

Initial Environmental Examination

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Thailand: Lower East Chao Phraya Irrigation System Improvement – Climate Adaptive Strengthening Investment Project

Prepared by the Royal Irrigation Department (RID), Government of Thailand for the Asian Development Bank (ADB).

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Abbreviations

ADB	Asian Development Bank
AIS	Alien Invasive Species
AOI	Area of Influence
AQ	Air Quality
AQG	Air Quality Guideline
BE	Buddhist Era
BKK	Bangkok
BMA	Bangkok Metropolitan Area
BOD	Biological Oxygen Demand
BOQ	Bill of Quantities
CCSP	Concrete corrugated sheet pile
CHA	Critical Habitat Assessment
COD	Chemical Oxygen Demand
CODI	Community Organization Development Institute
CPR	Chao Phraya River
EA	Executing agency
EHS	Environmental, Health and Safety
EIA	Environmental impact assessment
EMP	Environmental management plan
EMS	Environmental Management System
EN	Endangered
ES	Executive Summary
ESF	Environmental and Social Framework
EMP	Environmental and Social Management Plan
EWS	Early Warning System
GRC	Grievance Redress Committee
GRM	Grievance Redress Mechanism
IA	Impact Assessment
IAQM	Institute of Air Quality Management
IAS	Invasive Alien Species
IBA	Important Bird Areas
IBAT	Integrated Biodiversity Assessment Tool
IEAT	Industrial Estate Authority of Thailand
IEE	Initial Environmental Examination
IFC	International Finance Corporation
ILO	International Labour Organization
KBA	Key Biodiversity Areas
LC	Least Concern
LCEP	Lower East Chao Phraya
LECP	Lower East Chao Phraya
LMIC	Lower middle-income country
MRC	Mekong River Commission
NS	Non-significant
O&M	Operations and Maintenance
PAH	Polycyclic Aromatic Hydrocarbons
PIU	Project Implementation Unit
PMSC	Project Management and Supervision Consultancy
PMU	Project Management Unit
POP	Persistent Organic Pollutants

PSC	Project Steering Committee
RID	Royal Irrigation Department
SPRC	Source - Pathway - Receptor - Consequence
SPS	Safeguard Policy Statement
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UNFCCC	United Nations Framework Convention on Climate Change
VER	Valued Environmental Receptor
WB	World Bank
WDKBA	World Database of Key Biodiversity Areas
WDPA	World Database of Protected Areas
WHO	World Health Organization

EXECUTIVE SUMMARY

The Lower East Chao Phraya Irrigation System Improvement Project (hereinafter referred to as “LECPISIP” or “project” or “overall project”) is one of the nine large-scale plans under the comprehensive investment program prepared by the Government of Thailand to alleviate the flood issues in the Lower Chao Phraya River Basin. The project will be supported by ADB under a Multitranche Financing Facility (MFF), which will be implemented in three tranches over eight-year period.

The project includes modernization of irrigation and drainage infrastructure and other supporting outputs in the Lower East Chao Phraya area. The project is aligned with the following impact: Economic impacts from climate-induced floods and droughts reduced.¹ The project will have the following outcome: Resilience and preparedness to climate-induced risk in the Lower East Chao Phraya strengthened. The project will comprise the following three outputs:

- (i) Output 1: Modernized climate-resilient irrigation and drainage infrastructure established. Output 1 will upgrade existing irrigation canals, regulation structures, and pumping stations to function as dual-purpose irrigation and flood-conveyance systems, creating climate-resilient assets that mitigate both flood and drought risks. Physical modernization will include re-sectioning and stabilizing canal cross-sections, and constructing or upgrading flow-control structures, pumping stations, and operations buildings to enhance structural resilience and hydraulic performance. These improvements will increase the system’s flood-conveyance capacity from 210 m³/s to 400 m³/s, reducing downstream flood levels in the Lower Chao Phraya River and Bangkok.² Enlarged waterways will also expand storage capacity, improving water availability for irrigation and other uses during dry periods. The project will (i) upgrade approximately 473 km canals (both banks), 311 km under the loan funds and 162 km under domestic financing and (ii) construct or upgrade 16 structures, 11 under loan funds and 5 under domestic financing;
- (ii) Output 2: Climate smart and efficient water management capacity strengthened. Output 2 will establish and upgrade digital systems to improve operational efficiency, strengthen climate-risk management, and modernize irrigation network operations. A comprehensive decision-support system (DSS) will be developed for real-time flow monitoring, flood forecasting, early warning, and optimized irrigation and drainage operations. The output will also modernize the hydrometeorological observation network, strengthen institutional frameworks, and build RID’s capacity for digital O&M and asset management. Activities include: (i) upgrading flow-forecasting and early-warning systems; (ii) establishing a functional asset management system and institutionalizing O&M planning and execution processes; (iii) enhancing staff competencies in digitized water management; and (iv) adopting a strategy to advance women’s participation and leadership within RID; and
- (iii) Output 3: Community resilience and livelihood supported. Output 3 will build on ongoing government initiatives to empower communities and strengthen

¹ Government of Thailand. 2022. Thailand 2nd Updated Nationally Determined Contributions. Bangkok.

² United Nation Development Programme/Green Climate Fund are implementing the [*Enhancing climate resilience in Thailand through effective water management and sustainable agriculture*](#) project in the upstream Chao Phraya watershed, which include soil improvement and erosion control.

resilience at the local level. Effective gender-responsive CBDRM³ and early warning system (EWS) will be established in communities at risk to reduce losses caused by disasters triggered by natural hazards and contribute to livelihood development, and indirectly food security. Extensive training on livelihood development and diversification will be provided, specifically for the most vulnerable groups in the communities. In close cooperation with the DDPM of the Ministry of Interior, CBDRM groups will be established in the communities and provided with the necessary equipment to effectively operate, including community EWS linked to RID's DSS. Technical training on DSS, O&M, and EWS operations will be provided by RID and local governments. Training will also be provided to benefit communities by developing opportunities for livelihood diversification and improving existing agricultural activities to reduce flood risks. Cultural and gender aspects, the roles of women's community organizations, and local employment opportunities will be assessed and integrated. Specifically, this output will: (i) make CBDRM programs operational in communities around irrigation canals, (ii) allow affected households in RID right-of-way become legal land users, (iii) increase women in leadership/decision-making positions in CBDRM groups, and (iv) increase knowledge on livelihood enhancement and business development among farmers and Micro, Small, and Medium Enterprises (MSMEs), including female farmers and women-owned MSMEs.

The Project. The Government of Thailand is undertaking a major initiative to modernize the Lower Chao Phraya River canal system, aiming to address vulnerabilities caused by climate-induced floods and droughts. By retrofitting existing irrigation canals, the project seeks to enhance their capacity for flood diversion, local drainage, and irrigation, thereby reducing the need for new infrastructure that could have substantial environmental and social impacts. Improvements in irrigation efficiency are expected to support sustainable agriculture, ensure food security, and help local communities adapt to changing rainfall patterns, ultimately contributing to broader climate resilience and sustainable development goals.

Central to this effort is the LECPISIP or the project, which is part of a larger masterplan for flood risk management in the Chao Phraya River Basin. The LECPISIP will have the following components:

- (i) Upgrade of approximately 311 kilometers of existing canals by dredging to increase the cross-sectional area of these canals and by constructing retaining walls on either or both sides of these canals under Output 1; and
- (ii) Construction and/or upgrade of 11 flow regulator structures under Output 1.

³ Gender-responsive CBDRM considers and addresses differentiated needs and vulnerabilities of women and girls particularly those from vulnerable groups, during disaster prevention and response. It includes mechanisms for women's participation in consultation and decision-making. The program will ensure: (i) participation of women in planning, training, and implementation of pilot activities; (ii) women's participation and leadership in the CBDRM committees; (iii) actions that enhance women's safety, agency, and capacity to lead preparedness, response, and recovery; (iv) incorporation of gender considerations into early warning, maintenance, and community flood- and drought – response planning; and (v) GBV prevention measures within community preparedness and response systems.

The project's MFF approach allows flexible implementation across multiple tranches, focusing on civil works, equipment, and consulting services to ensure the infrastructure is resilient against future climate uncertainties.

Categorization. ADB requires the consideration of environmental issues in all aspects of ADB's operations, and the requirements for environmental assessment are described in ADB Safeguard Policy Statement (SPS), 2009. Based on the design and location of project components, the project is classified as Category B for environment per ADB SPS, 2009 as no significant impacts considered as diverse, irreversible and unprecedented are envisaged. Accordingly, an IEE has been undertaken, which assesses in more detail the likely environmental impacts of the project and provides the corresponding mitigation measures to ensure these impacts are managed to acceptable levels. While most water trans-basin development projects, like the project, typically require an EIA under the national regulations, exemptions are made for projects aimed at temporary diversion during disasters or those impacting national security. As the project sought this exemption, the IEE identified this gap and requires the project to follow the environmental assessment per ADB SPS requirements.

Description of the Environment. The proposed site of the project is located in the lower eastern part of Chao Phraya river basin, which is considered developed area yet mostly rural with existing residential, commercial and institutional establishments around. It is accessible from Bangkok via different routes, each with about 30-40km road to the eastern direction from central Bangkok area. These two-way roads ensure easy access during the construction and operation phase of the project. The construction sites will be at different locations but with similar environmental features all around – basically the embankments adjacent the canals that are to be rehabilitated. These areas are adjacent either or combination of vacant or barren government-owned land with no existing use, agricultural lands and rural communities.

The basin, situated between the Chao Phraya and Bang Pakong Rivers, is characterized by its low-lying terrain, intensive agriculture, primarily rice paddies, and a landscape dominated by human-modified features such as rectilinear irrigation canals and access roads. The region includes the outskirts of Bangkok, a densely populated urban area with nearly 11.4 million residents as of 2025, and features settlements that typically follow the pattern of canals and roads. Natural vegetation is limited, with riparian zones likely supporting the most native flora and fauna. Flora is considered the common species that grow naturally elsewhere in the country. To the south, the basin borders the Gulf of Thailand, where the marine environment, though formally recognized for biodiversity, experiences some disturbance from nearby urbanization. The area sees limited water discharge into the Gulf from irrigation systems compared to the larger natural river flows. Additionally, commercial aquaculture is present near the coast and far offshore, contributing to the basin's economic activities.

Assessment of Environmental Impacts. Potential environmental impacts were identified on the basis of review and analysis of the primary and secondary data or information and consultations, and field visits to the site. Impacts were identified in relation to the different phases of project implementation — pre-construction, construction, and operation of the built infrastructure. Evaluation of the likely degree of impacts has been done on each of identified potential impacts. Based on this evaluation, mitigation measures have been developed to reduce all negative impacts to acceptable levels. These were discussed with specialists and experts responsible for the engineering and environmental aspects. On the potential impacts due to construction activities (i.e. noise, vibration, ambient air quality, surface water quality, other forms of nuisance), these have been assessed to be site-specific, few, if any, of them are irreversible, and mostly can be readily mitigated and minimized by applying proven mitigation measures and environmentally sound engineering and construction practices consistent with international good practices as

reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines. These measures are included in the environmental management plan (EMP) of this IEE report.

Potential impacts to the physical environment. Impacts to air quality, acoustic environment, surface water and groundwater quality, waste disposal, and other forms of nuisance during construction phase are similar to impacts expected from other construction activities elsewhere, which can be mitigated through good international construction and engineering practices. Potential occupational hazards have been assessed due to exposure of workers to risks on canal excavation, working on surface waters, handling and transport of dredged materials, operating machineries and heavy equipment, etc. This set of potential impacts can be mitigated through the implementation of international best practices on occupational health and safety (OHS) such as those in the World Bank's EHS guidelines on OHS. Mitigation measures to avoid all potential impacts are included in the EMP. During the pre-construction phase, the Contractors will develop their respective site-specific EMPs (SSEMPs) and other allied work plans (e.g. traffic management plan, etc.), following applicable international best practices that will include World Bank's EHS Guidelines on Construction and Decommissioning Activities.⁴ In addition, the EMP also provides the measures that will be implemented during the operation and maintenance phase. These measures are similar to those that are developed for the construction phase and will be used as reference guide during operation phase in ensuring the entire flood control system is maintained to its designed effectiveness and efficiency. Thus, the EMP defines all the steps required for cost effective, efficient, safe, and reliable flood control system.

Potential impacts to physical cultural resources. The alignments of the canals that will be rehabilitated will pass through mostly vacant lands. However, there are some sections that are near or bounded by either or both residential establishments and physical cultural resources (PCRs), including temples (Wat) and other smaller structures such as spirit houses. Damage to these residential structures and PCRs could create conflict with the local people and the government as a whole. In order to avoid this consequence, the project will ensure to implement social safeguard measures in compliance with ADB SPS requirements on involuntary resettlement. The project will also ensure the conduct of pre-works survey to identify structures that may likely be affected by vibration, and implement measures to avoid impacts to these structures. All these mitigation measures are included in the EMP.

Potential impacts due to asbestos-containing materials (ACMs). Some of the adjacent communities along several alignments have structures made of ACMs like asbestos roofings. These will be demolished as part of the site preparation for the project. The demolition of these structures with ACMs during project implementation poses significant health risks to workers and the public. Improper handling may release asbestos dust and fibers into the air, which are hazardous when inhaled, potentially causing long-term illnesses such as asbestosis, lung inflammation, and cancer. To mitigate these risks, the project will coordinate closely with the social safeguards team and demolition contractors to ensure ACMs are not salvaged by affected households. An ACM Management Plan (AMP) will be developed and implemented, detailing hazard identification, safety gear requirements, disposal procedures, and record-keeping. Contractors are required to manage demolition activities in controlled sections, follow safety protocols outlined in the AMP, conduct safety awareness programs, and consult with asbestos experts as needed.

⁴ IFC World Bank Group. 2007. [Environmental, Health, and Safety \(EHS\) Guidelines – General EHS Guidelines: Construction and Decommissioning](#).

Potential impacts to biodiversity. Despite being located in a built-up and developed urban area, the project sites have been assessed in terms of biodiversity. An initial screening using the Integrated Biodiversity Assessment Tool (IBAT) was undertaken to screen and assess potential risks on sensitive areas or critical habitat that may exist around the project sites (default area of analysis of 50 km radius). Initial screening results show there are protected areas, key biodiversity areas and endangered and critically endangered species found within the 50-km radius. Accordingly, the project site is likely to be critical habitat due to these sensitive areas and species. A critical habitat screening and assessment was undertaken. Results show that biodiversity of the project area and its immediate surroundings is limited, primarily due to intensive agriculture and urbanization, resulting in scarce natural terrestrial habitats and a depauperate ecosystem. While northern regions feature protected forested areas, the immediate marine environment is significantly affected by human activities such as fishing, turtle hunting, and industrial and agricultural runoff. The most ecologically valuable habitats are the freshwater and riparian zones along rivers, canals, and ponds, which, despite being mostly engineered, serve as vital movement corridors and support stable aquatic communities provided water levels remain sufficient and significant disturbances are avoided.

The initial screening suggest that one species was likely to qualify the area as Critical Habitat, this being the Spoon-billed sandpiper (*Calidris pygmaea*), a migratory bird species which winters in wintering sites in Thailand and Myanmar. The critical habitat assessment finds that none of these wintering sites is near or within the project area. Other species were also identified, but the assessment suggests that these are not present within the project's area of influence. The critical habitat assessment conducted concluded that there are no critical habitats within the project area but did suggest areas outside of the project area which are likely or have potential to be classed as critical habitat based on their designation status.

Environmental Management Plan. From the results of assessment of impacts and mitigation measures, an environmental management plan (EMP) has been developed and included as part of this IEE, which outlines the following: (i) mitigation measures for environmental impacts during implementation; and (ii) an environmental monitoring program, and the responsible entities for mitigating, monitoring, and reporting.

In order to ensure sound environmental management and safety during various phases of the implementation, the Contractors will be required to prepare their respective site-specific environmental management plans (SSEMPs) based on the EMP of this IEE. Contractors will submit their SSEMPs for approval to PIUs. This will cover the following areas of impact which are potentially significant but can be mitigated by the adoption of good construction practices: (i) traffic management, (ii) vibration noise pollution, (iii) waste generation (iv) disposal of dredged materials from canal excavations, (v) water pollution, (vi) air and dust pollution, (vii) community health and safety risks, and (viii) occupational health and safety risks.

The EMP and SSEMPs will (i) ensure that the activities are undertaken in a responsible non-detrimental manner; (ii) provide a pro-active, feasible, and practical working tool to enable the measurement and monitoring of environmental performance on site; (iii) guide and control the implementation of findings and recommendations of the environmental assessment conducted for the project; (iv) detail specific actions deemed necessary to assist in mitigating the environmental impact of the project; and (v) ensure that safety recommendations are complied with. Copies of the EMP and SSEMPs shall be kept on-site during the construction phase. The Contractors will be responsible for the organization, direction, and execution of environmental management related activities during construction phase of the project. The Contractors will also

undertake all activities in accordance with the relevant environmental requirements, including support to continuing meaningful consultations with all stakeholders in coordination with PIUs and PMCSC, consent documentation and other regulatory and/or statutory and contractual requirements.

Consultation, Disclosure and Grievance Redress. The stakeholders were involved in undertaking the IEE through on-site discussions with affected stakeholders met during the field visits. These people consulted and encountered in the field conveyed their full support to the project, and thankful for the government for taking pragmatic plan. This consultation will continue throughout the project implementation, will be documented and included in the updating of the IEE. Meaningful consultation shall be carried out with affected people and other concerned stakeholders including civil society and facilitate their informed participation. In addition, contractors will be required to inform the local communities at least seven (7) days prior to the commencement of any construction activities. This notification shall be provided through appropriate means such as public announcements, distribution of notices, or meetings to ensure that affected residents and stakeholders are adequately informed in advance. Furthermore, contractors must install clearly visible informational boards at all active work sites, displaying contact details of relevant contractor representatives. These boards will provide community members with accessible channels to raise concerns or seek information regarding ongoing project activities. A Stakeholder Engagement Plan has been developed and will be used for the continuing meaningful consultation all throughout the project implementation

The project will adopt a grievance redress mechanism (GRM) to register grievances of the people regarding technical, social and environmental aspects. The process is designed to be transparent, gender responsive, culturally appropriate and commensurate to the risks and adverse impacts of the project, as well as readily accessible to all segments of the affected people. The project GRM will not supersede any legal government grievance procedures. Affected people are to be informed about the mechanism through media and public outlets. This participatory process shall ensure that all views of the people are adequately reviewed and suitably incorporated in the design and implementation process.

Implementation Arrangements. The Royal Irrigation Department (RID) is the Executing Agency of the MFF. A project management unit (PMU) will be established under the Medium Scale Water Resources Development Division of RID with close cooperation with the Treasury Department, the Ministry of Interior, and other relevant agencies. The PMU will have the overall responsibility for project management and implementation, including safeguards compliance. Project implementation units (PIUs) will be established to manage day-to-day implementation at the project site level. The project will engage a project management and construction supervision consultant (PMCSC) to support the PMU and PIUs. The implementation arrangements are discussed in detail in this IEE report.

Monitoring and Reporting. Consistent with the reporting requirements set out in the Facility Administration Manual, EMP compliance monitoring will be undertaken by PMU and PIUs with support from PMCSC. Contractors will submit their respective monthly reports to PMU through PMCSC, while PMU will prepare and submit reports to ADB on a semi-annual basis. The submission of environmental monitoring reports to ADB will continue until ADB issues a project completion report for the project.

Conclusion. The IEE was prepared using preliminary project information, draft bidding documents, and environmental data from the project area. The assessment identified potential environmental impacts and outlined mitigation measures to ensure compliance with

environmental regulations during construction and operation. The expected adverse impacts are localized and manageable, and with the recommended mitigation measures in place, the project is considered environmentally acceptable. Monitoring programs, including site inspections, documentation reviews, and community engagement, will ensure that mitigation measures are effectively implemented.

Meaningful consultation is a continuing activity and will be undertaken all throughout the project implementation. The IEE will be publicly disclosed through the ADB and RID websites. A grievance redress mechanism is in place to address concerns during implementation. The project is expected to benefit residents of the Chao Phraya River Basin by improving flood control, reducing economic and health burdens, and enhancing resilience to extreme climate events such as flooding. Based on the findings, the project is confirmed as Category B, with no significant environmental impacts anticipated

Recommendations. Below table summarizes the indicative activities to be completed at different stages of implementation.

Phase	Activity	Responsibility
Bidding and Contract Award	Inclusion of the IEE in the bid document as Appendix to Section 6: Employer's Requirements.	PMU, PMCSC
	Inclusion of safeguards (environment, health and safety) requirements in the bidders meeting.	PMU, PMCSC
	Submission of requirements including but not limited to personnel qualifications, safeguard qualifications, and environment, health and safety management plan (EHSMP).	Bidders
	Evaluation of safeguard-related submission of bidders.	PMU, PMCSC
	Confirm that contract documents of winning bidder include provision on compliance on all environmental requirements for contractor	PMU, PMCSC
Pre-construction Phase	Induction on safeguards to Contractor.	PIU, PMCSC
	Ensure Contractor appoints a qualified environment, health and safety (EHS) officer.	Contractor
	Preparation of SSEMP based on EMP.	Contractor
	Approval of SSEMP	PIU, PMCSC
	Instrumental monitoring for baseline environmental conditions per IEE.	PMCSC
	Pre-works photo-documentation of sites, access roads, existing structures, etc.	Contractor
	Obtain all statutory clearances, permits, no objection certificates (or equivalent) required under the project.	PIU/PMCSC, Contractor
	Continuing consultations with stakeholders, including the private sector, NGOs and civil society organizations	PMU and PIU, with support of PMCSC
After six months from effectivity of the loan	Submission of first semi-annual monitoring report (SEMR) to ADB	PMU
Construction Phase	Implementation of EMP and SSEMP	Contractor
	Monthly submission of report to PIU	Contractor
	Quarterly submission of report to PMU	PIU
	Semi-annual submission of SEMR to ADB,	PMU

	not later than 31 July (for period covering January to June) and not later than 31 January (for period covering July to December)	
	Preparation of corrective actions for non-compliances and non-conformances, if required for any reporting period.	PIU / PMCSC / Contractor
	Implementation of GRM	PMU, PIU
	Information disclosure and stakeholder engagement	PMU, PIU
	Preparation and delivery of safeguards capacity building plan (excluding those that are internally covered by the Contractor)	PMCSC
	Continuing consultations with stakeholders, including the private sector, NGOs and civil society organizations	PMU, PIU with support of PMCSC
	Updating of IEE for Tranche 2 and Tranche 3, if required	PMU, PMCSC
Post-construction Phase	Preparation and implementation of reinstatement and rehabilitation plan, which includes rehabilitation of disturbed areas/properties and revegetation/tree-planting.	Contractor
	Preparation of post-construction environmental audit report	
	Validation and approval of post-construction environmental audit report	PIU with support of PMCSC
Operation Phase	Implementation of EMP (Operation Phase)	PMU, PIU
	Continuing consultations with stakeholders, including the private sector, NGOs and civil society organizations	PMU, PMU
	Submission of SEMR to ADB, not later than 31 July (for period covering January to June) and not later than 31 January (for period covering July to December) until Project Completion Report is issued by ADB.	PMU

I. INTRODUCTION

A. Background

2. The The Lower East Chao Phraya Irrigation System Improvement Project (hereinafter referred to as “project” or “overall project”) is one of the nine large-scale plans under the comprehensive investment program prepared by the Government of Thailand to alleviate the flood issues in the Lower Chao Phraya River Basin. The project will be supported by ADB under a Multitranche Financing Facility (MFF), which will be implemented in three tranches over eight-year period.

3. The project includes modernization of irrigation and drainage infrastructure and other supporting outputs in the Lower East Chao Phraya area. The project is aligned with the following impact: Economic impacts from climate-induced floods and droughts reduced.⁵ The project will have the following outcome: Resilience and preparedness to climate-induced risk in the Lower East Chao Phraya strengthened. The project will comprise the following three outputs:

- (i) Output 1: Modernized climate-resilient irrigation and drainage infrastructure established. Output 1 will upgrade existing irrigation canals, regulation structures, and pumping stations to function as dual-purpose irrigation and flood-conveyance systems, creating climate-resilient assets that mitigate both flood and drought risks. Physical modernization will include re-sectioning and stabilizing canal cross-sections, and constructing or upgrading flow-control structures, pumping stations, and operations buildings to enhance structural resilience and hydraulic performance. These improvements will increase the system’s flood-conveyance capacity from 210 m³/s to 400 m³/s, reducing downstream flood levels in the Lower Chao Phraya River and Bangkok.⁶ Enlarged waterways will also expand storage capacity, improving water availability for irrigation and other uses during dry periods. The project will (i) upgrade approximately 458 km canals (both banks), 296 km under the loan funds and 162 km under domestic financing; and (ii) construct or upgrade 16 structures, 11 under loan funds and 5 under domestic financing;
- (ii) Output 2: Climate smart and efficient water management capacity strengthened. Output 2 will establish and upgrade digital systems to improve operational efficiency, strengthen climate-risk management, and modernize irrigation network operations. A comprehensive decision-support system (DSS) will be developed for real-time flow monitoring, flood forecasting, early warning, and optimized irrigation and drainage operations. The output will also modernize the hydrometeorological observation network, strengthen institutional frameworks, and build RID’s capacity for digital O&M and asset management. Activities include: (i) upgrading flow-forecasting and early-warning systems; (ii) updating asset management and O&M plans; (iii) enhancing staff competencies in digitized water management; and (iv) adopting a strategy to advance women’s participation and leadership within RID; and
- (iii) Output 3: Output 3 will build on ongoing government initiatives to empower communities and strengthen resilience at the local level. Effective gender-

⁵ Government of Thailand. 2022. Thailand 2nd Updated Nationally Determined Contributions. Bangkok.

⁶ United Nation Development Programme/Green Climate Fund are implementing the *Enhancing climate resilience in Thailand through effective water management and sustainable agriculture project* in the upstream Chao Phraya watershed, which include soil improvement and erosion control.

responsive CBDRM⁷ and EWS will be established in communities at risk to reduce losses caused by disasters triggered by natural hazards and contribute to livelihood development, and indirectly food security. Extensive training on livelihood development and diversification will be provided, specifically for the most vulnerable groups in the communities. In close cooperation with the Department for Disaster Prevention and Mitigation (DDPM) of the Ministry of Interior, CBDRM groups will be established in the communities and provided with the necessary equipment to effectively operate, including community EWS linked to RID's DSS. Technical training on DSS, O&M, and EWS operations will be provided by RID and local governments. Training will also be provided to benefit communities by developing opportunities for livelihood diversification and improving existing agricultural activities to reduce flood risks. Cultural and gender aspects, the roles of women's community organizations, and local employment opportunities will be assessed and integrated. Specifically, this output will: (i) make CBDRM programs operational in communities around irrigation canals, (ii) allow affected households in RID right-of-way become legal land users, (iii) increase women in leadership/decision-making positions in CBDRM groups, and (iv) increase knowledge on livelihood enhancement and business development among farmers and Micro, Small, and Medium Enterprises (MSMEs), including female farmers and women-owned MSMEs.

B. Purpose of the Initial Environmental Examination

4. The overall objective of the initial environmental examination (IEE) is to provide guidance to the Royal Irrigation Department (RID) as the implementing agency; contractors and other operators on how to plan, build and operate in an environmentally responsible manner the implementation of the project (description of project discussed in detail in Chapter III of this IEE report). This IEE will help ensure that all negative effects are prevented or mitigated, and positive impacts are enhanced. In the IEE, RID has identified the necessary tools to fit for the purpose. A set of actions that will need to be implemented in order to eliminate or at least reduce the environmental impacts to a level acceptable to ADB and Government of Thailand are identified and planned during the assessment.

C. Methodology

5. This IEE report has been prepared based on preliminary design, desk review, online research, field visits and site investigations, and stakeholder consultations to meet the requirements for environmental assessment process and documentation per ADB SPS, 2009. The environmental assessment process was conducted through primary data collection during site visits and secondary data from various sources, socio-economic, topographic, and surveys at project sites, meaningful consultation with the stakeholders, including concerned government

⁷ Gender-responsive CBDRM considers and addresses differentiated needs and vulnerabilities of women and girls particularly those from vulnerable groups, during disaster prevention and response. It includes mechanisms for women's participation in consultation and decision-making. The program will ensure: (i) participation of women in planning, training, and implementation of pilot activities; (ii) women's participation and leadership in the CBDRM committees; (iii) actions that enhance women's safety, agency, and capacity to lead preparedness, response, and recovery; (iv) incorporation of gender considerations into early warning, maintenance, and community flood- and drought – response planning; and (v) GBV prevention measures within community preparedness and response systems.

officials, project personnel and the general public. The data provided information on existing conditions against which predictions of changes and field measurements during the construction period will be compared in order to assess impacts or changes, if any, and their significance. Initial scoping and field reconnaissance visits were conducted at project sites, to establish the potential impacts and categorization of project activities. Assessment of potential risks on the environmentally sensitive areas such as critical habitats, including protected biodiversity species that may exist or occur around these habitats. A critical habitat assessment was undertaken following the requirements of ADB SPS.

6. Initial public consultation activities were also conducted through informal talks and discussions with the community people who were randomly met during field visits. The methodology of the IEE study was then conveyed and elaborated to these stakeholders in order to address all impacts and for those impacts requiring mitigation measures were proposed to reduce impacts within acceptable limits.

D. Structure of the Report

7. The report has been structured per suggested outline in ADB SPS, 2009.

- (i) **Executive Summary.** This is the summary of the entire IEE report, which describes concisely the critical facts, significant findings, conclusion, and recommended actions for the project.
- (ii) **Introduction.** Presents a brief overview of the project, along with the project background and objectives; and project scope of work and methodology, etc.
- (iii) **Policy, Legal, and Administrative Framework.** This chapter discusses both ADB SPS and Government of Thailand national and local legal and institutional framework within which the environmental assessment is carried out. It also identifies project-relevant international environmental agreements to which the government is a party.
- (iv) **Description of the Project.** This chapter describes the proposed project; its major components; and its geographic, ecological, social, and temporal context, including any associated facility required by and for the project.
- (v) **Description of the Environment.** This chapter describes relevant physical, biological, and socioeconomic conditions within the study area. It also looks at current and proposed development activities within the project's area of influence, including those not directly connected to the project. It indicates the accuracy, reliability, and sources of the data.
- (vi) **Anticipated Environmental Impacts and Mitigation Measures.** This chapter provides the discussion on the prediction and assessment of the project's likely positive and negative direct and indirect impacts to physical, biological, socioeconomic (including occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods through environmental media, and physical cultural resources in the project's area of influence, in quantitative terms to the extent possible; identifies mitigation measures and any residual negative impacts that cannot be mitigated; explores opportunities for enhancement; identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions and specifies topics that do not require further attention; and examines global, transboundary, and cumulative impacts as appropriate.
- (vii) **Information Disclosure, Consultation, and Participation.** This chapter (i) describes the process undertaken during project design and preparation for engaging stakeholders, including information disclosure and consultation with

- affected people and other stakeholders; (ii) summarizes comments and concerns received from affected people and other stakeholders and how these comments have been addressed in project design and mitigation measures, with special attention given to the needs and concerns of vulnerable groups, including women, the poor, and Indigenous Peoples; and (iii) describes the planned information disclosure measures (including the type of information to be disseminated and the method of dissemination) and the process for carrying out consultation with affected people and facilitating their participation during project implementation.
- (viii) **Grievance Redress Mechanism.** This chapter describes the grievance redress mechanism (both informal and formal channels), setting out the time frame and mechanisms for resolving complaints about environmental performance.
 - (ix) **Environmental Management Plan.** This chapter deals with the set of mitigation and management measures to be taken during project implementation to avoid, reduce, mitigate, or compensate for adverse environmental impacts (in that order of priority). It may include multiple management plans and actions (mitigation, monitoring and performance indicators).
 - (x) **Monitoring and Reporting.** This chapter provides the outlines of environmental monitoring program and reporting system including the cost of implementing the EMP.
 - (xi) **Conclusion and Recommendations.** This chapter presents the conclusion and recommendations of the IEE study.

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

8. ADB will not finance any project if it does not comply with ADB SPS nor will it finance any project if it does not comply with Government of Thailand environmental laws, rules and regulations. Where discrepancy between ADB and Government of Thailand policies exist, ADB's policy will prevail.

A. ADB Safeguard Policy Statement

9. ADB SPS requires borrowers to meet a set of requirements when delivering environmental safeguards for projects supported by ADB.⁸ The objectives are to ensure the environmental soundness and sustainability of projects, and to support the integration of environmental considerations into the project decision-making process. The project is required to comply with the policy principles, as summarized below.

10. **Screening and Categorization.** A project is to be screened for its potential environmental impacts and is assigned to a specific category as follows:

- (i) **Category A.** The project is likely to have significant adverse environmental impacts that are diverse, irreversible, and unprecedented. Impacts may affect an area larger than the sites or facilities subject to physical works. A full-scale environmental impact assessment (EIA) has to be undertaken, which includes an

⁸ ADB SPS Safeguard Requirements 1 is a set of requirement aimed to ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process. This set of requirements is triggered if a project is likely to have potential environmental risks and impacts. There are 11 key policy principles that need to be considered to ensure the requirements of addressing these impacts and risks are met.

environmental management plan (EMP) that has to be prepared by the borrower/client.

- (ii) **Category B.** The project's potential environmental impacts are less adverse and fewer in number than those in category A. Impacts are site-specific, and only few of which, if any, are irreversible. Impacts can be readily addressed through mitigation measures. An initial environmental examination (IEE) has to be undertaken, which includes an EMP that has to be prepared, by the borrower/client.
- (iii) **Category C.** The project is likely to have minimal or no adverse environmental impacts. An EIA or IEE is not required, but a desk review of the project's environmental implications will need to be conducted.
- (iv) **Category FI.** The project involves the investment of ADB funds to or through a financial intermediary. An environmental and social management system is required.

11. Categorization is to be based on the most environmentally sensitive component of the project. However, in the case of the project that will be funded under an MFF, all components need to be assessed and confirmed that none of these components can trigger Category A. If a particular project component is assessed to trigger Category A, the implementing agency shall examine alternatives to the component's location/s, designs, technologies, and subcomponents that would avoid, and, if avoidance is not possible, minimize adverse environmental impacts and risks, and to meet Category B categorization.

12. **Environmental Assessment.** Environmental assessment shall include description of environmental baseline to provide an understanding of current conditions forming the benchmark against which project impacts are assessed. Environmental impacts and risks will be analyzed for all relevant stages of the project cycle, including design and planning stage, construction, operations, decommissioning, and post-closure activities such as rehabilitation or restoration. The "no action" or "without project" alternative will also be considered.

13. This IEE follows the suggested outline provided in ADB SPS. This IEE will be updated if there is a change in scope, location, design, or based on the results of technical studies. Likewise, the IEE will also be reviewed and updated during the processing of subsequent tranches.

14. **Environmental Audit.** When the project involves existing activities or facilities, PMU is responsible to ensure that relevant external experts will perform environmental audits to determine the existence of any areas where the project may cause or is causing environmental risks or impacts. If the project does not foresee any new major expansion, the audit constitutes the environmental assessment for the project. As the project aims to rehabilitate the existing water conveyance system (i.e. existing regulators and canals), the IEE prepared for Output 1 constitutes environmental assessment covering these existing facilities.

15. **Physical Cultural Resources.** The PMU will identify all physical cultural resources (PCRs) in the project area. If the project is likely to affect the PCRs, the PMU will engage qualified and experienced experts to assess the project's potential impacts using field-based surveys. If there is high likelihood that PCRs are expected to be found as determined during the environmental assessment process, chance finds procedures shall be included in the environmental management plan (EMP).

16. **Environmental Planning and Management.** The EMP will describe and address the potential impacts and risks identified by the environmental assessment. The level of detail and complexity of the EMP and the priority of the identified measures and actions will be commensurate with the project's impact and risks. The EMP shall include the proposed mitigation measures, environmental monitoring and reporting requirements, emergency response procedures, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators. The EMP as part of the IEE shall be updated in every subsequent tranche.

17. **Pollution Prevention and Control Technologies.** During the design, construction, and operation of the project the PMU will apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines.⁹ These standards contain performance levels and measures that are normally acceptable and applicable to the project. When the national regulations differ from these levels and measures, the project shall achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, PMU will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in ADB SPS.

18. **Occupational Health and Safety.** The PMU¹⁰ will ensure that workers¹¹ are provided with a safe and healthy working environment, considering risks and specific classes of hazards in the project work areas, such as but not limited to physical, chemical, biological, and radiological hazards. PMU will ensure that the contractors shall take steps to prevent accidents, injury, and disease arising from, associated with, or occurring during the course of work by (i) identifying and minimizing, so far as reasonably practicable, the causes of potential hazards to workers; (ii) providing preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances; (iii) providing appropriate equipment to minimize risks and requiring and enforcing its use; (iv) training workers and providing them with appropriate incentives to use and comply with health and safety procedures and protective equipment; (v) documenting and reporting occupational accidents, diseases, and incidents; and (vi) having emergency prevention, preparedness, and response arrangements in place.

19. The PMU will ensure to apply preventive and protective measures consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environmental, Health and Safety Guidelines¹² and International Labor Organization (ILO).¹³

20. **Community Health and Safety.** The PMU will ensure to identify and assess the risks to, and potential impacts on, the safety of affected communities during the design, construction, operation, and decommissioning of the project, and will establish preventive measures and plans to address them in a manner commensurate with the identified risks and impacts.

21. **Consultation and Participation.** PMU will carry out meaningful consultation¹⁴ with affected people and facilitate their informed participation. Ensure women's participation in consultation. Involve stakeholders, including affected people and concerned nongovernment organizations, early in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account. Continue consultations with stakeholders throughout project implementation as necessary to address issues related to environmental assessment. The consultation process and its results are to be documented and reflected in the environmental assessment report.

22. **Grievance Redress Mechanism.** PMU will establish a grievance redress mechanism (GRM) to receive and facilitate resolution of affected peoples' concerns, complaints, and grievances about the project's environmental performance. The GRM will be scaled to the risks and adverse impacts of the project. As of the ADB loan processing for the project, a GRM meeting both environmental and social safeguard requirements of ADB SPS has been prepared and discussed in detail in this IEE report. PMU will officially issue the GRM establishment before loan effectiveness.

23. **Monitoring and Reporting.** The PMU will monitor and measure the effectiveness of mitigation measures and document the implementation of the EMP. If necessary, PMU will identify the necessary corrective actions, and reflect them in a corrective action plan. PMU will prepare and submit to ADB semi-annual environmental monitoring reports that describe progress with implementation of the EMP and compliance issues and corrective actions, if any. Reporting on semi-annual basis will continue until ADB issues a project completion report.

24. The PMU shall ensure that relevant information (whether positive or negative) about environmental safeguard issues is made available in a timely manner, in an accessible place, and in a form and language(s) understandable to affected people and to other stakeholders, including the general public, so they can provide meaningful inputs into project design and implementation.

25. ADB will post the following safeguard documents on its website:

- (i) EARF before ADB project appraisal;
- (ii) draft IEE upon receipt during the MFF processing stage;
- (iii) updated IEE based on tranche-specific information;^{15, 16}
- (iv) environmental due diligence reports; and
- (v) environmental monitoring reports, including corrective action plan prepared, if any.

26. **Unanticipated Environmental Impacts.** Where unanticipated environmental impacts become apparent during project implementation, to meet ADB SPS requirement on unanticipated impacts, the PMU will update the IEE and EMP, or prepare a new environmental assessment report with EMP to assess the potential impacts, evaluate the alternatives, and outline mitigation measures and resources to address those impacts.

B. National Environmental Impact Assessment Regulation

⁹ World Bank Group. 2007. *Environmental, Health, and Safety General Guidelines*. Washington, D.C.

¹⁰ In case where responsibility is delegated to project contractors during construction phase, PMU shall ensure that the responsibilities on occupational health and safety as described herein are included in the contract documents.

¹¹ Including nonemployee workers engaged by PMU through contractors or other intermediaries to work on project sites or perform work directly related to the project's core functions.

¹² <https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-occupational-health-and-safety-en.pdf>

¹³ <https://www.ilo.org/dyn/normlex/en/f?p=1000%3A12000%3A%3A%3A%3A%3A>

¹⁴ Per ADB SPS, 2009, meaningful consultation means a process that (i) begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle; (ii) provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people; (iii) is undertaken in an atmosphere free of intimidation or coercion; (iv) is gender inclusive and responsive, and tailored to the needs of disadvantaged and vulnerable groups; and (v) enables the incorporation of all relevant views of affected people and other stakeholders into decision making, such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.

¹⁵ The draft IEE will include detailed plan on required updating due to ongoing studies that will not be completed by the time ADB approves the MFF and future studies that will be conducted during implementation.

¹⁶ For each subsequent tranche, if the entire scope of the MFF remains unchanged since the approval of the previous tranche, the safeguard documents covering the entire scope of the MFF are assessed for validity. If valid, the same documents are used; otherwise, the documents are updated.

27. **The Enhancement and Conservation of the National Environmental Quality Act (NEQA), B.E. 2535 (1992) [with amendments in The Enhancement and Conservation of the NEQA, B.E. 2561 (2018)]**. This Act is the primary law that provides the specific regulations on environmental impact assessment of projects or undertaking in the country. It provides the general guidelines and processes on screening projects based on industry- or activity-specific classifications, preparation of required environmental assessment reports, review and approval process, timelines, etc. The Act also provides the process of public participation of the stakeholders related to the project.

28. **Notification of the Ministry of Natural Resources and Environment on Projects, Undertakings, or Operations Required to Provide an Environmental Impact Assessment Report and Rules, Procedure, and Conditions in Providing an Environmental Impact Assessment Report [B.E. 2561 (2018)]** with updates issued or notified in B.E.2562 (2019), and B.E. 2564 (2021). These Notifications provide supplemental or supporting implementing rules and regulations for the NEQA as amended or updated. Amendment and/or updating of the Notification is done as the need arise due to circumstances. They provide the classification of projects and activities with the corresponding required environmental assessment as stipulated in the NEQA as amended. Depending on the types and sizes of projects and activities, the following are the various kinds of environmental assessment reports that need to be prepared by the respective project proponents:

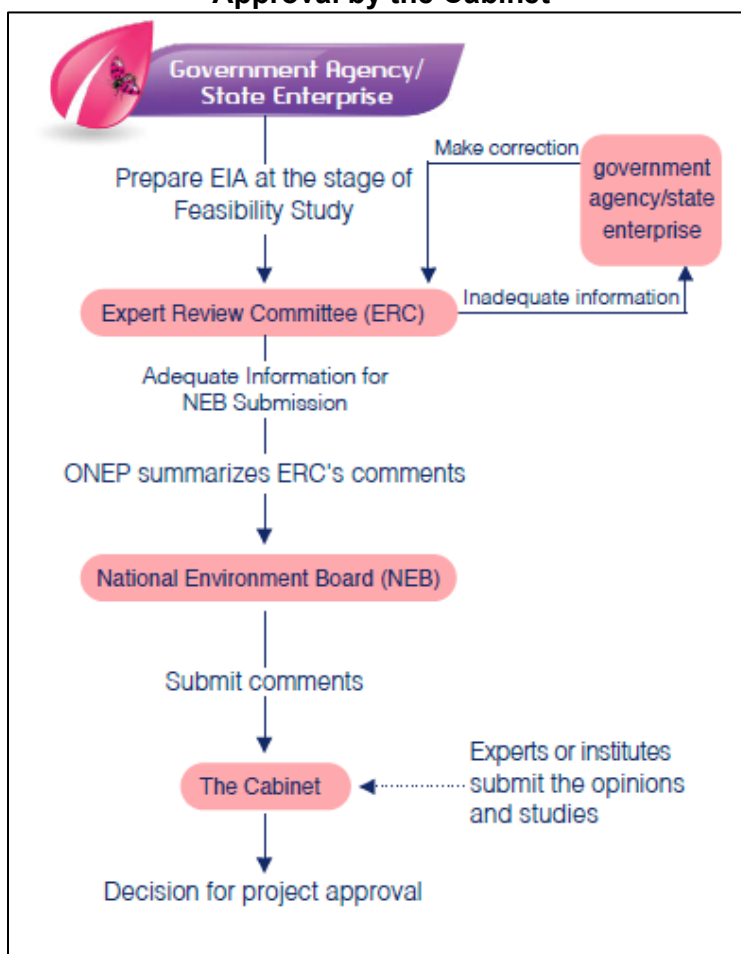
- (i) Environmental checklist;
- (ii) Initial Environmental Examination (IEE) report;
- (iii) EIA report; and
- (iv) Environmental and Health Impact Assessment (EHIA).

29. The Notifications also provide the suggested outline and contents of each of the reports.

30. Procedurally, an EIA report is prepared by consultant/s registered with the Office of Natural Resources and Environmental Policy and Planning (ONEP) in accordance with the guidelines published by ONEP. Required assessment covers aspects of physical environment, biological environment, socio-economic environment, and cultural environment, including physical cultural resources. The assessment should include evaluation of project activities, and ensuring these activities will comply with national environmental requirements, standards and other government commitments to international environmental agreements. The assessment also requires the conduct of public consultations as early as the project preparation stage.

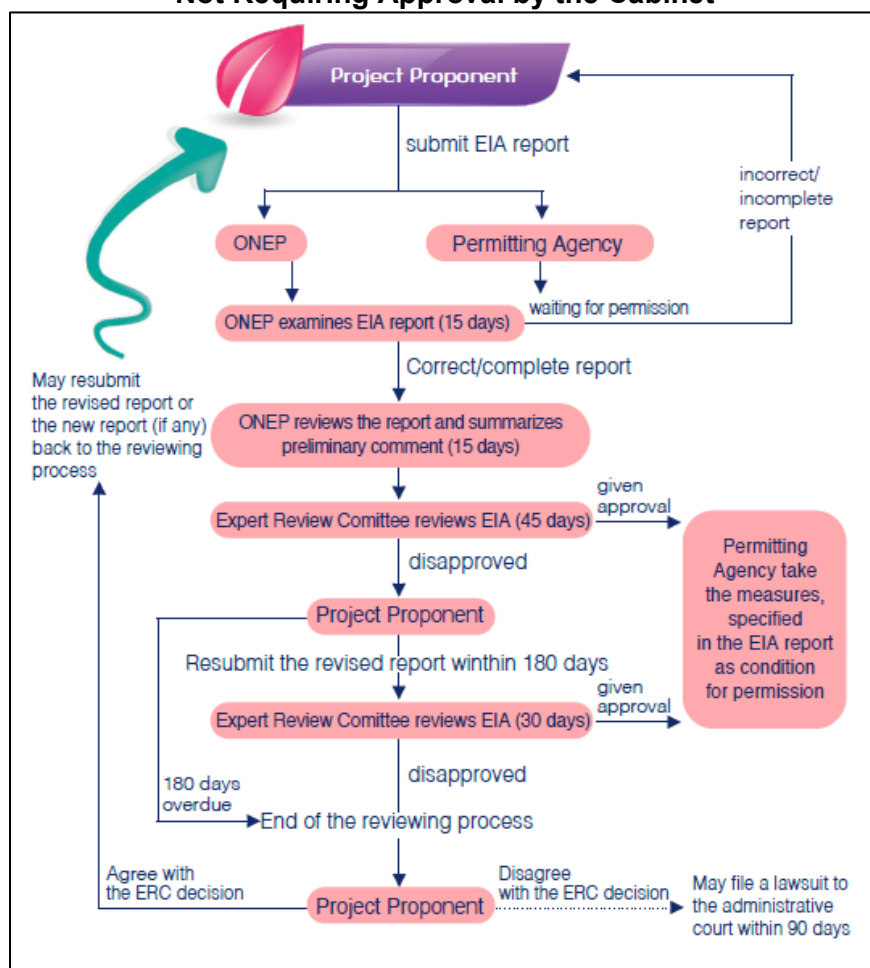
31. ONEP reviews the EIA report and submits its preliminary comments to an Expert Review Committee (ERC) appointed by the National Environment Board (NEB). The ERC will review and approve or disapprove the EIA report after receiving the EIA report from ONEP. If the ERC fails to provide feedback, the submitted EIA report is considered approved. The figures below show the flow charts of various scenarios on the EIA approval process depending on the level of impacts and on whether or not a project requires approval by the Cabinet.

Figure 1: Approval Process for Projects, Undertakings, or Operations Requiring the Approval by the Cabinet



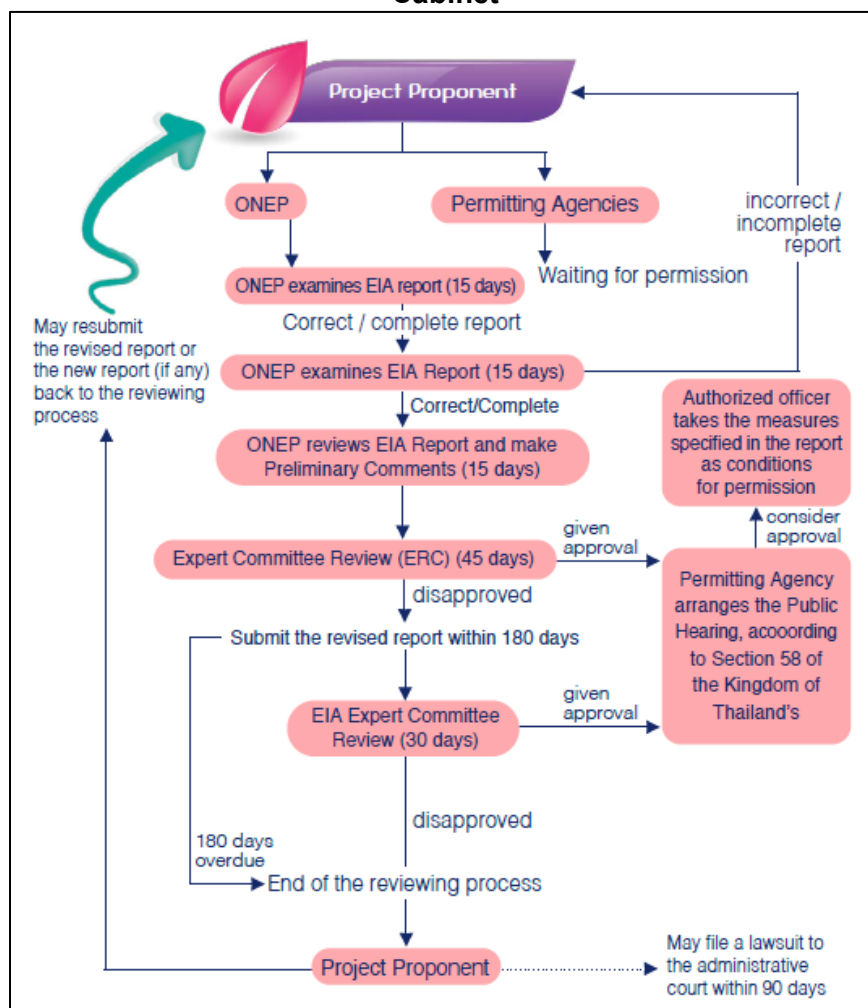
Source: Environmental Impact Assessment in Thailand. 4th Ed. Office of Natural Resources and Environmental Policy and Planning. Ministry of Natural Resources and Environment. September 2021.

Figure 2: Approval Process for Projects, Undertakings, or Operations Requiring EIA But Not Requiring Approval by the Cabinet



Source: Environmental Impact Assessment in Thailand. 4th Ed. Office of Natural Resources and Environmental Policy and Planning. Ministry of Natural Resources and Environment. September 2021.

Figure 3: Approval Process for Projects, Undertakings, or Operations Which May Seriously Impact Natural Resources, Environmental Quality, Health, Sanitation, Life Quality of People in a Community Requiring EHIA But Not Required for Approval by the Cabinet



Source: Environmental Impact Assessment in Thailand. 4th Ed. Office of Natural Resources and Environmental Policy and Planning. Ministry of Natural Resources and Environment. September 2021.

32. **Environmental Impact Assessment Exemption.** A project may also be exempted from undertaking an EIA and preparing an EIA report per “Notification of the Ministry of Natural Resources and Environment on Projects, Undertakings, or Operations Required to Provide an Environmental Impact Assessment Report and Rules, Procedure, and Conditions in Providing an Environmental Impact Assessment Report 2023 (B.E. 2566)”. Under the notification 35 categories of project require preparation of EIA report and submit to ONEP for approval. The development of Lower East Chao Phraya Irrigation System Improvement – Climate Adaptive Strengthening Program is categorized as Water Trans-basin Development Project which requires preparation of EIA report. However, as the project has an objective for temporary diversion in the case of a disaster or where there is an impact on national security therefore the project has been exempted from preparation of EIA. Letter from ONEP is attached as Appendix 6 in the EARF.

C. Other National Environmental Laws, Rules and Regulations

33. The legal framework on environmental protection, management of natural resources and public consultation is summarized in Table 1.

