, so water quality is under MOWRAM, Phnom Penh. - The DOWRAM is monitoring Mekong Water Level every day, especially during a flood (August-September). There is a permanent monitoring device installed along Mekong River. The emergency point of Mekong Water Level is at level 11.70m. When the water level rises to this emergency point, the DOWRAM will inform provincial departments, local authorities, and communities by phone, TV, radio. We don't have automatic alarm for any cases. - The provincial government had established the Disaster Response Committees for any disaster that may happen in the province (but not in the case of flood). The committees are set up in Provincial level, District level, and Commune level. - We already discussed the propose dumping site for solid waste disposal with concerning departments and authorities. I think this site is good, located in low land area, far from residential areas and there are no people living there. I think the waste water from the town will flow to this WWTP through drainages without pumping. - The WWTP is good to control and reduce some of the impact of waste water from town to Mekong River.
07 Aug 2017 1:30 pm	Trapeng Pring Village, Stung Treng Commune, Stung Treng Town	Mr. Pich Vuthy 60 year old, Male Trapeng Pring Village, Stung Treng Commune, Stung Treng Town. Ms. Mouv Sreang 54-year-old, female Trapeng Pring Village, Stung Treng Commune, Stung Treng Town.	- If the project will improve this road, it will be very good for us because now the traffic is increasing year after year and the road seemed narrow to accommodate the traffic. - We are living near the road and make small business for a long time now. - When construction will be implement, our business will be interrupted and other local businesses along the road. There will be increase noise and poor air quality, but I think is not a sensitive issue as we used to live near the road with the high noise level, poor air quality and vibration from passing vehicles. - Will the project include widening of road? - When is the start of the construction? - I think, the impacts of the project includes land acquisition and other relocation of local structures which may not be a big problem because this existing roadway is wide already.
08 Aug 2017 2:00 pm	Bachong Village, Preah Bat Commune, Stung Treng Town	Mr. Sok Heang 44-year-old, Male Bachong Village, Preah Bat Commune, Stung Treng Town,	- I think this is a good project for improving this road. - Sometimes this road is flooded from runoff during heavy rain. Water depth was about 2-3m above the road. - All the households in this village use water from town water supply authority. There are no wells (ground water) in this village. - For my household, the solid waste is collected by waste truck. The truck comes 3 days/ week, and we pay monthly for waste collection fee. - I think, there are few households which is not collected of their solid waste by truck collection. This is maybe because they don't want to pay or there is no road access for the truck to go to houses. - There are small impacts during construction stage (air, noise, vibration), but we think is not much of a concern. I hope the people are living along the roadside are not concern too much.

Mekong River Water Quality

Table A. Mekong River Water Quality – Kampong Cham Town

Parameter	Units	2017					Cambodia Standard Limit[3]		MRC Target Value[4]	
		03 Feb[1]	20 Mar[1]	24 Apr[1]	June[2]		For biodiversity conservation	For public health protection	for the protection of	
					Min.	Max.			human health	aquatic life
pH	-	7.4	7.64	7.23	7.5	8.4	6.5-8.5	-	6-9	6-9
TSS	mg/L	39	45	39	-	-	25-100	-	-	-
BOD_5	mg/L	0.68	0.89	0.92	-	-	1-10	-	4	3*
COD	mg/L	1.17	2.15	2.35	-	-	-	-	5	-
Cr^{6+}	mg/L	ND	ND	ND	-	-	-	< 50	0.05	0.05
TN	mg/L	0.5	0.48	0.55	-	-	-	-	-	-
TP	mg/L	0.11	0.06	0.11	-	-	-	-	-	-
Temperature	^0C		-	-	23.5	28.5	-	-	Natural	Natural
Turbidity	NTU	-	-	-	92	259	-	-	-	-
TDS	mg/L	-	-	-	127	78	-	-	-	-
Alkalinity	mg/L	-	-	-	56	64	-	-	-	-
EC	mS/m	-	-	-	15.5	25.4	-	-	70-150	-

ND No detect.

* An interim target value requiring further review by the MRC Technical Body on Water Quality.

Sources:

1 Analysis Reports for Mekong River water samples obtained at Upstream of Kizona Bridge on 03 February 2017, 20 March 2017 and 24 April 2017. Laboratory Department of the General Department of Environmental Protection. MOE.

2 Results of Raw Water Quality Monitoring on 30 June 2017 by Kampong Cham Water Treatment Plant. (See Table B below.)

3 Annexes 4 and 5. Sub-decree on Water Pollution Control (No. 27 ANRK.BK). 1999.

4 Technical Guidelines on the Implementation of the Procedures for Water Quality. Mekong River Commission. Approved in the 23rd Meeting of the MRC Council on 22 November 2016.