Table 1: Other Relevant Laws, Regulations and Standards

Legislations	Description and Relevance to the Project
Environmental Quality	
Constitution of The Kingdom of Thailand 2017(B.E.2560)	The Constitution contains provisions related to the conservation of natural resources. The acquisition of rights and access to natural resources and the environment are important factors in the livelihood of the people. Article 43 stipulates that "individuals and communities have the right to 1. preserve, restore or promote wisdom, art, culture, traditions and fine traditions both locally and nationally. 2. manage, maintain and utilize natural resources, the environment and biodiversity in a balanced and sustainable manner in accordance with the law. In terms of the duties, a person has the duty to cooperate and support the conservation and protection of the environment, natural resource, biodiversity and cultural heritage (Section 4 and Section 50 (8)) while the State has the duty to conserve, protect, maintain, restore, manage, and use or arrange the utilization of natural resources, the environment and biodiversity in a balanced and sustainable manner with the participation of the people and relevant local communities in the implementation and benefit from such activities as prescribed by law (Article 57 (2)). Applicability to the Project. The development of project including rehabilitation and construction of regulators, construction of retaining walls, and dredging of canals; which have potential impact to physical resources, biological resources, human use values and quality of life and values, including, but not limited to, water quality and water use. The development of the project has to be in line with conservation and protection of natural resources as mandated by the Constitution.
National Environmental Quality Promotion and Conservation Act B.E.2535 (1992) and its amendments Also referred to as the National Environmental Quality Act (NEQA)	1. The Act has the objective of encouraging the public and private organizations to participate in promoting and maintaining environmental quality by determining the authority and duties of government departments, state enterprises and local governments to coordinate and participate in environmental protection as well as to formulate pollution control measures, wastewater treatment system, exhaust air treatment system, and clearly define the responsibilities of the polluters. 2. Environmental Quality Standards. National Environment Board has the power to publish notification prescribing air, noise, vibration and water quality standards (clause 32). For the benefit of environmental quality conservation, the Ministry is authorized to prescribe list of projects which require to prepare environmental impact assessment (clause 48). 3. Environmental Quality Management Planning. The Minister has the power to publish notification prescribing environmental quality management plan and announce in the Government Gazette. Relevant government departments shall carry out their

Legislations	Description and Relevance to the Project
	powers and duties to implement the plan. The environmental quality management plan can be classified as a short-term medium-term and long-term plan. The environmental quality management plan consists of work plans for - management of air, water and other environmental quality – pollution control from sources – conservation of natural environment, natural resources - management of the national budget and funds necessary for the implementation of the plan and enactment and issuance of regulations, local ordinances, regulations, orders and notices necessary for the implementation of the plan (Section 36). 4. Conservation and Environmental Protection Areas. Any watershed area or has a natural ecosystem that is different from other areas or has a natural ecosystem that may be destroyed or affected by various activities. or an area of natural or artistic value that deserves to be conserved and the area has not yet been declared as a conservation area. The Minister shall have the power to issue Ministerial Regulation designating the area as an Environmental Protection Area (clause 43). 5. Environmental Impact Assessment. The Minister shall have the power to issue notification specifying any project, undertaking, or operation of the State or which the State will give any person permission to operate, requires preparation of environmental impact assessment report. Rules, procedures, and conditions to prepare environmental impact assessment report shall be prescribed in the Minister's notification. Preparation of environmental impact assessment report for a project, undertaking or operation of the State or which the State will give any person permission to operate, that may seriously impact natural resources, environmental quality, health, sanitary, quality of life or other important interests of people, communities, or environment, an operator or person asking for permission shall assess health impact and hold a public participation in accordance with the rules, procedure, and conditions prescribed in the Minister's notification (clause 48). 6. Effluent Standards from Pollution Sources. The Minister shall have the power to publish notification prescribing emission or effluent standards to control wastewater discharge, air emission or discharge of any wastes or pollutants from point sources to environment (clause 55) . 7. Pollution Control Area. Any area affected by pollution with the tendency to deteriorate health of the public or environmental quality, the National Environment Board shall have the power to publish notification to designate such an area as Pollution Control Area which allows any actions to be taken to reduce, minimize or control pollution (clause 59). 8. Air, Noise and Water Pollution. The Minister has the power to publish notification to specify point sources subject to emission control in conformity with prescribed emission/effluent standards (clause 68 and 69). Applicability to the Project. Development of the project to enhance drainage and flood water conveyance system through improvement of canal networks from Rama 6 headwork down to the gulf of Thailand comprising construction of retaining wall, dredging,

Legislations	Description and Relevance to the Project
	strengthening stability of canal embankment, construction/upgrading of regulators and pumping stations. These construction activities will have potential impacts to ambient air quality, noise quality, vibration, waste management, and agricultural activities, including fishery. The project needs to comply with environmental quality standards and environmental requirements set forth under the act.
Notification of the Ministry of Natural Resources and Environment on Projects, Undertakings, or Operations Required to Provide an Environmental Impact Assessment Report and Rules, Procedure, and Conditions in Providing an Environmental Impact Assessment Report 2023 (B.E.2566)	Projects, undertakings or operations which require preparation of IEE or EIA report have been grouped separately (clause 3). The IEE report shall include sections with description including (i) An introduction, (ii) project description, (iii) existing environmental conditions(physical resources, biological resources, human use values and quality of life and values), (iv) Impacts assessment, (v) Mitigation measures and impact monitoring, and (vi) reference documents (clause 7). The EIA report (Main Report) shall include sections with more detailed description including (i) An introduction, (ii) Project description, (iii) Existing environmental conditions(physical resources, biological resources, human use values and quality of life and values as well as results of socio-economic and public participation), (iv) Impacts assessment, (v) Mitigation measures and impact monitoring, and (vi) Reference documents. Project undertaken by government agency or undertaken together with private sector requires preparation of executive summary report (clause 8(1),8(2), 8(3)). Preparation of IEE or EIA report shall be carried out by licensed entity (clause 11). Applicability to the Project. The notification provides a list of projects by type, size and locations which require preparation of IEE or EIA. The nature of the project is included in this list. The project is required to ensure it complies with this notification.
Notification of the Ministry of Natural Resources and Environment on Projects, Undertakings, or Operations Which May Seriously Impact Natural Resources, Environmental Quality, Health, Sanitation, Life Quality of People in a Community that are Required to Provide an Environmental Impact Assessment Report and Rules, Procedure, and Conditions in Providing an Environmental Impact	Projects, undertakings or operations which require preparation of EIA report have been prepared by the authority for reference (clause 3). The EIA report(Main Report) shall include sections with more detailed description including (i) an introduction, (ii) project description, (iii) existing environmental conditions (physical resources, biological resources, human use values and quality of life and values as well as results of socio-economic and public participation), (iv) Impacts assessment, (v) Mitigation measures and impact monitoring and (vi) Reference documents.

Legislations	Description and Relevance to the Project
Assessment Report 2023 (B.E.2566)	Project undertaken by government agency or undertaken together with private sector requires preparation of executive summary report (clause 5(1),5(2), 5(3)). Preparation of IEE or EIA report shall be carried out by licensed entity (clause 8) Applicability to the Project. The notification provides a list of projects by type, size and locations which require preparation of EHIA. The nature of the project is included in this list. The project is required to ensure it complies with this notification.
Natural Resources	
The Promotion of Marine and Coastal Resources Management Act, B.E. 2558 (2015)	Protection of Marine and Coastal resources: Any person causes severe damage to marine and coastal resources, the Director-General or a person assigned by the Director-General shall have the power to order such person to temporarily stop an action or activity causing damage to marine and coastal resources as appropriate (clause 17). In the interest of the preservation, conservation and revival of mangrove forest areas to remain in natural condition, the Minister shall have the power to issue the Ministerial Regulation designating any mangrove forest area to be a conserved mangrove forest area (clause 18). An area designated to be a conserved mangrove forest area shall be an area that is neither in the area of national park under the law on national park or the area of wildlife sanctuary or non-hunting area under the law on the conservation and protection of wildlife or the area covered by ownership or possessory right under the Land Code of a person who is not a State agency. In the interest of the preservation, conservation and revival of the marine and coastal resources, which are not mangrove forest areas, to remain in natural condition and have surrounding conditions and ecosystem in pristine condition, the Minister shall have the power to issue the Ministerial Regulation to designate the area with the following characteristics to become a marine and coastal resources protected area: (i) An area with marine and coastal resources in pristine condition which merits preservation to be in its original natural condition. (ii) An area that is a habitat of animals and plants in its pristine natural condition. (iii) An area with significance for marine ecosystem which merits conservation. An area designated as a marine and coastal resources protected area shall not be an area in a conservation area or an area permitted to practice aquaculture under the law on fisheries (clause 20). To prevent the coastal erosion problem and prevent damage to the life and property of the population, the Minister shall have the power to issue the Ministerial Regulation to designate an area that measures for the prevention of coastal erosion shall be used. Applicability to the Project. Development of the project to enhance drainage system through improvement of canal networks from Rama 6 headwork downs to the gulf of Thailand in temporary disruption of flows and temporary change in quality of water along the canals during the construction period. These temporary

Legislations	Description and Relevance to the Project
	disturbances needs to be mitigated to ensure the protection of any mangrove forest areas and other receptors in the coastal area that will be affected by the project construction activities, if any.
Royal Ordinance on Fisheries B.E. 2558 (2015)	The provisions of this Royal Ordinance aim to reorganize fisheries in Thailand and in waters at large with a view to preventing illegal, unreported and unregulated (IUU) fishing to preserve aquatic animal resources as a sustainable source of food for humanity and preserve the environment in an appropriate state along the line of approaches, criteria and standards recognized internationally. <u>Conservation and Management Measures.</u> No person shall catch aquatic animals in an aquatic species sanctuary as prescribed by the Minister or by the provincial fisheries committee subject to the approval of the Minister, except for the purposes of academic advancement or for the purposes of the nurturing of aquatic animal breeds for which permission in writing has been granted by the Director-General or a person assigned by the Director-General (clause 56). No person shall engage in the following acts: (i) Releasing, pouring, disposing of, discharging or causing the passage of hazardous matters as prescribed by the Minister into a fishing ground. (ii) Acting in whichever way to cause the intoxication of aquatic animals in a fishing ground (iii) Releasing, pouring, disposing of, discharging or causing the passage of anything into a fishing ground in a manner harmful to aquatic animals. (iv) Causing fishing ground to be polluted such that it becomes harmful to aquatic animals (clause 58). Any person intentionally or through negligence causes a fishing ground to be polluted in a manner that may harm aquatic animals shall bear all the expenses incurred in rescuing or preventing the loss of aquatic animals' lives, and in restoring the fishing ground back to its natural state as prescribed by the Director-General (clause 59). No person shall install, place or build a damn, weir, dike, fence, built structure, tool fitted with nets or any other fishing tool in a fishing ground, and thereby blocking the passage of aquatic animals or preempting the natural growth of aquatic animals, unless permission in writing has been obtained from the competent official. The provisions under paragraph one shall not apply to undertakings implemented for the purposes of public disaster prevention or for official purposes relating to irrigation (clause 63). <u>Aquaculture Promotion.</u> It shall be a duty of the Department of Fisheries to promote, develop and provide guidance with respect to aquaculture to achieve standards pursuant to paragraph one without compromising the state of the ecological environment and the abundance of aquatic animal resources (clause 74) Applicability to the Project. Once completed, the project will inherently support agricultural and aquaculture activities in the area, including in the vicinity of coastal area. The canals and other project infrastructures will be the conduit of water that can be utilized in

Legislations	Description and Relevance to the Project
	these economic activities. During construction, project activities may likely disturb these activities and may pollute the waterbodies due to potential discharges. The project should ensure that all mitigation measures need to be put in place during the construction period to prevent or avoid adverse impacts. Project shall aware not to discharge any hazard material into fishing ground in coastal area under clause 58 of the Act.
Water Resources	
Water Resources Act B.E. 2561(2018)	This Act provides allocation, use, development, management, maintenance, restoration and conservation of water resources. Water rights, water use permits, water storage, and management in drought and flood conditions to achieve unity. shall be as prescribed in the Act, except in the case of any law prescribed in relation to the allocation. The use, development, management, maintenance, restoration and conservation of water resources and water rights in particular shall be carried out in accordance with that specific law, as long as it does not contradict or contradict this Act. (clause 3). (i) Water Resources. The state has the power and duty to manage water resources for the benefit of the public in a balanced and sustainable manner. For the benefit of the management of public water resources other than irrigation and groundwater, The Prime Minister may announce in the Government Gazette that any government agency or local government organization is responsible for supervising and maintaining any public water resource. The government agency or the responsible local government organization has the authority to determine the criteria for access to public water resources according to the framework of guidelines set by the National Water Resources Board. However, it must not be rules on water allocation and water use (Section 6). (ii) Water Right. Individuals have the right to use or store water as necessary for the benefit of their activities or on their land. without causing trouble or damage to other people who may use the water. This is except for this Act or a Ministerial Regulation, a regulation or a notification issued pursuant to this Act, or any other law as otherwise provided. (clause 7). (iii) Water allocation and use. Three types of water use are identified including - use for livelihood, household consumption, agriculture or animal husbandry for subsistence household industry, ecosystem preservation, customs, disaster relief. - Transportation and the use of a small amount of water. the use of public water resources for industry, tourism industry, electricity generation, water supply and other businesses - the use of public water resources for large-scale undertakings that use large amounts of water or may cause impacts across river basins or cover a wide area. Criteria of usage shall be in line with the Ministerial Regulations. (iv) Drought Management. Prime Minister shall have the power to notify in Royal Gazettes the area with severe drought together with necessary requirements or measures to be undertaken to alleviate the situation (clause 58).

Legislations	Description and Relevance to the Project
	(v) Flood Management. The Watershed Committee shall prepare a flood prevention and remediation plan. The plan shall cover normal and emergency conditions and consider the environment, ecosystem and biodiversity in the target area. Applicability to the Project. The project will be able to support the realization of the objectives of this Act. The project is designed to help in the management of drought and flood conditions in the area. This is in line with Part 5 section 2 and 3 of the Act.
Groundwater B.E.2520(1977) Amendments Act and	The Act regulates groundwater zones, groundwater drilling, including groundwater use and groundwater conservation. The act considers the conservation of natural resources. The definition of the term "groundwater" refers to groundwater that occurs in layers of soil, gravel, sand or rocks that are deeper than the depth specified by the Minister, but the depth cannot be less than ten meters. The act also regulates use of groundwater or the discharge of water into groundwater wells (clause 3). The Act does not apply to ministries, departments, departments or organizations of the State responsible for the supply of water for consumption or agriculture in relation to the drilling of groundwater and the use of groundwater, except in the localities which have been declared as groundwater crisis zones (areas where water is pumped up in quantities exceeding the amount of water flowing into the groundwater aquifer which may cause land subsidence or saltwater to spread into the groundwater or a decrease in the water level in the groundwater aquifer) and the Minister of Natural Resources and Environment is designated as the acting minister under this Act (clause 4). It is prohibited to carry out groundwater operation without the permit from Director General or designated person. The procedure to obtain the permit shall be in line with Ministerial regulations (clause 16). Three types of permits include drilling permit, usage permit and discharge into aquifer permit (clause 18). During drilling operation if discovery of antiques, minerals of economic value or any benefit to geological study it is required to report to concerned agencies (clause 23) Applicability to the Project. Project activities especially during construction period will have the potential to generate waste from sources including waste from machine maintenance (oils, lubricants, spent chemicals). These wastes could contaminate groundwater if no proper waste management in place. The project should ensure that it will not impact to groundwater quality as part of protection of ground water resource.
State Irrigation Act B.E. 2485 (1942) and its amendments	The Act has the objective to control and enhance irrigation service to benefit the public. Maintenance of Irrigation System. The Ministry shall have the power to issue Ministerial regulation on fee collection from water users. The fees shall be collected from users in agricultural and

Legislations	Description and Relevance to the Project
	non- agricultural sectors with the rate of 5 Baht/rai/year and 0.50 Baht/m3 respectively(clause 8). It is prohibited to encroach on irrigation waterways, connect or cause leaks in irrigation waterways, dump garbage, sewage, solid waste, or discharge wastewater into irrigation canals(clause 26). The irrigation technician shall be the officer with the authority and duty to control the violation of the said law. If a tree grown on a land of a person encroaches upon the irrigation waterway or cause damage to the irrigation waterway the competent official shall have the power to order the owner of the land to cut down or remove the tree (clause 24). Applicability to the Project. Project activities will be implemented along canals used for flood control and source of irrigation water. The aim of the project on improving these canals has direct beneficial impacts that will help achieve the objectives of the Act.
Biodiversity	
Biodiversity Act B.E. (Draft)	The Act covers the promotion of conservation and sustainable use of biodiversity, strengthening capacity and motivation, as well as supporting the participation of the public and local communities in the conservation and sustainable use of biodiversity. Fair and equitable sharing of benefits. Prevention and reduction of impacts on biodiversity, both from invasive alien species and Living Modified Organisms (LMOs), as well as prevention, remediation, or remediation in the event of impacts on the country's biodiversity Applicability to the Project. Some project sites or alignments are near areas that may have important biodiversity features. Thus, it is important that the project be screened upfront in terms of potential impacts to biodiversity features and include as part of the environmental assessment for the project.
Land Use and Land Laws	
Town Planning Act B.E.2562 (2019)	The National Urban Planning Policy Committee shall have the duty to prepare the Constitution of Town Planning and propose to the Cabinet for approval (Section 75(8)) and shall be binding on government agencies and other relevant agencies to continue to carry out their duties (Section 7). Types of Town Planning: (i) Policy Planning for Area Usage which specifies policy framework and strategy for country development in terms of area usage which includes national policy planning, regional policy planning and provincial policy planning. (ii) Land Use Planning which specifies approach and work plan for land use of specific areas comprising integrated urban planning (Comprehensive Plan) and planning of specific area. Preparation of Policy Planning for Area Usage and Land Use Planning requires public participation and consultation. Applicability to the Project. The development of the project is within the right of way of the canal. The act is not applicable to the project.

Legislations	Description and Relevance to the Project
Land Code B.E.2497(1954) and amendments	Land Code has been enforced to grant Land Deeds and Land Title Deeds. According to Land Code “Land” refers to general land area and includes mountains, creeks, swamps, lakes, islands, and seashores (clause 1). (i) State Land: Land which is not owned by any person shall be state land (clause 2). (ii) Private Land: a. Land with ownership which includes documents such as land deeds, map deeds, deed of reservation and seal that has been enacted as having been used. Land that a person has the right to occupy includes land that has no ownership including vacant land with a certificate of usage, reservation seal, as well as land with proof of notification of land possession. Applicability to the Project. The development of the project is within the right of way of the canal. The act is not applicable to the project.
Agricultural Land Reform Act B.E.2018 (1975) and amendments	The purpose of the Act is to improve land tenure rights, distribution of land rights from both state land and private land to farmers who have inadequate land for farming, infrastructure development, career development, improvement, promotion and support of various necessary inputs of production. Implementation of land reform (i) Land Reform comprising designation of Agricultural Land Reform Zones, procurement or expropriation of private land, procurement of State land by using public interest land, royal parcels, wasteland, vacant land, and degraded national forests in the land reform zone (clause 25, 26 and 29) (ii) Land Arrangement a. Agriculture : Provide landless farmers or those with little land to livelihood, arrange for the Farmer Institute by way of leasing. b. Arrange for the public for other businesses that support or are related to the agricultural land reform. (iii) Control of Land Right : Control before transfer of ownership and control after the transfer of ownership by prohibiting the division and transfer of ownership of land forever, unless it is inherited to the rightful heirs (clause 30 and 39). (iv) Development: Develop infrastructure by coordinating with relevant agencies, develop farmers in terms of occupation and income by coordinating with relevant agencies. Applicability to the Project. The development of the project to enhance the water drainage system will be undertaken within the right of way of the canal. The act is not applicable to the project.
Waste Disposal and Reuse	
Public Health Act B.E. 2535 (1992) and amendment	“Waste” means wastepaper, waste cloth, waste food, waste goods, waste materials, plastic bag, food container, soot, animal dung or carcasses, including any other thing swept away from road, marketplace, animal farm, or other places, including infectious waste, toxic or hazardous waste from community (clause 4).

Legislations	Description and Relevance to the Project
	Waste management under the Act shall not include waste of industrial origin. Sewage and Waste Management. Collecting, hauling or disposing of sewage or waste within the area of any local government shall be the authority of such local government. In carrying out the operations, the local government may do so in conjunction with other government agencies or other local governments under a joint agreement. However, for the benefit of the public, the Minister shall have the authority to issue ministerial regulations, on the advice of the Committee, prescribing criteria, methods, and conditions for the joint operation (clause 18). No person shall engage in the operation of collecting, hauling, or disposing of sewage or waste as a business or for reciprocal benefits, unless a license from the local official is granted (clause 19). The local official shall have authority to prohibit any person from causing a nuisance in a public place or way or private place and to abate nuisances, including watching over, improving, and maintaining roads, land routes, waterways, drainage, trenches, canals, and other places within his/her jurisdiction to be free from nuisances. In this regard, the local official shall have the authority to issue written orders to abate, eliminate, and control nuisances (clause 25,26) Applicability to the Project: During construction, contractors may set up worker camps, which will potentially generate wastes. Contractors are required to comply with this Act and shall contact the local government agency to collect waste for disposal.
Notification of National Environment Board "Soils Quality Standards "January 6,2021 (2564)	The notification prescribes soil standards suitable for residential purpose, to protect health conditions of resident and sensitive groups, and standards suitable for commercial, agricultural purposes and other activities. The notification regulates concentrations of heavy metals, volatile organic compound, pesticides and other toxic materials. Applicability to the Project. Dredging the canal is part of the activity of the project. Dredged or excavated soils from the canals will be disposed following the requirements of the Notification, and will be in compliance with the relevant quality standards set forth for where these will be disposed (i.e. residential, commercial or agricultural, industrial lands).
Forest and Agricultural Land Management	
Forest Act B.E.2484 (1941) and amendments	"Forest" means land that has not been acquired by a person under the Land Law. Land without the right of ownership or possession is considered as a forest and owned by the state. (i) Timber Harvesting and Forest Harvesting: all types of timber on land with ownership or possession rights under the Land Code are not prohibited timber. Logging does not require permission from the authorities. Restricted timber is still strictly controlled, only in "forests"(Forestry Act (No. 8) B.E. 2562 (2019)).

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	(ii) Forest Clearing: "no person shall build, clear or burn a forest, or do anything that destroys a forest, or occupies or occupies a forest for himself or others, except within an area classified as agricultural and has been announced by the Minister in the Government Gazette or with a permit from an officer (clause 54)." Applicability to the Project. The development of the project is carried out within the right of way of the canal, which is outside the coverage of a forest land. The act is not applicable to the project.
Mangrove Cabinet Resolution December 15, 2530 (1987)	Mangrove forest under jurisdiction of Forestry Act B.E.2484 (1941) and amendments, National Reserved Forest Act B.E.2507 (1964) and amendments, National Park Act B.E. 25/62 (2019) ,Wildlife Conservation and Protection Act B.E.2562(2019) and National Environmental Quality Promotion and Conservation Act B.E.2535 (1992) and its amendments shall be regulated under those acts. The resolution specifies 2 types of land use in mangrove areas of the country including conservation and economic zones. <u>Conservation Zone:</u> Prohibit any change in the area to conserve its environmental conditions and ecosystem. <u>Economic Zone:</u> (i) allowable for forest production such as concessionaires; and (ii) allowable for agriculture, industrial development, community, commercial purpose, pier and others. Agency that requires usage of mangrove area needs to obtain the permit from Department of Marine and Coastal Resources. Applicability to the Project. The development of the project will only involve rehabilitation or improvement of water drainage and conveyance system, which is within the right of way of the canal. These are not within the conservation or economic zones as defined in the resolution. The Resolution is not applicable to the project.
Health and Safety	
Occupational Safety, Health and Environment Act B.E. 2554 (2011)	The Act is under the jurisdiction of the Ministry of Labor. (i) General Provisions: Employer is obligated to provide and keep an establishment and an employee in safe and hygienic working conditions and environment including to support and promote an operation of the employee preventing the employee from any harm on life, physique, mentality and health(clause 6). (ii) Administration, Management and Operation on Occupational Safety, Health and the Environment: a. Employer is required to administer, manage and operate the occupational safety, health and environment in conformity with the standards prescribed in the ministerial regulation (clause 8). b. An Employer shall provide the Safety Officer, personnel, working unit, or group of persons to operate the safety in establishment according to criteria, methods and terms as prescribed in the ministerial regulation(clause 13). Whereas an employer assigns an employee to work in a working condition or environment that may be harmful to life,

Legislations	Description and Relevance to the Project
	physique, mentality and health of such employee, the employer shall inform the employee of danger which may arise out of work, and shall distribute the work manual to every employee before commencing work, changing work or changing workplace (clause 14), an employer shall provide for and control an employee to wear standard personal protective equipment as stipulated by the director-General (section22). (iii) Control, Supervision and administration: An employer shall (1) conduct hazard assessment; (2) conduct study on impacts of working conditions which have an effect on employee; (3) prepare operation plan on occupational safety, health and environment and supervisory plan for employee and the establishment; and (4) submit results on hazard assessment, impact study, operation plan and supervisory plan under (1), (2) and (3) to the Director-General or a person entrusted by the Director General. Applicability to the Project. The project will involve contractors whose workers and employees need to be protected by virtue of this Act. Contractors will need to comply with all provisions of the Act and ensure the health and safety of all workers and employees.
Ministerial Regulation Prescribing the Standards for Administration and Management of Occupational Safety Health Environment for Construction Work B.E. 2564 (2021)	Construction Work: Construction of all kinds of structures such as buildings, airport, railway, road ,tunnel, waterway, drainage including demolition of those structures (clause 2). Employer shall designate safety supervisor to conduct safety inspection before starting work and during working period (clause 5). Keep the construction area always clean, Nonhazardous waste shall be segregated from hazardous waste (clause 6). To transfer the excavated soil from the construction area, employers shall provide stockage area and implement mitigation measures to control hazard and dispersion of dust (clause 7). Provide suitable safety signs including enforce using PPE (clause 13). Specify danger construction zone together with fencing and signs. Only authorized people are allowed to enter the area(clause 16). Piling Works and Diaphragm Wall: Installation ,testing, inspection, operation ,maintenance of crane require compliance with manufacturer's recommendations in operation manual(clause30). After installation of the crane, it requires the engineer to inspect and endorse prior to start operation(clause 32). Prior to starting daily work the construction supervisor shall thoroughly inspect the machine, working area for readiness. Employer shall assign the experienced engineer to supervise the work during construction of diaphragm wall (clause 45).

Legislations	Description and Relevance to the Project
	Construction in Water: Employer requires employees to prepare work plan including safety management program and inform the employees (clause 59(1)). Prepare emergency response plan and provide rescue equipment as well as PPE to employees (clause 59(2,3)). Applicability to the Project: The project will have employees, workers who will be subject to occupation health and safety risks due to activities and construction works. Therefore, the project through the contractors shall comply with this regulation to ensure the health and safety of all employees and workers.
Labor Protection Act B.E. 2541 (1998) and amendments	Prohibition of works to women: Mining, construction work carried out underwater, underground or in tunnel except when the working conditions are safe to the employees, working at heights (more than 10 meters), production or transportation of explosive or flammable materials except the working conditions are safe to the employees (clause 38). Prohibition of works to pregnant women: working with vibrating machine, lifting work more than 15 kg, working in vessel, work related to transportation, and work during 22.00 - 6.00 AM (clause 39). Child Labor: Prohibit child labor under 18 years. In case it is necessary to assign work to children under 18 years, employer requires to comply with the procedures (clause 44,45). Child labor under 18 years shall not work during 22.00- 6.00 AM (clause 47) Prohibit assigning works to child labor under 18 years: melting and stamping works, works related to significant level of heat, light, noise and vibration, hazardous chemicals, toxic microbiological agents, crane controller. Work at height, radioactive work, underwater, underground or in tunnel, cleaning of machine while operating (clause 49) Applicability to the Project: Construction work of the project will require different groups of workers and therefore requires to comply with the Act.
Act on Ancient Monuments	
Antiques, Objects of Art and National Museums B.E. 2504(1961)	"Antique" means an archaic movable property, whether produced by man or by nature, or being any part of ancient monument or of human skeleton or animal carcass which, by its age or characteristics of production or historical evidence, is useful in the field of art, history or archaeology. "Objects of Art" means a thing produced by craftsmanship which is appreciated as being valuable in the field of art. Ancient Monuments: The Director-General shall, for the purpose of keeping, maintaining and controlling ancient monuments under this Act, have the power to cause any ancient monument as he thinks fit to be registered by means of publication in the Government Gazette, and to determine such area of land as he thinks fit to be its compound, which area shall also be considered as ancient

Legislations	Description and Relevance to the Project
	monument. Cancellation and modification of the same may likewise be made in the Government Gazette (clause 7). No person shall repair, modify, alter any ancient monument or excavate for anything within the compound of ancient monument, except by order of the Director-General, or permit has been obtained from the Director-General. If the permit contains any conditions, they have to be complied with (clause 10). The Director-General shall have the power in regard to any registered ancient monument, even owned or lawfully possessed by any individual, to order the competent official or any person to make a repair or to do whatsoever for its restoration or for the preservation of its original condition, provided that its owner or possessor has first to be notified thereof (clause 11). Antiques and Objects of Art. The Director-General is empowered, if he deems that any antique or object of art not being in the possession of the Department of Fine Arts is of special value in the field of art, history or archaeology, to cause such antique or object of art to be registered by means of publication in the Government Gazette (clause 14). No person shall repair, modify or alter any registered antique or object of art, unless permit has been obtained from the Director-General. If the permit contains any conditions, they must be complied with (clause 15). Applicability to the Project. During implementation, antiques and objects of art may be encountered affected by project activities. Therefore, the project will need to comply with the requirements of the Act to ensure these valued articles or objects are not negatively impacted. In cases of chance finds (encounter of underground artifacts or relics), the project will be required to stop construction and inform the Department of Fine Art for the findings and for necessary procedures which is in line with the Act.

D. Applicable Environmental Standards

34. The government provides the environmental standards applicable to the project. Table 2 below provides a list of the various Thailand national standards including international guidelines. Table 3 and Table 4 show the ambient air quality standards and noise level standards to be followed by the project. Following requirements of ADB SPS, the project shall apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in EHS Guidelines. When the government regulations differ from these levels and measures, the executing agency shall achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the PMU will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in ADB SPS.

Table 2: Key National and International Environmental Standards and Guidelines

Environmental Issue	Thai National Standards	International Guidelines
Ambient air quality	Announcement of National Environment Board No.10 1995 (B.E.2538) “Ambient Air Quality Standards” April 17, 1995 (B.E.2538) Announcement of National Environment Board No.21 2001(B.E.2544) “Ambient Sulfur Dioxide-1 Hr Standards” April 9, 2001 (B.E.2544) Announcement of National Environment Board No.24 2004(B.E.2547) “Ambient Air Quality Standards” August 9, 2004 (B.E.2547) Announcement of National Environment Board No.28 2007(B.E.2550) “Ambient Air Quality Standards” April 10, 2007 (B.E.2550) Announcement of National Environment Board No.33 2009(B.E.2552) “Ambient Nitrogen Dioxide Standards” June 17, 2009 (B.E.2552) Announcement of National Environment Board “Particulate Matter with an Aerodynamic Diameter Less Than or Equal to Nominal 2.5 micrometers (PM_{2.5}) Standards” June 23, 2023 (B.E.2565) Announcement of National Environment Board “Ambient Carbon Disulfide Standards” August 21, 2017 (B.E.2560) -Announcement of National Environment Board No.30 2007(B.E.2550) “Ambient Volatile Organic Compounds; VOCs-1-year Standards” September 14, 2007 (B.E.2550)	WHO Air Quality Guidelines, global update 2005
Noise	Announcement of National Environment Board No.5 1997 (2540) “Ambient Noise Standards” March 12, 1997 (B.E.2540) Announcement of National Environment Board No.29 2007 (2550) “Nuisance Noise Level” June 29, 2007 (B.E.2550)	WHO Guidelines for Community Noise, 1999
Groundwater quality	Announcement of Ministry of Industry No.12 1999(2542) “Groundwater Quality Standards-Drinking” March 10,1999(2542) Notification of National Environment Board No.20 2000 (2543)” Groundwater Quality Standards” August 31, 2000 (2543)	WHO Guidelines for Drinking-water Quality, Fourth Edition, 2011
Surface water quality	Announcement of National Environment Board No.8 1994 (2537) “Surface Water Quality Standards” January 20, 1994 (B.E.2537) Announcement of Pollution Control Department “Classification of Water Quality: Bang Pakong River, Nakhon Nayok River and Prachinburi River June 7, 1994 (2537)	US EPA National Recommended Water Quality Criteria Mekong River Commission (MRC) Technical Guidelines for the Protection of Aquatic Life
Sea water quality	Notification of National Environment Board “Sea Water Quality Standards” August 13,2021 (2564)	

Environmental Issue	Thai National Standards	International Guidelines
Effluent quality (including leachate)	Announcement of Ministry of Natural Resources and Environment” Effluent Standards from Industry, Industrial Estate and Industrial Park March 29, 2016 (2559) Announcement of Ministry of Natural Resources and Environment” Effluent Standards from Aquaculture Farming in Coastal Area March 19, 2004(2547) Announcement of Ministry of Natural Resources and Environment” Effluent Standards from Amphidromous fish, shrimp, crab farming May 9, 2007(2550) Announcement of Ministry of Natural Resources and Environment” Effluent Standards from freshwater fish, shrimp, crab farming November 23, 2007(2550)	27F CEHS General Guidelines, April 2007 27F CEHS Guidelines for Water and Sanitation, December 2007 27F CEHS Guidelines for Waste Management Facilities, December 2007 USEPA Effluent Limitations
Soil quality standards	Notification of National Environment Board “Soils Quality Standards” January 6, 2021 (2564)	
Bottom Sediment Standards Surface Water	Notification of National Environment Board “Bottom Sediment Standards, Surface Water 2022 (2565)” November 30, 2022 (2565)	
Sediment Standards Coastal Area	Notification of Pollution Control Department” Criteria for Sediment Quality in Coastal Area	

35. The government provides the environmental standards applicable to the project. Schedule 2 presents the national standards for ambient air quality and Schedule 4 presents the national standards for ambient noise. Following requirements of ADB SPS, the project shall apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in EHS Guidelines. When the government regulations differ from these levels and measures, the executing agency shall achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the PMU will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in ADB SPS. In view of this, Table 3 and Table 4 show the ambient air quality standards and noise level standards to be followed by the project. Paragraph 64 provides the standards on vibration.

Table 3: Ambient Air Quality Standards

Parameter	Thailand Ambient Air Quality Standard ($\mu\text{g}/\text{m}^3$) ^a	WHO Air Quality Guidelines 2021 ^b ($\mu\text{g}/\text{m}^3$)
PM _{2.5}	37.5 (24-hr)	15
PM ₁₀	120 (24-hr)	45 (24-hr)
	50 (1-yr)	15 (1-yr)
SO ₂	780 (1-hr)	
	300 (24-hr)	40 (24-hr)
	100 (1-yr)	
NO ₂	320 (1-hr)	

Parameter	Thailand Ambient Air Quality Standard ($\mu\text{g}/\text{m}^3$)^a	WHO Air Quality Guidelines 2021^b ($\mu\text{g}/\text{m}^3$)
CO		25 (24-hr)
	57 (1-yr)	10 (1-yr)
	34.2 (1-hr)	
Ozone		4 (24-hr)
	0.14 mg/m^3	100 (8-hr)
		60 (peak season)

^a National Air Quality Assessment and Management Regulation

^b These are not standards, but are guideline values only. Per WHO, the government may use these guideline values depending on its technical capabilities, economic capacity, air quality management policies and other political and social factors. Although these guidelines are neither standards nor legally binding criteria, they are designed to offer guidance in reducing the health impacts of air pollution based on expert evaluation of current scientific evidence.

Table 4: Ambient Noise Quality Standards

Receptor/ Noise Source	National Noise Standard Guidelines^a [dB (A)]	WHO Guidelines Value For Noise Levels Measured Out of Doors^b (One Hour LAeq in dBA)	
		07:00 – 22:00	22:00 – 07:00
Industrial area	70	70	70
Residential; institutional; educational (as receptor)	70	55	45

^a Notification of National Environment Board No.15 1997 " Ambient Noise Standards" March 12, 1997 (General standard is prescribed on the 24-hour average of 70 dB(A), but maximum noise level at 115 dB(A) at any time.

^b These are not standards, but are guideline values only. WHO. 1999. Guidelines for Community Noise; World Bank Group. 2007. Environmental, Health and Safety General Guidelines. Washington, D.C.

36. **National standard on Vibration Level to Prevent Impact to Buildings.** The following are the national standards taken from the Notification of the National Environmental Board No. 37, B.E. 2553:

- (i) Building Type 1 (Peak Particle Velocity (PPV) = 10 mm/s): for factories and commercial buildings;
- (ii) Building Type 2 (PPV = 5 mm/s): Residential building, hospital, place of study or religious activity; and
- (iii) Building Type 3 (PPV = 2.5 mm/s): Ancient monuments, antiques, objects of art, national museums, or structures of any other nature that are not stable and strong but have cultural value.

E. International Environmental Agreements

37. Thailand is party to the following international environmental agreements relevant to the project.

Table 5: International Environmental Agreements Relevant to the Project

Convention / Agreement	Key Provisions
Convention on the Protection of the World Cultural and Natural Heritage, 1975 (UNESCO World Heritage Convention)	Ratified in 1987, Thailand protects sites like Ban Chiang and Thungyai-Huai Kha Khaeng, balancing cultural and natural heritage. State Parties shall ensure that Environmental Impact Assessments, Heritage Impact Assessments, and/or Strategic Environmental Assessments be carried out as a pre-requisite for development projects and activities that are planned for implementation within or around a World Heritage property. States Parties have an obligation to notify UNESCO World Heritage Centre in advance before considering any proposed action that may have an impact on a World Heritage property.
United Nations Convention on Biological Diversity (1992)	Adopted in 1992 and entered into force in 1993, Thailand is a party, having signed it in 1992. The CBD aims to conserve biodiversity, promote sustainable use, and ensure fair benefit-sharing. Thailand's participation is evident through initiatives like the Thailand Biodiversity Network Alliance (B-DNA) and the National Biodiversity Action Plan (2023–2027). State parties are required to: • Establish management structures on biodiversity. • Report regularly.

Convention / Agreement	Key Provisions
	• Protect biological diversity from risks of living/genetically modified organisms and biotechnology. • Develop legislation for the protection of threatened species and populations. • Develop a national strategy for the conservation and sustainable use of biodiversity. • Incorporate mitigation of impacts on biodiversity in environmental impact assessment for development projects
United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol	Signed in 1992 as a Non-Annex I party, Thailand ratified it and the Paris Agreement (2016), committing to reduce greenhouse gas emissions by 30–40% by 2030. Recent policy shifts (e.g., 2022 NDC update) show ambition, but vulnerability to climate impacts (e.g., Bangkok's 1.5m elevation) questions adaptation capacity
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973	Ratified in 1983 after signing in 1975, CITES regulates trade in endangered species. Thailand's Elephant Ivory Act (2015) demonstrates compliance. State parties are required to: • Set up administrative and scientific bodies to manage the trade of endangered species and ensure, that all relevant authorities in the country, especially the customs, are fully aware of the regulations and the status of endangered species in the country. • Report the number of species imported/exported annually to CITES secretariat.
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention 02/02/1971)	Adopted in 1971 and effective from 1975, Thailand joined to protect wetlands of international importance. With 54 designated sites by 2022 progress is notable. The convention provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. State parties are required to: • Work towards the wise use of all wetlands through national land-use planning, appropriate policies and legislation, management actions, and public education. • Designate suitable wetlands for the List of Wetlands of International Importance and ensure their effective management. • Cooperate internationally concerning trans-boundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands.
United Nations Convention to Combat Desertification (UNCCD)	Established in 1994, Thailand is a party, focusing on land degradation. Its involvement in UNCCD COP15 (2025) indicates active participation, though desertification is less critical than flooding or deforestation in its context
International Labour Organization (ILO) Conventions and protocols	Thailand has ratified several ILO conventions and protocols, including: • Forced Labour Convention, 1930 (No. 29): Ratified in 1969, prohibits forced or compulsory labour, with the 2014 Protocol ratified in 2018 to enhance victim protection. • Abolition of Forced Labour Convention, 1957 (No. 105): Ratified in 1969, targets forced labour for economic or political purposes. • Minimum Age Convention, 1973 (No. 138): Ratified in 2004, sets a minimum age for work (15 years, with 13 for light work), addressing child labour.

Convention / Agreement	Key Provisions
	• Worst Forms of Child Labour Convention, 1999 (No. 182): Ratified in 2001, requires action against hazardous child labour, including trafficking and slavery. • Workmen's Compensation (Occupational Diseases) Convention, 1925 (No. 18): Ratified in 1961, covers compensation for work-related diseases. • Workmen's Compensation (Accidents) Convention, 1925 (No. 17): Ratified in 1961, addresses accident compensation. • Hours of Work (Industry) Convention, 1919 (No. 1): Ratified in 1939, limits work hours (48-hour week). • Right of Association (Agriculture) Convention, 1921 (No. 11): Ratified in 1969, protects agricultural workers' association rights. • Medical Examination of Young Persons (Industry) Convention, 1946 (No. 77): Ratified in 1968, mandates health checks for young workers. • Medical Examination of Young Persons (Non-Industrial Occupations) Convention, 1946 (No. 78): Ratified in 1968, extends health checks to non-industrial youth. • Labour Inspection (Commerce and Offices) Convention, 1947 (No. 86): Ratified in 1969, covers commercial inspections. • Social Security (Minimum Standards) Convention, 1952 (No. 102): Ratified in 1996, sets social security baselines. • Employment Injury Benefits Convention, 1964 (No. 121): Ratified in 1996, enhances injury compensation. • Occupational Safety and Health Convention, 1981 (No. 155): Ratified in 2001, promotes workplace safety. • Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187): Ratified in 2016, strengthens safety frameworks. • Protocol of 2014 to the Forced Labour Convention, 1930: Ratified in 2018, enhances forced labour prevention
The Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, 1995	The Mekong Agreement was established in 1995 by Laos, Thailand, Cambodia, and Vietnam to manage and coordinate the use of the Mekong River's resources. It aims to promote sustainable development, ensure equitable water use, and facilitate cooperation among the member countries. Under the Mekong Agreement, the parties have established five procedures including the Procedures for Notification, Prior Consultation and Agreement, or PNPCA. In accordance with the PNPCA, notification to the Mekong River Commission Secretariat is required for: • Intra-basin use and inter-basin diversion on the tributaries, including Tonle Sap (N/A) • Intra-basin use during the wet season on the mainstream Consultation with the Mekong River Commission Secretariat is required for: • Inter-basin diversion from mainstream during wet season • Intra-basin use on the mainstream during the dry season (relevant) • Inter-basin diversion of the surplus quantity of water during the dry season
Montreal Protocol on Substances that Deplete the Ozone Layer	Acceded to in 1989, Thailand meets obligations to phase out ozone-depleting substances, benefiting from Multilateral Fund support

Convention / Agreement	Key Provisions
Stockholm Convention on Persistent Organic Pollutants (POPs) of 17 May 2004	Relevant key provisions of the Convention require each party to: • Prohibit and/or eliminate the production and use, as well as the import and export, of the intentionally produced POPs that are listed annexes to the Convention. • Reduce or eliminate releases from unintentionally produced POPs that are listed in the Convention • Ensure that stockpiles and wastes containing POPs are managed safely.
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal	To control transboundary movement of hazardous waste before import, export and transshipment to other countries. It is required to provide necessary information in advance. Transshipment cannot be done till having the permit from target government. Key documents that shall be provided include documents relating to Transboundary Movements, Packaging, Labelling, Mode of transport, Financial Guarantee.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	The objective of this Convention is to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm and to contribute to their environmentally sound use, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties.
Minamata Convention on Mercury	The primary objective of the Minamata Convention is to protect human health and the environment from mercury pollution. Key provisions of the convention include: • Control and Reduction: The convention requires parties to control and reduce mercury emissions and releases across various sectors, including artisanal and small-scale gold mining, industrial processes, and the use of mercury in products. • Life-Cycle Approach: It takes a comprehensive life-cycle approach to mercury management, addressing its entire life cycle from production to disposal. • Prohibition of Certain Products: The convention prohibits the manufacture, import, and export of specific mercury-containing products, such as certain batteries, thermometers, and dental amalgams, with a phase-out timeline. Health and Safety Measures: It emphasizes the need for improved medical care and training for healthcare professionals to identify and treat mercury-related health effects.
International Covenant on Economic, Social and Cultural Rights (ICESCR)	Ratified in 1999, it includes provisions for safe working conditions • All people have the right of self-determination. By virtue of that right they freely determine their political status and freely pursue their economic, social and cultural development. • The States shall recognize the right to work, which includes the right of everyone to the opportunity to gain his living by work which he freely chooses or accepts, and will take appropriate steps to safeguard this right. nomic, social and cultural development. The State shall recognize the right of everyone to the enjoyment of just and favorable conditions of work including fair wages, decent living for themselves and their families, safe and healthy working conditions, equal opportunity for everyone to be promoted in his employment, rest, leisure and reasonable limitation of working hours and periodic holidays with pay,

Convention / Agreement	Key Provisions
	as well as remuneration for public holidays.
ASEAN Agreement on Transboundary Haze Pollution in 2006	Association of Southeast Asian Nations (ASEAN) shall 1) further strengthen international cooperation to develop national policies for preventing and monitoring transboundary haze pollution 2) co-ordinate national action for preventing and monitoring transboundary haze pollution through exchange of information, consultation, research and monitoring 3) undertake individual and joint action to assess the origin, causes, nature and extent of land and/or forest fires and the resulting haze, to prevent and control the sources of such land and/or forest fires and the resulting haze by applying environmentally sound policies, practices and technologies and to strengthen national and regional capabilities and cooperation in assessment, prevention, mitigation and management of land and/or forest fires and the resulting haze.
ASEAN Agreement on Disaster Management and Emergency Response, 2009	The objective of this Agreement is to provide effective mechanisms to achieve substantial reduction of disaster losses in lives and in the social, economic and environmental assets of the Parties, and to jointly respond to disaster emergencies through concerted national efforts and intensified regional and international co-operation. The Parties shall • co-operate in developing and implementing measures to reduce disaster losses including identification of disaster risk, development of monitoring, assessment and early warning systems, standby arrangements for disaster relief and emergency response, exchange of information and technology, and the provision of mutual assistance; • immediately respond to a disaster occurring within their territory. When the said disaster is likely to cause possible impacts on other Member States, respond promptly to a request for relevant information sought by a Member State or States that are or may be affected by such disasters, with a view to minimizing the consequences; • promptly respond to a request for assistance from an affected Party; and d. take legislative, administrative and other measures as necessary to implement their obligations under this Agreement.

Source: TRTA Consultant, July 2025

III. DESCRIPTION OF THE PROJECT

A. Background

38. The Government of Thailand aims to modernize and transform the Lower Chao Phraya River canal system to address climate-induced flood and drought vulnerabilities.¹⁷ By retrofitting irrigation canals to withstand climate-induced floods, existing assets can be used more efficiently to provide multiple functions of irrigation, local drainage, and flood diversion around urban areas like Bangkok. Upgrading these canals reduces the need to construct new flood diversion channels which have both significant environmental and resettlement impacts. Improving irrigation efficiency supports sustainable agriculture, ensures food security, and helps farmers adapt to shifting precipitation patterns. This provides reliable water sources for crops during prolonged

¹⁷ The design of the irrigation system started in 1903, while construction was finalized in the early 1960s.

droughts or irregular rainfall, contributing to broader climate resilience efforts. The government also aims to modernize water resource management practices and further empower local communities to enhance climate adaptation, mobilize resources for livelihood improvement and sustainable development, and mitigate ecosystem disruption and environmental degradation.

39. **Government Initiative.** Since the 2011 floods, comprehensive flood master-planning for the Chao Phraya River basin has been underway. The Chao Phraya River Flood Risk Management (CPRFRM) Masterplan¹⁸ was developed to improve all flood mitigation infrastructure in the Chao Phraya River Basin. The masterplan consists of nine extensive plans or projects that will focus on different but interconnected water conveyance channels (both man-made and natural canals) in the vast river basin. Among these plans or projects is the Lower East Chao Phraya Irrigation System Improvement Project¹⁹ which will rehabilitate and improve irrigation canals, regulating structures (gates) and other structures in the lower eastern part of the Chao Phraya basin. The existing infrastructure lacks sufficient flood conveyance capacity, making them vulnerable during flood events. Upgrading these canals will allow them to serve dual purposes of irrigation and flood mitigation, efficiently storing more water and conveying more floodwater while considering projected climate changes. The CPRFRM Masterplan provides a clear road map for phased investments.

B. The Project

40. This IEE covers the Lower East Chao Phraya Irrigation System Improvement Project (“project” or “LECPISIP” or “LECP project”). The project will be financed by ADB through a multitranchise financing facility (MFF) given the magnitude of investment and the scale and complexity of the government’s overall program. The MFF will tentatively comprise three tranches using a flexible, time-slicing approach that allows partially overlapping implementation. All tranches will finance civil works, goods and equipment, and consulting services across all three outputs, with Tranche 1 also financing project management and supervision services for the full program. The scope and timing of subsequent tranches will be determined by their implementation readiness.

41. **Project Components.** The project components will include civil works, goods, consulting services, and non-consulting services. The following components will involve civil works:

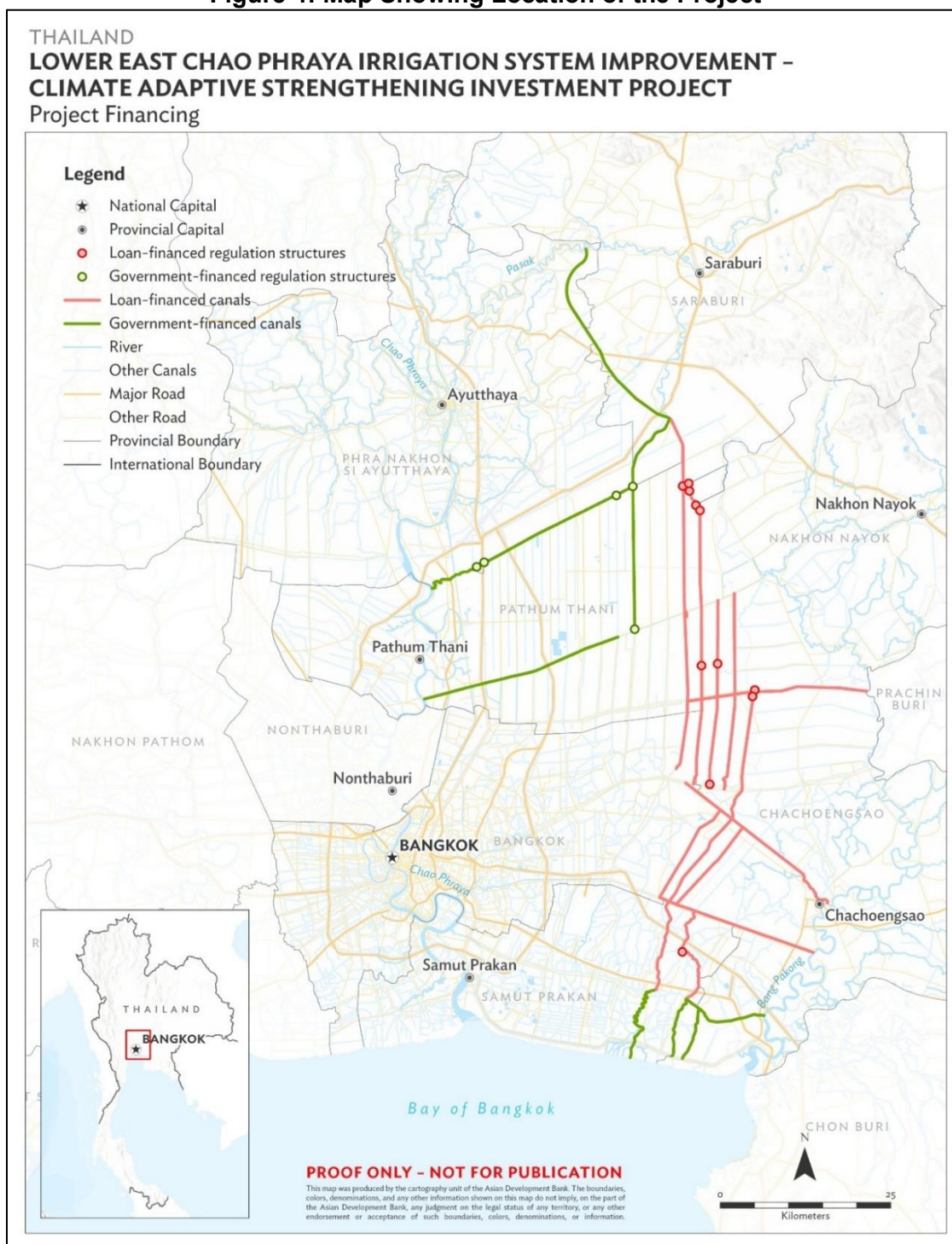
- (i) Upgrade of approximately 311 kilometers of existing canals by dredging to increase the cross-sectional area of these canals and by constructing retaining walls on either or both sides of these canals under Output 1; and
- (ii) Construction and/or upgrade of 11 flow regulator structures under Output 1.

42. **Project Location.** The project is located in the south of Thailand, with a southern border of the northern shore of the Gulf of Thailand. The project area is on the lower eastern section of the Chao Phraya River Basin and adjacent the eastern periphery of Bangkok Metropolitan Area. Figure 4 shows the location map of the project.

¹⁸ Project for the Study and Prioritization of Flood Mitigation Plans in the Chao Phraya River Basin, Final Report, Executive Summary Report by Kasetsart University, September 2020.

¹⁹ The other key plans include; (i) Project 2: Chai Nat-Pak Sakhon-Gulf of Thailand; (ii) Project 3: Japan International Cooperation Agency Study Project; (iii) Project 4: Western Chao Phraya River Basin System Enhancement; (iv) Project 5: Improving Water Discharge Efficiency; (v) Project 6: Out-of-Bank Area Management; (vi) Project 7: Bang Ban-Bang Sai Canal Project; (vii) Project 8: Enhancing Water Discharge Efficiency for the Chao Phraya River; and (xi) Project 9: Watershed Area Plan.

Figure 4: Map Showing Location of the Project



43. **Tranche-wise Distribution Under the MFF.** A schematic presentation of the tranche-wise civil works in existing canals and regulators under Output 1 is shown in Figure 5. The project site locations for each tranche are provided in Figure 6 to Figure 8. This is preliminary information and may be further updated during project implementation.

Tranche 1

Rama VI Barrage Pasak River

① K. Raphiphat

② K. Raphiphat Yeak Tok

③ K. Raphiphat Yeak Tai [contract1-4]

④ K. Rongrat

⑤ K. 14 Check Reg.

⑥ K. 15 Head Reg.

⑦ K. 16 Head Reg.

⑧ K. 17 Head Reg. (Lower Zone)

⑨ K. 18 Head Reg.

⑩ K. 19 Head Reg.

⑪ K. 20 Head Reg.

⑫ K. 21 Head Reg.

⑬ K. 22 Head Reg.

⑭ K. 23 Lat Phak Khwang

⑮ K. 24 Lat Phak Khwang

⑯ K. 25 Lat Phak Khwang

⑰ K. 26 Lat Phak Khwang

⑱ K. 27 Lat Phak Khwang

⑲ K. 28 Lat Phak Khwang

⑳ K. 29 Lat Phak Khwang

㉑ K. 30 Lat Phak Khwang

㉒ K. 31 Lat Phak Khwang

㉓ K. 32 Lat Phak Khwang

㉔ K. 33 Lat Phak Khwang

㉕ K. 34 Lat Phak Khwang

㉖ K. 35 Lat Phak Khwang

㉗ K. 36 Lat Phak Khwang

㉘ K. 37 Lat Phak Khwang

㉙ K. 38 Lat Phak Khwang

㉚ K. 39 Lat Phak Khwang

㉛ K. 40 Lat Phak Khwang

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㊱ K. 45 Lat Phak Khwang

㊲ K. 46 Lat Phak Khwang

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㊶ K. 50 Lat Phak Khwang

㊷ K. 51 Lat Phak Khwang

㊸ K. 52 Lat Phak Khwang

㊹ K. 53 Lat Phak Khwang

㊺ K. 54 Lat Phak Khwang

㊻ K. 55 Lat Phak Khwang

㊼ K. 56 Lat Phak Khwang

㊽ K. 57 Lat Phak Khwang

㊾ K. 58 Lat Phak Khwang

㊿ K. 59 Lat Phak Khwang

Work Groups

Symbol :

① Khlong 13

② Khlong Phra Ong Chaiyanuchit

③ ADB & Co-financier Budget

④ National Budget

⑤ Resettlement Preparation

⑥ RID Canal

⑦ Marine Department Canal

Gulf of Thailand

*** year 2026

Tranche 2

Rama VI Barrage Pasak River

① Phra Intharacha Pipe/Inlet

② Chiang Pak Pua Reg.

③ K. 10 Head Reg.

④ K. 10 Tail Reg.

⑤ K. 15 Head Reg.

⑥ K. 16 Head Reg.

⑦ K. 17 Head Reg.

⑧ K. 18 Head Reg.

⑨ K. 19 Head Reg.

⑩ K. 20 Head Reg.

⑪ K. 21 Head Reg.

⑫ K. 22 Head Reg.

⑬ K. 23 Lat Phak Khwang

⑭ K. 24 Lat Phak Khwang

⑮ K. 25 Lat Phak Khwang

⑯ K. 26 Lat Phak Khwang

⑰ K. 27 Lat Phak Khwang

⑱ K. 28 Lat Phak Khwang

⑲ K. 29 Lat Phak Khwang

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㊽ K. 58 Lat Phak Khwang

㊿ K. 59 Lat Phak Khwang

Work Groups

Symbol :

① Khlong 13

② Khlong Phra Ong Chaiyanuchit

③ ADB & Co-financier Budget

④ National Budget

⑤ RID Canal

⑥ Marine Department Canal

Gulf of Thailand

Tranche 3

Rama VI Barrage Pasak River

① K. 10 Head Reg.

② K. 10 Tail Reg.

③ K. 15 Head Reg.

④ K. 16 Head Reg.

⑤ K. 17 Head Reg.

⑥ K. 18 Head Reg.

⑦ K. 19 Head Reg.

⑧ K. 20 Head Reg.

⑨ K. 21 Head Reg.

⑩ K. 22 Head Reg.

⑪ K. 23 Lat Phak Khwang

⑫ K. 24 Lat Phak Khwang

⑬ K. 25 Lat Phak Khwang

⑭ K. 26 Lat Phak Khwang

⑮ K. 27 Lat Phak Khwang

⑯ K. 28 Lat Phak Khwang

⑰ K. 29 Lat Phak Khwang

⑱ K. 30 Lat Phak Khwang

㉑ K. 31 Lat Phak Khwang

㉒ K. 32 Lat Phak Khwang

㉓ K. 33 Lat Phak Khwang

㉔ K. 34 Lat Phak Khwang

㉕ K. 35 Lat Phak Khwang

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㊼ K. 57 Lat Phak Khwang

㊽ K. 58 Lat Phak Khwang

㊿ K. 59 Lat Phak Khwang

Work Groups

Symbol :

① Khlong 13

② Khlong Phra Ong Chaiyanuchit

③ ADB & Co-financier Budget

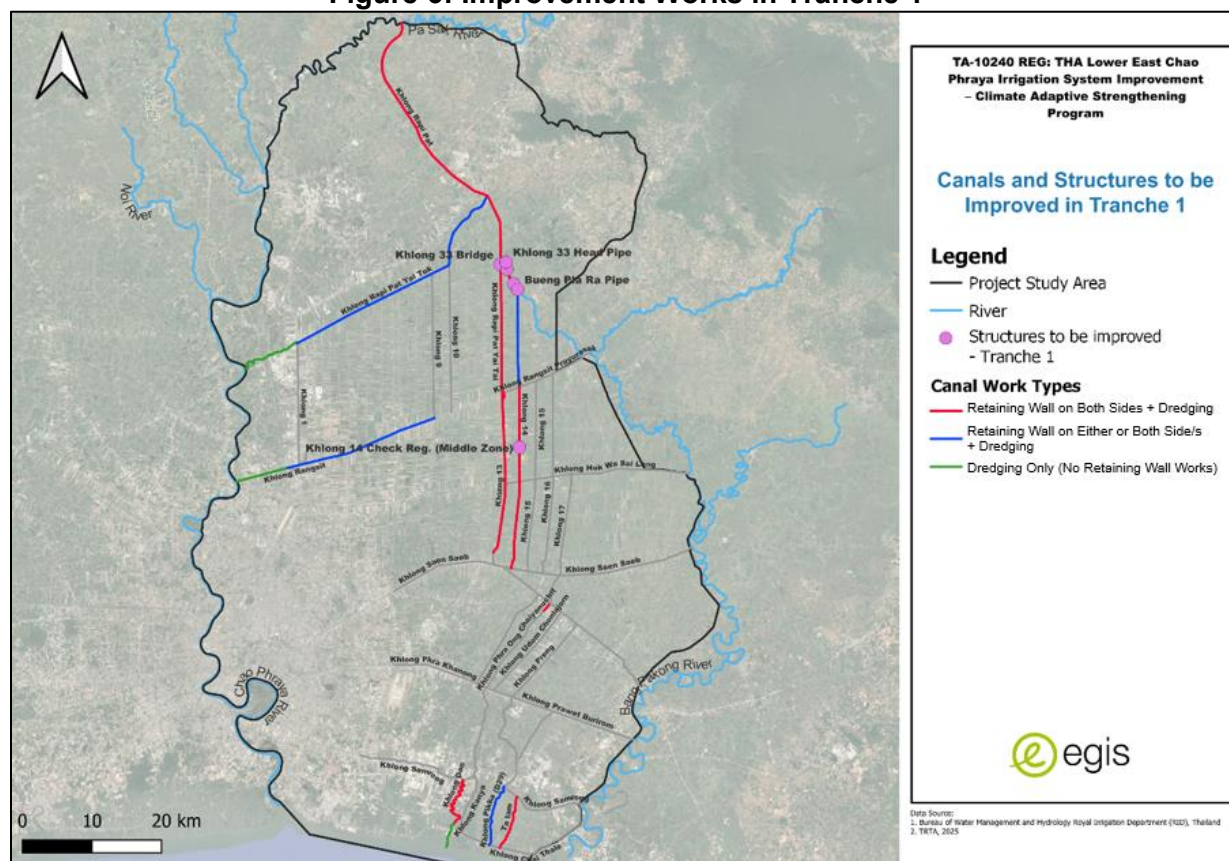
④ National Budget

⑤ RID Canal

⑥ Marine Department Canal

Gulf of Thailand

Figure 6: Improvement Works in Tranche 1



No.	Code	Sub-Projects	Canal/ Structure	Improvement Detail	Length of Improvement (km)	Existing Flow Capacity (m3/s)	Proposed Flow Capacity (m3/s)	Excavated material (m3)	Compaction soil using excavated material (m3)	Depth (m)	Top width (m)	Bottom width (m)
13	S2.5	Bueng Pla Ra Pipe Regulator	Structure									
14	S2.6	Canal 14 Check Regulator	Structure					16,112	2,285			
24	S2.7	Hok Wa Sai Lang Canal Check Regulator	Structure									
25	S2.8	Chuat Phrao Canal Check Regulator	Structure					7,058	952			

Figure 7: Improvement Works in Tranche 2

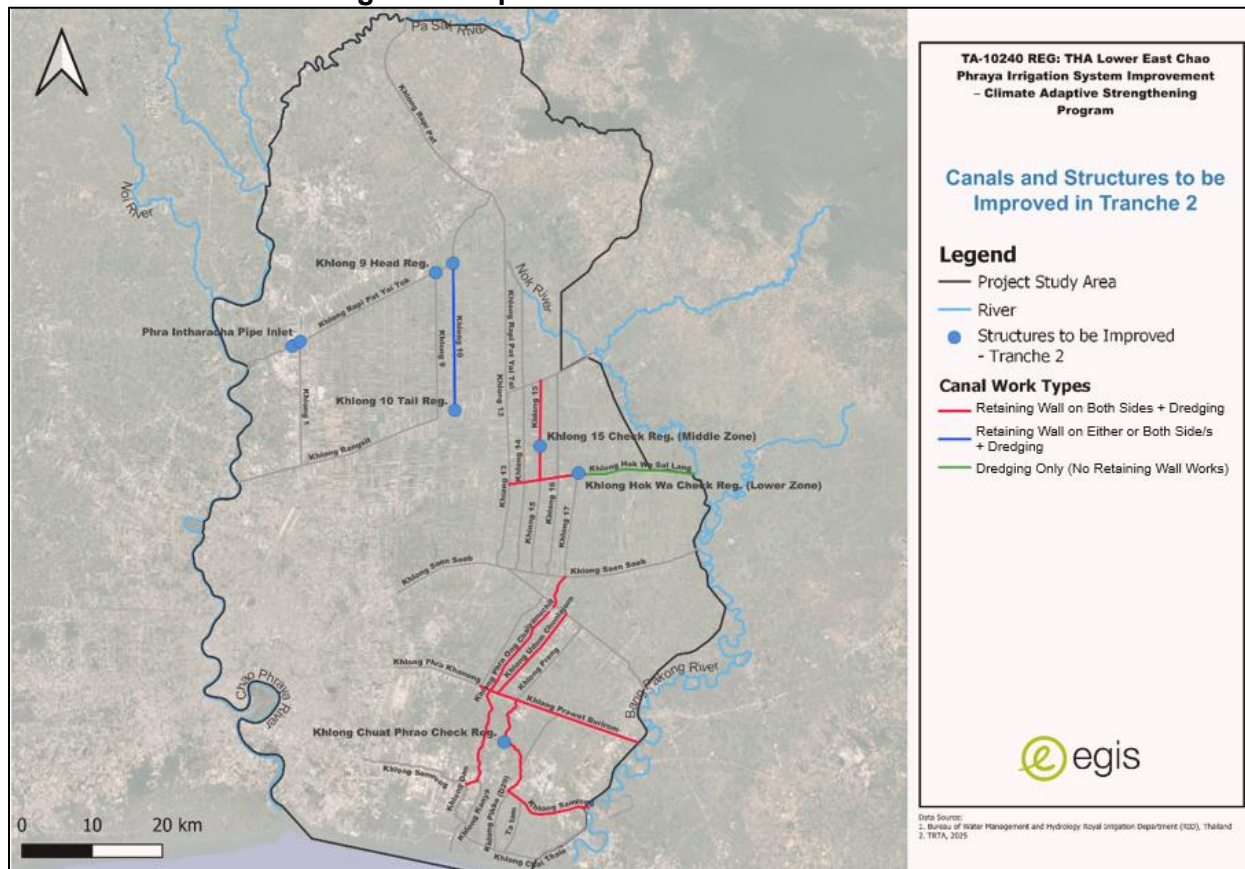


Table 7: Details of Tranche 2 Canal Alignments and Structures

[illegible]

No.	Code	Sub-Projects	Canal/ Structure	Improvement Detail	Length of Improvement (km)	Existing Flow Capacity (m3/s)	Proposed Flow Capacity (m3/s)	Excavated material (m3)	Compaction soil using excavated material (m3)	Depth (m)	Top width (m)	Bottom width (m)
25	S2.8	Chuat Phrao Canal Check Regulator	Structure					7,058	952			

Figure 8: Improvement Works in Tranche 3

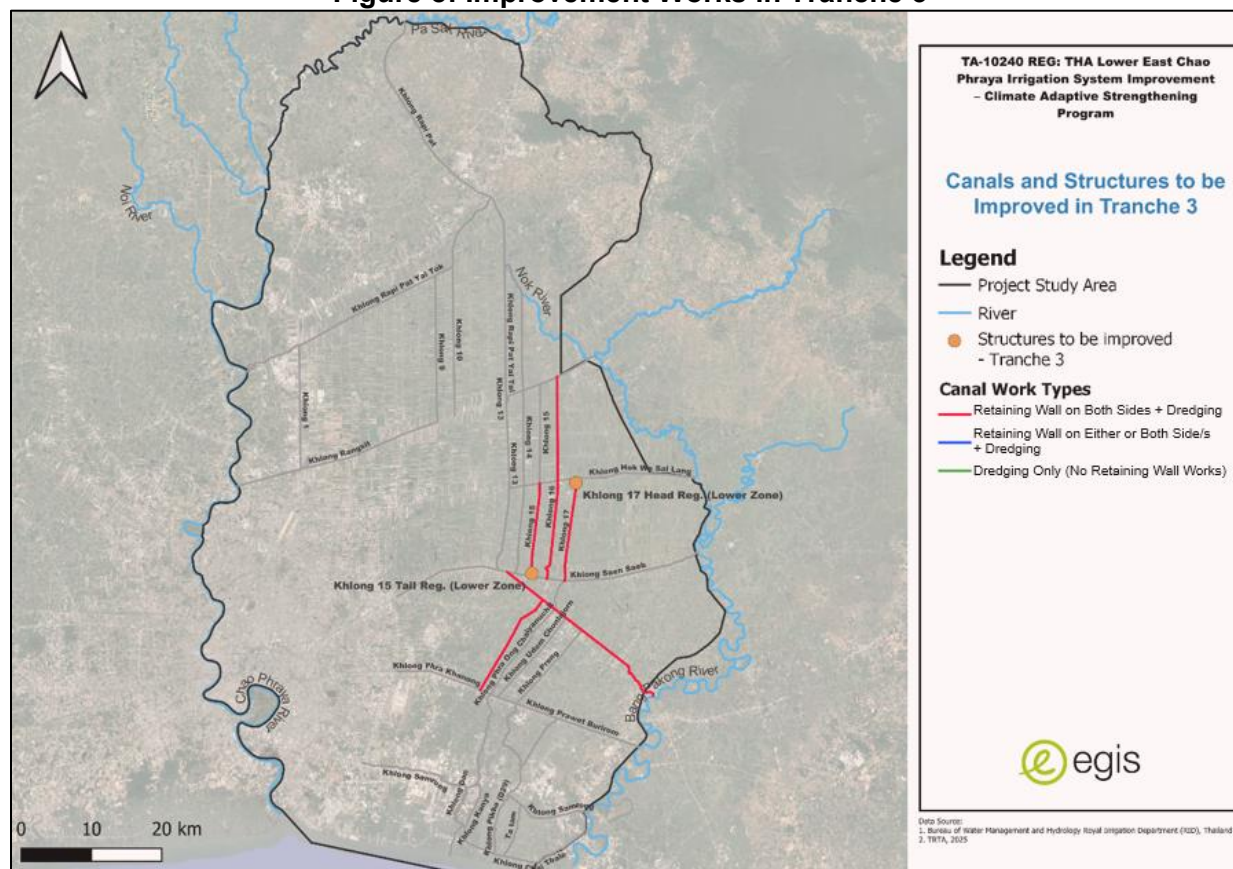


Table 8: Details of Tranche 3 Canal Alignments and Structures

No.	Code	Sub-Projects	Canal/ Structure	Improvement Detail	Length of Improvement (km)	Existing Flow Capacity (m3/s)	Proposed Flow Capacity (m3/s)	Excavated material (m3)	Compaction soil using excavated material (m3)	Depth (m)	Top width (m)	Bottom width (m)
		TRANCHE 3						3,259,785	385,507			
26	C1.4	Nakhon Nueng Khet Canal (Part1)	Canal	Wall on Both Sides with Dredging	8.630	32-50	55-85	116,297	13,679	2.9- 6.6	18-38	5-18
27	C3.6	Nakhon Nueng Khet Canal (Part2)	Canal	Wall on Both Sides with Dredging	19.070	12-25	24-60	256,976	30,226	2.9- 6.6	18-38	5-18
28	C3.2	Canal 15 (Part2)	Canal	Wall on Both Sides with Dredging	13.425	20	40	406,422	58,060	4.5-5	21-23	10-12
29	C3.3	Canal 16 (Part1)	Canal	Wall on Both Sides with Dredging	14.800	35	55	1,075,663	141,590	5.5	24-31	2-8
30	C3.4	Canal 16 (Part2)	Canal	Wall on Both Sides with Dredging	14.430	30	40					
31	C3.5	Canal 17	Canal	Wall on Both Sides with Dredging	14.720	40	80	915,000	79,000	5.4	31	20
32	C2.7	Luang Phaeng Canal	Canal	Wall on Both Sides with Dredging	15.865	14	30	460,425	58,838	3.5-4	21-28	9-13
33	S3.7	Canal 17 Head Regulator (Lower Zone)	Structure									
34	S3.2	Canal 15 Tail Regulator	Structure					29,002	4,114			

C. Indicative Construction Methods

44. In this section, representative examples of canal improvement design and the existing site conditions are presented. These are based on normal practices for similar projects in the project geographical region. It should be noted that the contractor when appointed will determine the most cost effective and appropriate construction techniques and may make modifications to the design, subject to approval of RID and ADB. Where changes to design and construction methodologies are proposed, there will be a requirement on the contractor to conduct environmental and social safeguard risk assessments based on the proposed design and method statements. Any significant risks outside of those reported within this IEE and any subsequent impact assessment reports shall be reported to the PIU and ADB.

45. Figure 9 shows the locations of three example cross-sections of canals which will be improved. The proposed changes with typical site conditions are presented in Figure 10, Figure 11 and Figure 12 for Sections 1, 2 and 3 respectively.

Figure 9: Location of Sample Cross-Sections 1, 2 and 3

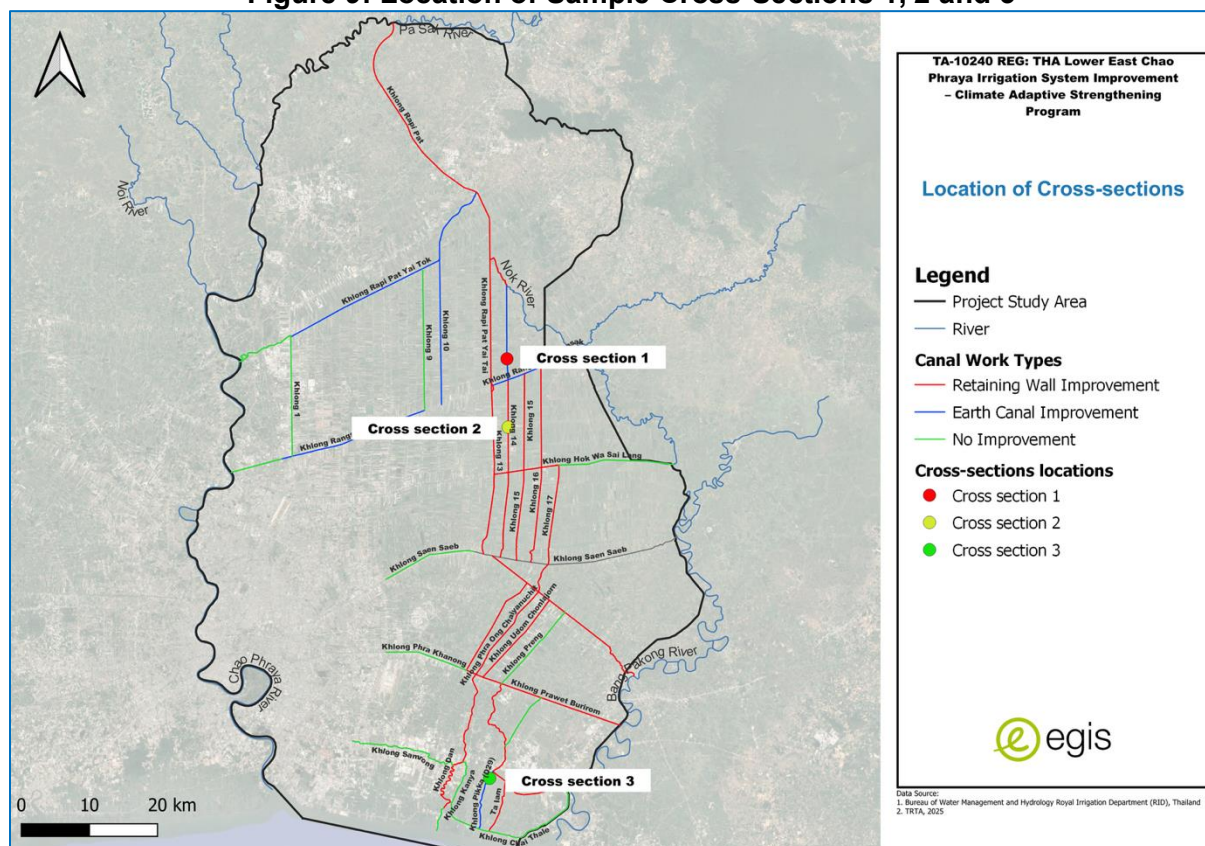


Figure 10: Cross-Section 1 in Canal 14 (Part 1) with Sheet Pile Wall on the Left Bank

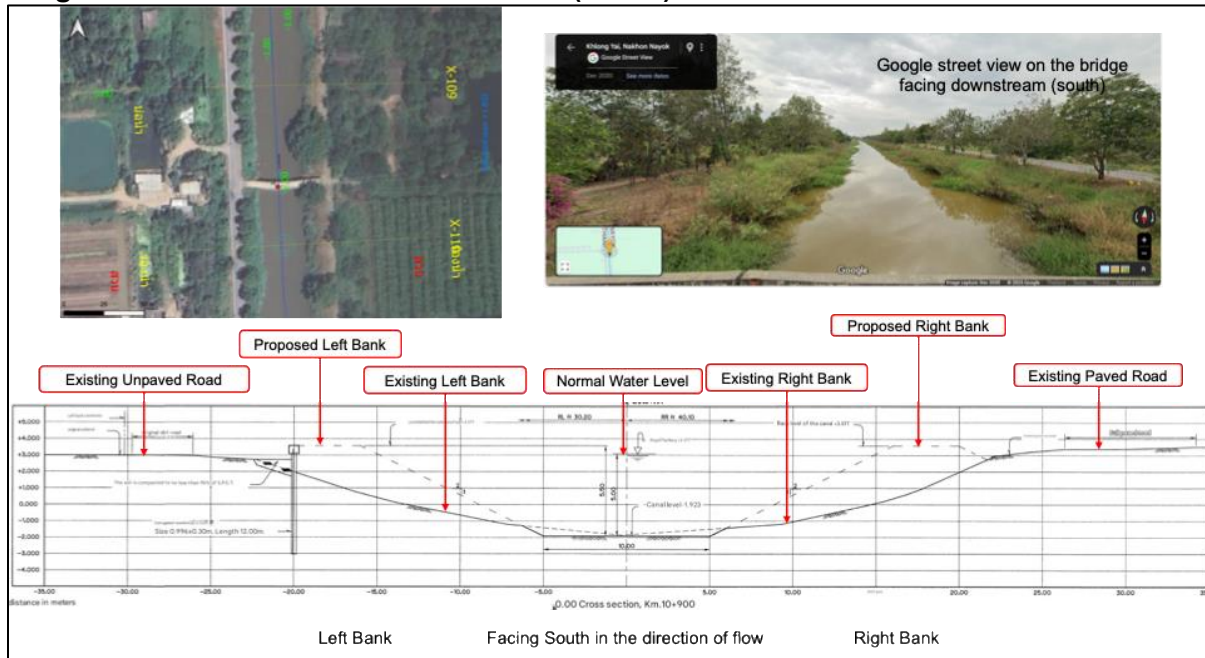


Figure 11: Cross-Section 2 in Canal 14 (Part 2) with Sheet Pile Wall on Both Sides

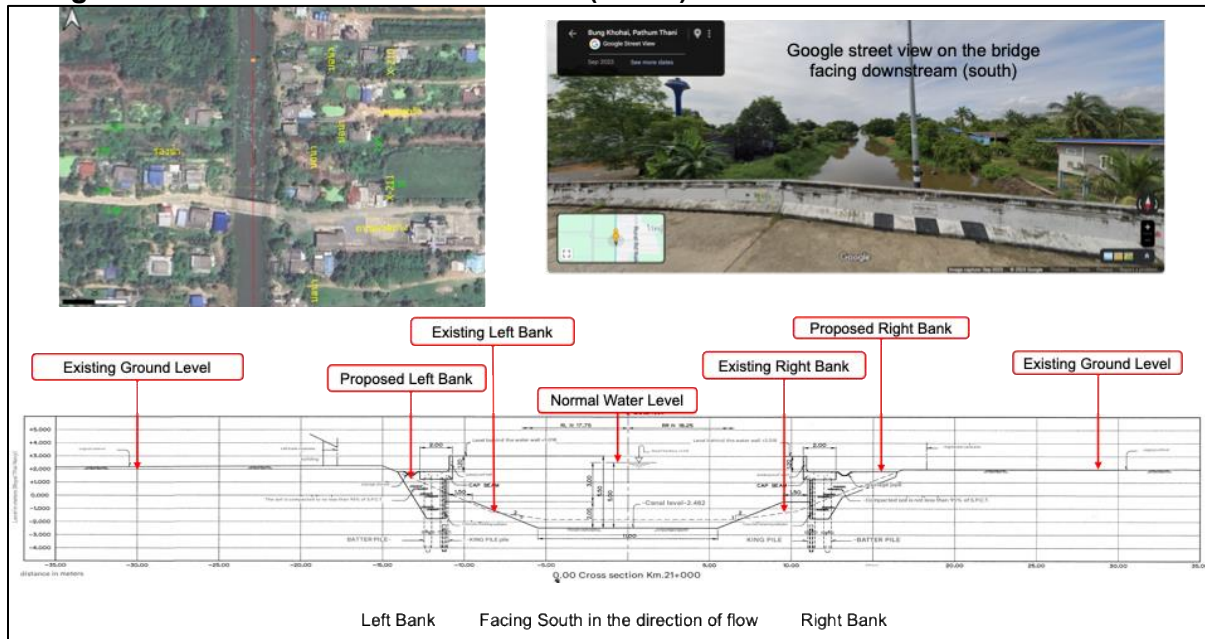
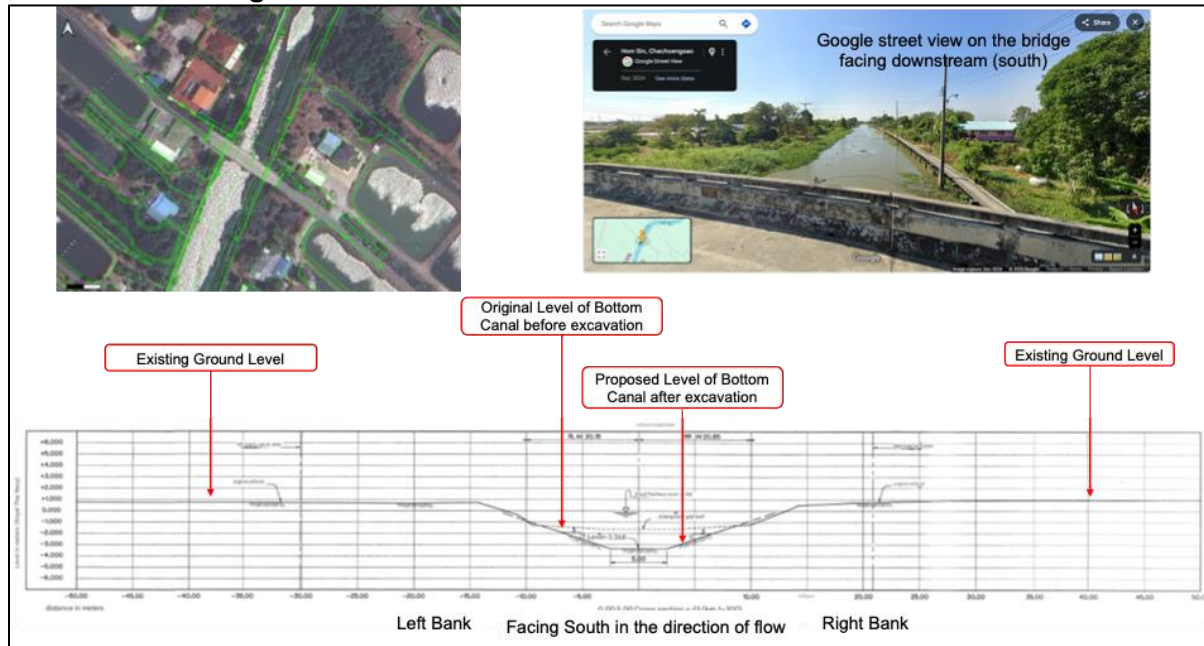


Figure 12: Cross-Section 3 in Pi Ka with no Sheet Pile Wall



46. The project will be open to national and international bids from contractors. At this stage of the project, while designs are well advanced and understood, the final decisions about methodologies for accessing sites, working processes, and schedules will be left to a contractor decision.

47. Set out below are descriptions of typical operations which will take place along with some sample images from similar works.

48. **Excavation from Canals.** As previously noted, a large amount of allochthonous material has entered the canal system from upstream sources. This has settled into canal beds and reduces the holding capacity of the canal and changes flow characteristics. The project will remove this sediment. Additionally, the project will change in some locations the depth and profile of the existing canal to achieve the required additional holding capacity of the system.

49. A range of options are available for removing the material from the canals. Some pilot projects and similar works have been conducted, and methods trialed.

50. A key factor is, if the sites are worked in dry conditions or while water is present within the canal. Previous works have been conducted in the dry season with temporary earth bunds creating a dry area within the canal from which in canal excavation can take place. This is a safe working method, with excavation machinery operating at ground level and not stretching down from the bankside. However, given the extent of the project and the timeline it is unlikely that all such works can be completed during the four month dry season. Therefore, alternative working methods will be required. The preferred approach will be from floating barges with the excavation machinery fixed to the barge. Dredging may be in the form articulated arms, i.e. typical backhoe type equipment or cutter suction, where a head cuts the sediment/base material and it is sucked up and discharged to adjacent barges or land.

51. Excavated material will need to be dewatered and dried prior to transportation from the site.

52. **Concrete Sheet Wall Piling.** The concrete sheet wall piling work is extensive across the project. Piles and the corrugated sheet will be pre-cast off site. The location of the pre-cast yard will be a decision for the contractor.

53. Two types of pile will be used. A king pile which is in the form of a capital I shape between which slot the corrugated sheet walls. To support horizontal stresses a second set of piles are placed behind the king piles and sheet wall, these are referred to as batter piles. These are tied into the king piles. Backfilling will be with suitable excavated material. A generalized set up is shown in Figure 13 where the king piles are on the left and the batter piles to the right. It should be noted that the images are from a project with much shorter piles than those which will be used for the LECP.

Figure 13: Example Layout of King and Batter Piles



54. The piles need to be inserted, sometimes down to 31 m depth. The piles need to reach stiff clay layers to provide the required stability for the wall. Based on known ground conditions the top layers will be mainly alluvial, with silt, gravels and sand. The piles will be pushed through these readily and may penetrate these softer layers under their own weight. However, at some point the piles will need to be driven into the stiff clay layer. Several options for this process are available. The two most likely to be used are impact pile driving, where a hammer falls onto the top of the pile to drive it into the ground, and vibratory insertion. The latter is where a vibration source is applied to the head of the pile which sets up vibrations at the base, liquifying the soil and allowing the weight of the pile to move it downwards.

55. Whatever method is used the process will include piling rigs and frames which hold the pile in place during the driving process. A typical frame and driver is shown in Figure 14, they are placed on rails and can be moved along to the location of the next pile. It should be noted that this approach requires space on the landside of the canal and good ground conditions to ensure that the frame and rig is stable.

Figure 14: Example of Pile Frame



56. Alternatively, driving can be conducted from a jack up barge as shown in Figure 15. For the LECP the use of barges may be restricted as the canals for the most part are not navigable due to regulator structures. It is possible to utilize modular barges brought in by road and constructed in the water. This would be a feasible option on canals with longer pounds without obstructions.

Figure 15: Example of Piling from Barge



57. Once the King piles are in-situ, the concrete slabs are dropped into the gaps between piles.

58. Work on excavation and piling will progress along the route. The pace of operations will depend upon the number of pieces of equipment the contractor will use and the complexity of the site, ground conditions and required length of pile.

59. **Rehabilitation and Construction of Discrete Structures.** Other components of the project include rehabilitation or construction of permanent site-specific structures such as regulators and pumping stations. These structures are located at discrete sites along the existing canals. Previous work has shown the work has taken place in the dry with a section of canal completely dewatered, and construction proceeds as a traditional civil works. Depending on the nature of works, construction of new structures may take several years to complete, but rehabilitation works may take shorter period.

D. Material Use

60. A summary of the likely usage of the main on-site work construction materials is shown in Table 9 for the canals and Table 10 for structures. This excludes the piles and sheet walls which will be produced offsite.

Table 9: Summary of Main Construction Material Quantities for Canals

Canal	Steel (Reinforced Concrete Work) (kg)	Ready Mix Concrete (m ³)
1. Khlong Raphiphat Yaek Tai	9,187,999	70,164
2. Khlong 33 - Khlong Lat Phak Khwang	489,016	4,311
3. Khlong 14	10,801,177	-
4. Khlong 13	7,062,018	54,849
5. Khlong 15	8,875,244	68,399
6. Khlong 16	7,256,219	89,877
7. Khlong Hok Wa Sai Lang	2,274,108	28,168
8. Khlong 17	1,739,751	19,992
9. Khlong Phra Ong Chaiyanuchit	7,552,104	102,019
10. Khlong Udom Cholaajorn	1,764,864	20,319
11. Khlong Luang Phaeng	4,235,972	35,604
12. Khlong Nakhon Neuang Khet	2,706,459	31,675
13. Khlong Prawet Buri Rom	6,500,076	54,030
14. Khlong Chuat Phrao - Lao Moo - Bang Phli Noi	3,713,029	50,159

Table 10: Summary of Main Construction Material Quantities for Structures

Structure	Steel (Reinforced Concrete Work) (kg)	Ready Mix Concrete (m ³)
1. Bridge (Khlong 33)	92,232	684
2. Khlong 33 Head Pipe	53,042	522

Structure	Steel (Reinforced Concrete Work) (kg)	Ready Mix Concrete (m³)
3. Lat Phak Khuang Reg.	197,979	1,888
4. Khlong 14 check Reg. @ km22+660	111,523	1,388
5. Khlong 15 check Reg. @ km9+340	98,603	1,156
6. Khlong 15 Tail Reg. @ km27+170	95,740	1,124
7. Khlong 24 Head Reg.	159,571	1,138
8. Khlong 23 Head Reg.	160,980	1,145
9. Khlong 22 Head Reg.	138,693	1,047
10. Khlong Chuat Phrao Check Reg.	110,886	1,824
11. Bueng Pla Ra Reg.	No data in BOQ (it is not included in detailed design), RID design by themselves	
12. Bueng Pla Ra Pipe	No data in BOQ (it is not included in detailed design), RID design by themselves	
13. Khlong Hok Wa Sai Lang Check Reg.	No data in BOQ (it is not included in detailed design), RID design by themselves	
14. Khlong 16 Tail Pipe	No data in BOQ (it is not included in detailed design), RID design by themselves	
15. Khlong 17 Head Reg. (Lower zone)	No data in BOQ (it is not included in detailed design), RID design by themselves	
16. Khlong 17 Tail Reg.	No data in BOQ (it is not included in detailed design), RID design by themselves	

E. Implementation Schedule

61. The current tentative implementation schedule for the construction works in Tranche 1 is shown in Table 11. The schedule illustrates the sequencing of key activities: public participation (in grey), resettlement implementation (in blue), construction of loan financed components (in orange), and construction funded by the national budget (in green), spanning the period from 2025 to 2031.

Table 11: Tentative Time Schedule for Tranche 1 Construction

Work Group	Code	Sub-projects	Length of Improvement (km)	Cost (Million THB)	Fiscal Year							Estimated Household
					Year 2025	Year 2026	Year 2027	Year 2028	Year 2029	Year 2030	Year 2031	
Preparation and Environmental Activity												
		Preparation Activity		200.0000								
		Environmental Activity		75.0000		8.9	8.24	9.24	8.24	9.24	31.14	
Contingency												
		Contingency		1,197.7206								
Fiscal Year 2026												
Fiscal Year 2027												
WG7	C2.6	Khlong Phra-Ong Chaiyanuchit (Pilot)	0.850	305.2500			61.05	244.2				37
WG3	C1.1	Khlong Raphiphat Yaek Tai [Contract 1]	7.150	1,552.7051								10
WG3		Khlong Raphiphat Yaek Tai [Contract 2]	7.150	1,552.7051								10
WG3	C1.1	Khlong Raphiphat Yaek Tai [Contract 3]	7.150	1,775.5508								10
WG3		Khlong Raphiphat Yaek Tai [Contract 4]	7.151	1,775.5508								11
WG3	C2.1	Khlong 33 - Khlong Lat Phak Khwang	5.230	1,098.9000			219.78	439.56	439.56			-
WG5	C1.2	Khlong 13 (Part 1)	13.000	2,123.7500			434.29	639.515	1049.945			-
WG6	C1.3	Khlong 13 (Part 2)	10.200	1,221.0000			244.2	488.4	488.4			-
WG3	C2.2	Khlong 14 (Part 1)	14.051	1,170.1250			234.025	468.05	468.05			-
WG6	C2.4	Khlong 14 (Part 3) [Contract 1]	6.310	1,475.3750								15
WG6	C2.4	Khlong 14 (Part 3) [Contract 2]	6.310	1,441.7980								14
WG5	C3.1	Khlong 15 (Part 1)	14.200	3,034.9710								5
WG5	S3.1	Khlong 15 Check Regulator @ km9+340		140.0000			140					-
WG3	S2.1	Khlong 33 Head Pipe		7.5000			7.5					-
WG3	S2.2	Bridge (Khlong 33)		10.0000			10					-
WG3	S2.3	Lat Phak Khwang Regulator		90.0000			90	40				-
WG3	S2.4	Bueng Pla Ra Regulator		91.3536			45.541	45.8126				-
WG3	S2.5	Bueng Pla Ra Pipe Regulator		50.7520			50.752					-
Fiscal Year 2028												
WG5	C2.3	Khlong 14 (Part 2)	13.590	2,806.5869				313	313	980.5869		79
WG5	S2.6	Khlong 14 Check Regulator @ km22+660		140.0000				140				-
WG6	C2.5	Khlong Hok Wa Sai Lang	9.150	1,981.0730				396.7101	792.186	792.186		150
WG6	S2.7	Khlong Hok Wa Sai Lang Check Regulator		121.8049				121.8049				-
WG6	C3.2	Khlong 15 (Part 2) [Contract 1]	6.710	1,526.2500				306.26	610.5	610.5		123
WG6	C3.2	Khlong 15 (Part 2) [Contract 2]	6.710	1,448.9200				287.784	579.568	579.568		123
WG6	S3.2	Khlong 15 Tail Regulator @ km27+170		101.7500				101.75				-
WG7	C1.4	Khlong Nakhon Neuang Khet (Part 1)	8.630	2,433.7560				486.736	294.7369			97
WG7	C2.6	Khlong Phra-Ong Chaiyanuchit (Part 1)	4.547	1,019.5350				203.9051	101.9526			115
WG7	C1.5	Khlong Phra-Ong Chaiyanuchit (Part 2)		5,673.8070				1,134.7614	2,269.523			672
WG7	C3.7	Khlong Udom Cholaom	14.980	3,258.2798				653.233	1,297.4199	1,879.2279		133
WG7	C2.7	Khlong Luang Phaeng	15.870	3,500.0000				710	1100	1100		309
WG7	C2.8	Khlong Chuat Phrao - Lao Mao - Bang Phi Noi	16.580	4,265.3600				853.072	1,706.144	1,706.144		159
WG7	S2.8	Khlong Chuat Phrao Check Regulator		120.0000				24.013	95.987			-
Fiscal Year 2029												
WG5	C3.3	Khlong 16 (Part 1)	14.800	3,248.1294						1,299.2518	1,299.2518	72
WG6	C3.4	Khlong 16 (Part 2) [Contract 1]		1,555.4250						620	620	54
WG6	C3.4	Khlong 16 (Part 2) [Contract 2]	14.430	1,597.4750						638.99	638.99	-
WG6	C3.5	Khlong 17 [Contract 1]		1,617.8250						647.13	647.13	164
WG6	C3.5	Khlong 17 [Contract 2]	14.720	1,617.8250						647.13	647.13	-
WG6	S3.7	Khlong 17 Head Regulator (Lower Zone)		203.0081						203.0081		-
WG7	C3.6	Khlong Nakhon Neuang Khet (Part 2) [Contract 1]	9.535	4,101.5070						1,640.603	1,640.603	49
WG7	C3.6	Khlong Nakhon Neuang Khet (Part 2) [Contract 2]	9.535	4,070.0000						1628	1628	48
WG7	C3.8	Khlong Prawet Buri Rom	23.320	5,181.1530						2,072.461	2,072.461	137
WG7	C1.6	Khlong Phra-Ong Chaiyanuchit (Part 3)	14.031	5,447.4559						2,178.982	2,178.9827	420
Digital Technology + Capacity Building												
		Digital Technology + Capacity Building		1,300.0000			260	260	260	260	260	
Total				95,000.0000								4,940

Source: TRTA, 2025

IV. DESCRIPTION OF THE ENVIRONMENT

62. **Delineating Project Area of Influence.** This section of the IEE provides information regarding the existing conditions within the location of project activities and the surrounding area. The Area of Influence, which is the area that is predicted to be affected by the project depends on the project activity and the type of emission or disturbance likely to be caused by that activity. Table 12 provides an overview of the areas of influence associated with the main project activities during the construction phase and their respective risks or impacts. Table 13 provides the same for the operation phase.

Table 12: Area of Influence During Construction Period

Project Activity	Risk or Impact	Area of Influence	Potential Receptors
Clearing of vegetation along canal banks	Loss of street trees Loss of habitats Increased erosion	Clearance zone Canal 500 m downstream	Wildlife Water users downstream (aquaculture, water supply)
Clearing of vegetation for temporary and permanent sediment disposal sites	Conversion of productive land use Loss of habitats Increased erosion	Clearance zone Any water bodies in a 100 m radius	Land users/owners Wildlife Water users
Excavation, dredging, loading/unloading, hauling of materials, operation of pumps and generators Operation of batching plants, workshops and other fabrication facilities	Noise emission Dust emissions Engine exhaust emissions Discharge of polluted wastewater	250 m radius of construction works 25 m from roadside	Local residents, businesses, institutions etc. near the construction sites and along haul roads Workers Recipient of wastewater
Dredging	Mobilization of pollutants in dredged material Removal of habitat for benthic animals	Dredging site Canal 500 m downstream	Water users (aquaculture, water supply) Aquatic life
Pile driving	Vibrations Impulsive noise	100 m radius	Local residents, businesses, institutions etc. Workers Houses Fragile structures
Excavation, loading, transport of sediments	Release of sediments into the canals causing increased turbidity and reduced light penetration in the canal water column	Canal 500 m downstream release point	Water users downstream (aquaculture, water supply) Aquatic life downstream
Temporary disposal of sediments	Release of sediment laden runoff into the canals causing increased turbidity and reduced light penetration in the canal water column Mobilization of pollutants in the sediment and transport with runoff in the canals	Canal 500 m downstream release point	Water users downstream (aquaculture, water supply) Aquatic life downstream

Project Activity	Risk or Impact	Area of Influence	Potential Receptors
Temporary sediment disposal site	Unsafe due to risk of being stuck in wet mud	The temporary disposal sites	Workers By passers (children)
Operating heavy equipment incl. dredgers	Injuries from struck by plant Drowning from fall into water (dredging)	Construction site	Workers
Construction of retaining walls	Injuries from slips and falls Drowning from fall into water	Construction site	Workers By passers
Construction of regulators	Injuries from slips and falls Drowning from fall into water Injuries from working in confined spaces	Construction site	Workers

Source: TRTA, 2025

Table 13: Area of Influence During Operation Period

Project Activity	Risk or Impact	Area of Influence	Potential Receptors
Clearing of vegetation for temporary and permanent sediment disposal sites	Conversion of productive land use Loss of habitats Increased erosion	Clearance zone Any water bodies in a 100 m radius	Land users/owners Wildlife Water users
Permanent disposal of sediments	Elevated content of pollutants released to the soil and taken up by crops Pollutants in sediments seeping into groundwater	Agricultural fields used for disposal Agricultural fields receiving runoff from the disposal site Local groundwater resources	Farmers Consumers of crops Groundwater users
Maintenance dredging	Release of sediments into the canals causing increased turbidity and reduced light penetration in the canal water column Mobilization of pollutants in dredged material	Canal 500 m downstream release point	Water users downstream (aquaculture, water supply) Aquatic life downstream
Maintenance dredging	Removal of benthic habitats	Dredging site	Aquatic life that depends on benthic animals
Temporary sediment disposal site	Unsafe due to risk of being stuck in wet mud	The temporary disposal sites	Workers By passers (children)
Operation of regulators	Changes in sediment loading and water quality	Canal 500 m downstream release point	Aquatic life in the canals
Operation of pumping stations/regulators discharging into the Inner Gulf of Thailand	Reduced salinity concentrations in the coastal waters affecting shellfish production	Approx. 2 km from the canal mouth into the sea at the point of discharge	Shellfish Shellfish farmers
Operation and maintenance of regulators	Injuries from struck by plant when cleaning/removing debris	Regulator sites	Operation and maintenance workers

Project Activity	Risk or Impact	Area of Influence	Potential Receptors
	Drowning from fall into water		
Operation and maintenance of dredgers	Injuries from struck by plant Drowning from fall into water	Dredging sites	Dredging operation workers

Source: TRTA, 2025

A. Overview of Project Area and Context

63. The LECP basin within the project area lies mainly between the Chao Phraya River on its western edge and the Bang Pakong River and its tributaries to the east. Much of the land is low lying at only a few meters above mean sea level. Higher ground is present to the north east of the overall project area.

64. Land use is characterized by intensive agriculture, mainly in the form of crop production with large area of rice growing paddy fields.

65. Within the western side of the basin lies the Thailand capital city of Bangkok with an estimated population, within its wider urban area, of nearly 11.4 million in 2025 (World Population Review, 2025).

66. The landscape and associated habitats are predominantly modified, with the agricultural production units and many manmade structures present. The pattern of drainage and irrigation canals, and interlinking road access is highly rectilinear. A dominant feature is the pattern of canals and irrigation channels and between these the field patterns which are often long narrow plots.

67. Outside of the main urban area of Bangkok, settlement patterns tend to follow this rectilinear pattern, with groups of houses along canals, irrigation channels or linking roads.

68. There is limited natural vegetation present within the landscape, the riparian vegetation and associated fauna is most likely to be natural and native.

69. The southern edge of the basin is formed by the Gulf of Thailand. The marine environment along the northern coastline has some formal designation for biodiversity but is a somewhat disturbed habitat due to its proximity to the urban areas of Bangkok. The irrigation system pumps water into the Gulf of Thailand under certain conditions during the rainy season but at rates and volumes which are considered insignificant compared to the natural discharge from the rivers along the northern coastline, including, within the project area the Chao Phraya and Bang Pakong Rivers.

70. Near to the coast and offshore there are commercial fish farms, including production of green-lipped mussels within the marine environment.

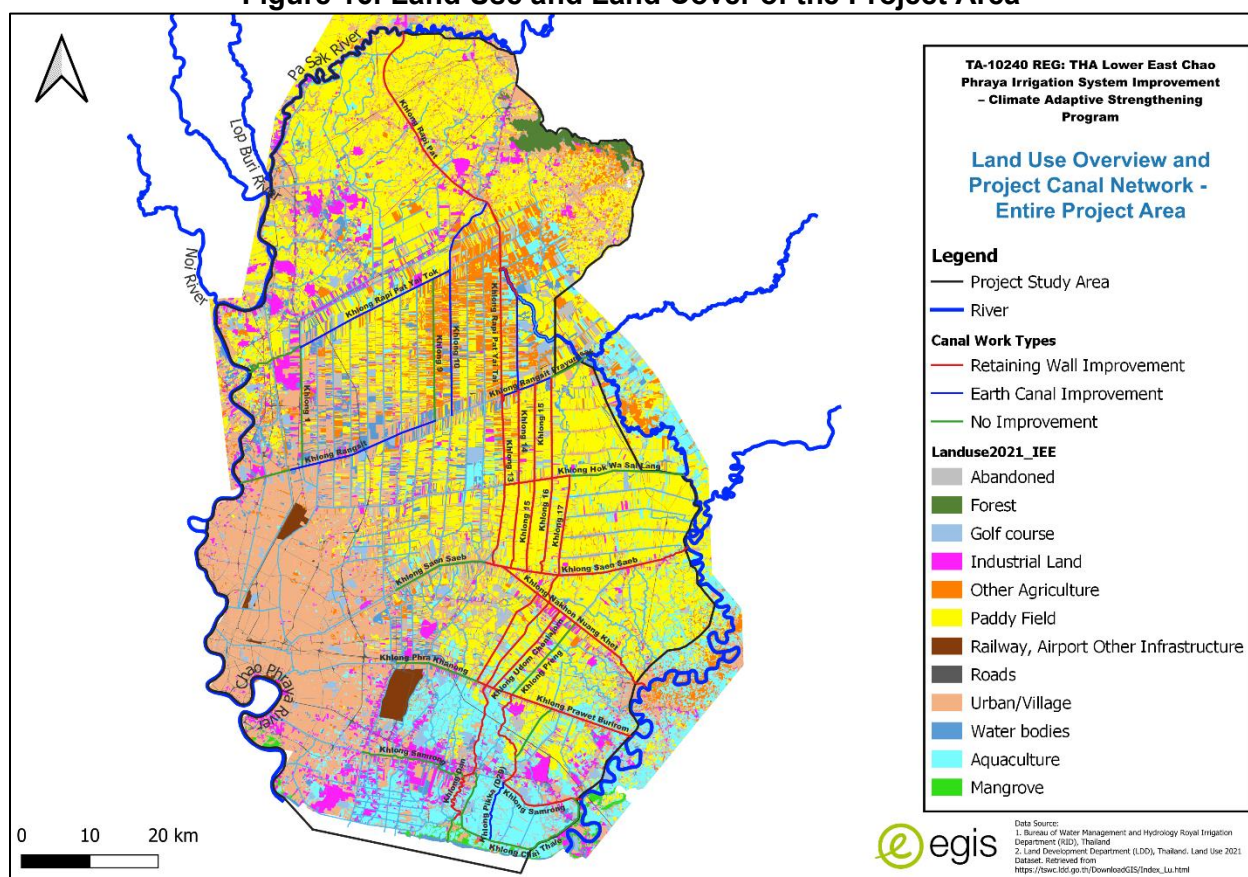
B. Land Use and Land Cover

1. Overall Spatial Features

71. The land use and land cover of the Project Area are displayed in Figure 16. The map shows that the upper (northern) and central parts of the Project Area are dominated by paddy fields with clusters of industries and densely populated areas in the outskirts of Bangkok. The upper-central area is dominated by other agricultural land use, mainly fruit plantations and cash crops with some aquaculture activities in between. The lower (southern) area bordering the Inner Gulf of Thailand mainly consists of aquaculture, paddy fields and densely populated built-up areas with clusters of industries.