Table B. Raw Water Quality from Mekong River – Kampong Cham Water Supply

អង្គភាពរដ្ឋាករទឹកខេត្តកំពង់ចាម Kampong Cham Water Treatment Plant

Year/Month: 30/06/ 2017

Day	Raw Water (ទឹកឆៅ)									Treated Water (ទឹកស្អាត)								
	Sampling Time	Temp °C	Color TCU	Turb NTU	Res. Chl	pH -	TDS mg/L	Alkal mg/L	Cond µs/cm	Sampling Time	Temp °C	Color TCU	Turb NTU	Res. Chl	pH -	TDS mg/L	Alkal mg/L	Cond µs/cm
1	8h:00	28		242	-	7.8	96		192	8h:30	28.3		0.110	0.22	7.6	104		208
2	8h:00	27.6		259	-	7.7	90		180	8h:30	28.0		0.120	0.17	7.5	99		197
3	8h:00	27.8		217	-	7.8	95		190	8h:30	26.5		0.140	0.28	7.4	105		210
4	8h:00	27.9		194	-	7.8	97		194	8h:30	26.5		0.090	0.32	7.5	103		206
5	8h:00	28.1		159	-	7.9	100		200	8h:30	26.5		0.100	0.30	7.4	98		195
6	8h:00	27.8		110	-	7.8	99		198	8h:30	23.5		0.120	0.34	7.4	123		245
7	8h:00	28.1		118	-	7.8	98	56	196	8h:30	25.6		0.100	0.41	7.4	104	67	207
8	8h:00	28.2		114	-	7.9	99		197	8h:30	24.5		0.100	0.31	7.4	105		209
9	8h:00	28.1		117	-	7.8	123		225	8h:30	27.5		0.100	0.48	7.3	116		231
10	8h:00	28.0		104	-	7.7	106		211	8h:30	26.5		0.110	0.64	7.2	111		222
11	8h:00	28.2		102	-	7.9	107		213	8h:30	24.5		0.010	0.76	7.3	111		221
12	8h:00	28.3		92	-	7.7	106		212	8h:30	28.0		0.240	0.87	7.2	116		231
13	8h:00	28.0		106	-	8.0	94		187	8h:30	27.6		0.370	0.48	7.3	100		200
14	8h:00	26.5		132	-	7.8	96	61	191	8h:30	27.8		0.220	0.25	7.4	102	69	204
15	8h:00	26.5		127	-	7.9	95		189	8h:30	27.9		0.120	0.29	7.5	99		198
16	8h:00	26.5		101	-	8.4	103		205	8h:30	28.1		0.120	0.35	7.3	114		228
17	8h:00	23.5		99	-	7.9	95		190	8h:30	27.8		0.100	0.56	7.3	106		212
18	8h:00	25.6		117	-	7.8	82		164	8h:30	28.1		0.110	0.48	7.4	102		204
19	8h:00	24.5		137	-	7.5	78		155	8h:30	28.2		0.150	0.47	7.3	93		186
20	8h:00	28.5		132	-	7.7	85		170	8h:30	28.1		0.260	0.58	7.1	88		176
21	8h:00	27.5		125	-	7.6	84	63	167	8h:30	28.0		0.120	0.56	7.2	96	67	191
22	8h:00	26.5		140	-	7.5	84		167	8h:30	28.2		0.160	0.34	7.1	205		210
23	8h:00	24.5		125	-	7.9	85		169	8h:30	28.3		0.140	0.32	7.3	89		177
24	8h:00	24.5		137	-	7.9	86		171	8h:30	28.0		0.160	0.41	7.2	89		178
25	8h:00	28.0		147	-	8.0	84		168	8h:30	29.0		0.130	0.39	7.3	87		174
26	8h:00	27.5		165	-	8.3	87		173	8h:30	28.8		0.120	0.41	7.2	90		179
27	8h:00	28.3		170	-	7.8	88		176	8h:30	27.5		0.120	0.56	7.1	117		233
28	8h:00	28.0		145	-	8.0	91	64	182	8h:30	26.5		0.090	0.48	7.2	94	69	187
29	8h:00	26.5		137	-	7.9	127		254	8h:30	24.5		0.110	0.73	7.2	139		277
30	8h:00	26.5		132	-	7.9	94		187	8h:30	28.0		0.100	0.43	7.2	122		244
Max		28.5	0	259	-	8.4	127	64	254		29.0	0.000		0.87	7.6	205	69	277
Min		23.5	0	92	-	7.5	78	56	155		23.5	0.000		0.17	7.1	87	67	174
Ave		27.1	#DIV/0!	139	-	7.8	95	61	189		27.2	#DIV/0!		0.44	7.3	108	68	208

Date: / / 2017

ប្រធានអង្គភាព

Director

ព្រាប សូម៉ាឡា

Date: 03 / ក្កដា/ 2017

ប្រធានផ្នែកផលិតកម្ម

Chief of Production (Laboratory)

Date: 30/ 06 / 2017

អ្នកធ្វើតេស្ត

Analyst

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