72.

Figure 16: Land Use and Land Cover of the Project Area

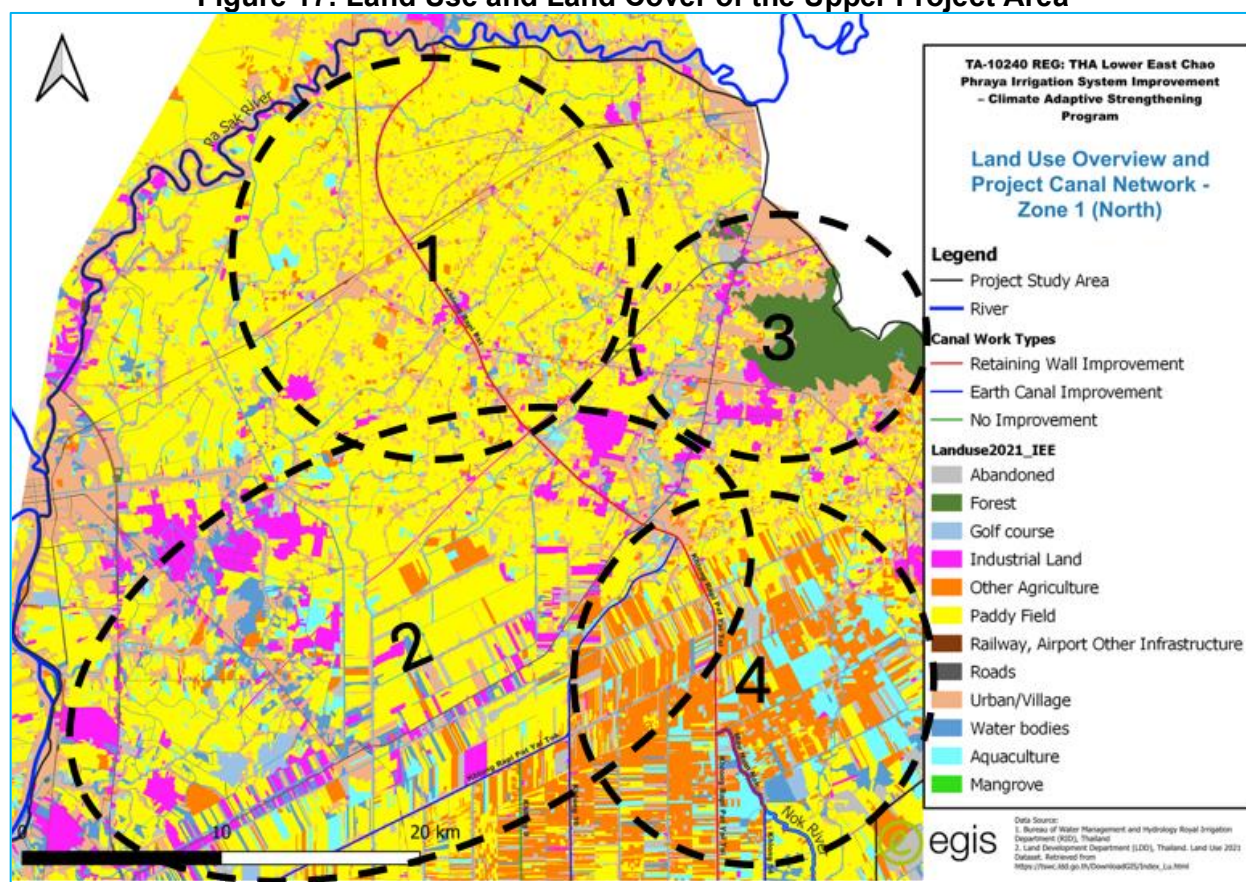


Source: Royal Irrigation Department (RID) and Land Development Department (LDD), 2021

2. Upper Project Area

73. The spatial features of the upper project area are indicated in Figure 17. The project canals in sub-area 1 are mainly surrounded by paddy fields with a cluster of industries in the lower part. Sub-area 2 is dominated by industries and built-up areas along roads and with paddy in between. However, the project canal is mainly surrounded by paddy fields with strips of densely populated residential areas and some industries. Sub-area 3 consists of a forested hilly area to the east surrounded by densely populated built-up areas with industries. There are no project canals running through this sub-area. Sub-area 4 is dominated by other agricultural lands with some aquaculture activities in between.

Figure 17: Land Use and Land Cover of the Upper Project Area

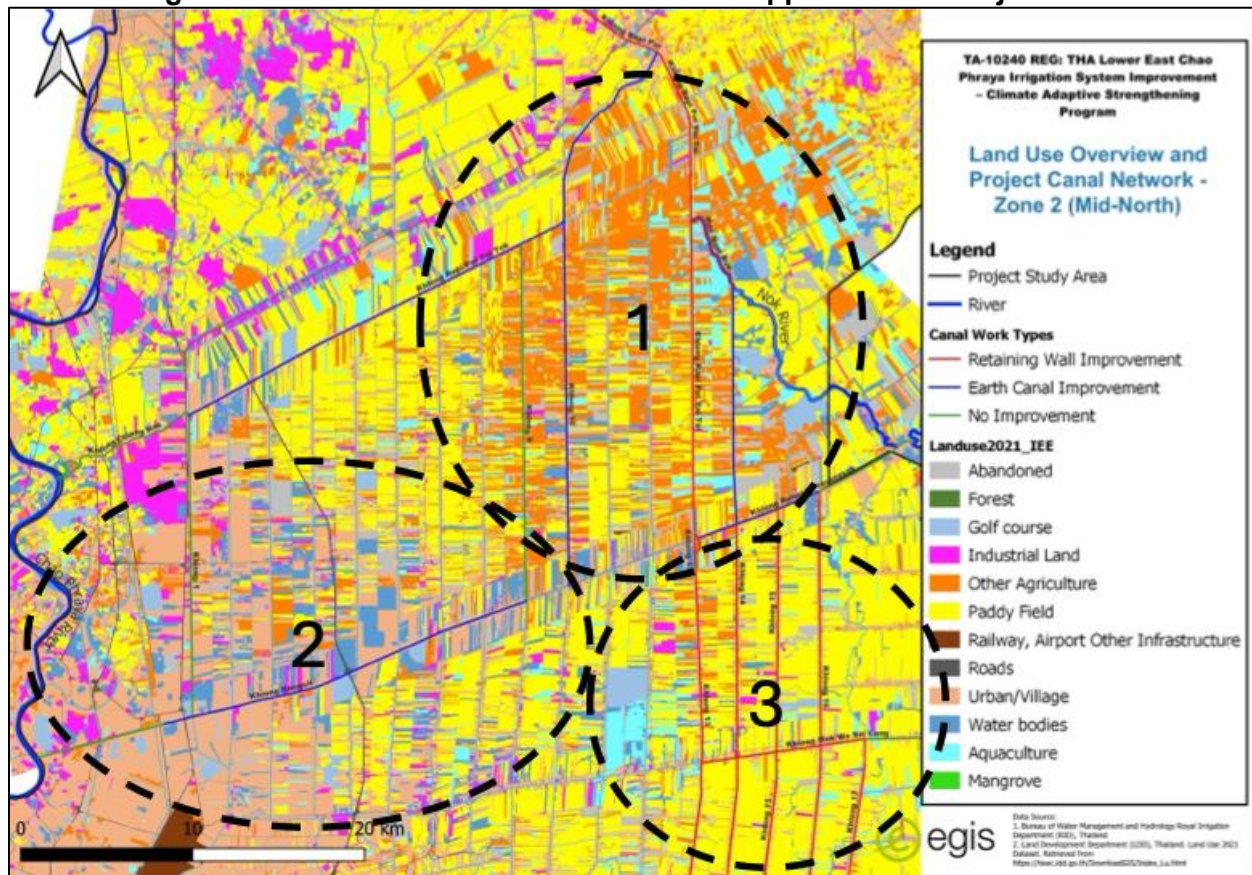


Source: Royal Irrigation Department (RID); Land Development Department (LDD), 2021

3. Upper-Central Project Area

74. The spatial features of the upper-central project area are indicated in Figure 18. Sub-area 1 (overlaps with sub-area 4 of the upper project area) is dominated by other agricultural land with some aquaculture activities in between and single houses along the canals. The project canals in sub-area 2 are surrounded by densely populated built-up areas with some industries. The project canals in sub-area 3 are mainly surrounded by paddy fields, aquaculture areas to the southwest and some industries along the canals in between single houses.

Figure 18: Land Use and Land Cover of the Upper-Central Project Area

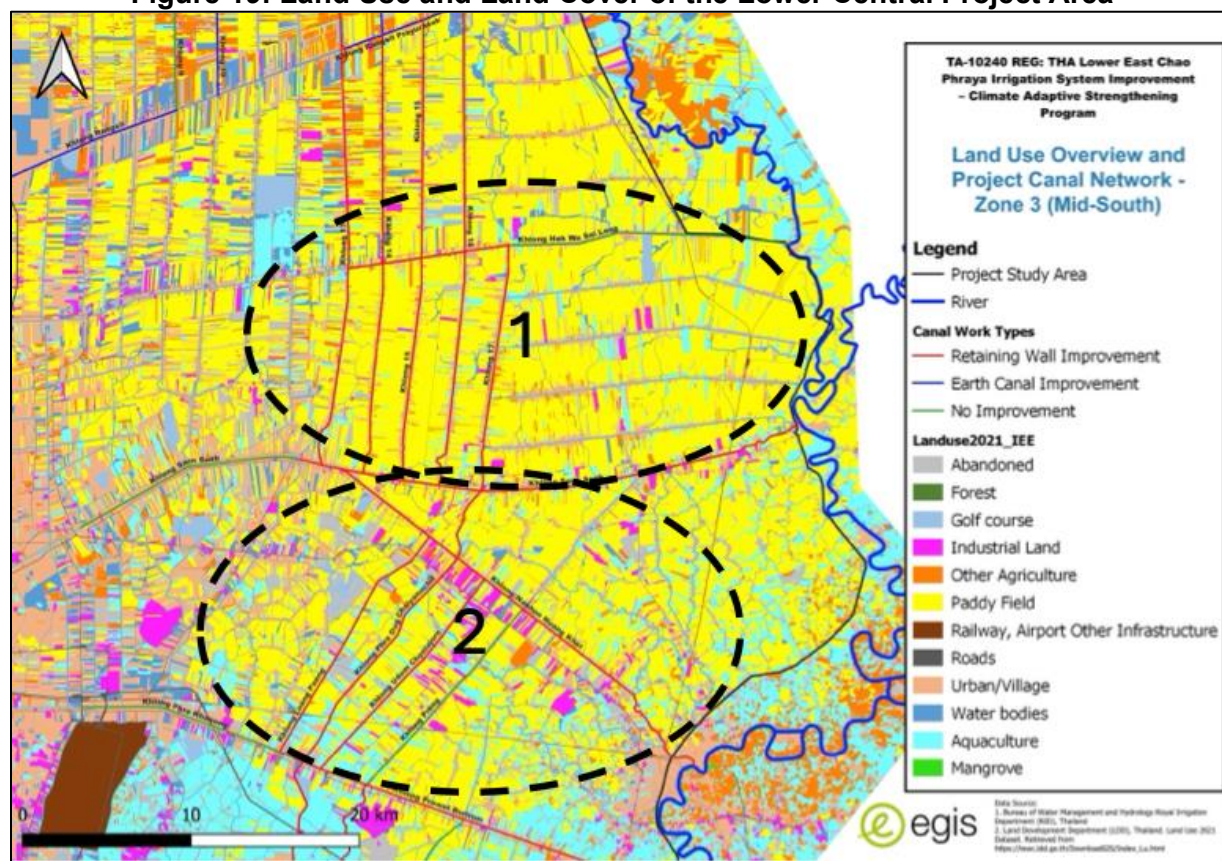


Source: Royal Irrigation Department (RID); Land Development Department (LDD), 2021

4. Lower Central Project Area

75. The spatial features of the lower central project area are indicated in Figure 19. Sub-area 1 is dominated by other paddy fields with single houses along the canals. The project canals in sub-area 2 are surrounded by industries with paddy fields in between and densely populated built-up areas at the western and eastern parts.

Figure 19: Land Use and Land Cover of the Lower Central Project Area



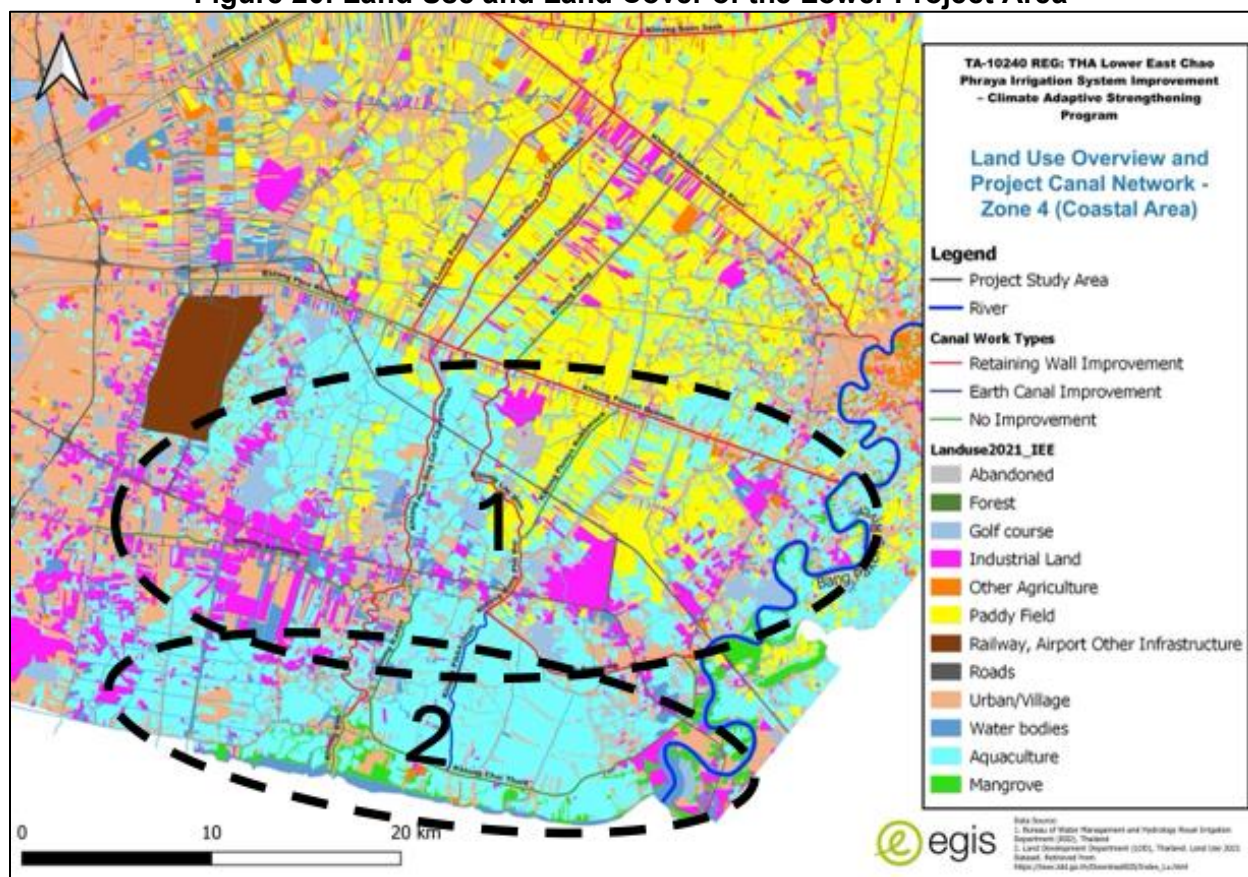
Source: Royal Irrigation Department (RID); Land Development Department (LDD), 2021

5. Lower Project Area

76. The spatial features of the lower project area are indicated Figure 20. There are large clusters of industries and densely populated built-up areas in sub-area 1 with aquaculture in the northwestern part of the sub-area and paddy fields in the central part. Sub-area 2 is dominated by aquaculture projects with built-up areas along the canals and main roads going west-east.

77. Images of the work areas along the canals is provided as Appendix 1 along with statistics of land use within the project area in Appendix 2.

Figure 20: Land Use and Land Cover of the Lower Project Area



Source: Royal Irrigation Department (RID); Land Development Department (LDD), 2021

C. Topography and Geology

1. Topography

78. The project area is located in the eastern part of the Chao Phraya flood plain. The topography of the area is displayed in Figure 21.

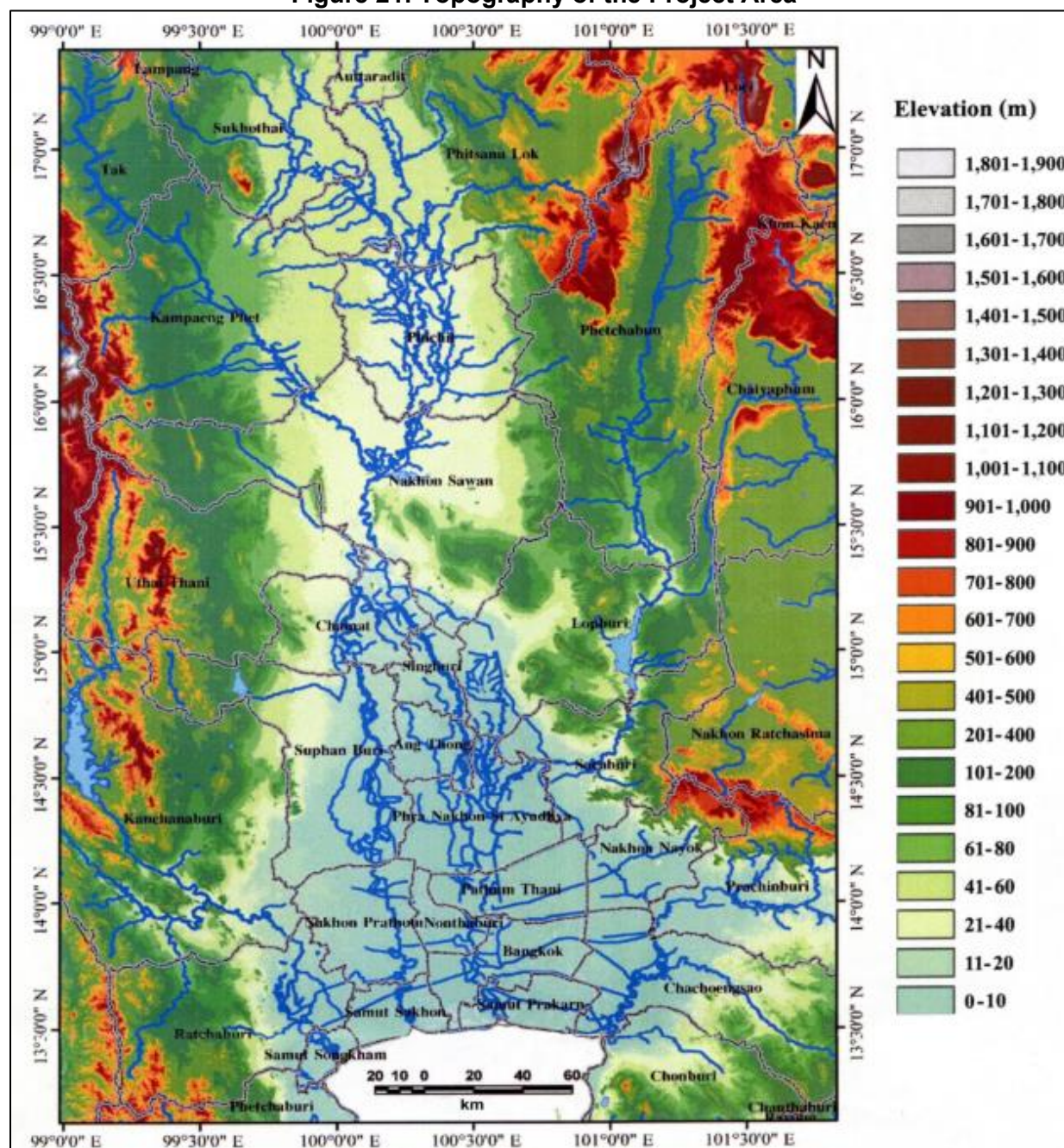
79. The average ground levels of the areas from Rangsit Canal to Hok Wa Sai Lang Canal are +2.00 m asl, and the areas from Hok Wa Sai Lang Canal to Saen Saep Canal and Nakhon Nueng Khet Canal were +1.50 masl.

80. The average ground levels of the areas from Saen Saep Canal to Prawet Burirom Canal are +1.00 m asl. Such average ground levels also cover the areas eastwardly to the right bank of the Bang Pakong River which was in the boundary of Phra ong Chaianuchit Operation and Maintenance Project.

81. Project areas with the lowest ground levels were those from Prawet Burirom Canal to Samrong Canal and from the royal flood protection dikes to Phra Ong Chaianuchit Canal, which were at average of +0.50 m asl to +0.40 masl.

82. The average ground levels in coastal areas of the Gulf of Thailand from Samrong Canal to Chai Thale Canal were slightly increased to about +0.50 m asl up to +0.90 masl.

Figure 21: Topography of the Project Area



Source: Dept. of Groundwater Resources, Ministry of Natural Resources and Environment, quoted in (Fornés & Pirarai, 2014)

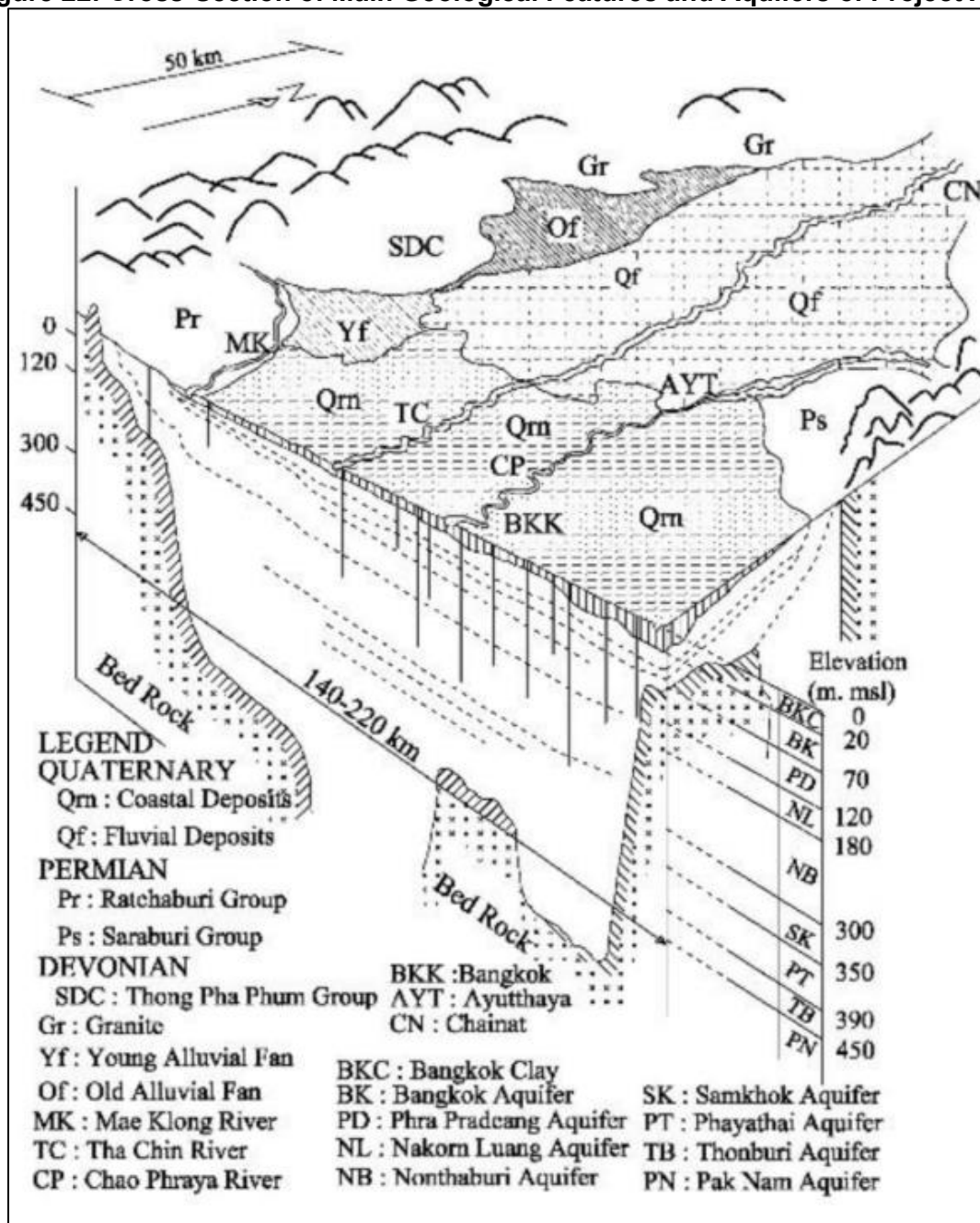
2. Geology

83. Based on the 2001 Geological Map of Thailand published by the Department of Mineral Resources, the hard-rock geology along the eastern and western margins of the lower central plain basin is shown to be the principal source of sediments carried by rivers into the basin. The quaternary geology consists of unconsolidated to semi-consolidated deposits, gravel, sand, silt,

and clay, formed through natural processes of weathering, transport, and deposition within the basin.

84. Figure 22 provides a schematic cross-section of solid geology and aquifers for the area.

Figure 22: Cross-Section of Main Geological Features and Aquifers of Project Area



Source: (Tanachaichoksirikun & Seeboonruang, 2020)

85. **Hard Rock Geology.** Only one rock unit is found within the project study area, located along the upper eastern edge of the area. This unit is from the Permian-Triassic (PTRv) era, and it comprises rhyolite, andesite, flow tuff, volcanic breccia, rhyolitic tuff, and andesitic tuff, found particularly in Wihan Daeng District, Saraburi Province.

86. **Quaternary Geology.** The quaternary geology consists of gravel, sand, silt, and clay, which were transported and deposited by watercourses in the river floodplains of the Lower Chao Phraya Basin. These sediments date from approximately 1.6 million years ago to the present and are classified into two subgroups as set out in the following sections.

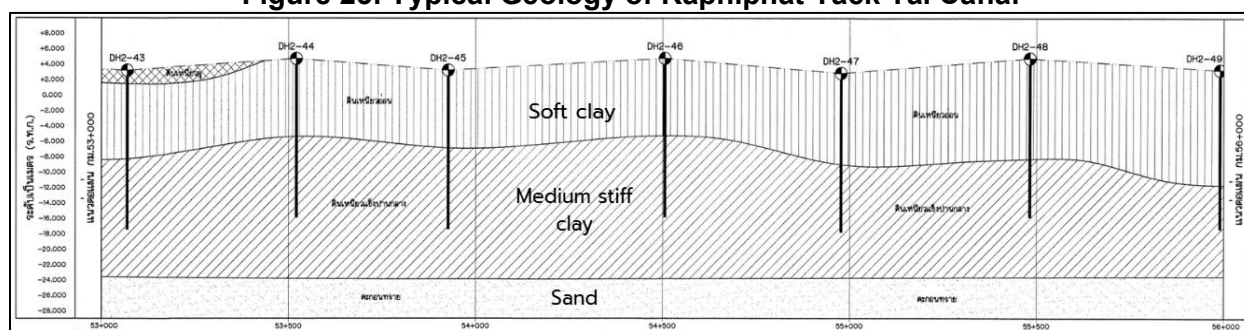
87. Coastal-marine tidal deposits (Qmc) which formed under the influence of tides, comprising clay, silt, and fine sand found in lowland areas influenced by tidal flows, swampy zones, waterlogged areas, mangroves, and estuaries.

88. Alluvial deposits (Qa) are sediment accumulations along river channels, levees, and flood basins, consisting of gravel, sand, silt, and mud, carried by streams. These sediments are generally unconsolidated and vary in thickness depending on hydrological conditions and geomorphology. Swamp deposits are also present. In the study area, such deposits are widespread along the Chao Phraya River, from Phra Nakhon Si Ayutthaya Province to Samut Prakan Province.

3. Site Investigations

89. Site investigations have comprised drillholes at about 0.5 km spacing to depths of 22 m to about 26 m. All of the drill holes within the canal sections generally encountered 2-4 m of fill or soft sediments followed by soft clays down to about 14 m before firm clays and sands were encountered to the end of the drillholes.

Figure 23: Typical Geology of Raphiphat Yaek Tai Canal



Source: Design drawing of 02-Raphiphat Yaek Tai Canal (02-คลองระพีพัฒน์แยกใต้), page 9

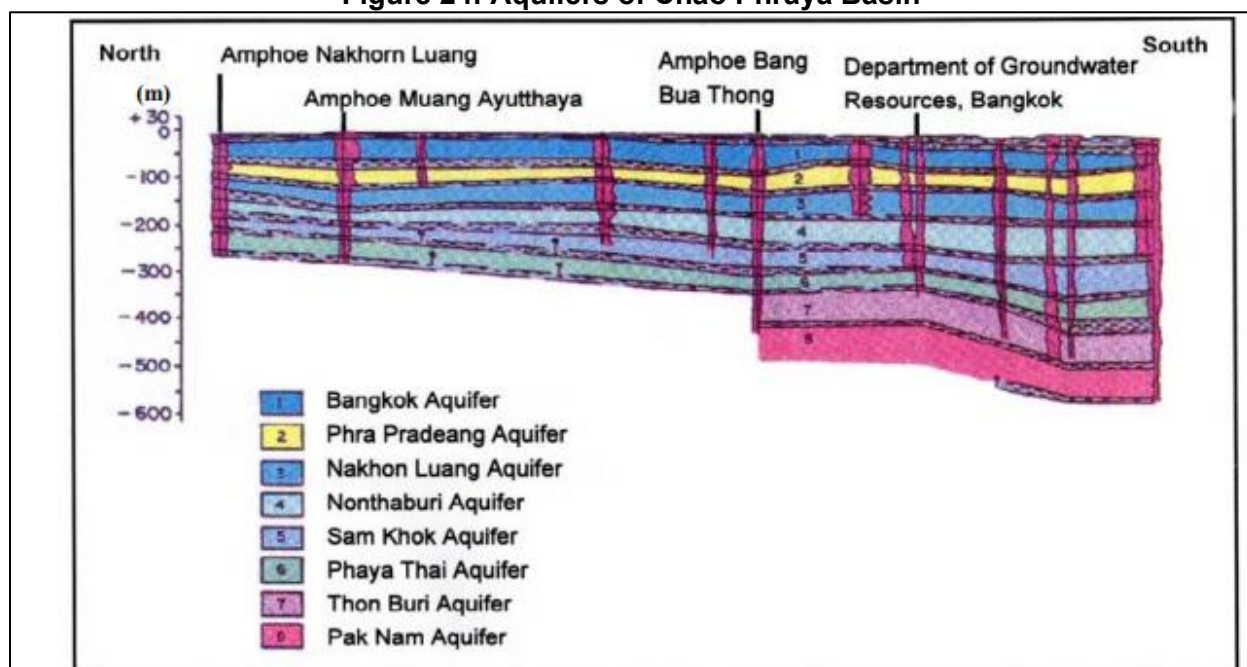
D. Hydrology and Hydrogeology

90. The groundwater aquifers in the Chao Phraya River Basin are found in alternating layers of gravel-sand deposits, with each layer separated by dense clay layers. This creates multiple confined aquifer systems stacked beneath the ground. In some areas, the uppermost shallow groundwater aquifer may not be capped by clay (such as at basin edges where clay layers thin out or are absent), resulting in unconfined aquifers where surface water can directly infiltrate and recharge. However, in most areas of this central plain, the major aquifers are overlain by Bangkok

clay, creating an artesian groundwater system where water under pressure rises higher than the actual groundwater table level when wells are drilled due to confinement.

91. The hydrogeological setting of the project area lies within the Lower Chao Phraya River Basin, covering the eastern side of the Chao Phraya River down to the Gulf of Thailand, including the provinces of Saraburi, Phra Nakhon Si Ayutthaya, Nakhon Nayok, Pathum Thani, Nonthaburi, Bangkok, Samut Prakan, and Chachoengsao. The eight primary aquifers within the Chao Phraya Basin are shown in Figure 24.

Figure 24: Aquifers of Chao Phraya Basin



Source: Dept. of Groundwater Resources, Ministry of Natural Resources and Environment, quoted in (Fornés & Pirarai, 2014)

92. The hydrogeological characteristics are largely defined by the presence of alluvial aquifers, old terrace aquifers, and volcanic rock aquifers. Based on studies of groundwater well data from both government and private sectors, including in Bangkok and surrounding areas, the eight main groundwater aquifers shown in Figure 24 are at the following depths.

- (i) Bangkok Aquifer – The uppermost shallow aquifer at approximately 50 meters depth from surface;
- (ii) Phra Pradaeng Aquifer – at approximately 100 m depth;
- (iii) Nakhon Luang Aquifer – at approximately 150 m depth;
- (iv) Nonthaburi Aquifer – at approximately 200 m depth;
- (v) Sam Khok Aquifer – at approximately 300 m depth;
- (vi) Phraya Thai Aquifer – at approximately 350 m depth;
- (vii) Thonburi Aquifer – at approximately 450 m depth; and
- (viii) Pak Nam Aquifer – at approximately 550 m depth.

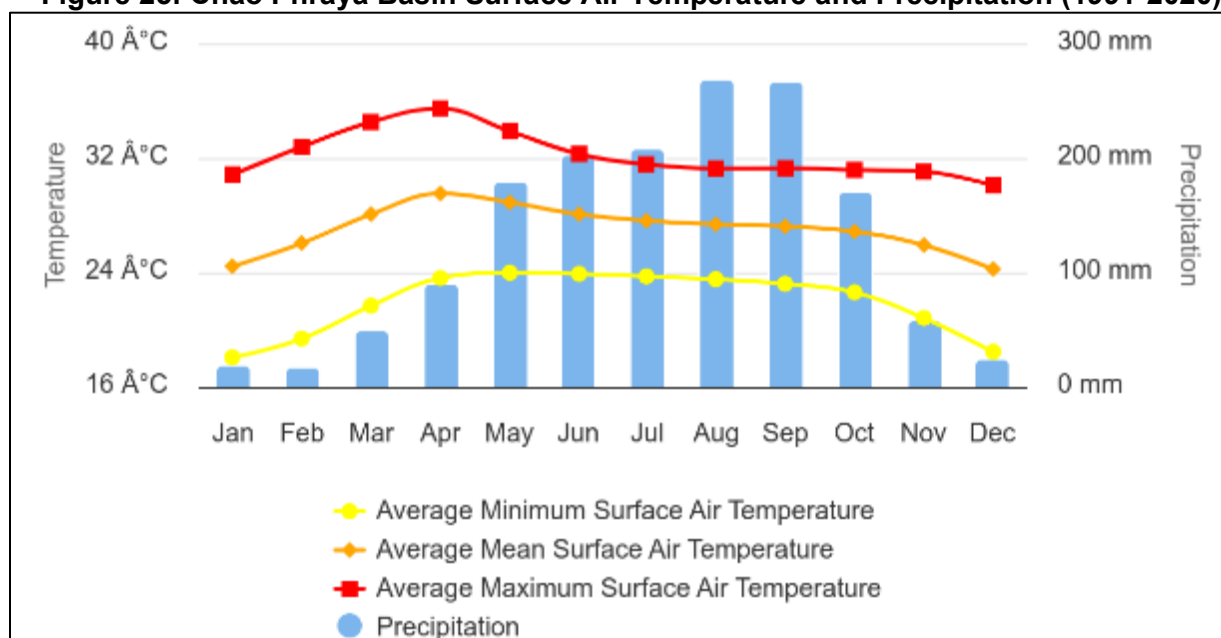
E. Meteorology and Climate

1. Climatology

93. According to Köppen-Geiger climate classification system, the Chao Phraya River Basin, located in central Thailand, falls primarily under the Tropical Monsoon Climate (Am). The climate in the basin is governed by southwest monsoon from the Indian ocean which brings majority of the annual rainfall during the period of May to October (Rainy season). Similarly, November to February is influenced by the Northeast monsoon, which is brings cooler and drier air from the Asian continent (winter season). Summer season extends from March to May. The basin also experiences migratory meteorological phenomena, particularly depressions and typhoons originating from the southeast.

94. Figure 25 presents the monthly climatology in terms of maximum, minimum, and average surface air temperature and precipitation for the Chao Phraya River Basin during 1991-2020. The average maximum temperature in the basin is between 30.1 to 35.5°C while the average minimum temperature is between 18.5 to 23.6°C. July and August are the wettest months with average rainfall of just above 260 mm.

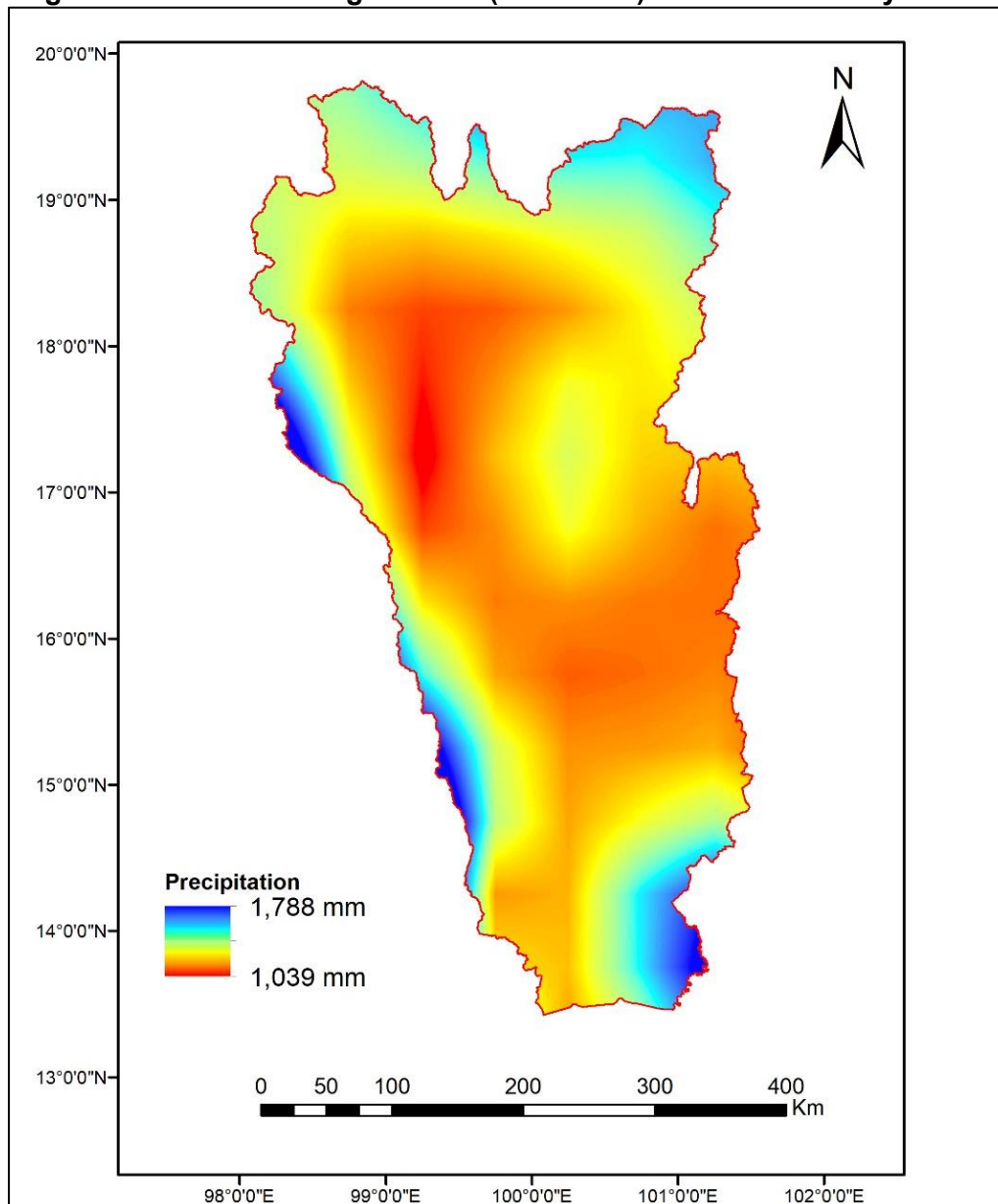
Figure 25: Chao Phraya Basin Surface Air Temperature and Precipitation (1991-2020)



Source: Climate Change Knowledge Portal of the World Bank Group

95. The Climate Research Unit (CRU) dataset shows that the annual rainfall in the basin varies spatially between 1,000 to 1,800 mm in the basin (Figure 26). This variation in precipitation is attributed to the diverse topographic conditions and seasonal variations specific to each area within the basin.

Figure 26: Annual average rainfall (1991-2020) in the Chao Phraya Basin



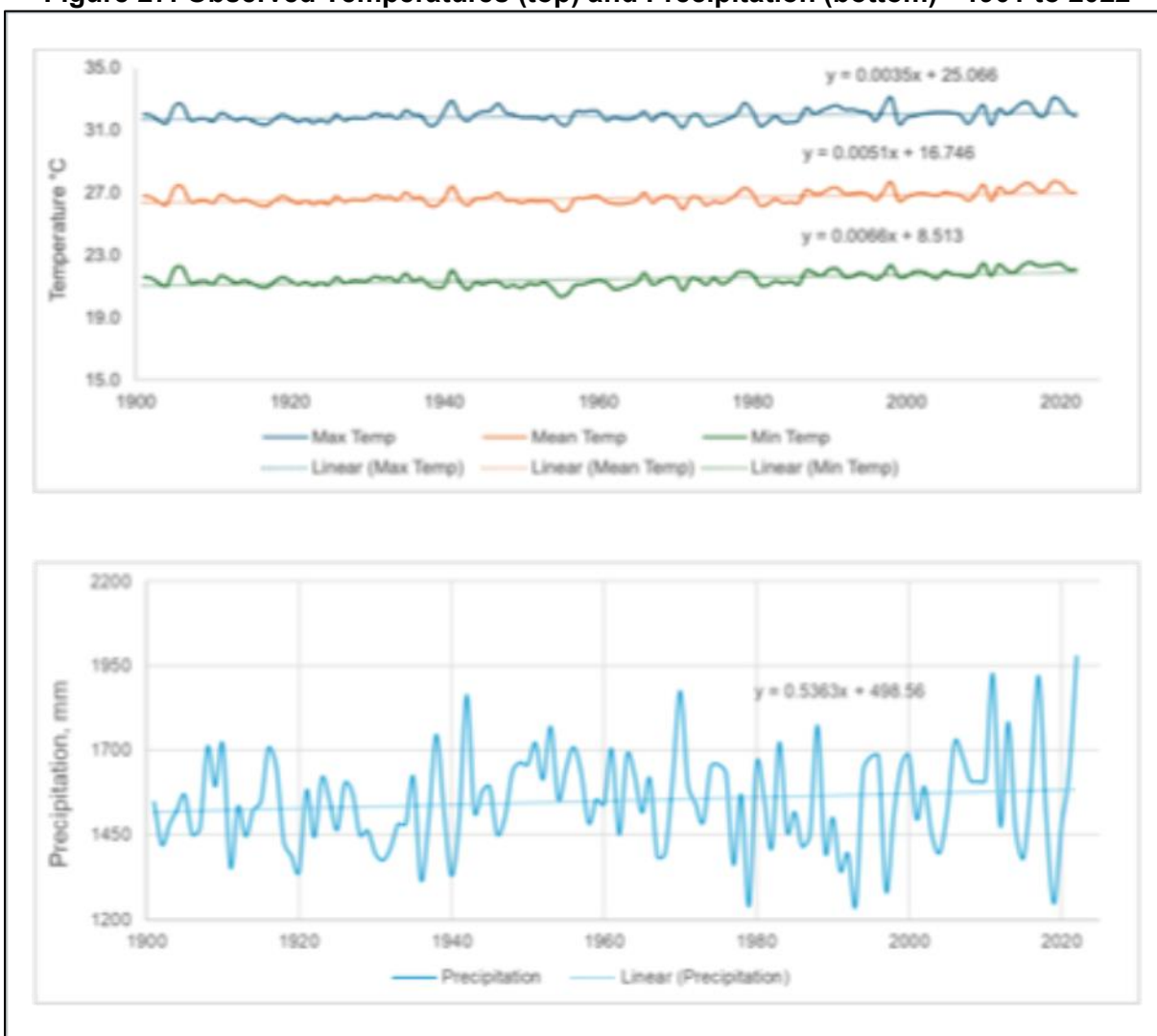
Source: TRTA 2025, Assessing climate risks and challenges related to water resources in the Chao Phraya River Basin, Thailand, CRU dataset resampled using bilinear method

96. **Climate Trends and Variability.** Climate trends described in this section are based on the 100 years of CRU data for the Chao Phraya River (CPR) basin, which are accessed from the Climate Change Knowledge portal of the WB. Figure 27 presents the comparison of 30-year climatology from 1901 to 2020 for temperature and precipitation. The minimum temperature has a stronger trend (0.066°C/decade) compared to the maximum temperature (0.035°C/decade) in the CPR Basin.

97. Figure 27 shows the observed trends in the annual precipitation in the basin. While the precipitation has remained relatively consistent over the long-term, there has been a slight decrease in precipitation in more recent decades.

98. Normally, May is the beginning of the rainy season in the basin and the decreasing rainfall trend during this month may indicate late onset of the rainy season. Similarly, rainfall during the rainy season (June – Oct) has either an increasing or no significant trend in most of the decades.

Figure 27: Observed Temperatures (top) and Precipitation (bottom) - 1901 to 2022



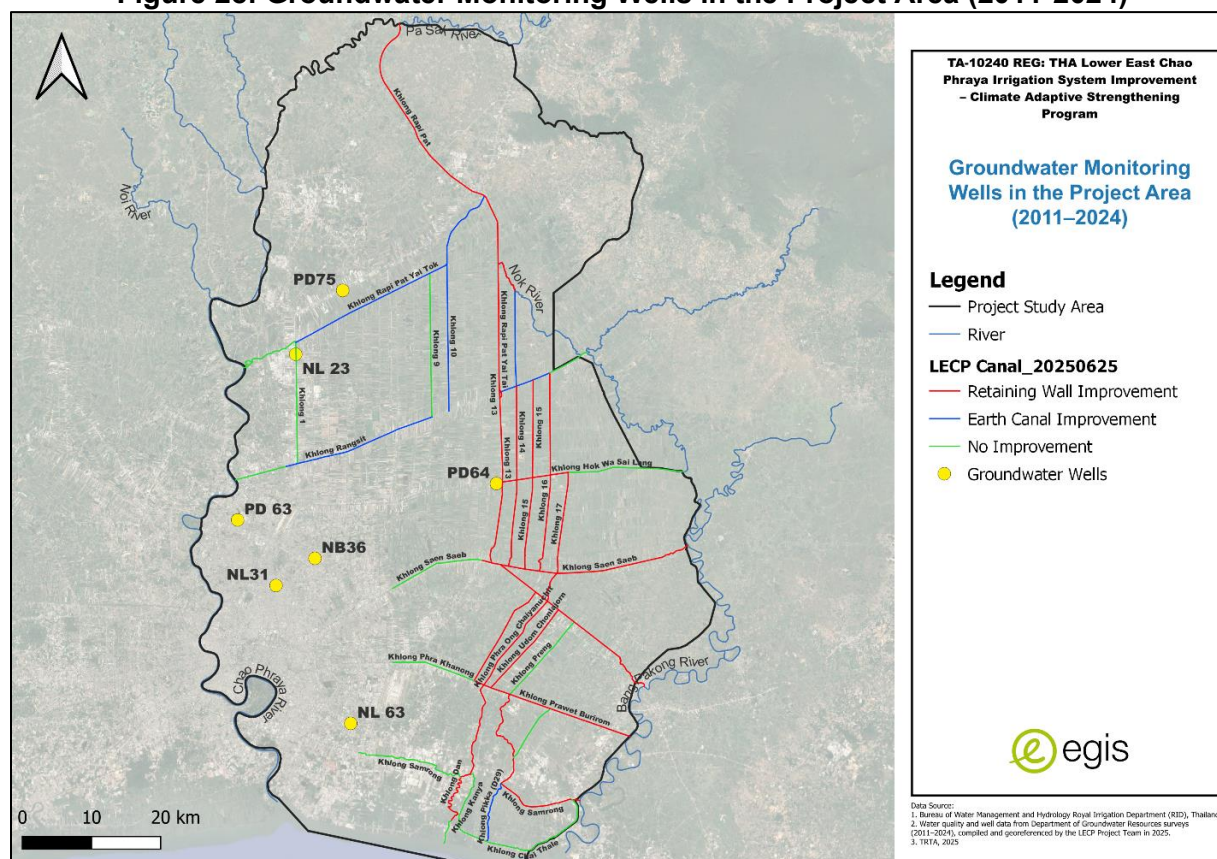
Source: TRTA 2025, Assessing climate risks and challenges related to water resources in the Chao Phraya River Basin, Thailand. Climate Change Knowledge Portal of the World Bank Group

F. Ground Water Quality

1. Monitoring Locations

99. The Department of Groundwater Resources conducted water sample and analysis from seven groundwater wells in Bangkok, Nonthaburi, Ayutthaya, Pathum Thani and Samutprakarn provinces. Water sampling and analysis were in 2011, 2022, 2023 and 2024. Well depth varies between 106 m – 232.9 m. Well locations are shown in Figure 28 and description of wells is provided in Table 14.

Figure 28: Groundwater Monitoring Wells in the Project Area (2011-2024)



Source: Department of Groundwater Resources (2011, 2022, 2023, 2024) Survey Data compiled by Project Team, 2025

Table 14: Groundwater Monitoring Wells - Location and Characteristic

Well No.	Location	Sub-District	District	Province	Year	Well Depth (m)	Aquifer
NL31	SiriKomalawat School	Latprao	Latprao	Bangkok	2024	169	Nakhon Luang Aquifer
NB36	Siripongthamanimit Temple	Tha Raeng	Bang khen	Bangkok	2023	232.9	Nonthaburi Aquifer
PD63	Phasook maneechak Temple	Bangpood	Pakkred	Nonthaburi	2022	110	Phra Pradaeng Aquifer
PD64	Pheud Udom Temple	Pheud Udom	Lamlook a	Pathum Thani	2011	106	Phra Pradaeng Aquifer
NL23	Khunying Somchine Temple	Klong Neung	Klong luang	Pathum Thani	2024	156	Nakhon Luang Aquifer

Well No.	Location	Sub-District	District	Province	Year	Well Depth (m)	Aquifer
PD75	Latsai Temple	Lam Sai	Wang noi	Ayutthaya	2011	119	Phra Pradaeng Aquifer
NL63	Bangplee Telephone Office	Bang Plee Yai	Bangplee	Samutprakarn	2024	140	Nakhon Luang Aquifer

2. Monitoring Results

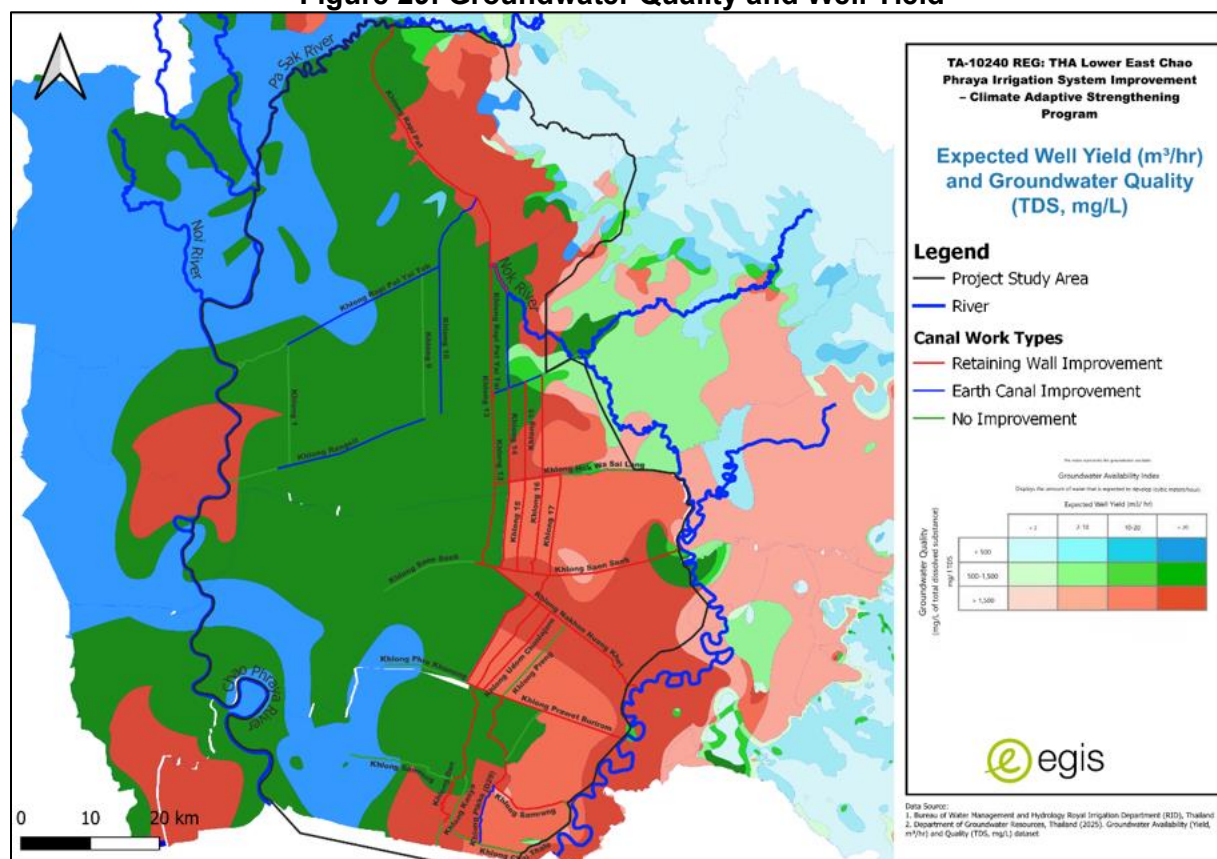
100. The results of the groundwater analyses are summarized in Table 15. The results are assessed against the standards for ground water

Table 15: Results of Groundwater Quality Monitoring

Parameters	Units	Standards *	NL31	NB36	PD 63	PD64	NL 23	PD75	NL 63
pH	unit	-	-	4.3	6.6	8.6	-	7.6	-
Electrical Conductivity	µS/cm	-	-	2,620	4,240	2,200	-	1,900	-
Calcium	mg/l	-	150	88	260	47	28	66	36
Magnesium	mg/l	-	140	120	130	26	9.6	51	9
Sodium	mg/l	-	850	240	370	420	150	280	180
Potassium	mg/l	-	9.7	4	13	3.5	1.8	5.7	2.4
Iron	mg/l	-	46	130	15	2.4	0.1	10	0.3
Manganese	mg/l	0.5	0.2	1.6	2.2	1.1	0.1	1.2	0.3
Sulphate	mg/l	-	1	20	98	320	14	190	9
Chloride	mg/l	-	2,000	890	1,300	270	14	290	130
Fluoride	mg/l	-	0.1	ND	0.1	0.8	0.3	0.4	0.2
Nitrates	mg/l	-	< 0.9	1.9	< 0.9	<0.9	<0.9	3.3	<0.9
Total Dissolved Solids	mg/l	-	3,770	1,700	2,760	1,430	497	1,240	663
Copper	mg/l	1	ND	ND	ND	-	ND	-	ND
Zinc	mg/l	5	12	15	ND	-	2.7	-	3.5
Arsenic	mg/l	0.01	< 0.0028	-	-	-	< 0.0028	-	< 0.0028
Lead	mg/l	0.01	0.0007	-	-	-	0.001	-	0.001
Cadmium	mg/l	0.003	< 0.0004	-	-	-	< 0.0004	-	< 0.0004
Cyanide	µg/l	200	-	-	-	-	-	-	-
Chromium	mg/l	0.05	< 0.0024	-	-	-	< 0.0024	-	<0.0024
Mercury	mg/l	0.001	< 0.0002	-	-	-	< 0.0002	-	< 0.0002
26.Selenium	mg/l	0.01	< 0.0018	-	-	-	< 0.0018	-	< 0.0018
Nickel	mg/l	0.02	< 0.0010	-	-	-	< 0.0010	-	< 0.0010
Silver	mg/l	-	< 0.0022	-	-	-	< 0.0022	-	< 0.0022
Barium	mg/l	-	0.2305	-	-	-	0.0538	-	0.1777

101. As shown in Figure 29, the Lower Chao Phraya Basin, particularly in Samut Prakan Province, exhibits distinctive chloride contamination characteristics. The primary source of contamination stems from saline intrusion from the Gulf of Thailand into aquifers subjected to extensive groundwater extraction. Historically, intensive pumping from Bangkok's multi-layer aquifer system throughout the late 20th century for municipal, industrial, and private purposes—resulted in significant declines in piezometric levels and subsequent land subsidence. These conditions promoted the inland migration of saltwater both directly from the sea and from subsurface pockets of residual saline water (Laonamsai, et al., 2023).

Figure 29: Groundwater Quality and Well Yield



Source: (Laonamsai, et al., 2023) after TRTA Consultant

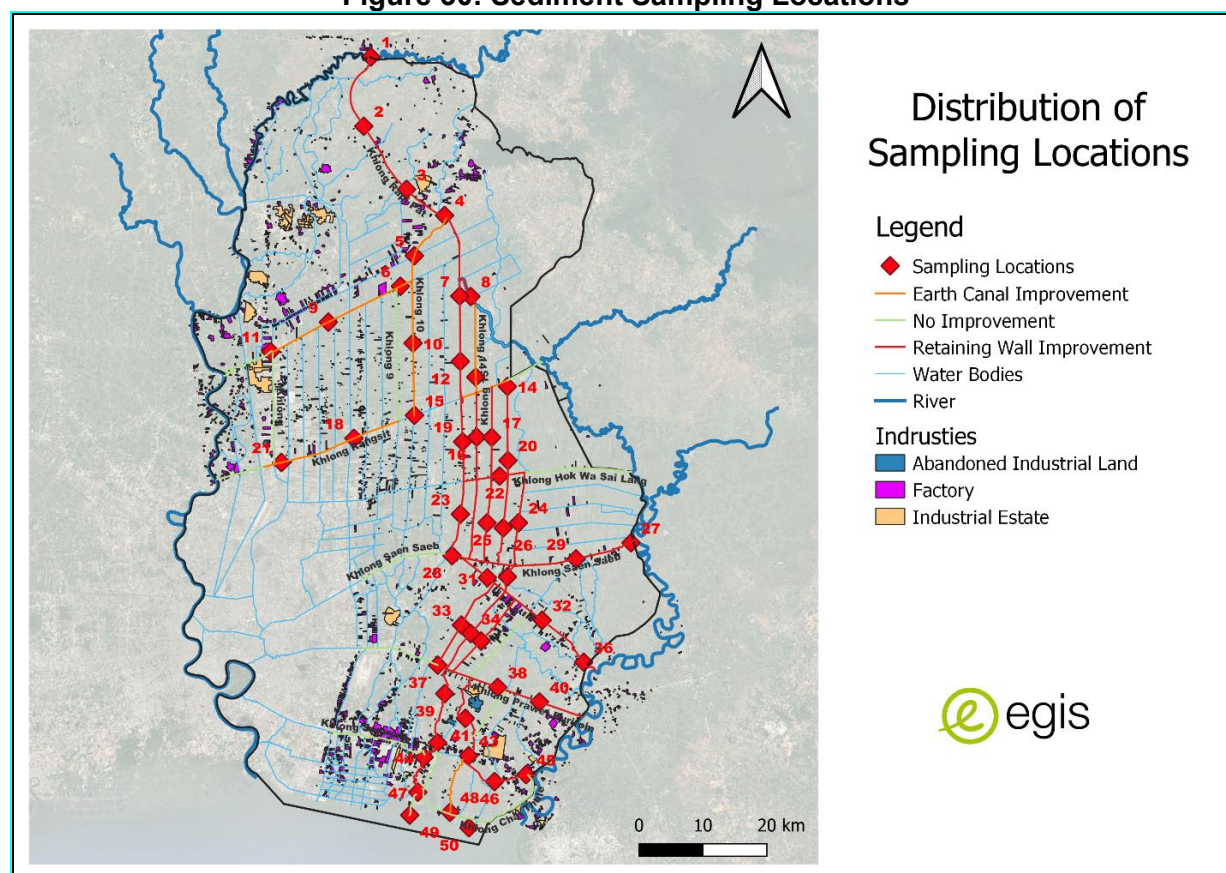
102. An environmental assessment indicated chloride concentrations in Bangkok's groundwater ranging from 2.4 - 4,400 mg/L in 2001, subsequently rising to between 3.4 -9,200 mg/L by 2010. Furthermore, groundwater quality consistently deteriorates during periods of high extraction, as evidenced by elevated chloride levels across various areas. Analysis comparing chloride concentrations between 1993 and 2009 highlights that regions with high chloride contamination in 1993 experienced notable decreases following reduced extraction rates by 2009. Historically intensive groundwater pumping practices are believed to have facilitated the diffusion or leakage of saline water from overlying strata and isolated saline zones into freshwater aquifers (Lorphensri, et al., 2016).

G. Sediment Quality Survey

103. The sediment quality in the project canals has been tested as part of the IEE study through a comprehensive field sampling and analysis program. The objectives of the program are to characterize sediment conditions in each canal section providing a baseline for the proposed dredging activities and gaining data on sediment composition, potential contamination, and other key parameters, thereby ensuring that the materials to be dredged are appropriately handled according to regulatory requirements and ADB SPS requirements.

104. Fifty sediment sampling stations were established across the project area (see Figure 30), strategically distributed across three designated zones. These stations were selected to capture a representative range of sediment conditions, ensuring that all critical areas of the canal and river system are adequately covered. The survey was carried out by a third party entity over the period of April to May 2025. The full survey report including survey methodology, field observations and laboratory results is attached in Appendix 3.

Figure 30: Sediment Sampling Locations

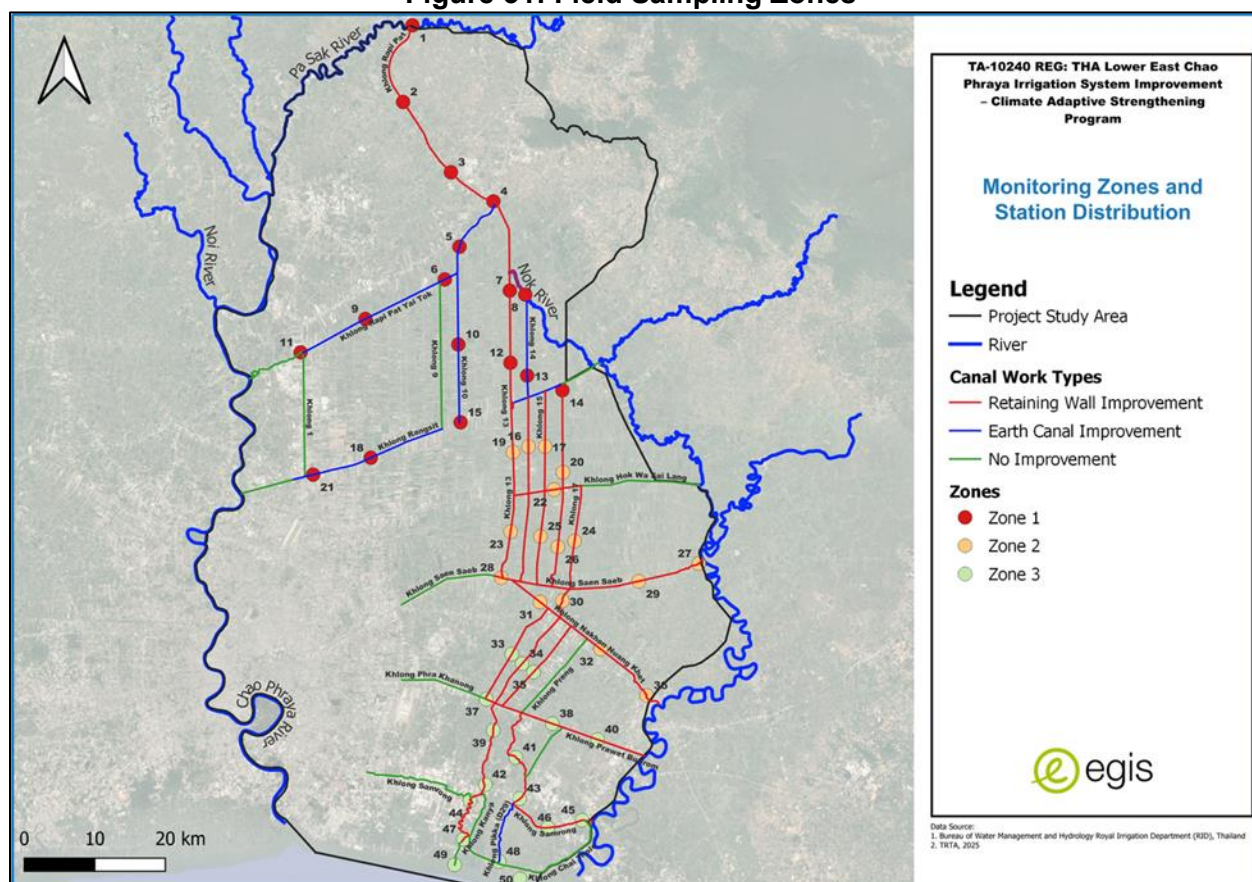


Source: TRTA, 2025

105. The field sampling was conducted across three designated zones as displayed in Figure 31. Zone 1 is the northern part of the Project area, Zone 2 the central part and Zone 3 is the southern part of the project area.

106. The sediments were collected as core samples, length about 1 m. Each core sample was homogenized in the laboratory and then tested for chemical and physical parameters.

Figure 31: Field Sampling Zones



Source: United Analyst and Engineering Consultant Co., Ltd. (2025). Final Report: Water and Sediment Quality Surveys and Analysis for the LECIP Irrigation System Improvement - Climate Adaptive Strengthening Investment Program

107. **Sediment Analyses.** The sediment quality in all three zones (Zone 1, Zone 2, and Zone 3) was assessed based on a range of physical, chemical, and biological parameters. These parameters were compared to Thailand's national sediment quality standards to ensure that the sediment conditions within the project area comply with the established environmental guidelines. Table 16 lists the mean results for the measured parameters in each zone. Additional information is provided in Appendix 3.

Table 16: Sediment Quality Data

Parameter	Unit	Standards	Mean Concentration Zone 1	Mean Concentration Zone 2	Mean Concentration Zone 3
Moisture	Percent		63.3	66.2	72.4
pH			7.4	7.3	7.4
Arsenic	mg/kg dry matter	10	5.1	5.4	6.8
Cadmium	mg/kg dry matter	1	1.8	1.8	2.4

Parameter	Unit	Standards	Mean Concentration Zone 1	Mean Concentration Zone 2	Mean Concentration Zone 3
Chromium, hexavalent	mg/kg dry matter	43.4	0.3	0.3	0.3
Copper	mg/kg dry matter	31.5	22.2	20.0	25.1
Lead	mg/kg dry matter	36	15.5	18.1	21.3
Mercury	mg/kg dry matter	0.2	0.1	0.1	0.1
Nickel	mg/kg dry matter	23	24.0	28.0	33.5
Zinc	mg/kg dry matter	120	68.5	75.2	116.6
Total Phosphorous	mg/kg dry matter	No standard	1520.1	1987.8	2254.5
Nitrate - Nitrite	mg/kg dry matter	No standard	31.4	47.8	40.4
Ammonia-Nitrogen	mg/kg dry matter	No standard	83.1	130.4	189.4
Chlordane	mg/kg dry matter		<0.001	<0.001	<0.001
Endrin	mg/kg dry matter	2.2	<0.001	<0.001	<0.001
Dieldrin	mg/kg dry matter		<0.0005	<0.0005	<0.0005
Heptachlor	mg/kg dry matter		<0.0005	<0.0005	<0.0005
Lindane	mg/kg dry matter		<0.0005	<0.0005	<0.0005
DDT	mg/kg dry matter		<0.001	<0.001	<0.001
DDD	mg/kg dry matter		<0.001	<0.001	<0.001
DDE	mg/kg dry matter		<0.001	<0.001	<0.001

Parameter	Unit	Standards	Mean Concentration Zone 1	Mean Concentration Zone 2	Mean Concentration Zone 3
Polycyclic Aromatic Hydrocarbons (PAHs)	mg/kg dry matter		<90	<90	<90
Toxaphene	mg/kg dry matter		<0.0005	<0.0005	<0.000

Source: TRTA Consultant's calculations based on UAE Report

108. Basic statistics for the most important chemical substances and physical properties of the sediments have been calculated and are summarized in Table 17 and the spatial distribution in the Project area of the concentrations of these substances are displayed in a series of maps from Figure 32 to Figure 38.

109. In summary, the results of the physical and chemical analyses indicate that:

- (i) The moisture content in the sediment samples had minor variations. The median moisture content was at 69% with a narrow interquartile range of about 10% and a coefficient of variation of 13% (see Figure 32).
- (ii) The median pH in the sediment was 7.3 with only two samples below pH 7 (pH 6.8) (see Figure 33).
- (iii) Total organic carbon had a median concentration of 21.1 g/kg dry weight and an interquartile range of 6.8 g/kg dry weight. The coefficient of variation for all samples was 30% indicating high variability, but with a coefficient of variation of 49% in Zone 1 and only 16% in Zone 2 and 3 suggesting minor variability in Zone 2 and 3 (see Figure 34).
- (iv) The median concentration of ammonia-nitrogen was 139 mg/kg dry weight, 33.7 mg/kg dry weight for nitrate-nitrogen and 1716 mg/kg dry weight for total phosphorous. The coefficient of variation for ammonia-nitrogen was 65%, 59% for nitrate-nitrogen and 42% for phosphorous indicating high variability for all three substances. The median concentration of ammonia-nitrogen was about three times higher in Zone 3 than in Zone 1 and about twice as high in Zone 2 as in Zone 1. The median concentrations of phosphorous also indicate a spatial distribution with higher levels in Zone 3 than in Zone 2 and Zone 1 - with the lowest median level in Zone 1 (see Figure 35 and Figure 36).
- (v) Polyaromatic hydrocarbons have not been detected in any of the sediment samples.
- (vi) Pesticides have not been detected in any of the sediment samples.
- (vii) Low levels of arsenic, hexavalent chromium, copper, lead, zinc, and mercury below the Thai sediment quality standards for the protection of benthic organism in about 90% of the samples and with only minor to moderate exceedances in the remaining samples. The coefficients of variation were at about 30% except for mercury with a 60% coefficient of variation indicating moderate to high variability.
- (viii) Concentrations of nickel and cadmium were found to be moderately raised above the Thai sediment quality standards for the protection of benthic organism in 76-96 percent of the samples respectively. The coefficients of variation were at about 25% indicating moderate variability, however with higher median concentrations in Zone 3 than in Zone 2 and Zone 1 (lowest values in Zone 1) (see Figure 37 and Figure 38).

- (ix) None of the samples had heavy metal concentrations exceeding the Thai soil quality standards for residential areas or for agricultural areas.

Table 17: Statistics for Selected Properties

Statistic	Moi- sture	Ammonia -Nitrogen	Nitrate- Nitrogen	Total Phosphorus	Total Organic Carbon	Arsenic (As)	Cadmium (Cd)	Nickel (Ni)
	%	mg/kg (Dry weight)	mg/kg (Dry weight)	mg/kg (Dry weight)	g/kg (Dry weight)	mg/kg (Dry weight)	mg/kg (Dry weight)	mg/kg (Dry weight)
Max	84.2	347.00	140.00	4808.00	36.61	10.20	3.40	43.50
Quartile 3	73.5	199.50	61.73	2468.00	23.46	6.87	2.33	34.80
Median	68.	139.00	33.65	1716.00	21.12	5.88	1.96	28.30
Quartile 1	63.2	68.38	30.00	1206.50	16.62	4.57	1.73	23.28
Min	45.3	10.00	10.00	787.00	4.09	1.42	0.72	9.12
Mean	67.3	135.50	46.11	1919.44	19.96	5.77	2.01	28.53
Interquartil e range	10.3	131.13	31.73	1261.50	6.84	2.31	0.61	11.53
Standard Deviation	8.7	88.64	26.98	803.59	5.93	1.89	0.54	7.08
Coefficient of Variation	13%	65%	59%	42%	30%	33%	27%	25%

Figure 32: Spatial Distribution of Moisture Content in Sediment

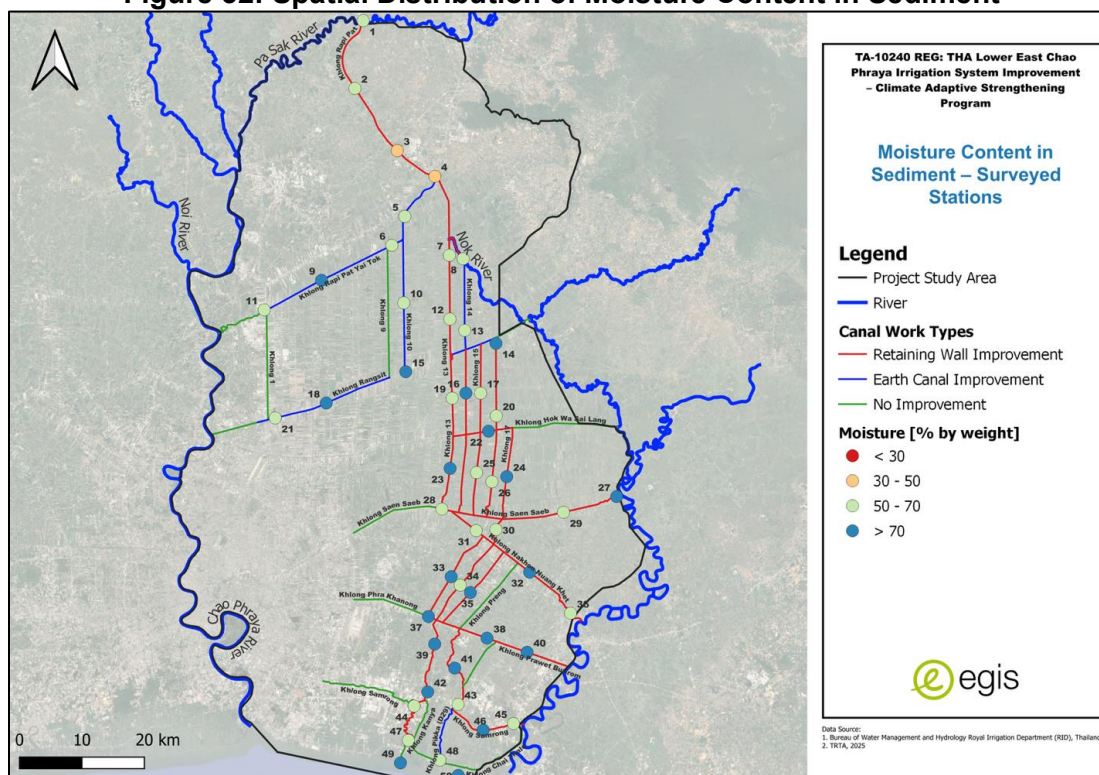


Figure 33: Spatial Distribution of pH in Sediment

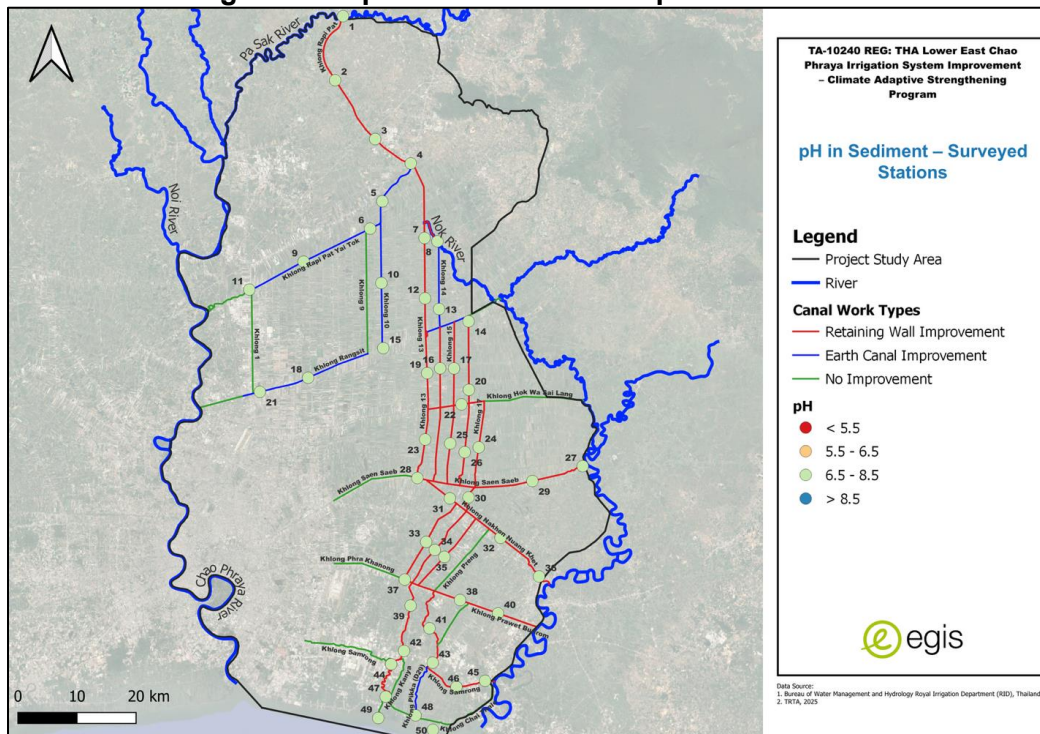


Figure 34: Spatial Distribution of Total Organic Carbon in Sediment

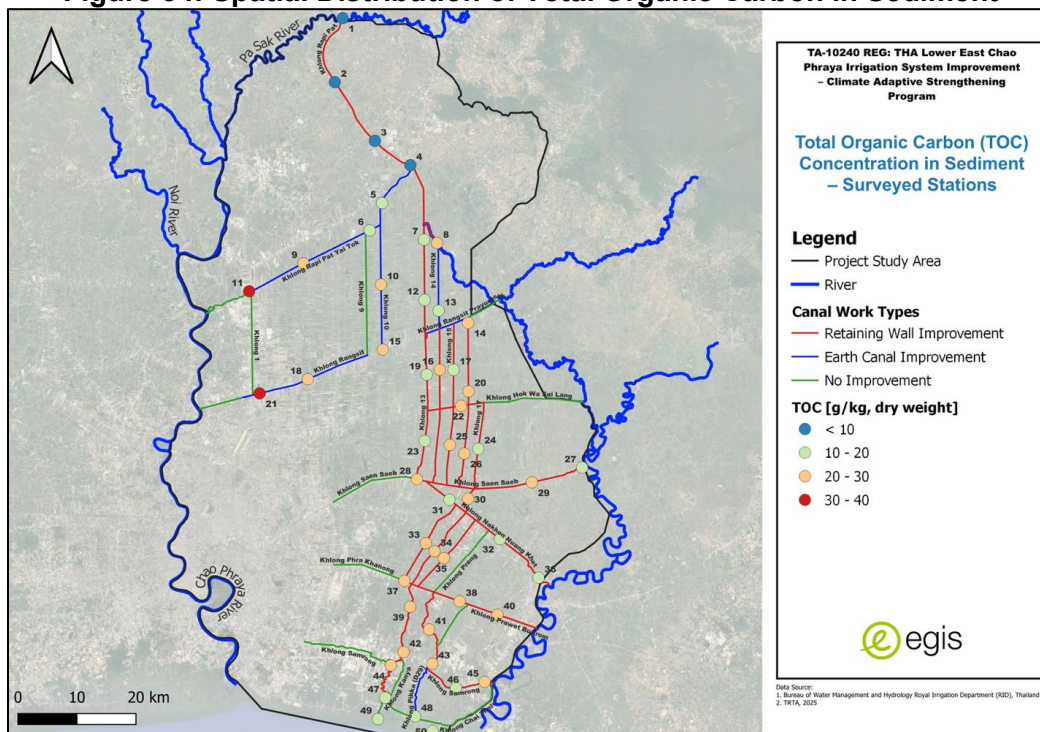


Figure 35: Spatial Distribution of Total Phosphorus in Sediment

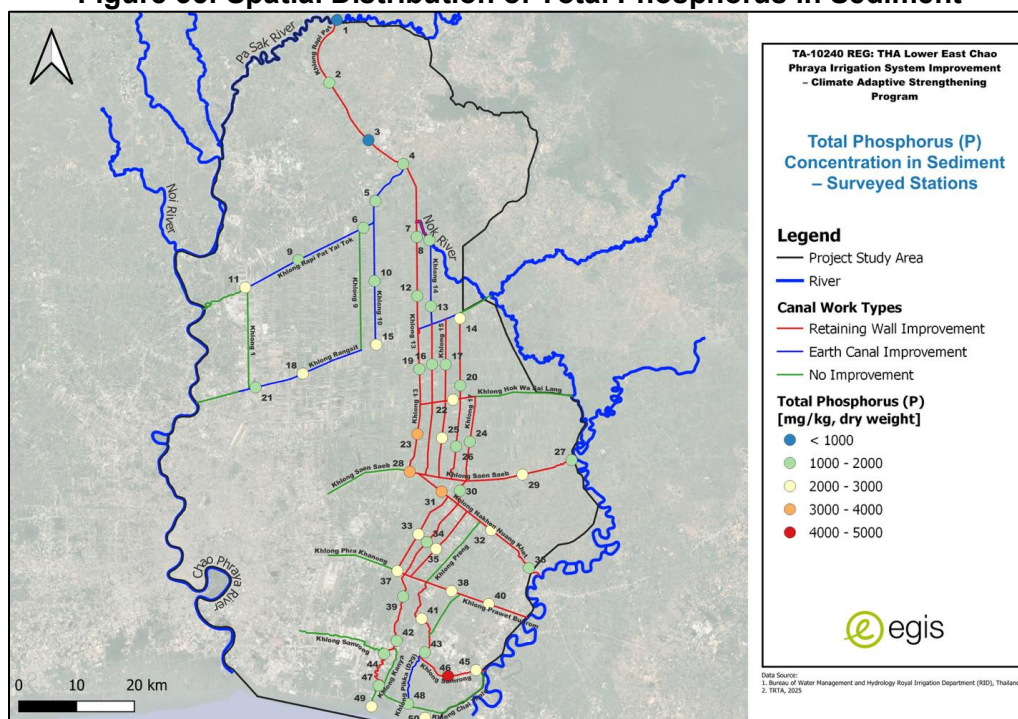


Figure 36: Spatial Distribution of Ammonia-Nitrogen in Sediment

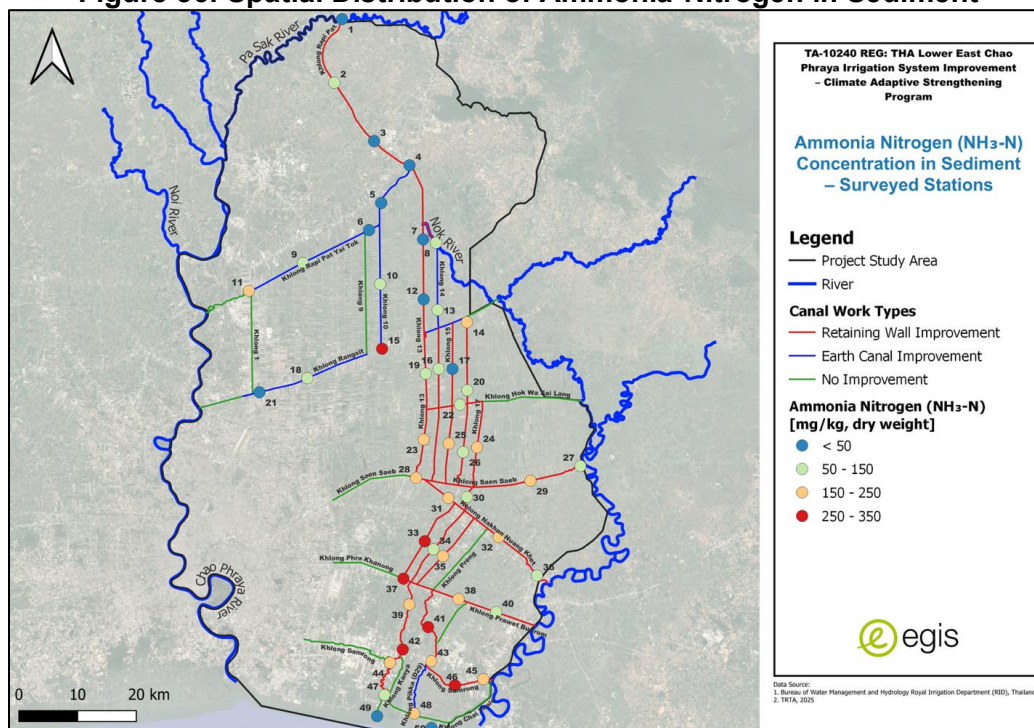


Figure 37: Spatial Distribution of Cadmium in Sediment

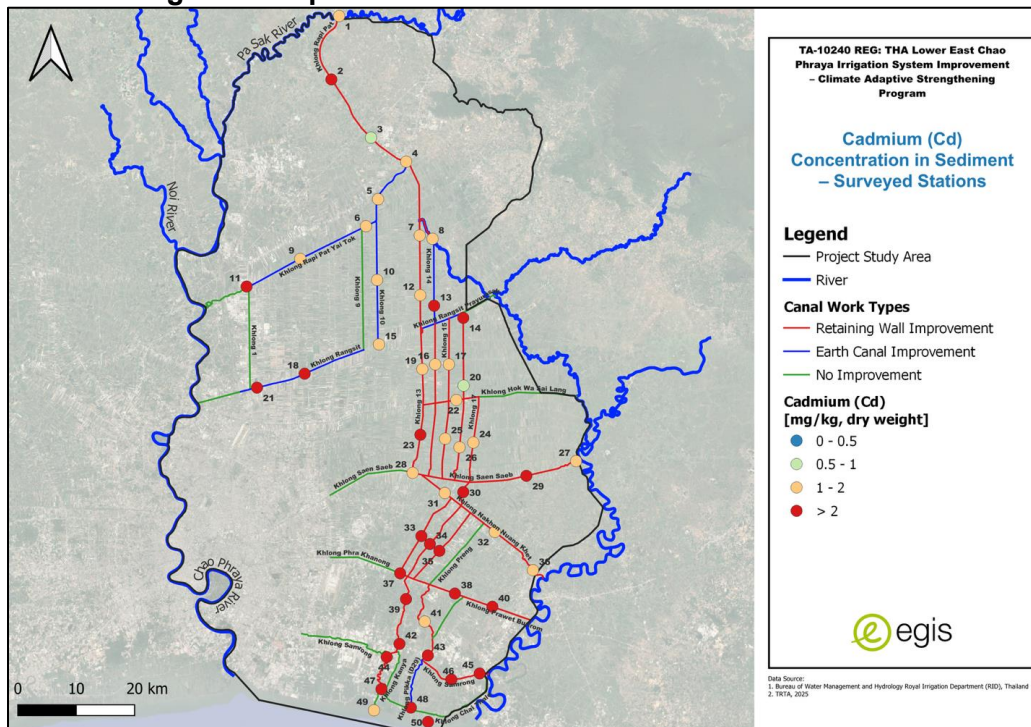
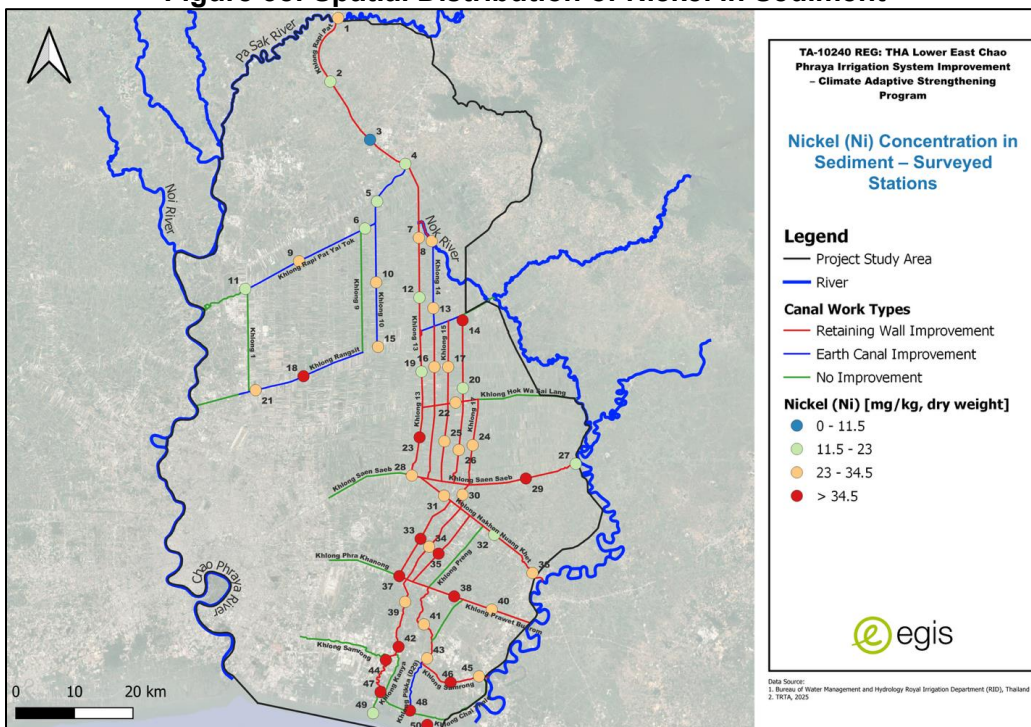


Figure 38: Spatial Distribution of Nickel in Sediment



1. Field Observations

110. **Zone 1.** Sampling in Zone 1 was conducted in upstream irrigation canals, characterized by moderate to slow water flow. The sediment composition in this zone was primarily composed of medium silt to fine sand, with a mixture of both textures at several stations. The water depth generally ranged from 1.0 to 6.0 meters, which was sufficient for sediment coring, although the presence of floating debris, such as bamboo and plastics, required minor adjustments to on-site equipment. Several sampling locations were near agricultural areas, where aquatic vegetation, including floating grass and algae mats, was more abundant. Sediment compaction was slightly higher than in Zone 3, requiring additional force for core penetration at a few locations.

111. **Zone 2.** Sampling in Zone 2 was conducted along the central section of the irrigation canal network and connecting waterways within the Lower Chao Phraya project area. Field observations revealed a variety of environmental conditions between the upstream and downstream sections. Water depth ranged from 1.2 to 3.0 meters, generally suitable for sediment coring. Several stations in Zone 2 experienced moderate to dense aquatic vegetation, particularly at Stations 25 and 28, requiring physical clearing before sampling could proceed. The sediment textures varied; some locations displayed soft, silty deposits, while others had firmer sediments with higher sand content, especially in mid-reach canals influenced by intermittent flushing flows. Boat access was generally achievable with minor adjustments. Sediment core penetration reached the expected 1-meter depth at most stations, with all field activities completed safely.

112. Organic matter levels, as indicated by Total Organic Carbon, ranged from 12.8 to 23.6 g/kg DW (average of 19.6 ± 3.1 g/kg DW), slightly higher and more homogeneous than in Zone 1. The highest organic matter values were found near vegetated, organic-rich canal segments. No contamination from hydrocarbons (PAHs) or pesticide compounds was detected in the sediment samples.

113. **Zone 3.** During sampling in Zone 3, the field team observed that most of the sites were located in wide, open canals and downstream estuarine sections, influenced by moderate water flow and tidal effects. The sediment at these stations was predominantly soft, fine-grained, and rich in silt and clay. Water depths ranged from approximately 1.0 to 3.0 meters, which were generally adequate for gravity coring. At several locations, aquatic vegetation, such as water hyacinths and submerged macrophytes, impeded boat access, requiring manual clearing before sampling. Despite these challenges, sediment penetration was successful at all sites, with the standard 1-meter gravity cores confirming the suitability of the sediment characteristics for effective sample retrieval.

H. Surface Water Quality

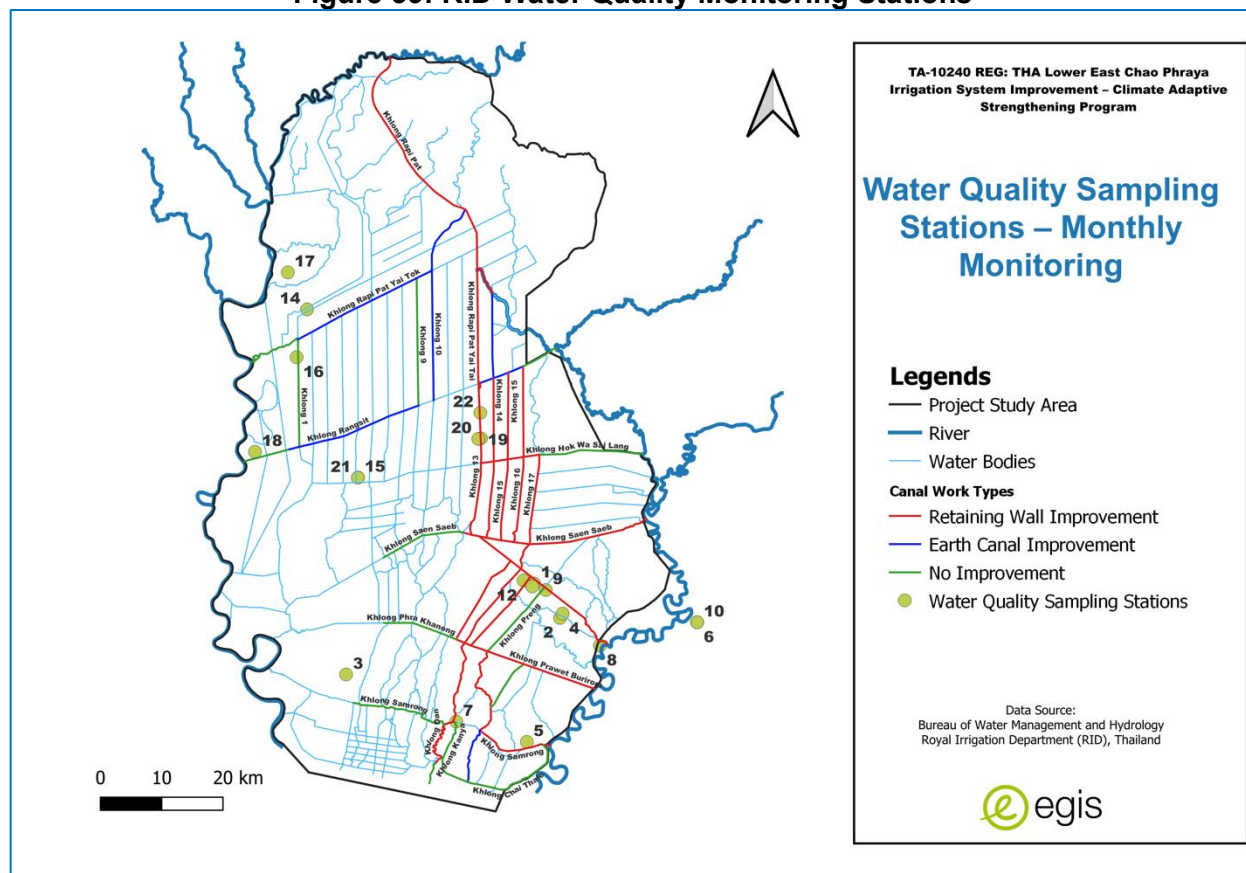
114. In parallel with the sediment survey, water samples were collected close to each of the sediment sampling stations. The water samples were brought to the laboratory and tested for a range of chemical, physical and biological parameters. The locations of the fifty water sampling stations are displayed in Figures 40 – 48.

115. The objectives of the water quality analyses are to provide a baseline prior to project implementation and to test the water quality against applicable Thai water quality standards.

116. The results of the water quality analyses are summarized in Table 18 and the spatial distribution in the Project of key parameters are displayed in a series of maps in Figure 40 to Figure 48. Additional Information is provided in Appendix 3.

117. In addition to the project specific sampling locations, water quality monitoring is conducted at designated RID monitoring stations within the project area. These stations are part of ongoing water quality surveillance efforts by RID. The monitoring stations in the Project area are shown in Figure 39.

Figure 39: RID Water Quality Monitoring Stations



Source: TRTA, 2025

Table 18: Surface Water Quality Data

Parameter	Unit	Standard	Results For zone 1 (mean)	Results For zone 2 (mean)	Results For zone 3 (mean)
Temperature	Degree Celsius (°C)		31.4	32.6	31.4
pH			7.7	7.2	7.7
Electric conductivity	µS/cm		422.6	838	4212.4
Dissolved oxygen	mg/L		3.9	4.3	4.1
Salinity	g/L (ppt)		0.2	0.4	2
Total Suspended Solids (TSS)	mg/L		49.1	38.5	39.1
Biochemical Oxygen Demand (BOD5)	mg/L		5.7	3.3	10.8

Parameter	Unit	Standard	Results For zone 1 (mean)	Results For zone 2 (mean)	Results For zone 3 (mean)
Total Phosphorous	mg/L		0.2	0.1	0.7
Total Nitrogen	mg/L		1.3	0.7	1.9
Nitrate - Nitrite	mg/L		0.2	0.2	0.1
Ammonia-Nitrogen (total)	mg/L		0.9	0.1	1.5
Arsenic	mg/L		<0.001	<0.001	0.005
Cadmium	mg/L		<0.0005	<0.0005	0.0007
Chromium, hexavalent	mg/L		<0.0005	<0.0005	<0.0005
Copper	mg/L		0.003	0.004	0.002
Lead	mg/L		0.004	0.004	0.0035
Mercury	mg/L		0.00005	0.00005	0.00009
Nickel	mg/L		0.014	<0.007	<0.013
Zinc	mg/L		<0.007	<0.008	0.005
Total Petroleum Hydrocarbons (C5-C8)	mg/L		<0.040	<0.040	<0.040
Total Petroleum Hydrocarbons (C9-C16)	mg/L		<0.016	<0.016	<0.016
Total Petroleum Hydrocarbons (C17-C35)	mg/L		<0.042	<0.042	<0.042
Total Organochlorine Pesticide	mg/L		<0.0004	<0.0004	<0.0004
Aldrin	µg/L		<0.01	<0.01	<0.01
Endrin	µg/L		<0.02	<0.02	<0.02
Dieldrin	µg/L		<0.01	<0.01	<0.01
Heptachlor	µg/L		<0.01	<0.01	<0.01
DDT	µg/L		<0.02	<0.02	<0.02
Total Coliform	MPN/100 mL		14,738	9,552	34,167
Faecal Coliform	MPN/100 mL		12,091	3,532	9,921

Source: UAE, TRTA, 2025

118. **Results for Zone 1.** The surface water quality results from Zone 1 indicate that most parameters fell within the acceptable ranges of Thailand's Class III surface water quality standards, with minor variations due to local conditions. The following are significant findings:

- (i) pH of surface water in Zone 1 ranged from 7.1 to 8.6, with an average of 7.4 ± 0.3 . This range is consistent with expected conditions for surface waters in this region, which support a healthy aquatic ecosystem.

- (ii) The water temperature in Zone 1 ranged from 29.7°C to 33.2°C, reflecting typical seasonal fluctuations associated with the dry season. These temperatures are within the expected range for this part of the river system.
- (iii) Electrical conductivity levels in Zone 1 ranged from 288 to 851 $\mu\text{S/cm}$, with an average of $422 \pm 145 \mu\text{S/cm}$. These levels are typical for freshwater systems and indicate a lack of significant seawater intrusion in this zone.
- (iv) Dissolved oxygen concentrations ranged from 1.6 to 5.0 mg/L, with an average of $3.86 \pm 0.94 \text{ mg/L}$. These values suggest that oxygen levels are adequate for aquatic life, though some lower DO concentrations may indicate localized organic enrichment.
- (v) Salinity levels were relatively low in Zone 1, ranging from 0.1 to 0.4 ppt, with an average of $0.19 \pm 0.07 \text{ ppt}$, consistent with freshwater conditions.
- (vi) TSS ranged from 12.9 to 132 mg/L, with an average of $49.0 \pm 31.51 \text{ mg/L}$. The high TSS values reflect the presence of fine particles in the water, particularly in areas with more dynamic water flow.
- (vii) Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). BOD ranged from 5.72 to 6.37 mg/L (average $5.72 \pm 6.37 \text{ mg/L}$), and COD ranged from 29.5 to 14.16 mg/L, indicating a moderate level of organic loading in Zone 1.
- (viii) Nutrient concentrations were moderate, with Total Nitrogen ranging from 0.4 to 7.9 mg/L (average $1.27 \pm 1.98 \text{ mg/L}$), Nitrate-N from <0.01 to 0.47 mg/L (average $0.18 \pm 0.17 \text{ mg/L}$), and Total Phosphorus at $0.17 \pm 0.23 \text{ mg/L}$. Elevated levels were recorded near agricultural zones, suggesting nutrient runoff.
- (ix) Coliform Levels. Total and faecal coliform concentrations were higher than Class III standards at several sites, with average total coliform counts exceeding 20,000 MPN/100 mL.
- (x) Heavy metals were not detected in the samples, with the exception of arsenic, which was detected at very low concentrations (0.0014 mg/L). No organo-pesticide compounds or petroleum hydrocarbons were found above detection limits.

119. **Results for Zone 2.** The surface water quality results from Zone 2 show that most parameters fell within the acceptable ranges for Class III surface waters, with some variability due to land use impacts and hydrological conditions. The following are significant findings.

- (i) The pH in Zone 2 ranged from 6.9 to 7.8, with an average of 7.3 ± 0.23 , indicating that the water quality remains within acceptable limits.
- (ii) Water temperatures ranged from 31.4°C to 35.5°C, consistent with typical dry season conditions in the region.
- (iii) Electrical conductivity ranged from 360 to 3,257 $\mu\text{S/cm}$, with an average of $838 \pm 763 \mu\text{S/cm}$. The higher conductivity observed downstream reflect the influence of saline water and agricultural runoff.
- (iv) Dissolved Oxygen (DO) values ranged from 2.5 to 5.3 mg/L, with an average of $4.29 \pm 0.73 \text{ mg/L}$. Lower DO concentrations were observed at Station 16, likely due to stagnant water and organic matter.
- (v) Salinity was detected at levels ranging from 0.2 to 1.5 ppt (average $0.38 \pm 0.34 \text{ ppt}$), indicating slight seawater influence near the downstream reaches of the zone.
- (vi) TSS ranged from 15.1 to 79.3 mg/L, with an average of $38.4 \pm 18.5 \text{ mg/L}$. TSS values were generally higher in the shallower, slower-moving canals where resuspension occurred.
- (vii) BOD and COD. BOD ranged from 1.5 to 7.4 mg/L (average $3.3 \pm 1.6 \text{ mg/L}$), and COD ranged from 15.6 to 45.6 mg/L (average $27.6 \pm 9.2 \text{ mg/L}$), reflecting moderate organic loading in the zone.

- (viii) Nutrient concentrations were relatively low, with Total Nitrogen averaging 0.69 ± 0.17 mg/L, Nitrate-N at 0.22 ± 0.13 mg/L, and Total Phosphorus at 0.10 ± 0.04 mg/L.
- (ix) Coliform Levels. Total coliform levels were within acceptable ranges, with average levels below 10,000 MPN/100 mL. Faecal coliform was also found but within Class III standards.
- (x) Heavy metals including mercury, cadmium, copper, lead, and zinc were not detected in significant concentrations. Arsenic was detected at a low concentration (0.0014 mg/L), but it was still within acceptable limits.

120. **Results for Zone 3.** The surface water quality results from Zone 3 indicate that most parameters fell within the acceptable ranges of Thailand's Class III surface water quality standards, with some variations reflecting the tidal influence and organic loading typically observed in this estuarine zone. The following are significant findings:

- (i) pH of surface water in Zone 3 ranged from 7.0 to 8.7, with an average of 7.7 ± 0.47 . This range is higher compared to Zones 1 and 2, indicating a greater variability in water quality. The variability is primarily attributed to the tidal mixing that occurs in this downstream section, where both freshwater and seawater interact.
- (ii) The water temperature in Zone 3 ranged from 30.1°C to 33.6°C , consistent with typical dry season conditions. The temperatures observed align with expectations for the region, with slight variations attributable to seasonal fluctuations and local hydrological conditions.
- (iii) Electrical conductivity levels ranged from 839 to 11,076 $\mu\text{S/cm}$, averaging $4,212 \pm 2,793$ $\mu\text{S/cm}$. These high values indicate a significant mixture of freshwater and seawater. Coastal stations, particularly Stations 49 and 50, had even higher readings, with values of 39,800 $\mu\text{S/cm}$ and 40,403 $\mu\text{S/cm}$ respectively, reflecting the influence of seawater intrusion near the river mouth.
- (iv) Dissolved oxygen concentrations in Zone 3 ranged from 2.3 to 6.2 mg/L, with an average of 4.15 ± 1.24 mg/L. The lowest DO values were recorded at coastal stations (49 and 50) and Station 41. These low values are likely due to organic loading and stagnant water conditions, which are more prevalent in the downstream sections of the river.
- (v) Salinity levels in Zone 3 ranged from 0.3 to 5.7 ppt, with an average of 2.0 ± 1.44 ppt. This range reflects typical seawater intrusion, characteristic of the estuarine environments found in this part of the river, where freshwater meets seawater.
- (vi) TSS in Zone 3 ranged from 16.0 to 77.3 mg/L, with an average of 39.1 ± 18.8 mg/L. However, coastal stations showed significantly higher values, with readings of 126 mg/L and 89 mg/L at Stations 49 and 50, respectively. These elevated TSS levels suggest the influence of suspended solids from both tidal movements and local water flow patterns.
- (vii) BOD and COD. BOD values ranged from 2.2 to 20.6 mg/L, with an average of 10.8 ± 5.9 mg/L. COD ranged from 38.4 to 116 mg/L, with an average of 73.5 ± 22.7 mg/L. These relatively high values reflect the organic loading present in the downstream areas of Zone 3, particularly where agricultural runoff and organic waste may contribute to increased biological activity.
- (viii) Nutrient levels in Zone 3 were relatively higher compared to Zones 1 and 2. Total Nitrogen ranged from 1.97 ± 2.43 mg/L, Nitrate-N from 0.26 ± 0.20 mg/L, Ammonia-N from 1.71 ± 2.25 mg/L, and Total Phosphorus from 0.67 ± 0.64 mg/L. These nutrient concentrations are indicative of nutrient enrichment, likely influenced by agricultural runoffs and other land use activities in the region.

- (ix) Coliform Levels. Four stations (39, 43, 44, and 45) in Zone 3 showed high levels of total coliform and faecal coliform, exceeding Class III standards. On average, total coliform levels exceeded 34,000 MPN/100 mL, and faecal coliform levels surpassed 9,900 MPN/100 mL. These elevated coliform levels suggest potential contamination from agricultural runoffs or wastewater discharges.
- (x) Heavy Metals. Most heavy metals, including cadmium, copper, lead, nickel, and hexavalent chromium, were either undetected or present at very low concentrations, within acceptable limits. However, arsenic (0.0054 ± 0.0036 mg/L), mercury (0.0009 ± 0.0002 mg/L), and zinc (0.0103 ± 0.0107 mg/L) were slightly elevated but still within the acceptable thresholds for surface waters. The detection of these metals, while minimal, suggests the need for continuous monitoring to prevent any long-term accumulation of pollutants.

Figure 40: Spatial Distribution of pH in Water

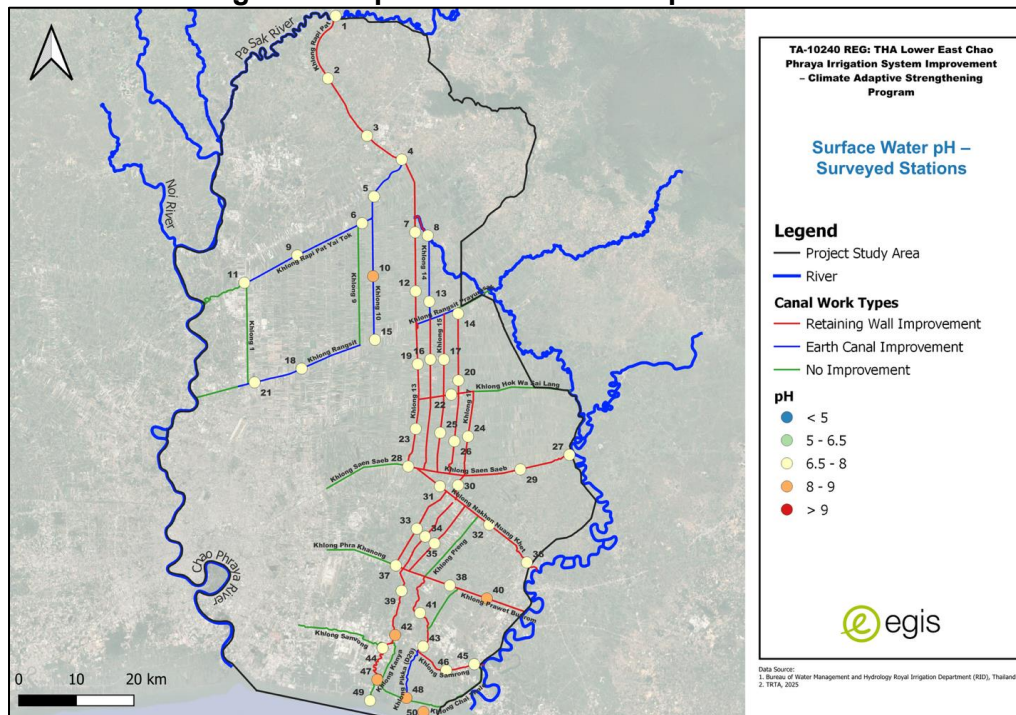


Figure 41: Spatial Distribution of Dissolved Oxygen in Water

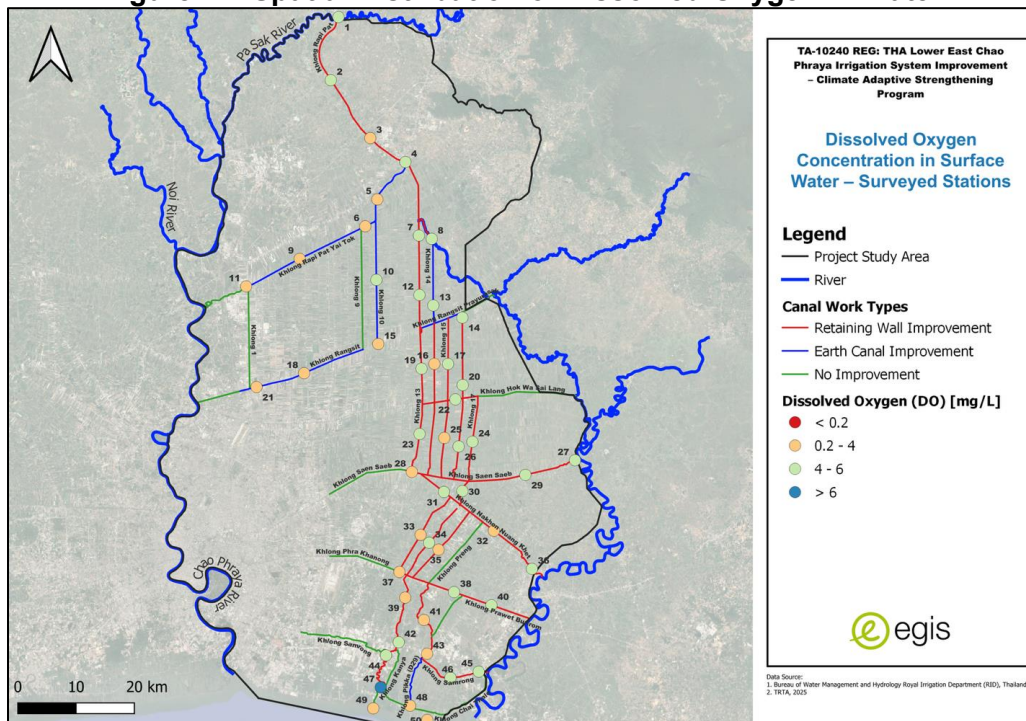


Figure 42: Spatial Distribution of Nitrate-Nitrogen in Water

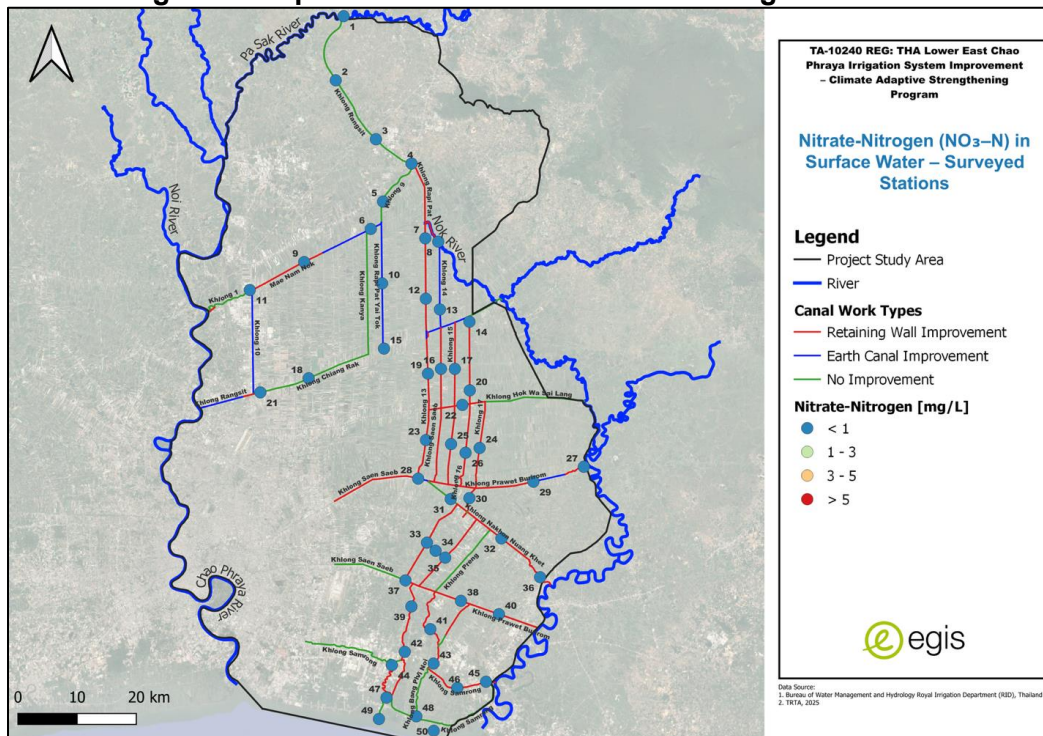


Figure 43: Spatial Distribution of Ammonia-Nitrogen in Water

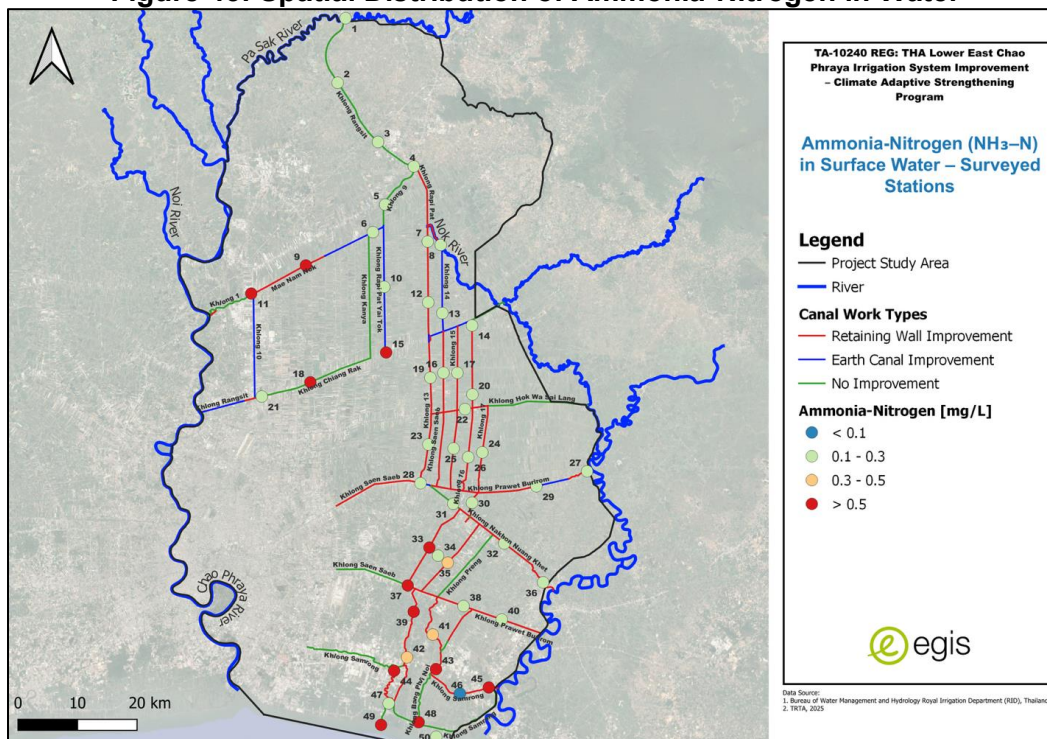


Figure 44: Spatial Distribution of Total Phosphorus in Water

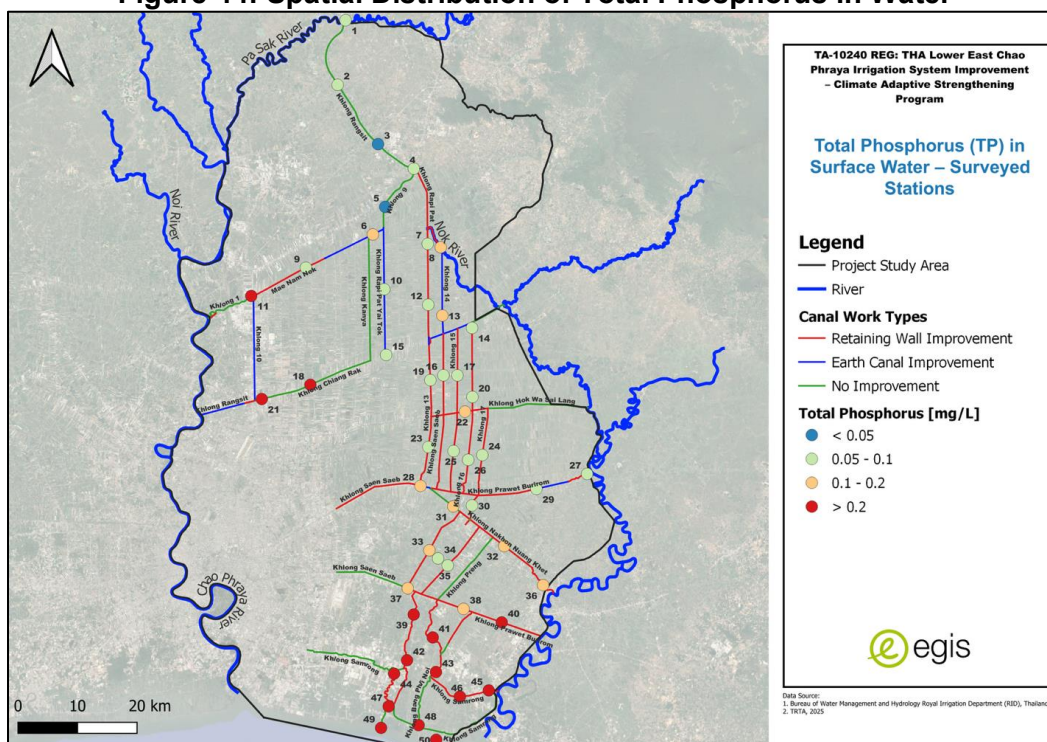


Figure 45: Spatial Distribution of Chemical Oxygen Demand in Water

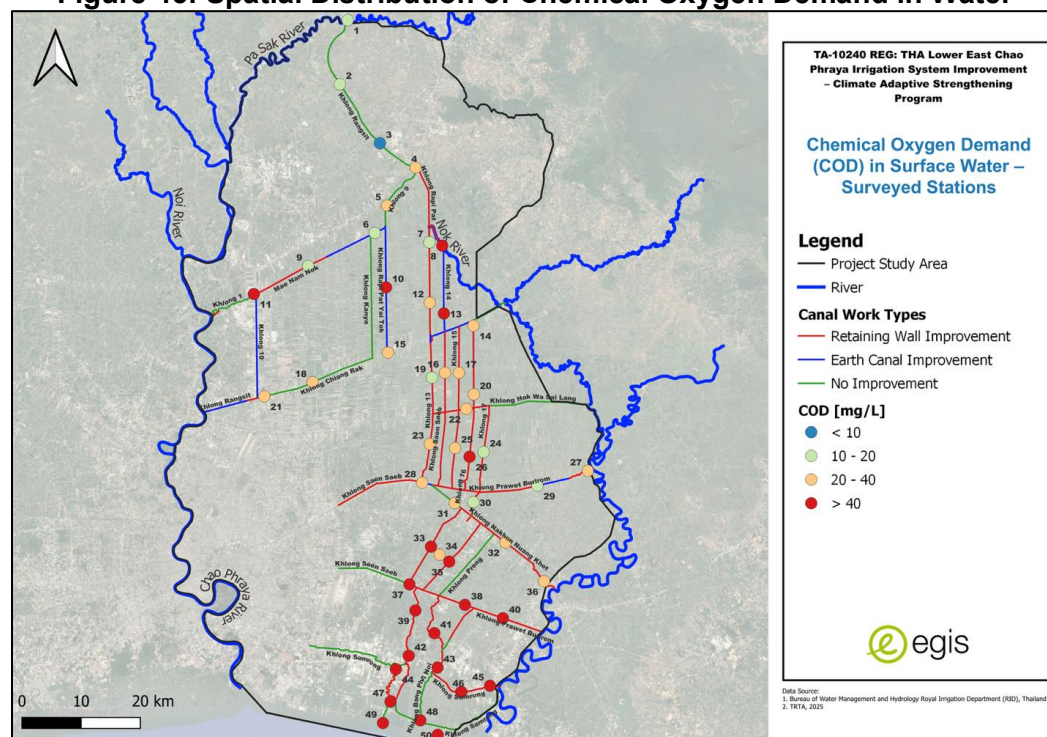


Figure 46: Spatial Distribution of Biochemical Oxygen Demand in Water

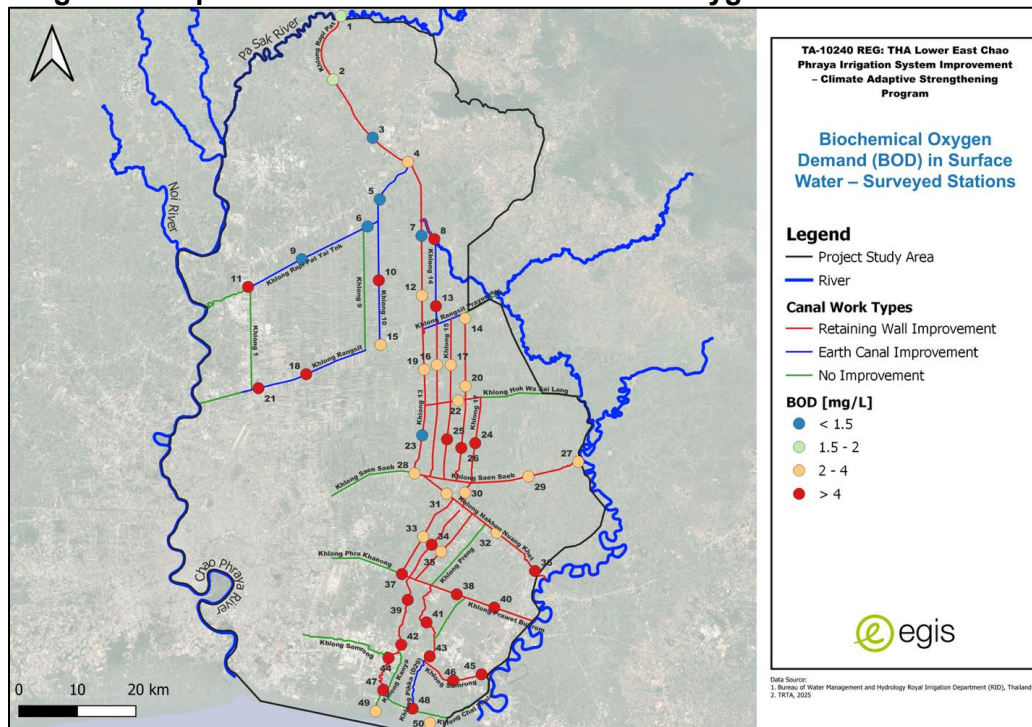
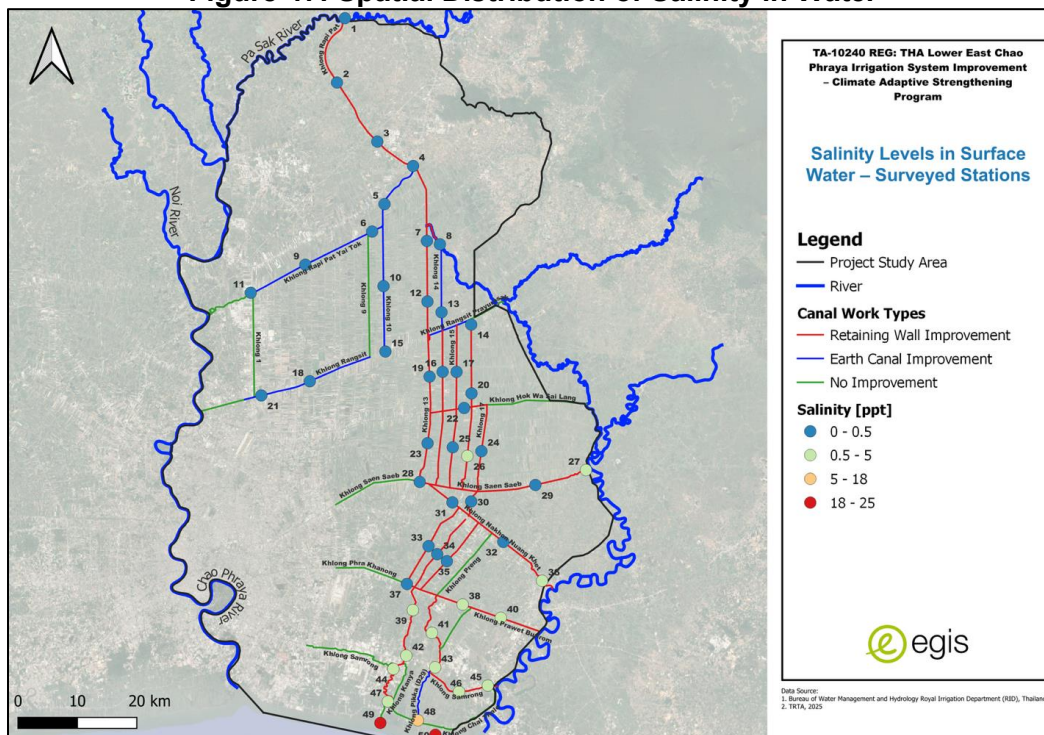


Figure 47: Spatial Distribution of Salinity in Water



I. Baseline Ambient Air Quality

121. Air quality monitoring data has been obtained from records of the Pollution Control Department, Ministry of Natural Resources and Environment and Environment Department of Bangkok Metropolitan Administration. Monthly records of five monitoring stations are summarized in Table 19 while the locations of the monitoring station are shown in Figure 49.

122. It can be concluded that PM_{2.5} concentrations are high during December- February basically due to lack of rain and open burning. While in other periods of the year such as from June to September the concentrations are much lower.

123. The number of days in each month in 2024, where PM_{2.5} exceeds the ambient Thai and project standards of 37.5 mg/m³ is shown in Table 19.

Table 19: Monthly Average of PM2.5 at Five Monitoring Stations in 2024 and 2025 Within the Project Area

Station	2024												2025				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
1*	47 (25)	36.5 (9)	29.2 (2)	28.9 (3)	20.4 (1)	9.5	10.3	11.5	17.6	21.4	29.5 (3)	33.6 (12)	-	-	-	-	-
2**	-	-	-	-	-	-	-	-	-	22.7	26.6	36.2	54.4	46.6	37.8	24.6	23.2
3**	-	-	-	-	-	-	14.5	-	17.3	20.1	24.7	5.8	51.7	12.7	18.6	-	29.9
4*	41 (16)	31 (6)	27 (3)	27 (3)	22 (3)	14	15	15	17	19	21	29 (3)	-	-	-	-	-
5*	38 (11)	29 (5)	23 (1)	22 (2)	17	12	12	14	17	20	23	29 (2)	-	-	-	-	-
Standard: Average 24 hr 37.5 micrograms per cubic meter ***																	

Sources:

* Pollution Control Department Ministry of Natural Resources and Environment

** Environment Department Bangkok Metropolitan Administration

- No Data

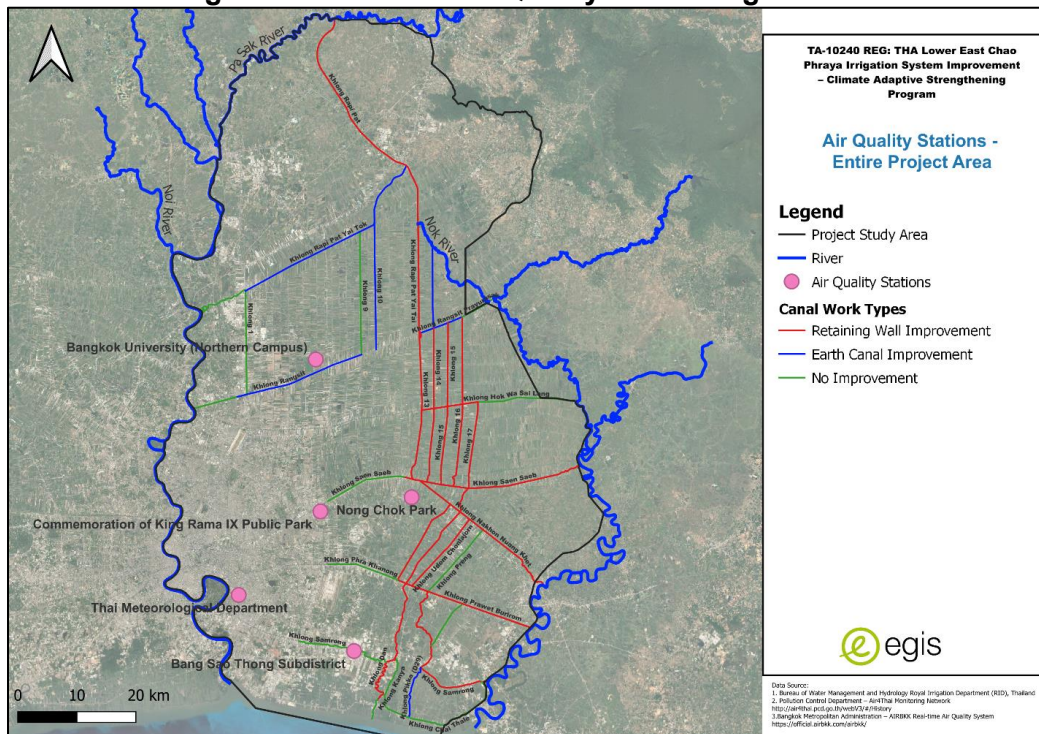
*** Announcement of National Environment Board “ Particulate Matter with an Aerodynamic Diameter Less Than or Equal to Nominal 2.5 micrometers (PM2.5) Standards” June 23, 2023 (B.E.2565).

Number in parentheses indicates number of days exceeding the standards of 37.5 micrograms per cubic meter

Table 20: Days of Exceedance of PM_{2.5} in 2024 at Three Monitoring Stations

Station	J	F	M	A	M	J	J	A	S	O	N	D
Station number 1	25	9	2	3	1						3	12
Station number 4	16	6	3	3	3	-	-	-	-	-	-	3
Station number 5	11	5	1	2	-	-	-	-	-	-	-	2

Figure 48: Ambient Air Quality Monitoring Stations

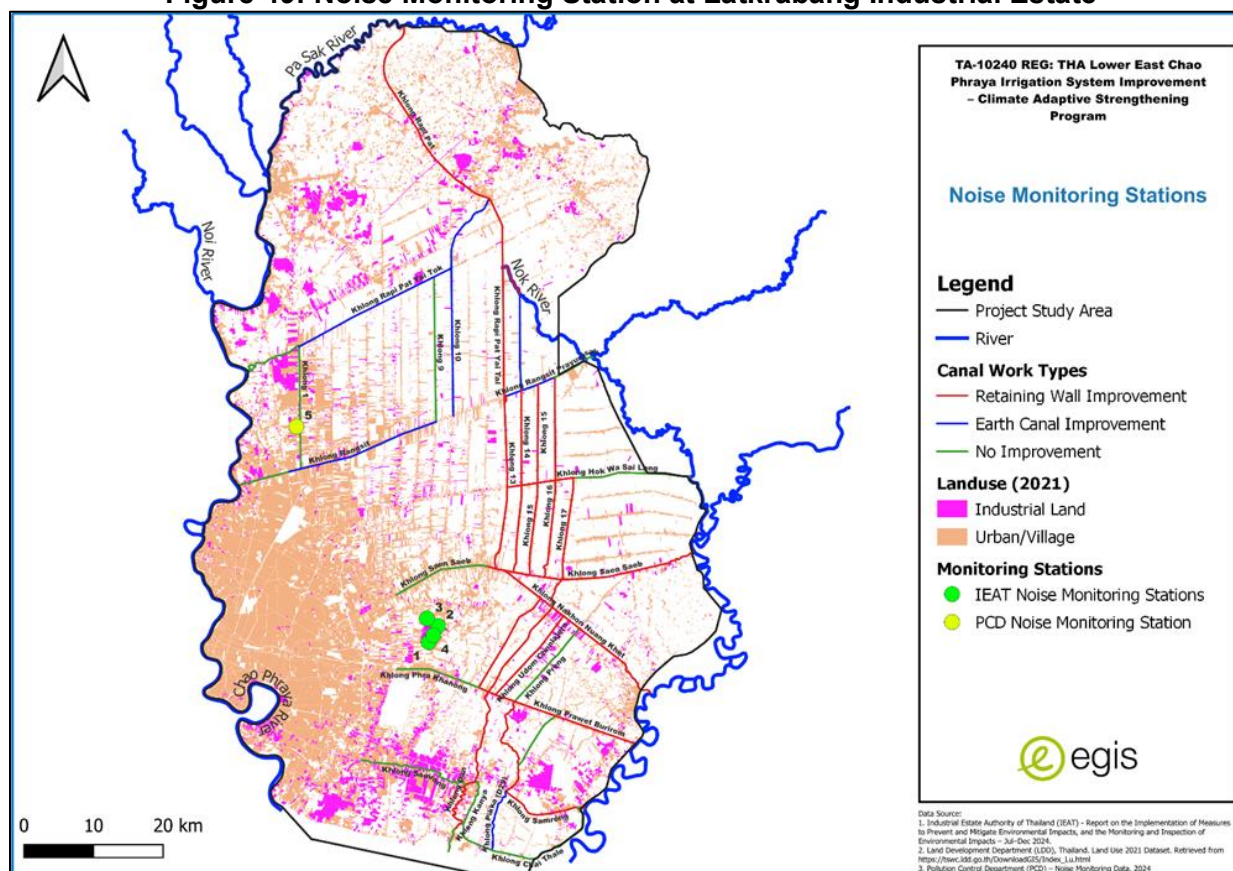


124. LatKrabang Industrial Estate conducted air quality monitoring at four stations including Lat Krabang Industrial Estate Office, Thippawan Temple (Early Childhood Development Centre - Thippawan Pattana), Bueng Bua Temple (Bueng Bua Temple School) and Northeast Station of Industrial Estate Area as indicated in Figure 48. The results of monitoring during 2022 -2024 are summarized in Table 21. All parameters are well within the ambient air quality standards of Thailand.

Table 21: Air Quality at Latkrabang Industrial Estate and its Vicinity During 2022 – 2024

Station No.	Date	TSP mg/m3	PM10 mg/m3	CO (8 hrs.) ppm	SO2 (1 hr.) ppm	SO2 (24 hrs.) ppm	NO2 ppm	O3 ppm
1. Lat Krabang Industrial Estate Office	18-25 May 2022	0.014-0.091	0.007-0.065	0.57-0.62	0.0023-0.0044	0.0024-0.0036	0.0010-0.0090	0.0008-0.0055
	11-18 May 2022	0.057-0.084	0.006-0.055	0.62-0.73	0.0011-0.0095	0.0017-0.0043	0.0017-0.0096	0.0005-0.0025
	23-30 May 2023	0.081-0.124	0.042-0.064	0.57-0.71	0.0013-0.0065	0.0022-0.0039	0.0009-0.0085	0.0008-0.0076
	4-11 Oct 2023	0.017-0.070	0.008-0.039	0.38-0.65	0.0013-0.0045	0.0024-0.0032	0.0009-0.0069	0.0002-0.0047
	14-21 Aug. 2024	0.035-0.080	0.013-0.030	0.32-0.60	0.0022-0.0041	0.0029-0.0031	0.0002-0.0066	0.0032-0.0051
2. Thippawan Temple (Early Childhood Development Center Thippawan Pattana)	21-28 Nov. 2024	0.061-0.091	0.032-0.057	1.74-2.41	0.0009-0.0028	0.0014-0.0022	0.0059-0.0114	0.0182-0.0331
	18-25 May 2022	0.047-0.129	0.011-0.029	0.43-0.53	0.0007-0.0089	0.0031-0.0040	0.0009-0.0085	0.0007-0.0089
	11-18 May 2022	0.042-0.165	0.016-0.074	0.48-0.58	0.0023-0.0099	0.0032-0.0061	0.0012-0.0098	0.0004-0.0029
	23-30 May 2023	0.066-0.182	0.018-0.059	0.38-0.62	0.0013-0.0073	0.0018-0.0025	0.0010-0.0090	0.0013-0.0073
	4-11 Oct. 2023	0.015-0.112	0.010-0.023	0.32-0.48	0.0005-0.0040	0.0014-0.0024	0.0023-0.0060	0.0003-0.0039
3. Bueng Bua Temple (Bueng Bua Temple School)	14-21 Oct. 2024	0.048-0.112	0.028-0.060	0.36-0.48	0.0008-0.0028	0.0018-0.0021	0.0012-0.0069	0.0022-0.0058
	21-28 Nov. 2024	0.124-0.219	0.032-0.053	1.72-2.37	0.0010-0.0035	0.0016-0.0028	0.0052-0.0089	0.0213-0.0340
	18-25 May. 2022	0.075-0.121	0.007-0.027	0.45-0.50	0.0008-0.0061	0.0016-0.0033	0.0014-0.0083	0.0008-0.0076
	11-18 May. 2022	0.055-0.130	0.029-0.063	0.49-0.60	0.0010-0.0088	0.0022-0.0037	0.0030-0.0079	0.0003-0.0030
	23-30 May. 2023	0.075-0.112	0.006-0.033	0.33-0.58	0.0009-0.0085	0.0024-0.0037	0.0013-0.0083	0.0009-0.0055
4. Northeast Station of Industrial Estate Area	4-11 Oct. 2023	0.030-0.072	0.006-0.032	0.31-0.42	0.0001-0.0047	0.0013-0.0029	0.0011-0.0051	0.0001-0.0042
	14-21 Aug. 2024	0.113-0.287	0.036-0.094	0.39-0.51	0.0008-0.0028	0.0018-0.0020	0.0013-0.0071	0.0028-0.0048
	21-28 Nov. 2024	0.057-0.078	0.027-0.051	1.51-2.40	0.0011-0.0034	0.0018-0.0023	0.0061-0.0106	0.0224-0.0388
	18-25 May. 2022	0.024-0.054	0.016-0.034	0.48-0.63	0.0025-0.0047	0.0029-0.0035	0.0013-0.0083	0.0023-0.0050
	11-18 May. 2022	0.040-0.082	0.013-0.036	0.53-0.64	0.0007-0.0093	0.0019-0.0050	0.0030-0.0079	0.0004-0.0017
	23-30 May. 2023	0.058-0.116	0.025-0.050	0.42-0.66	0.0011-0.0060	0.0023-0.0037	0.0010-0.0090	0.0013-0.0073
	4-11 Oct. 2023	0.019-0.035	0.014-0.030	0.52-0.71	0.0001-0.0037	0.0012-0.0022	0.0004-0.0043	0.0001-0.0038
	14-21 Aug. 2024	0.021-0.037	0.010-0.014	0.34-0.58	0.0004-0.0018	0.0011-0.0013	0.0012-0.0070	0.0018-0.0038
	21-28 Nov. 2024	0.054-0.071	0.027-0.038	2.14-2.91	0.0010-0.0031	0.0017-0.0026	0.0052-0.0122	0.0198-0.0330
	Standards	<0.33 2/	<0.12 2/	<9 3/	<0.30 4/	<0.12 2/	<0.17 5/	≤0.10 3/
Note : 1/ The data is at standard condition (Temperature 25 deg.Celsius ,1 atm. 2/ Announcement of National Environment Board No.24 2004(B.E.2547) "Ambient Air Quality Standards" August 9, 2004(B.E.2547) 3/ Announcement of National Environment Board No.10 1995(B.E.2538) "Ambient Air Quality Standards" April 17, 1995(B.E.2538) 4/ Announcement of National Environment Board No.21 2001(B.E.2544) "Ambient Sulfur Dioxide-1 Hr Standards" April 9, 2001(B.E.2544) 5/ Announcement of National Environment Board No.33 2009(B.E.2552) "Ambient Nitrogen Dioxide Standards" June 17, 2009(B.E.2552) Sources: Flood Control Improvement Project of Lat Krabang Industrial Estate- Monitoring Report 2024 Industrial Estate Authority of Thailand								

Figure 49: Noise Monitoring Station at Latkrabang Industrial Estate



J. Baseline Ambient Noise Levels

125. Noise monitoring data for five stations within the project area has been obtained from records of Pollution Control Department Ministry of Natural Resources and Environment and Lat Krabang IEAT. Table 22 summarizes average noise level-24hr (Leq24hr) and maximum noise level within Lat Krabang Industrial Estate area in 2022, 2023 and 2024; while Table 23 summarizes the monthly average noise level-24hr (Leq24hr) in 2022, 2023 and 2024 at Bangkok University (North Campus) station. The 24-hr average noise level and the maximum noise level at all stations are within the standards of not more than 70 dB(A) and 115 dB(A) respectively. The monitoring stations are shown in Figure 51.

Table 22: Noise Level at Office of Lat Krabang Industrial Estate and its Vicinities

Stations	Date	Noise Level ,dB(A)	
		Leq 24 hr	Lmax
1 (Office of Lat Krabang Industrial Estate)	18-25 October 2022	53.4-60.7	76.3-95.2
	11-18 May 2022	63.6-65.0	85.8-99.2
	23-30 May 2023	57.9-65.8	76.0-97.1
	4-11 October 2023	58.2-65.6	80.0-97.2
	14-21 August 2024	63.5-66.1	87.2-96.7
	21-28 November 2024	61.3-62.1	84.4-94.2
2 (Tippawat Temple)	18-25 October 2022	55.9-65.2	70.4-96.6

Stations	Date	Noise Level ,dB(A)	
		Leq 24 hr	Lmax
	11-18 May 2022	57.5-61.0	87.9-99.4
	23-30 May 2023	58.0-59.9	77.4-84.9
	4-11 October 2023	55.9-61.1	81.3-95.7
	14-21 August 2024	61.2-63.2	78.9-94.8
	21-28 November 2024	58.1-62.2	83.0-88.7
	18-25 October 2022	48.6-52.8	67.1-80.4
3 (Wat Bueng Bua School)	11-18 May 2022	58.4-60.4	79.2-99.1
	23-30 May 2023	59.8-64.9	81.3-99.5
	4-11 October 2023	55.4-61.0	76.7-92.3
	14-21 August 2024	57.7-63.9	83.3-102.5
	21-28 November 2024	58.5-60.5	82.6-98.4
	18-25 October 2022	52.1-57.5	70.8-98.1
4 (Northeast Station of Industrial Estate Area)	11-18 May 2022	58.4-60.9	86.0-99.6
	23-30 May 2023	56.4-59.2	79.7-98.9
	4-11 October 2023	52.2-63.8	71.8-94.4
	14-21 August 2024	58.6-61.7	83.3-94.6
	21-28 November 2024	56.6-58.9	79.1-87.2
	18-25 October 2022	52.1-57.5	70.8-98.1
Standards		70	115

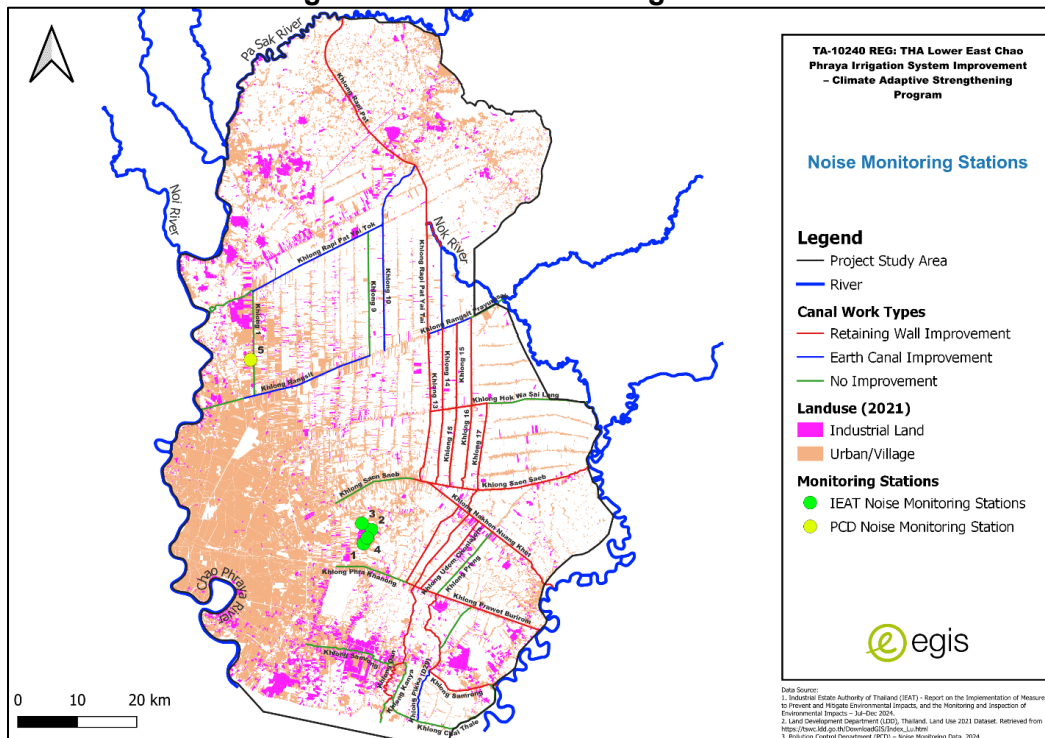
Source: Flood Control Improvement Project of Lat Krabang Industrial Estate- Monitoring Report 2024

Table 23: Monthly Noise Levels (Leq 24 hr) at Bangkok University (North Campus)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	60.9-49.2	59.5-49.6	63.6-50.4	61.1-49.8	59.9-48.8	56.7-47.9	55.3-47.4	58.5-48.1	60.9-49.1	60.8-47.6	58.4-49.1	60.1-47.4
2023	60.9-48.6	61.1-49.1	62.8-48.4	59.3-47.5	52.4-47.5	61.1-47.5	61.5-47.8	57.7-47.9	63.7-48.1	62.7-49.2	60.5-48.7	63.7-47.4
2024	61.3-47.6	60-48.6	59.6-49.9	59.3-49.1	59.6-48.5	59-47.4	61.4-49.3	62.2-47.9	63-47.9	61.9-49.8	64.9-48.6	55.6-47.7

Source: Air Quality and Noise Management Division, Pollution Control Department 2025

Figure 50: Noise Monitoring Stations



Source: TRTA, 2025

K. Natural Hazards or Disasters

126. The Land Development Department has conducted analysis on flood and drought within the project area. Results of the analysis are in Table 24.

127. Almost all the districts within the project area are at risk of flooding for 4 - 7 times in 10 years. Only the districts in Ayuthaya province are at risk to flooding more frequent at 8 -10 times in 10 years.

Table 24: Flood Risk by Area (Rai) in the Project Area

Province	District	8 -10 times in 10 years	4 -7 times in 10 years	Not more than 3 times in 10 years	Total, rai
1.Saraburi	Nongkae	-	66,277	5,135	71,412
2.Ayuthaya	Tha rua	427	27,441	6969	34,837
	Bang Pa in	2,113	61,675	43,557	107,345
	Pranakonsiayuthaya	159	23,373	30,157	53,689
	Wang noi	604	32,866	75,139	108,609
	Uthai	-	61,537	17,148	78,685
3.Pathumthani	Nong sua	-	10,903	59,021	69,924
	Thanyaburi	-	7,670	5,686	13,356
	Lamlukka	-	81,767	23,682	105,449
	Muang	-	18,794	2,561	21,335
	Klong luang	-	1,496	67,925	69,871

Province	District	8 -10 times in 10 years	4 -7 times in 10 years	Not more than 3 times in 10 years	Total, rai
4.Bangkok	NongCkok	-	54,717	34,605	89,322
	Latkrabang	-	15,206	14,240	29,446
	Klongsamwa	-	12,021	16,581	28,602
	Minburi	-	2,802	5,384	8,186
	Saphansoong	-	117	640	757
5.Samutprakarn	Bang bo	-	18,575	52,256	70,831
	Bangplee	-	-	9,461	9,461
	Bangsaothong	-	5,548	23,462	29,010
	Muang	-	-	560	560
6.Chachoengsao	Bangnampreao	-	62,015	133,148	195,163
	Muang	-	16,747	68	84,846
	Ban pho	-	4,352	8,170	12,522
	Bangpakong	-	479	8,833	9,312
7.Nakonnayok	Ongkarak	-	177,105	58,522	235,627
Note: 1 rai= 1,600 m2					

Source: Office of Natural Calamity and Agricultural Risk Prevention, Land Development Department 2025

128. As shown in Table 25 and compared to data in Table 24, there is lesser areas with risk to drought compared to areas with risk to flooding. The areas risk to drought are in Saraburi, Bangkok, Ayuthaya and Pathumthani provinces, and the occurrence is generally not more than 3 times in 10 years with the largest area is in Nongkae district of Saraburi province. Only the Nongkae district that has the risk to drought for more than 6 times in 10 years, and for 4 - 5 times in 10 years.

Table 25: Drought risk by area (Rai) in the Project Area

Province	District	More than 6 times in 10 years	4 -5 times in 10 years	Not more than 3 times in 10 years	Total ,rai
1.Saraburi	Nongkae	485	2,140	17,627	20,252
2.Ayuthaya	Bang Pa in	-	-	2,292	2,292
3.Pathumthani	Muang	-	-	908	908
4.Bangkok	Latkrabang	-	-	1,338	1,338
	Klongsamwa	-	-	1,131	1,131
	Saphansoong	-	-	380	380
Note: 1 rai = 1,600 m2					

Source: Office of Natural Calamity and Agricultural Risk Prevention, Land Development Department 2025

L. Physical Cultural Resources

129. Thailand is rich in cultural heritage and has numerous physical cultural resources (PCRs) that can be found everywhere in the country, including the project area of influence. These PCRs include historic buildings, archaeological sites, monuments, and other significant cultural heritage elements.

130. Table 26 shows the locations of historical and cultural resources within the project area. Each historical site is assigned a unique identification (ID) number corresponding to the ID numbers, which provides additional details for each site, including the site name and the province in which it is located.

Table 26: List of Historical Sites in the Project Area

No.	Site Name	District	Province	Distance to the nearest canal
1	Wat Ratchakosa	Lat Krabang	Bangkok	73 m from Phra Khanong Canal
2	Wat Sangkaracha	Lat Krabang	Bangkok	977 m from Phra Khanong Canal
3	Wat Thippawat	Lat Krabang	Bangkok	6224 m from Phra Khanong Canal
4	Wat Bueng Bua	Lat Krabang	Bangkok	4490 m from Phra Khanong Canal
5	Wat Nong Chok	Nong Chok	Bangkok	47 m from Saen Saeb Canal
6	Wat Lam Wang Ka Sutthawat	Nong Chok	Bangkok	683.0m from Luang Paeng Canal
7	Wat Bang Na Nok	Bang Na	Bangkok	14343 m from Samrong Canal
8	Wat Bang Na Nai	Bang Na	Bangkok	14343 m from Samrong Canal
9	Wat Sothon (Wat Sothonwararam Worawihan)	Mueang Chachoengsao	Chachoengsao	2371 m from Nakhon Nueng Khet Canal
10	City Wall	Mueang Chachoengsao	Chachoengsao	1291 m from Nakhon Nueng Khet Canal
11	Wat Phayakkhaintharaham (Wat Chedi)	Mueang Chachoengsao	Chachoengsao	2883 m from Nakhon Nueng Khet Canal
12	Old Post Office Building	Mueang Chachoengsao	Chachoengsao	570 m from Nakhon Nueng Khet Canal
13	Buddhist Association Building (Old Court)	Mueang Chachoengsao	Chachoengsao	396 m from Nakhon Nueng Khet Canal
14	Wat Pitulathirachrungsit (Wat Mueang)	Mueang Chachoengsao	Chachoengsao	562 m from Nakhon Nueng Khet Canal
15	Old Chachoengsao Provincial Hall	Mueang Chachoengsao	Chachoengsao	540 m from Nakhon Nueng Khet Canal
16	Wat Saichon Na Rangsi	Mueang Chachoengsao	Chachoengsao	2946 m from Nakhon Nueng Khet Canal
17	Wat Nakhon Nueng Khet (Wat Ton Tan)	Mueang Chachoengsao	Chachoengsao	74 m from Nakhon Nueng Khet Canal
18	Wat Bang Prong	Mueang Chachoengsao	Chachoengsao	2983 m from Prawet Burirom Canal
19	Wat Sawang Arom	Bang Nam Priao	Chachoengsao	29 m from Nakhon Nueng Khet Canal
20	Wat Sukanthasilaram (Hom Sin)	Bang Pakong	Chachoengsao	33 m from Samrong Canal
21	Wat Pak Khlong Bang Khanak	Bang Nam Priao	Chachoengsao	88 m from Saen Saeb Canal
22	Wat Pho Yen	Bang Nam Priao	Chachoengsao	102 m from Saen Saeb Canal

No.	Site Name	District	Province	Distance to the nearest canal
23	Wat Phai Dam	Bang Nam Priao	Chachoengsao	289 m from Saen Saeb Canal
24	Wat Phutthaudomwihan	Bang Nam Priao	Chachoengsao	5641 m from Saen Saeb Canal
25	Wat Khao Din (Wat Pathawipappataram)	Bang Pakong	Chachoengsao	2868 m from Samrong Canal
26	Wat Tha Sa-an	Bang Pakong	Chachoengsao	778 m from Samrong Canal
27	Wat Uspharam (Wat Bang Wua)	Bang Pakong	Chachoengsao	1985 m from Samrong Canal
28	Wat Don Sai	Ban Pho	Chachoengsao	6612 m from Prawet Burirom Canal
29	Wat Sanam Chan	Ban Pho	Chachoengsao	3120 m from Prawet Burirom Canal
30	Wat Hua Noen	Ban Pho	Chachoengsao	3535 m from Prawet Burirom Canal
31	Khok Phanom Rap	Ban Pho	Chachoengsao	9107 m from Prawet Burirom Canal
32	Wat Don Si Non	Ban Pho	Chachoengsao	5830 m from Prawet Burirom Canal
33	Wat Chana Songkhram	Mueang Chachoengsao	Chachoengsao	47 m from Nakhon Nueng Khet Canal
34	Tha Khai Regulator	Mueang Chachoengsao	Chachoengsao	39 m from Nakhon Nueng Khet Canal
35	Wat Sampathawan Nok	Mueang Chachoengsao	Chachoengsao	3585 m from Nakhon Nueng Khet Canal
36	Wat Ko Chantharam	Mueang Chachoengsao	Chachoengsao	4824 m from Nakhon Nueng Khet Canal
37	St. Paul's Church	Mueang Chachoengsao	Chachoengsao	1062 m from Nakhon Nueng Khet Canal
38	Na Mueang Market	Mueang Chachoengsao	Chachoengsao	1360 m from Nakhon Nueng Khet Canal
39	Wat Thepnimit	Mueang Chachoengsao	Chachoengsao	1070 m from Nakhon Nueng Khet Canal
40	Chachoengsao Governor's Residence	Mueang Chachoengsao	Chachoengsao	1633 m from Nakhon Nueng Khet Canal
41	Chachoengsao City Pillar Shrine	Mueang Chachoengsao	Chachoengsao	914 m from Nakhon Nueng Khet Canal
42	Chinese Community Temple Leng Hok Yi	Mueang Chachoengsao	Chachoengsao	1240 m from Nakhon Nueng Khet Canal
43	Wat Phikkhu Sangkhon (Wat Laem Tai)	Mueang Chachoengsao	Chachoengsao	689 m from Nakhon Nueng Khet Canal
44	Wat Uphaphatikaram	Mueang Chachoengsao	Chachoengsao	757 m from Nakhon Nueng Khet Canal
45	Wat Prasithiwet	Ongkharak	Nakhon Nayok	2494 m from Canal 14
46	Wat Chetwong (Ruins)	Mueang Pathum Thani	Pathum Thani	1059 m from Rangsit Prayunsak Canal
47	Church and Pagoda of Wat Lum (Ruins) (PT Technical College)	Mueang Pathum Thani	Pathum Thani	6059 m from Rangsit Prayunsak Canal
48	Wat Bang Luang	Mueang Pathum Thani	Pathum Thani	3367 m from Rangsit Prayunsak Canal
49	Old Pathum Thani Provincial Hall, Old Court and Office	Mueang Pathum Thani	Pathum Thani	6123 m from Rangsit Prayunsak Canal

No.	Site Name	District	Province	Distance to the nearest canal
50	Wat Makham	Mueang Pathum Thani	Pathum Thani	4135 m from Rangsit Prayunsak Canal
51	Wat Hatthasarnkaset	Khlong Luang	Pathum Thani	8713 m from Rangsit Prayunsak Canal
52	Wat Khian Khet	Thanyaburi	Pathum Thani	171 m from Rangsit Prayunsak Canal
53	Wat Mulchindaram	Thanyaburi	Pathum Thani	121 m from Rangsit Prayunsak Canal
54	Old Wat Chinwararam School Building	Mueang Pathum Thani	Pathum Thani	922 m from Rangsit Prayunsak Canal
55	Wat Chinwararam Worawihan	Mueang Pathum Thani	Pathum Thani	847 m from Rangsit Prayunsak Canal
56	Wat Talad Nuea	Mueang Pathum Thani	Pathum Thani	745 m from Rangsit Prayunsak Canal
57	Wat Pa Klang Thung	Mueang Pathum Thani	Pathum Thani	989 m from Rangsit Prayunsak Canal
58	Wat Bang Khu Wat Nai	Mueang Pathum Thani	Pathum Thani	3589 m from Rangsit Prayunsak Canal
59	Wat Nam Won	Mueang Pathum Thani	Pathum Thani	1758 m from Rangsit Prayunsak Canal
60	Old Provincial Health Office	Mueang Pathum Thani	Pathum Thani	6283 m from Rangsit Prayunsak Canal
61	Wat Bot	Mueang Pathum Thani	Pathum Thani	5839 m from Rangsit Prayunsak Canal
62	Khlong Lat Tret Yai	Mueang Pathum Thani	Pathum Thani	5239 m from Rangsit Prayunsak Canal
63	Wat Chang	Mueang Pathum Thani	Pathum Thani	4440 m from Rangsit Prayunsak Canal
64	Wat Khok	Mueang Pathum Thani	Pathum Thani	3785 m from Rangsit Prayunsak Canal
65	Field Marshal P. Phibunsongkhram Air Raid Shelter	Mueang Pathum Thani	Pathum Thani	539 m from Rangsit Prayunsak Canal
66	Wat Thian Thawai	Mueang Pathum Thani	Pathum Thani	220 m from Rangsit Prayunsak Canal
67	Wat Prasat (1)	Phra Nakhon Si Ayutthaya	Ayutthaya	21582 m from Raphiphat Yaek Tok Canal
68	Wat Monthop (2)	Phra Nakhon Si Ayutthaya	Ayutthaya	21487 m from Raphiphat Yaek Tok Canal
69	Wat Khom	Phra Nakhon Si Ayutthaya	Ayutthaya	21422 m from Raphiphat Yaek Tok Canal
70	Wat Pak Nam	Phra Nakhon Si Ayutthaya	Ayutthaya	21127 m from Raphiphat Yaek Tok Canal
71	Wat Ko Kaeo	Phra Nakhon Si Ayutthaya	Ayutthaya	21777 m from Raphiphat Yaek Tok Canal
72	Wat Kluai	Phra Nakhon Si Ayutthaya	Ayutthaya	22124 m from Raphiphat Yaek Tok Canal

No.	Site Name	District	Province	Distance to the nearest canal
73	English Village	Phra Nakhon Si Ayutthaya	Ayutthaya	20993 m from Raphiphat Yaek Tok Canal
74	Wat Satue	Tha Ruea	Ayutthaya	500 m from Raphiphat Canal
75	Khlong Ban Bat - Khlong Kramang	Phra Nakhon Si Ayutthaya	Ayutthaya	22116 m from Raphiphat Yaek Tok Canal
76	Ban Wat Phichai	Phra Nakhon Si Ayutthaya	Ayutthaya	21612 m from Raphiphat Yaek Tok Canal
77	Wat Sam Bandit	Uthai	Ayutthaya	9086 m from Raphiphat Canal
78	Wat King Kaeo	Bang Phli	Samut Prakan	6099 m from Phra Khanong Canal
79	Ban Bang Phriang	Bang Bo	Samut Prakan	33 m from Dan Canal
80	Wat Bang Phli Yai Nai	Bang Phli	Samut Prakan	126 m from Samrong Canal

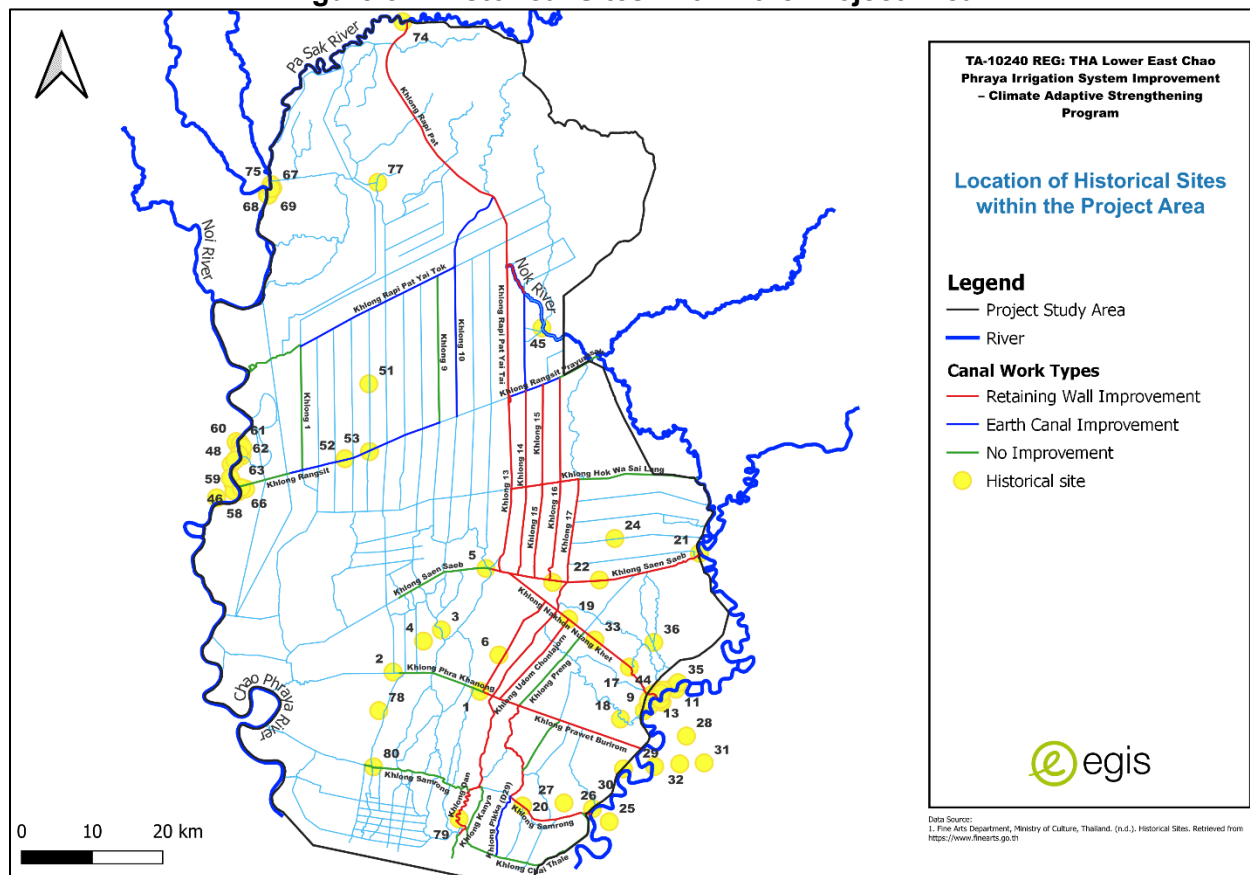
Note: Sites within 250 m of a canal are highlighted in yellow and sites 250 m – 1000 m from a canal are highlighted in light green

Source: Fine Arts Department, Ministry of Culture, 2025

131. It is noted that there are additional sites identified during field survey, such as the relatively smaller temples, which are not on the provided list.

132. Figure 52 shows the map indicating the locations of the historical and cultural resources within the project area. This map serves as a tool to visually understand the distribution of cultural sites in relation to the project's proposed work zones. It is important that these sites are considered during all stages of the project, from planning and design to implementation and monitoring, to minimize any adverse effects on these resources.

Figure 51: Historical Sites Within the Project Area



Source: Fine Arts Department, Ministry of Culture, 2025.

M. Biodiversity

133. The following text provides a summary of the biodiversity features of the project area and surrounding land. The text provides information based on desk top studies, in particular those related to the determination of the presence or absence of likely or potential Critical Habitat, and field studies. The latter were conducted for another project but cover much of the same area as this current project.

134. Based on existing land use, which is predominantly intensive agriculture and urbanization, there is limited natural terrestrial habitat within the project area. To the north where the land rises there are protected areas with forest cover in some locations.

135. The marine environment in the immediate vicinity of the project area is also affected by human activities and is modified habitat. Activities which affect the marine biodiversity include fishing, turtle hunting and effluent inputs from industrial, urban and agricultural activities.

136. The area is considered to be depauperate in biodiversity due to land use, with valued receptors being limited to small areas of land.

137. Perhaps the most valued habitat will be fresh water and riparian zones along the rivers, canals and ponds present. Although mainly engineered structures, fresh water bodies are readily colonized by species, the linear nature of the rivers and canals provide important 'movement' corridors through other habitats and providing water levels do not dry out, the habitat is relatively stable in the absence of significant works within the riparian zone and water.

1. Protected Areas and Key Biodiversity Areas

138. As part of the process for determination of the presence or absence of Critical Habitat a review of the presence of Protected Areas and Key Biodiversity Areas (KBA) was conducted. The CHA Screening Report findings in relation to Protected Areas and KBAs is set out below.

139. **Protected Areas.** Encompassed within the ISA are ten protected areas. Some are extensive areas of land and others very small areas around a single island. Two of the Protected Areas have the same boundary but a different designation, so they are presented as two Protected Areas within this report.

140. The ten Protected Areas are listed, with their designation in Table 27. These Protected Areas are more than 50km from the nearest project alignments.

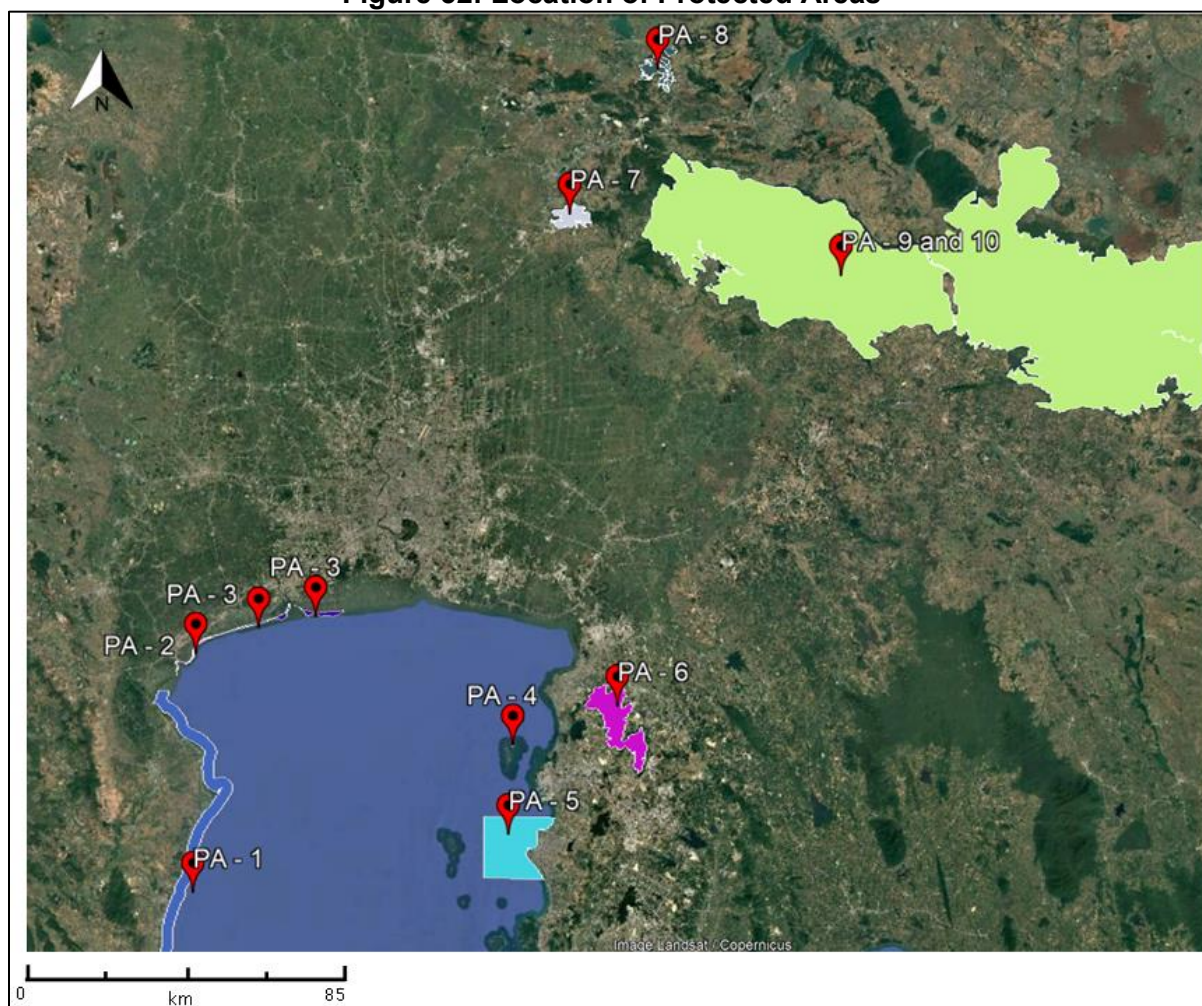
Table 27: Name and Designation of Protected Areas within ISA

Reference	Name	Designation
PA- 1	Phetchaburi and Prachuap Khirikhan Environmental Protected Area	National Marine Protected Area
PA - 2	Don Hoi Lot	International - Ramsar Site, Wetland of International Importance
PA - 3	Phan Thai Norasing	National – Non-Hunting Site
PA - 4	Ko Kam Yai Marine Fisheries Reserved Area	National - Marine Fisheries Reserved Area
PA - 5	Chonburi Environmental Protected Area	National - Environmental Protected Area
PA - 6	Khao Khiew - Khao Chomphu	Wildlife Sanctuary
PA - 7	Phra Budda Chai (Khao Samlan)	National - National Park

Reference	Name	Designation
PA - 8	Namtok Ched Sao Noi	National - National Park
PA - 9	Dong Phrayayen-Khao Yai Forest Complex	International – World Heritage Site
PA - 10	Khao Yai	National and Regional - National Park and ASEAN Heritage Park

141. The locations of these sites are shown in Figure 52. Some of the areas are too small to show at this map scale, hence the use of site numbers.

Figure 52: Location of Protected Areas



Source: Google Earth Basemap, WDPA for Site Outlines where visible

142. **Key Biodiversity Areas.** Within the ISA there are five KBA's. Four were highlighted in the Integrated Biodiversity Assessment Tool (IBAT) PS6 search and a fifth identified directly on the IBAT Website, World Database of KBAs (WDKBA) and Bird Life Data Zone for Important Bird Areas (IBA). The five areas are shown in Table 28. Project alignments are within the Lower Central Basin.

Table 28: Key Biodiversity Areas within ISA

Site No.	Site Name	Designation
KBA - 1	Lower Central Basin	KBA and IBA
KBA - 2	Inner Gulf of Thailand	KBA and IBA
KBA - 3	Mae Klong Basin	KBA
KBA - 4	Chao Phraya River from Nonthaburi to Nakon Sawan	KBA
KBA - 5	Khoa Yai	KBA and IBA

1.2 Critical Habitat Assessment

143. The project is located within the Chao Phraya River Basin which has varied proximity to some environmentally sensitive areas in Thailand. Therefore, the project site was also assessed in terms of critical habitat status. A screening using the Integrated Biodiversity Assessment Tool (IBAT) was undertaken to screen and assess potential risks on sensitive areas or critical habitat that may exist around the project sites (default area of analysis of 50 km radius). The IBAT screening shows biodiversity species potentially to occur within the default 50-km radius that could likely trigger critical habitat. These species include both endangered and critically endangered species per IUCN Red List of Threatened Species. During the field visits and consultations, it was confirmed that *none of these species* exist along stretches of the project alignments, and have not been observed or encountered for the past several years or decades. Nevertheless, a critical habitat assessment (CHA) study was undertaken as part of the biodiversity assessment for the project. The CHA follows ADB SPS guideline for assessing critical habitat status, and International Finance Corporation's Guidance Note 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources).

144. In the CHA, potential critical habitat-triggering species (both terrestrial and aquatic species), including all species identified in the IBAT screening covering a radius of 50 km around the project sites, were screened under Critical Habitat Criteria 1, 2, and 3.

145. The initial screening suggest that one species was likely to qualify the area as Critical Habitat, this being the Spoon-billed sandpiper (*Calidris pygmaea*), a migratory bird species which winters in Thailand and Myanmar. During migration, it consistently returns to the same sites. However, habitat loss along the flyway has reduced the global population to only about 200 breeding pairs. Four other species were added following the additional research and consultations. In Thailand, the species is observed annually between October and April. It has been recorded in Samut Sakhon (Khok Kham) which lies to the west of the project area, Phetchaburi (Pak Thale–Laem Phak Bia) which lies on the western coast of the northern Gulf of Thailand, and Rayong (Prasae) which lies over 100 km from the project area, with the highest count of ten individuals observed at Pak Thale–Laem Phak Bia. None of the sites are within the project area.

146. Other species which were identified in the assessment were subject to additional research. The LECP contracted a national consultant to undertake consultation with specialists and relevant government entities. These consultations suggested that while potential trigger species may be present within the wider study area, they would not be present within the project's area of influence.

147. The CHA conducted concluded that there are no critical habitats within the project area but did suggest areas outside of the project area which are likely or have potential to be classed as Critical Habitat based on their designation status. The CHA used the IFC Performance Standard No 6 Criteria for determining the presence of Critical Habitat qualifying species. A single species, the Spoon-billed piper was identified as having the potential to qualify an area as Critical Habitat. However, the known wintering sites for this very rare migrant water bird lie well outside the project area of influence.

148. Critical Habitat will not be affected by the project. As noted above, much of the project area and surrounding landscape is intensively managed and thus there remains limited natural habitat present. Riparian zones are managed and frequently canalized or engineered.

149. The complete CHA report is in Appendix 4.

N. Socio-Economic Data

150. Thailand is classified as an upper-middle-income country by the WB, reflecting its diverse economy and robust sectors in tourism, agriculture, and manufacturing. Relative to its neighbors, aside from Malaysia, Thailand has significantly higher income levels.

151. The country's infrastructure is notably well-developed, featuring extensive road networks, airports, and efficient public transportation systems. Additionally, Thailand's universal healthcare system, established in 2001, is recognized regionally as a model for delivering affordable and accessible medical services.

152. The project is located on the eastern edge of the capital city which affects social conditions within the project area, with better job opportunities and access to schools, universities, government departments and medical care than purely rural locations.

153. The following sections provide an overview of national and regional demographics.

1. Demographics

154. Table 29 summarizes key population demographic indicators for Thailand as estimated by Mahidol University's Institute for Population and Social Research, with data accurate as of 1 July 2024.

Table 29: Regional Population and Age

	Male ('000s)	Female ('000s)	Total ('000s)
Total National population	31,694	34,173	65,867
Regional Population Analysis			
Urban areas	19,662	21,230	40,892

	Male ('000s)	Female ('000s)	Total ('000s)
Rural (non-urban)	12,032	12,943	24,975
Bangkok (BKK) metro	3,989	4,327	8,316
Central (excl BKK metro)	9,590	10,290	19,880
Northern	5,108	5,573	10,681
North eastern	8,518	9,232	17,750
Southern	4,489	4,751	9,240
Age group			
Children under 15 yrs	5,028	4,791	9,819
Labour force (15 – 59 yrs)	20,811	21,281	42,092
Elderly (60 and over)	9,604	13,722	23,326
Pre-school (0-5yrs)	1,668	1,588	3,256
School age (6-21 yrs)	6,231	5,950	12,181
Women of reproductive age (15-49 yrs)		15,782	
Life expectancy at birth	71.9 years	79.9 Years	

Source: Mahidol University's Institute for Population and Social Research, 2024

155. Women constitute approximately 51.9% of the total population, yet girls represent only 48.8% of children under the age of 15, suggesting shifts in birth ratios. Women also exhibit significantly higher life expectancy (79.9 years) compared to men (71.9 years), leading to women accounting for nearly 59% of the population aged over 60. This demographic pattern indicates a potentially increased proportion of elderly women, many of whom may require additional family or social support.

156. According to the World Population Review, approximately 2% of households in Thailand are headed by single women—a proportion that has remained consistent since 2018. This figure compares favorably to neighbouring countries, including Vietnam (4–5%), Cambodia (up to 20%), Lao PDR (around 12%), and Myanmar (approximately 22%). Nevertheless, female-led households in Thailand, especially in rural areas, remain particularly vulnerable to poverty and economic shocks due to limited access to savings, social safety nets, land, productive assets, employment opportunities, household labour, and greater time constraints.

2. Poverty

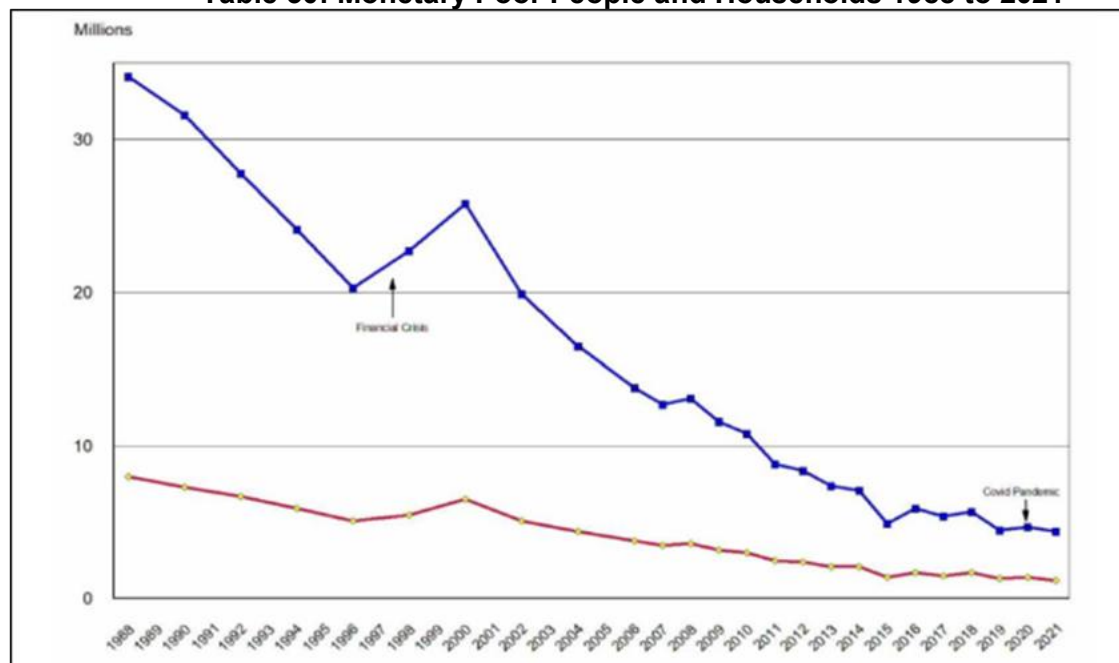
157. The causes of poverty in Thailand are varied, encompassing factors such as illness and disease, accidents, natural disasters (including fires, floods, and droughts), gambling, substance abuse, and domestic violence. Additional contributors to poverty include inadequate education, vocational and financial planning skills, limited investment funds, and poor decision-making. The proposed Project aims to reduce poverty mainly through reduction in economic losses from floods. Specifically, the project will help prevent lower-income and marginal households from slipping into poverty following major flood events, as observed during the 2011 floods.

158. Thailand has made significant strides in reducing poverty, guided by explicit poverty alleviation targets in successive National Economic and Social Development Plans since the 1960s. The national monetary poverty threshold is adjusted annually to account for inflation, rising from THB 579 per person per month in 1988 to THB 2,803 in 2021. Correspondingly, the number of individuals living in poverty declined dramatically from 34.1 million in 1988 to 4.4 million in 2021, while poor households decreased from 8 million to 1.2 million in the same period. However, poverty reduction progress was disrupted during the Asian Financial Crisis (1997–2002) and, more recently, by the COVID-19 pandemic. The latter significantly impacted global supply chains,

production, exports, and imports, and led to substantial revenue losses in Thailand's tourism and service sectors, causing widespread business closures.

159. From 1988 to 2021, poor households in Thailand fell sharply from 8 million to 1.2 million, demonstrating substantial poverty reduction achievements. Despite consistent year-on-year declines, two notable disruptions occurred due to external shocks: the Asian Financial Crisis in July 1997, which led to a 20% devaluation of the Thai Baht, and the COVID-19 pandemic. While poverty rates are presumed to have risen during the pandemic, national economic recovery had notably commenced by 2023/24.

Table 30: Monetary Poor People and Households 1988 to 2021



Source: UNICEF. *Measuring Poverty in Thailand*. March 2024

160. A UNICEF report released in 2024 highlights Thailand's poverty reduction trends using various poverty benchmarks. The analysis compares Thailand's national monetary poverty line against the World Bank's international poverty thresholds, including the extreme poverty line (USD 2.15 per person per day), the lower middle-income country (LMIC) poverty line (USD 3.65 per person per day), and the upper middle-income (UMIC) poverty line (USD 6.85 per person per day). According to the report, extreme poverty in Thailand dropped from 23% in 1981 to zero by 2004. Similarly, the LMIC poverty rate fell from 48% in 1981 to zero by 2014, while the UMIC poverty rate significantly decreased from 77% in 1981 to 12% by 2021.

Table 31: Annual Poverty Rate Reduction

Year	Poverty Rate	Increase/Decrease
2018	15.6	-0.5 from 2017
2019	13.1	-2.5% from 2018
2020	13.2	-0.1% from 2019
2021	12.2%	-1% from 2020

Source: UNICEF, 2024

161. Since the 1960s, Thailand's development has been guided by National Economic and Social Development Plans, which have included specific poverty reduction targets. The current (Thirteenth Plan from 2023 to 2027) has a focus on improving the opportunities and outcomes of about 600,000 intergenerational poor households, to eradicate intergenerational poverty in Thailand by 2027.

162. Provincial Poverty Rates in 2024. According to NESDB data, the national poverty rate dropped from 6.32% in 2021 to around 5.3% in 2023. There are, however, considerable regional disparities. The South, Northeast, and North regions have the highest poverty rates. Specifically, 9.3% of people in the South, 7.81% in the Northeast, and 6.8% in the North live in poverty. The top 10 provinces with the highest poverty rates are: Mae Hong Son, Pattani, Tak, Narathiwat, Kalasin, Nong Bua Lamphu, Yala, Si Sa Ket, Chai Nat, and Ranong. Six provinces (Mae Hong Son, Narathiwat, Kalasin, Pattani, Tak, and Si Sa Ket) have faced persistent poverty over the years with little reduction. The rates below (Table 32) indicate the percentage of the population living below the poverty line in provinces affected by Chao Phraya flooding.

Table 32: Poverty Rates in the Project Area and Regions

Province in Project Area	Poverty Rate (%)	Region	Poverty Rate
Bangkok	1.4	Northeast	7.8
Nakorn Nayok	1.3	South	9.3
Samut Prakan	1.4	North	6.8
Ayutthaya	1.1	Central	2.5
Saraburi	1.6	Bangkok	1.4
Pathum Thani	0.9		
Phra Nakhon Si Ayutthaya	1.1		

Source: Thai People Map and Analytics Platform (TPMAP) - NESDC – Dec 2024

163. The Northeast and Southern regions exhibit the highest poverty rates, while the Central region and Bangkok experience significantly lower poverty levels. This disparity can largely be attributed to prolonged political instability in the South and a heavier reliance on agriculture in both the Northeast and South compared to other regions. Regions with more diverse economies, encompassing services, manufacturing, industry, and tourism, benefit from multiple economic drivers. Additionally, recurrent drought conditions in the Northeast significantly affect agricultural productivity and income stability, contributing further to regional poverty.

3. Fertility

164. Mahidol University's estimates indicate that, as of July 2024, Thailand's population reached approximately 65.87 million, with females representing 51.88% of the total population. Key gender-related demographic indicators are summarized in Table 33.

Table 33: Natality Rates for Thailand

Crude birth rate (per 1,000 population)	6.7
Crude death rate (per 1,000 population)	9.1
Infant mortality rate (per 1,000 live births)	7.3
Child mortality rate (under 5 yrs per 1,000 live births)	10.5
Total fertility rate (average number of children a woman has throughout reproductive years)	1

Contraceptive prevalence rate (rate of currently married women aged 15-49 using contraception).	73
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Source: Mahidol University's Institute for Population and Social Research 2024

4. Education

165. Education has significantly contributed to poverty reduction in Thailand, with substantial improvements observed over the past five decades. In 1950, approximately 40% of men and 60% of women had no formal education. By 2000, the average years of schooling were 6.3 years for men and 5.9 years for women. This educational gap narrowed significantly by 2010 and was nearly eliminated by 2015, with men averaging 8.8 years and women 8.7 years of schooling. According to Mahidol University's 2024 data.

166. Lower Secondary Education Completion Rate: Girls had a completion rate of 131.7%, while boys had 130.3%. Rates exceed 100% due to the inclusion of individuals who completed schooling beyond the typical age range.

167. Adult Literacy Rate: 95.5% for women and 92.8% for men.

5. Local Socio-Economic Systems and Receptors

168. Most of the project area is within agricultural production including aquacultural activities, and this is reflected in land use patterns along the canals. Appendix 1 provides an overview of land use within a 100 m area each side of the canal centerline and main features along each of the canals where works will take place.

V. ANTICIPATED IMPACTS AND MITIGATION MEASURES

A. Environmental Audit of Existing Facilities or Associated Facilities

169. ADB SPS defines that when a project involves existing activities or facilities, environmental audit should be undertaken to determine the existence of any areas where the project may cause or is causing environmental risks or impacts. ADB SPS also defines that the area of influence of any project may encompass associated facilities that are not funded as part of the project and whose viability and existence depend exclusively on the project and whose goods and services are essential for the successful operation of the project. With these definitions, the existing canals and regulators are considered as existing facilities relative to the project. Therefore, environmental audit has been undertaken to determine whether the actions and activities pertaining to operation of these facilities were in accordance with ADB safeguard principles and requirements, and to identify and plan for appropriate measures to address outstanding compliance issues. Based on interview with RID, these existing facilities do not require any permits to operate. Site visits to sample alignments indicate minor but important environmental safeguard issues that need to be addressed by RID and ensure these are addressed. In particular, the environmental audit highlights critical deficiencies in siltation control, aquatic vegetation management, and waste disposal that compromise hydraulic efficiency, and compliance with the ADB SPS principles. Minor corrective actions are therefore required to bring operations into full compliance and ensure long-term sustainability. Specifically, RID should establish a scheduled desilting program to ensure full canal coverage; expand the use of mechanical water hyacinth removal boats and introduce biological control agents to reduce regrowth; and implement segregation facilities to separate vegetation from plastics and domestic waste, with composting or reuse of biomass and proper disposal of residual solid waste. At dam regulator gates, more

floating waste barriers should be installed upstream and routine cleaning schedules enforced to maintain uninterrupted water flow. By implementing these corrective measures within defined timelines and monitoring frameworks, RID will not only achieve safeguard compliance but also enhance climate resilience, operational sustainability, and community participation, ensuring that modernization investments proceed on a sound and environmentally responsible foundation. The full environmental audit report is in Appendix 6.

B. Impact Prediction and Assessment

170. Environmental impact assessment is the systematic identification and evaluation of the potential impacts (effects) of proposed projects, plans, programs, or legislative actions relative to the physical, chemical, biological, cultural, and socioeconomic components of the total environment. The primary purpose of this assessment process is to encourage the consideration of the environmental issues in planning and decision making and to ultimately arrive at actions that are more environmentally compatible.²⁰

171. Impact assessment must take account of the nature, scale and duration of effects on the environment, whether such effects are positive (beneficial) or negative (detrimental). It is also imperative that each issue/impact is assessed according to the project stages from planning, through construction and operation to the decommissioning phase. Where necessary, the proposal for mitigation or optimization of an impact is noted. The environmental impact assessment is focused on the following phases of the project namely: (i) pre-construction; (ii) construction phase; and (ii) operation phase. As the project entails development of water supply infrastructures, which will be permanent, decommissioning is not applicable to this specific project.

172. In particular for the project, the project area will require extensive site preparation primarily due to the extensive vegetation clearing, construction of access, and establishing work areas adjacent waterbodies. Other major activities will involve construction of labor camps and temporary facilities, other site preparation works, transport of machinery and ancillaries, storage of equipment and materials for construction, erection of all equipment and machineries, etc. The project-related activities will have diversified impacts on the environment and socio-economic conditions of the local people. Impacts related to these activities occur mostly during the pre-construction and construction phases.

173. Most of the possible impacts are largely construction related and can be addressed through adoption of good engineering practices, good housekeeping, better construction materials management at site, observing health and safety for workers and community people during project implementation. A number of activities with possible impacts on existing environmental settings were identified and their individual mitigation measures to be addressed during construction were indicated. Some of the impacts will be minimized to acceptable levels by following site-specific mitigation measures as required. Damage to properties and risk to occupational and community safety due to vibration from piling activities, noise, dust generation and other nuisance during the day time, clearing of vegetations during site preparation and labor camp induced sanitation and social stress are the most significant impacts of the construction works.

²⁰ Environmental Impact Assessment by Larry W. Canter. McGraw-Hill Publications. 1996.

C. Methodology

174. Potential environmental impacts were identified on the basis of the review and analysis of the primary and secondary data or information and stakeholder consultations, and several field visits to the sites. In order to sketch out the potential impacts posed by the project interventions, it was necessary to single out every activity under the project; thereafter a detailed understanding of the existing environmental and socio-economic settings of the project area was made. The significance of potential impacts was assessed using the criteria and methodology given below.

175. **Impact Magnitude.** All the interventions associated with the project can be grouped into three major types- (i) existing structure and vegetation clearing, (ii) construction of access roads to sites, and (iii) dredging and piling works. All activities will have detrimental impacts on immediate surrounding environment, including the communities surrounding the project sites. The potential impacts of the project have been categorized as major, moderate, minor or negligible based on consideration of the parameters such as: (i) duration of the impact; (ii) spatial extent of the impact; (iii) reversibility; (iv) likelihood; and (v) legal standards and established professional criteria. These magnitude categories are defined in the below Table.

Table 34: Parameters for Determining Magnitude

Parameter	Major	Medium/Moderate	Minor	Negligible
Duration of potential impact	Long term (more than 15 years)	Medium Term Lifespan of the project (5 to 15 years)	Limited to construction period	Temporary with no detectable potential impact
Spatial extent of the potential impact	Widespread far beyond project boundaries	Beyond immediate project components, site boundaries or local area	Within project boundary	Specific location within project component or site boundaries with no detectable potential impact
Reversibility of potential impacts	Potential impact is effectively permanent, requiring considerable intervention to return to baseline	Baseline requires a year or so with some interventions to return to baseline	Baseline returns naturally or with limited intervention within a few months	Baseline remains constant
Likelihood of potential impacts occurring	Occurs under typical operating or construction conditions (Certain)	Occurs under worst case (negative impact) or best case (positive impact) operating conditions (Likely)	Occurs under abnormal, exceptional or emergency conditions (occasional)	Unlikely to occur

Source: ADB training module on prediction of impacts and development of site specific EMPs. 2018.

176. **Sensitivity of Receptor.** The sensitivity of a receptor has been determined based on review of the population (including proximity/numbers/vulnerability) and presence of features on the site or the surrounding area. Each detailed assessment has defined sensitivity in relation to the topic. Criteria for determining receptor sensitivity of the project's potential impacts are outlined in the following Table.

Table 35: Criteria for Determining Sensitivity

Sensitivity Determination	Definition
Very Severe	Vulnerable receptor with little or no capacity to absorb proposed changes
Severe	Vulnerable receptor with little or no capacity to absorb proposed changes or limited opportunities for mitigation.
Mild	Vulnerable receptor with some capacity to absorb proposed changes or moderate opportunities for mitigation
Low	Vulnerable receptor with good capacity to absorb proposed changes or/and good opportunities for mitigation

Source: ADB training module on prediction of impacts and development of site specific EMPs. 2018.

177. **Assigning Significance.** Following the determination of impact, magnitude and sensitivity of the receiving environment or potential receptors, the significance of each potential impact has been established using the impact significance matrix shown below in the table.

Table 36: Significance of Impact Criteria

Magnitude of Potential Impact	Sensitivity of Receptors			
	Very Severe	Severe	Mild	Low
Major	Critical	High	Moderate	Negligible
Medium	High	High	Moderate	Negligible
Minor	Moderate	Moderate	Low	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Source: ADB training module on prediction of impacts and development of site specific EMPs. 2018.

D. Summary of Impacts

178. The project's potential impacts on the key environmental parameters have been assessed and their significance determined using the methodology described above. A summary of the potential impacts of the project on the key environmental parameters and significance of these impacts are presented in the following table.

Table 37: Summary of the Potential Impacts of the Project

Potential Impacts	Duration of Impact	Spatial Extent	Reversible or not	Likelihood	Magnitude	Sensitivity	Significance Prior to Mitigation	Significance after Mitigation
Design/Pre-Construction Phase								
Impacts due to climate change	Long term	Local	Yes	Certain	Major	Severe	High	Low
Impacts due to loss of vegetation or trees	Long term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Sources of Materials	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Loss or damage to environmentally sensitive areas	Long term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Conflict on land use	Short term	Local	Yes	Unlikely	Negligible	Low	Moderate	Negligible
Disruption of Utilities/services	Short term	Local	Yes	Certain	Negligible	Low	Moderate	Negligible
Physical and Cultural Heritage	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Exposure to ACM	Long term	Local	Yes	Likely	Medium	Mild	Moderate	Negligible
Social conflicts due to displacement of communities	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Indiscriminate disposal of dredged materials	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Damage of properties due to vibration	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Impacts Due to Construction Camps	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Impacts Due to Temporary Facilities	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Construction Phase								

Potential Impacts	Duration of Impact	Spatial Extent	Reversible or not	Likelihood	Magnitude	Sensitivity	Significance Prior to Mitigation	Significance after Mitigation
Construction Camps, Stockpile Areas and Storage Sites	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Noise Pollution and Vibration	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Air and dust pollution	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Dislocation or involuntary resettlement of people	Long term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Surface Water Quality	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Groundwater Quality	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Soil Erosion and Sediment Mobilization	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Socio-economic status-loss of livelihoods	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Socio-economic status-employment	Short term	Local	Yes	Certain	Minor	Mild	Positive	Positive
Community health and safety	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Occupational health and safety	Short term	Local	Yes	Certain	Major	Severe	High	Negligible
Operation and Maintenance Phase								
Deteriorated environmental conditions after civil works	Short term	Local	Yes	Certain	Medium	Mild	Moderate	Negligible
Operation and Maintenance Phase								
Health and safety of workers and communities	Short term	Local	Yes	Likely	Medium	Mild	Moderate	Negligible

E. Anticipated Impacts and Mitigation Measures During Design Phase and Pre-Construction Phase

1. Climate Change

179. **Impact.** Unprecedented flooding and other natural catastrophic events due to climate change could destroy the project infrastructures.

180. Mitigation Measures.

- (i) Ensure design is based on the basic hydraulic principles of designing the rehabilitation works on canals, taking into consideration the impact of climate change over the long term. This includes proper estimation of volumetric flows during various seasons that will accommodate the expected throughput, and other hydrologic and hydraulic design requirements;
- (ii) Use of construction materials that could withstand potential stresses during extreme events, temperatures, pressures, etc.; and
- (iii) The structural designs of the infrastructures shall be able to withstand possible seismic events that may happen in the future.

2. Loss of vegetation or trees

181. **Impact.** Prior to any dredging or piling activities, the project will need to clear the vicinity of the work areas, which could lead to loss of vegetation or trees.

182. Mitigation Measures.

- (i) Avoid removal of vegetations to extent possible. If unavoidable, ensure to conduct pre-works survey to record vegetations that will be removed. Plan translocation of trees or vegetations, if possible.
- (ii) If the tree cutting is extensive for the entire project, develop and implement a tree plantation program that could replace all trees that will be cut.

3. Conflict of Land Use

183. **Impact.** The implementation of the project could lead to conflict on land use associated with the development of new access roads and the surrounding lands.

184. Mitigation Measures.

- (i) Select road alignments that avoid ecologically sensitive areas, densely populated zones, and culturally significant lands.
- (ii) Coordinate with local authorities to align road development with existing land use plans and avoid overlapping or incompatible uses.
- (iii) Establish green belts or buffer zones between roads and residential/agricultural areas to reduce noise, pollution, and encroachment.
- (iv) Conduct early and continuous engagement with affected communities to understand land use patterns and concerns.
- (v) Involve local stakeholders in decisions about land access, compensation, and resettlement.

4. Disposal Sites

185. **Impact.** The project is expected to generate significant amounts of dredged materials and waste vegetations during construction phase due to dredging and clearing activities. Assuming no other uses for excess spoils, their indiscriminate or unmanaged disposal will negatively impact the environment, such as siltation and clogging of canals, damage to paved roads, and safety to pedestrians and community as a whole. The same fate could happen to the waste vegetations if not managed properly at the sites.

186. **Mitigation Measures.** PIU to ensure that:

- (i) Immediately after award of contract and prior to any civil works, contractor will identify a location for the temporary disposal of dredged materials that will be generated during the construction phase. This temporary storage area needs to be approved by the PIU. No civil works shall commence until the temporary disposal location is identified and any relevant clearance required is obtained.
- (ii) Based on the results of sampling of excavated soil, identify the permanent disposal site following the requirements of the sediment management plan developed under the project.

5. Source of Materials

187. **Impact.** Extraction of construction materials that will be used for the project (cement, sand, aggregates) can disrupt natural land contours and vegetation at the source sites resulting in accelerated erosion, disturbance in natural drainage patterns, ponding and water logging, and water pollution.

188. **Mitigation Measures.** PMU and PIU will guide the contractor in minimizing the use of non-renewable resources and rock-based materials. The contractor will be responsible for:

- (i) Sourcing construction materials, including aggregates, etc., from legitimate suppliers authorized by the government;
- (ii) Avoiding any form of quarrying activities; and
- (iii) Maintain a construction material register at the site.

6. Shifting of Utilities

189. **Impact.** Disturbance of services due to shifting of utilities (electric poles, wires, water pipes, etc.). In some alignments, utilities such as electric poles, electrical wires, water pipes, etc. may be disturbed or damaged during the construction works. Any damage to these utilities will disrupt the daily lives and livelihood activities of the people affected. The potential impacts arising from disruption and damage to public utilities are summarized in following table.

Table 38: Potential Impacts of Disruption to Public Utilities

Disrupted or Damaged Utility	Potential Impacts
Electricity Posts and Cables	Interruption of electric supply
	Personal injury due to electrocution
	Cost of Repair/Delay to Works
Water Pipelines	Interruption of water supply
	Cost of Repair/Delay to Works
Telephone and/or Internet Cables	Interruption of communication system
	Cost of Repair/Delay to Works

190. **Mitigation Measures.**

- (i) PMU to ensure all planning and design interventions and decisions are made in consultation with local communities and reflecting inputs from public consultation and disclosures
- (ii) With approval from PIU, contractor shall liaise with each of the agencies

responsible for the maintenance of utilities that are to be crossed, temporarily diverted or otherwise affected by the works as to the timing and nature of any disruption of service. Where required, the responsible agency shall be requested by PIU to carry out the necessary works at the time required and at PIU cost. The tender documents shall contain sufficient information on utilities at the sites to permit the Contractor to include the cost of the works for which it is responsible in the bid.

7. Physical Cultural Resources

191. **Impact.** The alignments of the project pass through near or adjacent locally important cultural heritage site and structures such as temples (Wat), other religious places, spirit houses, etc. Damage to these physical cultural resources (PCRs) could create conflict with the local people and the government as a whole.

192. Mitigation Measures.

- (i) Avoid construction activities in or near PCRs. If cannot be avoided, consult with relevant authorities such as the National Office of Buddhism, the Abbot and local communities surrounding or hosting the PCR.
- (ii) In unavoidable cases, and in consultation with the relevant authorities, conduct assessment if deemed warranted depending on the scale or scope of project activities and sensitivity of PCRs. Engage the support of PMCSC PCR experts if necessary to execute the assessment.
- (iii) Develop “chance find” procedures that include a pre-approved management and conservation approach for materials that may be discovered.

8. Asbestos-Containing Materials

193. **Impact.** During site visits on sample project alignments, it was determined that there will be structures with asbestos-containing materials, such as asbestos roofings, that will be demolished in order to implement the project. Thus, during the demolition works, there may be instances that these will be dismantled improperly. Handling asbestos-containing materials may result to the generation of asbestos dust and fibers, which could go airborne and harm the workers and the public. When inhaled, asbestos fibers may cause long term health issues such as asbestosis and other lung inflammation and diseases including cancer.

194. Mitigation Measures. PIU will ensure the following:

- (i) Close coordination with the project social safeguards team and demolition contractor (or equivalent) to ensure demolished or recovered materials during project implementation period, which contain ACMs such as asbestos cement roofings shall not be included in the salvageable materials by affected households.
- (ii) Develop and implement an ACM Management Plan (AMP) that includes identification of hazards, the use of proper safety gear, and disposal methods, among others, for all ACMs recovered during the project implementation period.
- (iii) Conduct awareness program on safety during the construction work.
- (iv) Contractor to undertake construction work stretch-wise to control the volume of ACMs recovered, handled and disposed at a given time. This will ensure that all precautionary measures on the proper handling, transport and disposal of ACMs as provided in this EARF and in the AMP are complied with.
- (v) Contractor to follow and adhere to appropriate actions as defined in the AMP.
- (vi) Contractor to maintain records of ACMs per the AMP.

- (vii) Contractor to refer to the instructions in the AMP, or by the Asbestos Expert.

9. Social Conflicts

195. **Impact.** The implementation of the project may lead to various social conflicts arising from displacement of communities, including impacts on poor, women and children, Indigenous Peoples or other vulnerable groups.

196. **Mitigation Measures.** PMU to:

- (i) Avoid land acquisition to maximum extent possible. For potential involuntary resettlement impacts, implement the Resettlement Plan developed under the project following ADB SPS requirements.
- (ii) Identify vulnerable groups early and ensure their meaningful participation in consultations and decision-making.
- (iii) Use local languages, visual aids, and gender-sensitive formats to ensure understanding and inclusion.
- (iv) Provide income-generating support, skills training, and access to credit for displaced or economically affected groups.

10. Vibration

197. **Impact.** Piling works will be undertaken in some areas with surrounding communities and infrastructures, which include houses, commercial buildings, septic tanks, common community properties, temples, and other structures. Potential damage to structures due to vibration may occur.

198. **Mitigation Measures.** Contractor to ensure to undertake the following:

- (i) Structural survey and documentation (photo-video documentation) along the alignments to document that integrity and pre-project conditions of structures that will likely be impacted by the excavation and piling activities.
- (ii) Monitor these structures on a regular basis, and document the same in the presence of the owners or caretakers of structures; and
- (iii) Compensate owners of structures should damage occurs due to the construction activities. Any valid claim for compensation shall be paid by the contractor.

11. Construction Camps or Workers' Accommodation

199. **Impact.** There may be instances that workers will need to stay within or near the construction sites. Contractors would normally provide construction camps or accommodation at these sites. However, the haphazard construction of these camps without basic amenities could result in social stress and eventual degradation of the local environment.

200. **Mitigation.** The Contractor will need to ensure that the camps or accommodations be provided with sanitary amenities at designated areas. In addition to any local regulations, Contractor will need to follow the standards for workers accommodation pertaining to *"Workers' accommodation: processes and standards. A guidance note by IFC and the EBRD" 2009.*²¹ This shall include the development of a plan to manage effluents from construction camps and Contractor's offices, which should be incorporated in the facility designs.

²¹ https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_gpn_workersaccommodation

Contractor may also use the International Labor Organization's Workers' Housing Standards,²²

12. Storage Areas, Laydown Areas and other Project Temporary Facilities

201. **Impact.** Inappropriate siting and planning for any project temporary facilities such as storage areas and laydown areas could damage or degrade the immediate environment.

202. **Mitigation.** The Contractor will need to ensure the following:

- (i) Ensure sites for temporary facilities are approved by the PIU, in close consultation with local government entities;
- (ii) Avoid locating in sensitive zones, near water bodies, wetlands, or in areas that disrupt natural drainage;
- (iii) Ensure sites are clearly marked and confine storage (materials, waste, fuels) to specific, agreed-upon zones, keeping them separate from walkways and emergency routes;
- (iv) Ensure to minimize footprint. Keep bare soil exposure to a minimum and plan deliveries to reduce on-site clutter;
- (v) Ensure site designs and layouts integrate environmental safeguard elements such as, but not limited to, avoidance or prevention of pollution to ambient air quality, noise level, surface water and groundwater quality; and avoidance or minimization of nuisance to communities.

F. Anticipated Impacts and Mitigation Measures During Construction Phase

1. Noise Pollution

203. **Impact.** Elevated noise level at construction sites is a common issue for piling works and other civil works such as site clearing, dredging, including operation of other stationary machines, movement of vehicles for transportation of construction material, and hauling of dredged materials from the construction site. These noise will disturb the communities nearby.

204. **Mitigation Measures.**

- (i) Provide prior information of the scheduled works, particularly to residents in the nearby communities;
- (ii) In residential areas and other areas of night time-sensitive institutions such as hospitals, schedule noisy or otherwise invasive activities during periods of the day which will result in least disturbance;
- (iii) In areas near schools or other areas of daytime-sensitive institutions such as temples and churches, schedule noisy or invasive activities during night time or holidays;
- (iv) Use of high noise generating equipment shall be stopped during night time;
- (v) In unavoidable case of night works (due to local rules) provide prior information to public on work schedule, noisy activities and need to conduct the works at night. Use best construction methods to minimize noise to possible extent;
- (vi) Vehicle horns should not be used unless necessary to avoid untoward incidents or accidents;
- (vii) All vehicles and equipment to be used in construction shall be fitted with exhaust silencers;

²² <https://www.ilo.org/publications/workers-housing>

- (viii) If it is not practicable to reduce noise levels to or below noise exposure limits, post warning signs in the noise hazard areas. Maintain maximum of noise level of 45 dB(A) at the nearest residence relative to the specific worksite;
- (ix) Conduct noise level monitoring. Ensure to conduct monitoring when construction activities are at peak. Important areas to test are at locations nearest the community residents and construction camp, if any;
- (x) If using generators, use generator set with capacity just enough for the electricity needs at night;
- (xi) Ensure generator set complies with the noise standards; and
- (xii) Ensure generator set has acoustic enclosure and silencer (if necessary) in the exhaust muffler.

2. **Vibration**

205. **Impact.** Piling works and the passage of construction heavy equipment are the primary sources of vibration from the project. The vibration will have the tendency to affect nearby structures depending on their integrity.

206. **Mitigation Measures.**

- (i) Employment of piling techniques with minimum vibration impacts;
- (ii) Based on the results of pre-works survey, identify all locations with structures that may be structurally weak and monitor all piling works in these locations. Avoid use of pneumatic drills or operating heavy equipment near structures surveyed to be fragile to withstand heavy vibration. Complete work in these areas quickly;
- (iii) Monitor these structures on a regular basis, and document the same in the presence of the owners or caretakers of structures; and
- (iv) Compensate owners of structures should damage occurs due to the piling and other activities. Any valid claim for compensation shall be paid by the contractor, or as may be agreed between contractor and PIU and clarified in contract documents.

3. **Access to Establishments**

207. **Impact.** Construction activities could lead to interference with other utilities and blocking of access to residential establishments and/or commercial buildings.

208. **Mitigation Measures.**

- (i) Identify all critical access points to establishments, if any, prior to executing works;
- (ii) Schedule works in short segments to maintain access to at least one side of the establishment at all times; and
- (iii) Design and communicate temporary detours or bypasses for vehicles and pedestrians.

4. **Dislocation or Involuntary Resettlement of People.**

209. **Impact.** During the construction, there may still be possibilities of dislocation or involuntary resettlement of people that were not identified during the social safeguards survey and planning.

210. **Mitigation Measure.** Develop and implement a resettlement plan in compliance with ADB SPS requirements.

5. Air Pollution

211. **Impact.** Construction activities could cause air pollution in the area due to dust generation and vehicle emissions at the construction sites.

212. Mitigation Measures.

- (i) Use dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles;
- (ii) Use of water suppression for control of loose materials on paved or unpaved road surfaces. Ensure unpaved surfaces used for haulage of materials within settlements are dust-free;
- (iii) Proper covering (e.g. tarpaulin) of hauling equipment such as dump trucks during transport of construction materials or dredged materials;
- (iv) Provide temporary barriers or covers around active excavation or dredging sites;
- (v) Limit vehicles speed at work site to minimize dust being airborne;
- (vi) Prohibit idling of heavy equipment or vehicles for a long time;
- (vii) Regular maintenance of heavy equipment and vehicles to ensure compliance with national vehicle emissions standards;
- (viii) Use modern vehicles and machinery with the requisite adaptations to limit noise and exhaust emissions and ensure that these are maintained to manufacturers' specifications at all times;
- (ix) Use of older vehicles or equipment should ensure that these have valid permits at all times (permits are assumed to ensure the vehicles or machines are in compliance with the relevant vehicle emission standards);
- (x) Prohibit burning of any liquid or solid wastes;
- (xi) Ensure all generator sets and ventilation systems installed at work sites are functioning efficiently. Undertake daily inspection of components when possible and institute immediate repairs for either minor or major issues;
- (xii) Conduct regular visual inspections to identify and address other potential sources of dust emissions; and
- (xiii) Conduct ambient air quality monitoring at strategic locations. Ensure that sampling locations are based on the wind and dust/smoke dispersion direction at the site. Should results of sampling show values exceeding the required limits, ensure that all mitigation measures are in place and effectively implemented. Frequency of implementing dust suppression measures should also be intensified.

6. Soil Erosion/Landslide and Silt Runoff

213. **Impact.** Road blocking and temporary flooding due to excavation during rainy season, resulting to continuing soil erosion/silt runoff in or near construction sites

214. Mitigation Measures.

- (i) As much as possible, conduct of excavation, dredging and piling activities during dry season;
- (ii) Measures to minimize soil erosion/silt runoff to be incorporated when conducting earthworks during monsoon season;
- (iii) Bioengineering will be carried out in disturbed areas especially in project access roads;
- (iv) Disposal sites will be compacted and consistent with the relevant requirements in the sediment management plan developed for the project; and
- (v) Appropriate drain structures and slope protection structures such as revetment walls, retaining walls benches or terraces, riprap and spurs will be made to retain unstable soil masses.

7. Surface Water Pollution

215. Impact. Construction activities could lead to contamination of surface water bodies and land due to release of chemicals, such as fuels and lubricants, from sites.

216. Mitigation Measures

- (i) Prioritize re-use of excess spoils and materials in construction activities, provided that these do not contain hazardous substances beyond the standards. Take all precautions to prevent entering of wastes into streams, watercourses, fisheries ponds or irrigation systems;
- (ii) Manage solid waste according to the following preferred hierarchy: reuse, recycling and disposal to designated areas;
- (iii) Provide drainage systems around excavation areas to prevent soil erosion and siltation into the canals;
- (iv) Water from excavation activities should be pumped and drained towards settling ponds and drained through overspill to ensure settling of sediments.
- (v) Minimize civil works activities during monsoon season;
- (vi) Stop excavation activities during sudden heavy downpour or rains, especially for works adjacent the canals;
- (vii) Store excavated soils/spoils at least 100 meters from the edge of the river or any receiving body of water. If this distance cannot be met due to unavailability, any storage area for spoils should ensure all design and engineering measures are in place to prevent soil erosion. However, selected sites should not be disturbing or blocking the natural flow of any waterbody;
- (viii) Store fuel, oil and other chemicals in secure, managed areas with lined impervious floors and bunded with 110% volume.
- (ix) Allow refueling at designated areas only, which should be situated at least 100 meters from residential areas and edge of any receiving body of water. If this distance cannot be met due to unavailability, designated area should have appropriate design and engineering measures to prevent seepage and runoff to the receiving body of water;
- (x) Provide adequate facilities at construction camps to ensure no indiscriminate dumping of liquid and solid wastes happens;
- (xi) Institute good housekeeping practices at work sites and construction camp sites;
- (xii) Conduct water quality monitoring at the upstream and downstream portions of affected receiving bodies of water, in accordance with the monitoring plan; and
- (xiii) Compact and stabilize disturbed areas as soon as works are completed in such areas. For the construction of new roads, compact and stabilize the alignment as soon as final grading is completed.

8. Land, Soil and Groundwater Pollution

217. **Impact.** Leakages from the storage and handling of fuel, oil, and other chemicals at construction sites and domestic wastes at the construction camps could pollute the land, soil and groundwater.

218. Mitigation Measures.

- (i) Store fuel, oil and other chemicals in secure, managed areas with lined impervious floors and bunded with 110% volume;
- (ii) Ensure refueling area has lining to avoid seepage of unavoidable spills during refueling. Ensure to clean up spills immediately and all used cleaning materials are disposed properly; and
- (iii) Ensure to provide appropriately designed temporary toilets with septic tanks in construction camps.

9. Traffic

219. **Impact.** Vehicle movements due to the project activities will increased road traffic and may require road closures at times around the project sites. This will create traffic congestions in the area.

220. Mitigation Measures.

- (i) Prepare traffic management plan.
- (ii) Communicate the traffic management plan to the public (road users) and communities.
- (iii) Ensure contractors have the obligation to restore damaged roads. Contracts should have sufficient financial provisions for road restoration

10. Social Conflicts

221. **Impact.** During construction period, social conflicts may arise between construction workers from other areas and community workers.

222. Mitigation Measures.

- (i) Employ labor force from local communities to maximum extent possible
Restrict activities and movement of staff and workers only within designated construction areas.

11. Community Health and Safety

223. **Impacts.** Numerous threats could be encountered in the vicinities of the projects, including storage camps or yards and workers' camps. Easy access by pedestrians, animals, and other community people to the sites could expose them to these threats, such as the dangers due to moving heavy equipment or electrocution at the sites. There may also be risk of accidental fall of these community people or animals in excavated areas.

224. In case of communicable diseases, there is a serious threat of spreading them in the communities surrounding the project sites due to interaction of Contractor's staff and construction workers with the locals. This can lead to possible loss of human lives.

225. **Mitigation.** Contractor will need to implement the following measures:

- (i) Appoint full time EHS officer per contract requirement;
- (ii) Install signages, warning signs, warning tapes, hard barricades, and notices around the work site perimeter to avoid unauthorized entry. For excavated sections that cannot be isolated or enclosed due to access issues for the community or residents, ensure to cover these with steel planks or durable wood planks during off-work hours. If during work hours that these excavated sections, especially the deep trenches, cannot be covered entirely, provide steel planks or durable wood planks with handrails that can be used by pedestrians;
- (iii) Install sturdy fence around storage camps or yards and workers' camps;
- (iv) Assign guards around the project sites, including storage camps or yards and workers' camps, on a 24/7 basis;
- (v) Provide lighting all around the project site, including storage camps or yards and workers' camps, to ensure the perimeter is well-lit at nighttime;
- (vi) Follow a code of construction practice, which should include restricting workers in designated areas, no open defecation, no littering, no firewood collection, no setting of fire except when needed but in designated places, no trespassing, no unauthorized overstaying at construction sites, and no obligation to undertake potentially dangerous work without the use of proper personal protective equipment, among others;
- (vii) Follow international best practices on community health and safety such as those in Section 4.3 of World Bank EHS Guidelines on Construction and Decommissioning Activities;²³ The community health and safety plan shall ensure the following:
 - a. implement risk management strategies to protect the community from physical, chemical, or other hazards associated with sites under construction and decommissioning;
 - b. restricting access to the site, through a combination of institutional and administrative controls, with a focus on high risk structures or areas depending on site-specific situations, including fencing, signage, and communication of risks to the local community;
 - c. removing hazardous conditions on construction sites that cannot be controlled affectively with site access restrictions, such as covering openings to small confined spaces, ensuring means of escape for larger openings such as trenches or excavations, or locked storage of hazardous materials; and
 - d. implement measure to prevent proliferation of vectors of diseases at work sites;
 - e. adequate space and lighting, temporary fences, shining barriers and signage at active work sites;
 - f. contractor's preparedness in emergency response;
 - g. adequate dissemination of GRM and contractor's observance and implementation of GRM; and
 - h. upon availability, local people should be given an opportunity for work in the project activities;
- (viii) Follow international best practices on traffic safety such as those in Section 3.4 of the World Bank Environmental Health and Safety (EHS) Guidelines on

²³ IFC World Bank Group. 2007. <https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-construction-and-decommissioning-en.pdf>

Community Health and Safety;²⁴ The community health and safety plan should include the following:

- a. Adoption of best transport safety practices across all aspects of project operations with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public. Measures should include:
 - Emphasizing safety aspects among drivers;
 - Improving driving skills and requiring licensing of drivers;
 - Adopting limits for trip duration and arranging driver rosters to avoid overtiredness;
 - Avoiding dangerous routes and times of day to reduce the risk of accidents;
 - Use of speed control devices (governors) on trucks, and remote monitoring of driver actions;
- b. Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure.

Where the project may contribute to a significant increase in traffic along existing roads, or where road transport is a significant component of a project, recommended measures include:

- a. Minimizing pedestrian interaction with construction vehicles;
 - b. Collaboration with local communities and responsible authorities to improve signage, visibility and overall safety of roads, particularly along stretches located near schools or other locations where children may be present. Collaborating with local communities on education about traffic and pedestrian safety (e.g. school education campaigns);
 - c. Coordination with emergency responders to ensure that appropriate first aid is provided in the event of accidents;
 - d. Using locally sourced materials, whenever possible, to minimize transport distances. Locating associated facilities such as worker camps close to project sites and arranging worker bus transport to minimizing external traffic; and
 - e. Employing safe traffic control measures, including road signs and flag persons to warn of dangerous conditions.
- (ix) Follow the established community and occupational health and safety protocol on emerging infectious diseases;
 - (x) Maintain a complaint logbook at the site and take action promptly of complaints;
 - (xi) Schedule transport and hauling activities by avoiding peak traffic periods;
 - (xii) Clean wheels and undercarriage of haul trucks prior to leaving construction sites;
 - (xiii) Educate drivers and advice to limit speed between 20-25 km/h while traversing settlement areas and avoid use of horn unless necessary to prevent accidents; and
 - (xiv) Earmark parking place for construction equipment and vehicles when idling; no parking shall be allowed on the roads, that may disturb the traffic movement.

²⁴ IFC World Bank Group. 2007. <https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-community-health-and-safety-en.pdf>

12. Occupational Health and Safety

226. **Impacts.** Health risks and safety problems for workers are concerns in all construction projects. Safety risks and health issues arise from storage, handling and transport of hazardous construction material. Health hazard is also significant due to exposure of workers to drainage silts or soils that could be contaminated with hazardous elements such as heavy metals and pathogens. Construction workers are also at risk of accidents due to moving vehicles, and other construction related activities. Workers are also exposed to high level of pollution from dust, exhaust of vehicles and machinery, and noise. Further, extended working hours of workers could lead to risk of accidents due to fatigue.

227. Given the experience with COVID-19 pandemic, concern is high for the site workers' safety and health. Clustering and gathering of workers can easily trigger spread of diseases. Such a situation is dangerous and could potentially lead to loss of human lives. The health risk is also very high within the construction camps due to possibility of high density and unhygienic living conditions.

228. **Mitigation.** The Contractor will need to implement its health and safety protocols approved by PMU. This will contain normal internationally accepted procedures in relation to the risks imposed by the nature of the work to be undertaken, including risks associated with emerging infectious diseases. The Contractor shall ensure all authorized persons present on all sites, be they Contractor staff, representatives of the implementing agency or the construction manager, or other visitors, are aware of any site-specific safety requirements and are supplied with hard hats and other protective clothing appropriate for the work being undertaken, including other precautionary measures against airborne diseases.

229. In particular, the Contractor shall implement the following mitigation measures:

- (i) Appoint full time EHS officer per contract requirement;
- (ii) All relevant provisions of the local labor laws and relevant WHO guidelines will be adhered to, concerning the provision of adequate measures to avoid contracting and/or spreading diseases during construction phase;
- (iii) Follow international best practices on occupational health and safety such as those in Section 4.2 of World Bank EHS Guidelines on Construction and Decommissioning Activities,²⁵ which include the following elements, whichever are applicable:
 - a. Communication and Training
 - i Training of all workers on occupational health and safety prior to construction works;
 - ii Conduct of orientation to visitors on health and safety procedures at work site;
 - iii Signages strategically installed to identify all areas at work site, including hazard or danger areas;
 - iv Proper labeling of equipment and containers at construction and storage sites; and
 - v Suitable arrangements to cater for emergencies, including: first aid equipment; personnel trained to administer first aid; communication with, and transport to, the nearest hospital with an accident / emergency department; monitoring equipment; rescue equipment; firefighting equipment; and

²⁵ IFC World Bank Group. 2007. [*Environmental, Health, and Safety \(EHS\) Guidelines – General EHS Guidelines: Construction and Decommissioning.*](#)

- vi communication with nearest fire brigade station;
- b. Physical Hazards
 - i. Use of personal protective equipment (PPE) by all workers such as earplugs, safety shoes, hard hats, masks, goggles, etc. as applicable, including specific use of appropriate gumboots, gloves and other PPEs when handling and transporting silts and soils excavated from canals, and ensure these are used properly;
 - ii. Avoidance of slips and falls through good house-keeping practices, such as the sorting and placing loose construction materials or demolition debris in established areas away from foot paths, cleaning up excessive waste debris and liquid spills regularly, locating electrical cords and ropes in common areas and marked corridors, and use of slip retardant footwear;
 - iii. Use of bracing or trench shoring on deep excavation works;
 - iv. Adequate lighting in dark working areas and areas with night works;
 - v. Rotating and moving equipment inspected and tested prior to use during construction works. These shall be parked at designated areas and operated by qualified and trained operators only;
 - vi. Specific site traffic rules and routes in place and known to all personnel, workers, drivers, and equipment operators; and
 - vii. Use of air pollution source equipment and vehicles that are well maintained and with valid permits;
- c. General Facility Design and Operation
 - i. Regular checking of integrity of workplace structures to avoid collapse or failure;
 - ii. Ensuring workplace can withstand severe weather conditions;
 - iii. Enough work spaces available for workers, including exit routes during emergencies;
 - iv. Fire precautions and firefighting equipment installed;
 - v. First aid stations and kits are available. Trained personnel should always be available who can provide first aid measures to victims of accidents;
 - vi. Secured storage areas for chemicals and other hazardous and flammable substances are installed and ensure access is limited to authorized personnel only;
 - vii. Good working environment temperature maintained;
 - viii. Worker camps and work sites provided with housekeeping facilities, such as separate toilets for male and female workers, drinking water supply, wash and bathing water, rest areas, and other lavatory and worker welfare facilities; and
 - ix. Maintain records and make reports concerning health, safety and welfare of persons, and damage to property. Take remedial action to prevent a recurrence of any accidents that may occur.
- (iv) Follow established occupational health and safety protocol on emerging infectious diseases;
- (v) Provide regular health check-ups, sanitation and hygiene, health care, and control of diseases for the workforce;

- (vi) Provide at cost all labor and materials and construct/install and maintain site safety, hard barricading, flexible green net, signboards, and lightings throughout the construction site;
- (vii) Launch awareness programs concerning human trafficking and the possibility of spread of sexually transmitted diseases (STDs) and HIV/AIDS using brochures, posters, and signboards;
- (viii) Make available ambulance facility at the construction site and camp site, if any;
- (ix) Compensation for the loss of life (a zero tolerance to loss of life policy should be developed and implemented) or for any type of injuries; and
- (x) Provide insurance to the workers. Health and safety training for all site personnel is very important and must be mandatory.

13. Terrestrial Flora and Fauna Resources

230. **Impacts.** While the critical habitat screening and results of site visits show no likely presence of endangered and critically endangered species per IUCN Red List, the construction phase of the project may pose impact to other flora and fauna resources in the immediate vicinity of the sites. Vegetations found along the alignments were determined to be common and abundant species found elsewhere in Thailand.

231. **Mitigation.** The Contractor will ensure that awareness training on environmental safeguards is provided to all construction workers, which will include the following reminders that need to be observed and complied with during the construction period:

- (i) Avoid any cutting of trees and shrubs at the construction site. The spaces are wide enough for any activities without cutting any of the trees or locally important plants, if any;
- (ii) Prohibit use of wood as fuel at construction camp sites, if any;
- (iii) Provide LPG/kerosene to workforce staying at the construction camp sites; and
- (iv) Prohibit the harvest and trade of any plants or poaching of animals found in the area.

14. Socioeconomic Resources

232. **Impact.** Construction works may result in temporary loss of livelihoods and interruption of social and economic activities in some alignments. In areas where there are shops or other commercial activities, these could lose some business if access is difficult for customers.

233. **Mitigation.** The Contractor will ensure the following:

- (i) Adopt the GRM of the project, and respond to grievances;
- (ii) The construction works do not interfere with the convenience of the public or access to, use, and occupation of public or private roads, or any other access to properties, whether public or private.
- (iii) If needed for the convenience of the public, temporary access to properties adjacent to the construction site will be provided through the construction of ramps. Handrails may be provided to ramps or planks depending on the width of excavations;
- (iv) In critical areas such as institutions, operating hours are factored into work schedules and workforce is increased for speedy completion;
- (v) Advance information on works to be undertaken including appropriate signage is provided; and

- (vi) The diversion is done in coordination with the traffic police for necessary rerouting of traffic and traffic management.

G. Post-Construction Impacts and Proposed Mitigation Measures

234. **Impact.** The dismantling and abandonment of temporary sites such as construction camps, storage facilities and work areas could lead to deteriorated environmental conditions and nuisance to the people living in nearby communities.

235. **Mitigation Measures.**

- (i) Develop and implement a post-construction rehabilitation and restoration plan to ensure sites are restored to pre-project conditions or better.
- (ii) Implement an environmentally suitable waste management and disposal for all wastes and debris left at the sites.
- (iii) If necessary, landscaping and revegetation will be undertaken. Any damages to roads caused by the project will be rehabilitated and restored to at least their pre-project conditions as well.

H. Operation Phase Impacts and Proposed Mitigation Measures

236. **Impact.** During the operation phase or when the project is already fully implemented and the flood control system is already completed, there may always be maintenance works to ensure the system functions effectively and efficiently. During these works, risks to the health and safety RID workers and community people will be present.

237. **Mitigation Measures.**

- (i) Implement relevant procedures following schedules and in timely manner. This will ensure all facilities are working properly even during the occurrence of extreme weather events such as heavy rainfall.
- (ii) Develop and implement an emergency response procedure that need to be followed before, during and after extreme weather events.
- (iii) Formalize and implement existing practice of informing affected communities prior to release of irrigation water in the downstream areas.
- (iv) Continue the conduct of meaningful consultations with the affected communities all throughout the O&M period.
- (v) Implement the GRM of the project, and ensure that concerns of stakeholders are addressed early and properly taking into account the welfare of these stakeholders.
- (vi) Ensure that all site personnel have a basic level of health and safety training and protective equipment.

VI. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

A. Consultation and Information Disclosure

238. Meaningful stakeholder consultation and participation is part of the project preparation and implementation strategy. Consultation and participation will ensure information is provided and feedback is obtained and considered on the implementation of the project. Affected persons will be consulted at various stages of project preparation to ensure: (i) incorporation of views/concerns of affected persons, particularly the vulnerable, on environmental impacts and mitigation measures; (ii) identification of any help required by affected persons during

project implementation; and (iii) avoidance of potential conflicts for smooth project implementation.

239. Meaningful consultation will also provide adequate opportunities for participation of all stakeholders and inclusion of the vulnerable in project process. This is also the avenue where relevant information on any major changes to the project will be shared with beneficiaries, affected persons, vulnerable groups, and other stakeholders.

1. Objective and Purpose

240. The objectives of the consultations are to inform the project-affected people about the project, the present status of environmental, social and ecological condition in the area, potential impacts of the proposed project, suggested measures to mitigate these impacts, and at the same time to seek other possible solutions to these impacts from them. The consultations are also an avenue to reduce conflict through the early identification of controversial issues about the project and work with the stakeholders to find acceptable solutions; increase public confidence about the proponent, reviewers and decision makers, and develop a proposal which is truly sustainable which will be integrated into the project design.

2. Summary Consultation Meetings

241. **Consultation Methodology.** The methods to be adopted for consultations are a combination of short introductory speeches, presentation of overall project and project details utilizing photos and maps, and two-way discussions. The use of visual aids and materials enabled the participants to comprehend the issues easily, encouraging them to participate in the discussions more effectively and provide informed comments and opinions. See Appendix 7 for the Stakeholder Engagement Plan.

[insert summary of previous consultations included in the SEP, and attach SEP as appendix]

3. Information Disclosure

242. Preliminary project information was disclosed through the different one-on-one consultations done during field visits. Once the detailed designs of the various components are finalized, the same will be disseminated again, including more formally by making written documents and other materials available in form and at locations which can be easily accessed by stakeholders, such as the RID, PMU and PIU offices. This will also include providing summary reports in the local language and posted at public locations in the affected communities. The aim is to provide wider reach and means for the receipt of comments from the general public. Subsequently, all documents will be disclosed on ADB and RID websites. A copy of this IEE report will also be disclosed on the ADB and RID websites.

B. Future Consultations and Communication Plan

243. Future consultation and disclosure activities shall include the following:

1. Consultations During Construction Phase

- (i) Public meetings with affected communities to present the project design, discuss and plan work programs and allow issues to be raised, if there still any, and addressed once construction has started; and

- (ii) Smaller-scale meetings to discuss and plan construction work with individual communities to reduce disturbance and other impacts, and to provide a mechanism through which stakeholders can participate in project monitoring and evaluation.

2. Information Disclosure

- (i) Public information campaigns (via newspaper, flyers, and media) to explain the project's final detailed design to the wider population of the project area and prepare them for disruptions they may experience once construction is underway;
- (ii) Public disclosure meetings at key project stages to inform the public of progress and future plans, and to provide copies of summary documents in local language;
- (iii) Formal disclosure of completed project reports by making copies available at convenient locations in the project area, and informing the public of their availability; and
- (iv) Providing a mechanism through which comments can be made.

VII. GRIEVANCE REDRESS MECHANISM

244. The PMU will be responsible for establishing and coordinating the project specific grievance redress mechanism (GRM). Hotline for LAR issues, as described in the RF and RPs and will be made fully functional prior to start of construction. The GRM Hotline will ensure grievances of affected people are resolved in a timely manner and trigger remedial action. The GRM comprises a set of clear procedures to receive, record, and address concerns of complaints raised about safeguard issues at all levels with the responsible agency.

245. **RID Hotline.** All complaints are encouraged to be submitted and handled through a single system under the existing RID Hotline for complaints, which will coordinate and direct the complaints to the relevant RID offices, including the government line agencies. The complaints for the Hotline can be received from 10 different channels as detailed below:

Table 39: Channels for Submitting Complaints

No.	Channel	Source
1.	Hotline 1460	Receiving complaints from Hotline 1460, RID's public service, and recording details in the complaint management system.
2.	Letter	Received from the Office of the Secretary, with an electronic reference number, CHP number, and date of receipt.
3.	P.O. Box	From P.O. Box 1460 of the RID and P.O. Box 1111 of the Office of the Prime Minister and received from the complaint system (accessible only by authorized personnel with a code).
4.	Voicemail	Received from the voicemail system of Hotline 1460 during non-office hours.
5.	In Person	Complaints written in the complaint form.
6.	Comment Box	Complaints placed in the comment boxes provided by the RID.
7.	News Report	News clippings from the Public Relations and Publication Division, Office of the Secretary.
8.	Public Forum	Public forum reports.
9.	Mobile Agricultural Clinic	Mobile agricultural clinic reports.
10.	Facebook/Email	Complaints via Facebook: 1460 RID Public Service and Email: callcenter1460@gmail.com and 1460@rid.go.th

246. Any complaint filed or raised through the RID Hotline should be immediately addressed as soon as possible; typical matters that can be resolved immediately should be responded to within 7 working days.

247. **The Damrongtham Center.** In parallel to the RID Hotline, If the complaint is not satisfactorily resolved by the project, the affected person can use existing system in place at the Damrongtham Center, under the Department of Local Administration of the Ministry of Interior (MOI), which serves as a key government GRM for the general public. It handles complaints and grievances submitted by citizens seeking assistance, resolution, or factual investigations related to injustices or illegal activities of any Government agency or organization. APs can visit the local Damrongtham Center in-person to register complaint, or can send an email to moi1567@hotmail.com or call 1568 hotline a 24/7 call center, or access an online database system through a website www.1567.moi.go.th or via application Damrongdham App (MOI1567). To ensure timely resolution, the Damrongtham Center monitors progress and issues reminders when deadlines are missed (after 30 days, 15 days later, and again after 7 more days). Upon conclusion of investigations, findings are submitted, reviewed, and analyzed by the Center before being reported to MOI leadership. Final resolutions are shared with both complainants and referring agencies.

248. **ADB's Accountability Mechanism.** In addition to the project GRM, ADB's accountability mechanism (May 2012) also applies to the project. The accountability mechanism provides opportunities for people that are adversely affected by ADB-financed projects to express their grievances, seek solutions, and report alleged violations of ADB's operational policies and procedures, including safeguard policies. ADB's accountability mechanism comprises (i) consultation led by ADB's special project facilitator to assist people adversely affected by ADB-assisted projects in finding solutions to their concerns and (ii) providing a process through which those affected by projects can file requests for compliance review by ADB's Compliance Review Panel.

VIII. ENVIRONMENTAL MANAGEMENT PLAN

249. This chapter outlines the Environmental Management Plan (EMP) for the project in accordance with the ADB SPS. The EMP is designed to manage the environmental risks associated with the project throughout its design, construction, and operational stages. The EMP provides essential background, context, and guidance for the remainder of the project documentation. The Royal Irrigation Department (RID) will act as the executing and implementing agency for the project.

250. The project focuses on improving sections of the existing flood control and irrigation system as part of a broader initiative led by RID to address severe flooding and ensure sustainable irrigation water supplies. By increasing the hydraulic conveyance capacity of the Raphiphat Canal and downstream systems from 210 m³/s to 400 m³/s through eight sub-projects, the scheme seeks to bolster flood protection, secure and enhance irrigation water availability, and improve social and economic conditions in the Lower Chao Phraya Basin, including Bangkok.

251. The project responds to Thailand's vulnerability to extreme flooding, highlighted by the 2011 disaster that resulted in significant loss of life, widespread displacement, and massive economic impact. With climate change expected to worsen flood risks and droughts, the LECP incorporates climate adaptation and resilience measures, aiming to protect people, infrastructure, agriculture, and industry, while also increasing irrigation capacity during the dry season to support agricultural production.

252. Although the LECP project is exempted from the national Environmental Impact Assessment (EIA) law, it remains subject to the environmental safeguard requirements of ADB and other international lenders. Accordingly, the project must adhere to rigorous environmental standards and management practices as stipulated by these institutions to ensure that potential impacts are properly identified, mitigated, and monitored throughout all project phases.

253. This EMP constitutes a fundamental component of the IEE, ensuring that all environmental safeguards and best practices are systematically applied across every aspect of the project. The scope of the EMP encompasses all works involving civil construction—including but not limited to site clearing, land grading, excavation, foundation preparation, and the installation or rehabilitation of both temporary and permanent project facilities. It explicitly applies to all project zones where contractors or subcontractors operate, regardless of the nature or timing of their activities.

254. The EMP extends to a comprehensive range of facilities and support areas utilized during project execution. These include construction camps and worker accommodations (providing housing, canteen, recreation, and first aid), equipment and vehicle maintenance workshops, vehicle and machinery wash-down bays, storage yards for construction machinery and materials, aggregate and sand stockpiles, concrete and asphalt batching plants, site offices, warehouses, temporary laydown areas, access and haul roads, parking areas for vehicles and equipment, security checkpoints, and designated waste collection and segregation zones. Additionally, the EMP covers sanitation facilities (toilets, showers, laundry), potable water supply and distribution points, stormwater drainage structures, fuel storage and refueling stations, hazardous material storage and handling facilities (such as chemicals and lubricants), temporary fencing and signage, and any other temporary or auxiliary structures erected for project implementation.

255. By addressing all facilities and activities—whether permanent or short-term—the EMP aims to ensure that contractors meet rigorous standards for environmental protection, occupational health and safety, pollution prevention, and community wellbeing throughout every phase of the project.

A. Objectives of the EMP

256. The objectives of the EMP are as follows:

- (i) Provide the project, contractors and sub-contractors with a document which clearly sets out the project agreed processes and measures to manage impacts and risks to the environment and the people, in accordance with the ADB SPS requirements;
- (ii) Provide information on the institutional arrangement for the project implementation of environmental safeguards;
- (iii) EMP Compliance requirements and monitoring;
- (iv) Detailed mitigation measures;
- (v) Environmental monitoring requirements; and
- (vi) Reporting Requirements.

B. Institutional Arrangement

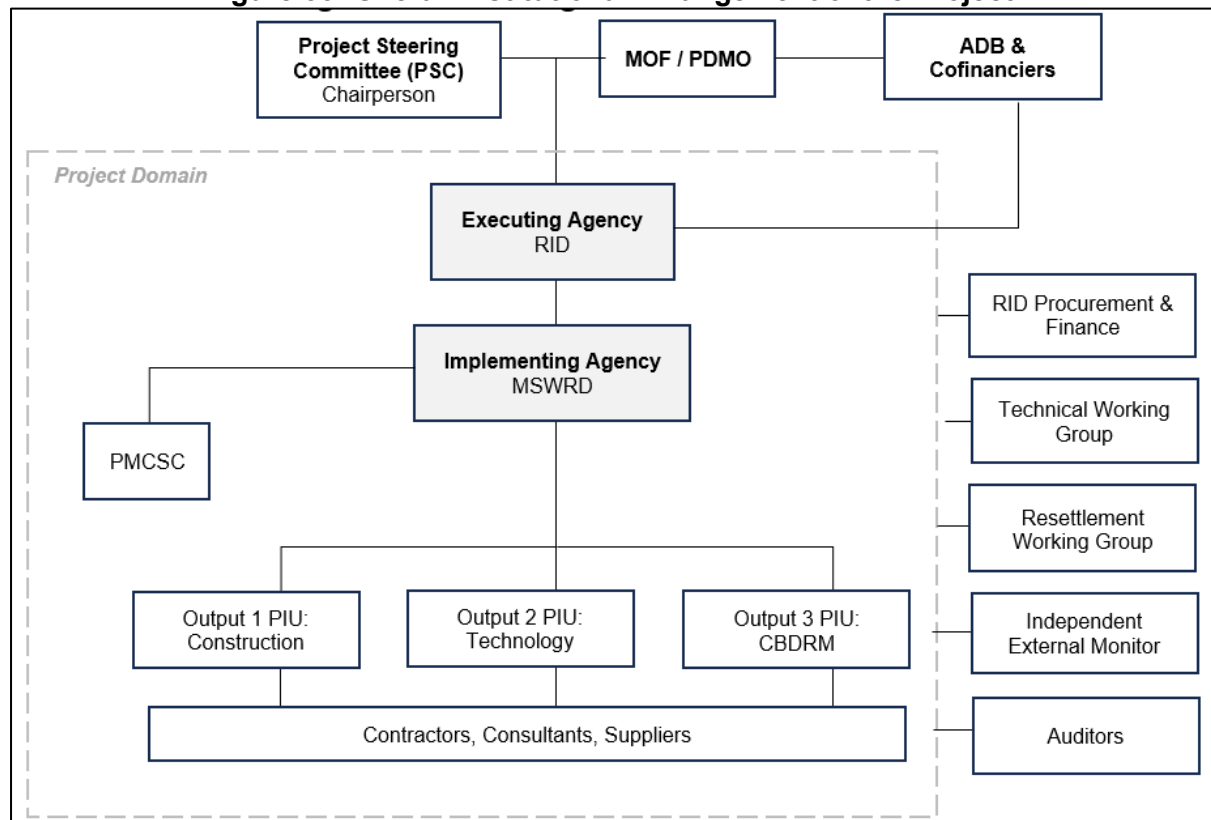
257. The overall institutional arrangement of the project is structured to ensure clear lines of responsibility, effective coordination, and comprehensive oversight across all project phases. A Project Steering Committee, chaired by the permanent secretary for the Ministry of Agriculture and Cooperatives, provides high-level policy and technical direction, drawing on representatives from key ministries, departments, and local communities.

258. The Royal Irrigation Department (RID) acts as the Executing Agency, maintaining ultimate accountability for compliance with national laws, ADB safeguard requirements, and project-specific commitments. Supporting the RID, the Project Management Unit (PMU) leads and coordinates environmental safeguards, regulatory compliance, and reporting, while Project Implementation Units (PIUs) manage on-the-ground activities, community engagement, and monitoring at the project level. This arrangement is further strengthened by the involvement of specialized consultants and a multidisciplinary team structure, ensuring that technical, environmental, and social aspects are integrated throughout the project's lifecycle.

259. The responsibilities include:

- (i) RID will be responsible for assessing projects and their environmental and social impacts, preparing safeguard plans, and engaging with affected communities through information disclosure, consultation, and informed participation following all policy principles and safeguard requirements.
- (ii) RID will submit all required information, including assessment reports, safeguard plans/frameworks, and monitoring reports, to ADB for review.
- (iii) RID will comply with Government of Thailand laws, regulations, and standards, including obligations under international law.
- (iv) RID will implement safeguard measures agreed with ADB to deliver the policy principles and meet the requirements specified in ADB SPS Safeguard Requirements 1–4.
- (v) To ensure that contractors appropriately implement the agreed measures, RID will include the safeguard requirements in bidding documents and civil works contracts.
- (vi) Where national safeguard policies and regulations differ from ADB SPS including Safeguard Requirements 1–4, ADB and RID will formulate and agree on specific measures to ensure that ADB's safeguard policy principles and requirements are fully complied with.

Figure 53: Overall Institutional Arrangement of the Project

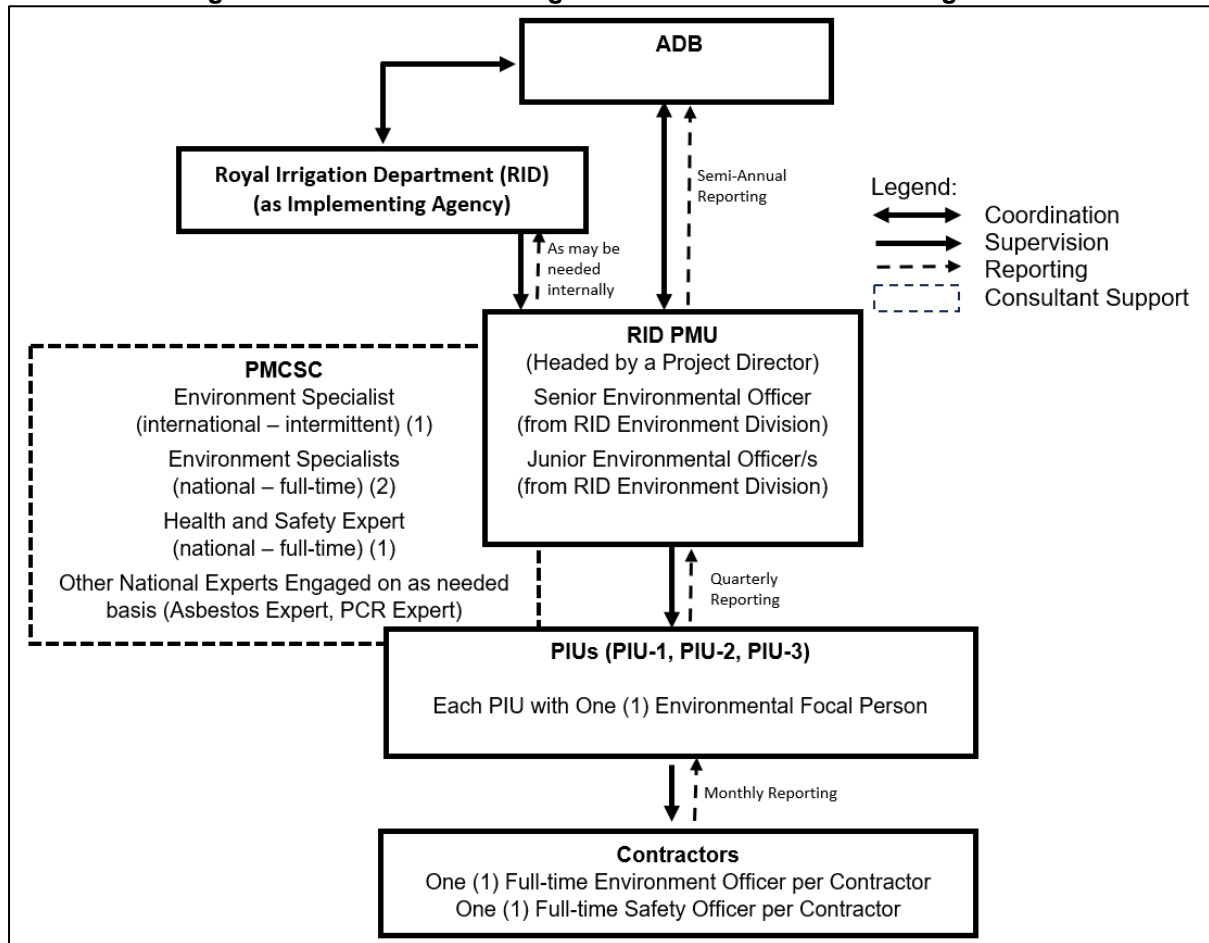


ADB = Asian Development Bank, CBDRM = Community-Based Disaster Risk Management, MOF = Ministry of Finance, MSWRD = Medium Scale Water Resourced Development, PDMO = Public Debt Management Office, PIU = project implementation unit, PMCSC = project management and construction supervision consultant, PMU = project management unit, RID = Royal Irrigation Department

C. Project Management and Implementation Units

260. The Project Management Unit (PMU) and Project Implementation Units (PIUs) play pivotal roles in the successful delivery of the project. The PMU serves as the central coordinating body, overseeing environmental safeguards, regulatory compliance, and reporting at the program level, while the PIUs are responsible for managing on-the-ground activities, engaging with local communities, and ensuring effective implementation and monitoring at the project sites. Together, these units facilitate seamless collaboration, strategic alignment, and comprehensive oversight throughout all phases of the project. Figure 54 shows the implementation arrangement of environmental safeguards.

Figure 54: Institutional Arrangement for Environmental Safeguards



ADB = Asian Development Bank, PCR = physical cultural resources, PIU = project implementation unit, PMCS = project management and construction supervision consultant, PMU = project management unit

261. PMU will be responsible for leading and coordinating environmental safeguards throughout the MFF implementation. This includes conducting environmental assessments, updating the IEE, and ensuring alignment with the EARF, Facility Administration Manual (FAM), and national regulations. The PMU will liaise with government agencies for regulatory compliance, oversee utility shifting and clearance processes during pre-construction, and supervises EMP implementation during construction and operation. The PMU will also monitor environmental performance, support implementation of the GRM, and collaborate with PIUs, PMCS experts, and social safeguards officers to ensure effective environmental oversight and reporting. The detailed responsibilities include:

- (i) Responsible for overall project management during implementation.
- (ii) Review and confirm that the IEE is consistent with the project scope, locations and designs.
- (iii) Update IEE, if needed, for processing of subsequent tranches following the guidelines in the EARF.
- (iv) Ensure that EMP is included in bidding documents and contracts of civil works packages.
- (v) Ensure that the ECOCP is included in bidding documents and contracts of goods packages that will involve installation or small civil works.
- (vi) Ensure that the contractor will comply with the measures and requirements relevant to the contractor set forth in the IEE and EMP, and any corrective or

preventative actions set out in the environmental monitoring reports; make available a budget for all such environmental measures; provide the employer with a written notice of any unanticipated environmental risks or impacts that arise during construction, implementation or operation of the project that were not considered in the IEE or EMP; adequately record the condition of roads, agricultural land and other infrastructure prior to starting to transport materials and construction; fully reinstate pathways, other local infrastructure, and agricultural land to at least their pre-project condition upon the completion of construction; comply with all applicable labor laws and core labor standards on (a) prohibition of child labor as defined in national legislation for construction and maintenance activities; (b) equal pay for equal work of equal value regardless of gender, ethnicity, or caste; (c) allowing freedom of association and effective recognition on the right to collective bargaining; (d) elimination of forced labor; (e) the requirement to disseminate information on sexually transmitted diseases, including HIV/AIDS, to employees and local communities surrounding the project sites, particularly women; submit to PMU, for review and approval, a site-specific environmental management plan (SSEMP) with Site-Specific Health and Safety Management Plan (SSHSMP), including (a) proposed sites/locations for construction work camps, storage areas, hauling roads, lay down areas, temporary and final disposal areas for solid and hazardous wastes; (b) specific mitigation measures following the approved EMP; (c) monitoring program as per EMP; and (d) budget for SSEMP implementation.

- (vii) Approve/clear SSEMPs of contractors. Ensure no works will commence prior to approval of SSEMP.
- (viii) Confirm compliance with applicable government laws, rules and regulations.
- (ix) Ensure timely disclosure of draft, final, and updated IEE in form and language understandable by affected people and other stakeholders.
- (x) Ensure full compliance with safeguard-related provision in loan and financial agreements.
- (xi) Ensure full capacity of safeguards staff on environment health and safety.
- (xii) Resolve complaints brought through the Grievance Redress Mechanism (GRM) that have not been resolved at lower level.
- (xiii) Immediately investigate reported serious or fatal incidents that occur on site, and immediately inform ADB of such incident. Information may be relayed initially through call or via email, and followed by a written formal report within 48 hours of the incident. The report should contain the result of investigation and actions undertaken by the project.
- (xiv) Submit semi-annual environmental monitoring reports to ADB until the project completion report is issued.
- (xv) Approve and sign off in the validation of PMCSC' post-construction environmental audit reports (PCEARs). Suggested outline of PCEAR is in Appendix 13 of the EARF.

262. PIUs will be responsible for environmental compliance and effective safeguards implementation at the project level. PIUs will assist PMU in conducting environmental assessments, updating IEEs, and securing necessary regulatory clearances. PIUs will oversee construction activities, engage with affected communities, participate in grievance redressal, and submit regular monitoring reports to the PMU. Additionally, they contribute to documenting good practices and fulfill all responsibilities outlined in the EARF, FAM and IEE. The detailed responsibilities include:

- (i) Supervise the day-to-day implementation of safeguards at project sites.

- (ii) Supervise environmental management aspects of the construction activities and ensure that SSEMPs are implemented by contractors and aligned with the project EMP.
- (iii) Ensure PMCSC diligently monitor and supervise contractors on the implementation of the SSEMPs.
- (iv) Ensure all environmental monitoring, including instrumental measurements, are undertaken.
- (v) Confirm locations of disposal sites of cleared vegetations and excavated sediments. Ensure locations of disposal sites for excavated sediments comply with the recommendations of the sediment management plan.
- (vi) Confirm locations of all temporary facilities that will be utilized by the project.
- (vii) Disseminate project information through meaningful consultations and by making project documents available at PIU and PMCSC offices or at locations easily accessed by stakeholders.
- (viii) Ensure feedback and suggestions raised during consultations are considered and incorporated in the project implementation design or execution of works.
- (ix) Identify necessary corrective actions to address non-compliances.
- (x) Address any grievances brought about through the grievance redress mechanism (GRM) in a timely manner.
- (xi) Ensure that PMCSC consolidate monthly environmental monitoring reports from contractors.
- (xii) Coordinate with PMU on the conduct of immediate investigation of reported serious or fatal incidents from the contractors.
- (xiii) Ensure that quarterly environmental monitoring reports are prepared and submitted to PMU.

D. Project Consultants

263. For the implementation of environmental safeguards, concerned staff from PMU and PIUs will work together with support from PMCSC. The PMCSC will provide assistance in all aspects of project management and implementation. The responsibilities include:

- (i) Assist PMU in:
 - a. Ensuring EMP requirements are integrated into bidding documents and contracts.
 - b. Ensuring compliance of the project with all environmental safeguard requirements as defined in loan covenants, FAM, and environmental safeguard documents such as EARF and IEE, including Environmental Due Diligence Report of other project components not covered by the IEE (i.e. Output 2 hydromets).
 - c. Providing technical support to PIUs when needed to ensure compliance with safeguard requirements at the community or project site level.
 - d. Overseeing technical studies needed for environmental assessment and update of IEE, including review and approval of results of technical studies.
 - e. Updating IEE in subsequent tranches.
 - f. Liaising with ADB and national environmental agencies.
 - g. Conduct periodic site visits and audits to verify environmental compliance of the project.
 - h. Conduct of meaningful consultations
 - i. Preparing environmental assessment or corrective action plan for unanticipated impacts.
 - j. Ensuring timely resolution of grievances elevated through the GRM at

- the project level.
- k. Investigating reported serious or fatal incidents at project sites, and preparing investigation reports for PMU's submission to ADB.
- l. Review and consolidation of quarterly environmental monitoring reports from PIUs.
- m. Preparation and submission of semi-annual environmental monitoring reports to ADB until project completion report is issued.
- (ii) Provide guidance or support to PIUs on the shifting of utilities and services, including obtaining necessary clearances from the respective government agencies, prior to award of civil works contracts.
- (iii) Organize capacity building activities on environmental safeguards and health and safety through training and seminars for the RID management, PMU and PIU staff, PMCSC, and contractors.
- (iv) Develop manuals, checklists, and other technical documents as may be required to help achieve safeguard compliance during project implementation.
- (v) Review and validate post-construction environmental audit reports of PMCSC.

264. The PMCSC will also support in day-to-day execution of activities at field level and assist the PIUs in:

- (i) Securing local environment-related permits required of the project, if any.
- (ii) Review and approval of SSEMPs of contractors.
- (iii) Managing the day-to-day field-level implementation of environmental safeguard requirements of the project.
- (iv) Supervising contractors to ensure compliance with mitigation measures in SSEMPs and aligned with the EMP.
- (v) Conducting meaningful consultations with the local communities and ensure that feedbacks and environmental concerns/ suggestions are incorporated and implemented in the project.
- (vi) Conducting regular monitoring of project sites based on frequency indicated in the monitoring program.
- (vii) Ensuring timely resolution of grievances elevated through the GRM at the field or site level. If not resolved, escalating the issue to the PMU level.
- (viii) Investigating reported serious or fatal incidents at project sites, and providing relevant information for PMU's preparation of incident reports for ADB.
- (ix) Review and approving monthly environmental monitoring reports from contractors.
- (x) Preparing and submitting quarterly environmental monitoring reports to PMU.
- (xi) Ensuring all temporary facilities are removed by contractors after the construction period, and sites rehabilitated and restored to pre-project conditions or better.
- (xii) Certifying that all environmental obligations of contractors have been fulfilled prior to recommending issuance of final payment to such contractors.
- (xiii) Ensure contractors conduct baseline (pre-works) conditions surveys as part of preparation of their SSEMPs (example: photo or video documentation, instrumental monitoring of environmental parameters, habitats of value, valued trees and vegetation, fauna species, structural and technical condition survey of properties that will be potentially affected by vibration and construction works, etc.).
- (xiv) To support the meaningful consultations, establish one-on-one and informal dialogue with the local people to accommodate their openness during discussions.
- (xv) Review of SSEMPs of contractors and provide recommendation of approval or

- non-approval of such SSEMPs to PIUs.
- (xvi) Monitor and record environmental conditions at sites during construction and post-construction, including conduct of instrumental measurements of environmental quality parameters.
- (xvii) Maintain records of environmental performance of contractors, including register of incidents at project sites based on reports from contractors.
- (xviii) Conduct consultations and disclose environmental safeguard documents such as the EMP, SSEMPs, and other relevant information to local communities.
- (xix) Verify and report occurrence of unanticipated environmental impacts to PIU and PMU, with recommendations of corrective measures for consideration by PIU and PMU.
- (xx) Conduct audit of post-construction rehabilitation and restoration works at the sites by contractors, and prepare post-construction environmental audit report for submission to PIU and PMU.

E. Contractors

265. The contractors of the project will have specific roles in the implementation of the EMP. The contractors shall prepare their respective SSEMPs in compliance with the EARF and IEE prior to commencement of the construction activities. Each contractor shall have at least one full-time dedicated environmental officer (or equivalent) and one full-time dedicated safety officer on site. These officers will be responsible for implementing applicable measures in the EMP. All these specific roles and responsibilities will be defined in the IEE reports, which shall form part of the contract documents. PIUs, with the support of PMCSC, will actively monitor contractors' environmental performance. The responsibilities include, among others:

- (i) Ensure that the execution of works will not have impacts to the environment and people that are considered diverse, irreversible or unprecedented.
- (ii) Designate full-time environmental officer (or equivalent) and full-time safety officer.
- (iii) Adequately record the condition of roads, agricultural land and other infrastructure prior to starting to transport materials and construction.
- (iv) Conduct baseline (pre-works) conditions surveys as part of preparation of their SSEMPs (example: photo or video documentation, instrumental monitoring of environmental parameters, habitats of value, valued trees and vegetation, fauna species, structural and technical condition survey of properties that will be potentially affected by vibration and construction works, etc.).
- (v) Prepare SSEMP based on the EMP. The SSEMP shall include (a) proposed sites/locations for construction work camps, storage areas, hauling roads, laydown areas, disposal areas for solid and hazardous wastes; (b) specific mitigation measures following the approved EMP; (c) monitoring program as per EMP; and (iv) budget for SSEMP implementation.
- (vi) Secure approval of SSEMP from PIU/PMU prior to start of works, including site preparation, vegetation clearing and mobilization.
- (vii) Inform the local communities at least seven (7) days prior to the commencement of any construction activities. This notification shall be provided through appropriate means such as public announcements, distribution of notices, or meetings to ensure that affected residents and stakeholders are adequately informed in advance. Furthermore, contractors must install clearly visible informational boards at all active work sites, displaying contact details of relevant contractor representatives. These boards will provide community members with accessible channels to raise concerns or seek information regarding ongoing project activities.

- (viii) Ensure that the execution of works consider mitigation measures in the SSEMP.
- (ix) Inform affected people and surrounding communities about the works, impacts, duration, mitigation measures, monitoring activities, contact persons and contact details.
- (x) Acquire necessary permits and clearances prior to construction.
- (xi) Ensure all sites, facilities, and lands including temporary and final disposal sites are approved by PMU and PIU.
- (xii) Understand the EMP requirements and allocate necessary resources for implementation.
- (xiii) Implement all mitigation measures in the SSEMP to avoid or minimize the environmental impacts of construction activities.
- (xiv) Exert all efforts and utilize methodologies that will avoid or minimize impacts of works to both environment and man-made structures.
- (xv) Hold regular toolbox talks to educate or remind workers with all mitigation measures in the SSEMP, and health and safety procedures to improve safety.
- (xvi) Compensate owners of properties or structures damaged due to execution of works.
- (xvii) Compensate individuals injured due to execution of works.
- (xviii) Implement compensatory or offset measures per EMP for residual impacts that remain significant after implementing mitigation measures.
- (xix) Ensure compliance with labor laws, rules and regulations.
- (xx) Ensure that all workers including sub-contractors are fully aware of requirements on environmental, health and safety.
- (xxi) Ensure that all workers (including those of subcontractors', if any) are paid and treated according to the local labor legislations.
- (xxii) Provide worker camps and work sites with housekeeping facilities, such as separate toilets for male and female workers, drinking water supply, wash and bathing water, rest areas, and other lavatory and worker welfare facilities following international good practices as reflected in internationally recognized standards such as IFC/EBRD Guidance Note on Workers' accommodation: processes and standards".
- (xxiii) Conduct environmental monitoring, including vibration monitoring, as required by the EMP.
- (xxiv) Act promptly on complaints and grievances concerning the construction activities in accordance with the project's GRM.
- (xxv) Implement corrective actions as required by PMU or PIU or their representatives from PMCSC.
- (xxvi) Notify the PMU, PIU or PMCSC immediately if any incident occurs whether on or off the work sites which results in any serious or fatal injury to any person whether directly concerned with the work site or a third party. Such notification may initially be verbal and shall be followed by a written full investigation report within 24 hours of the accident.
- (xxvii) Inform PMCSC one month before the target completion of construction, including rehabilitation and restoration of disturbed areas, such that PMCSC can plan for its preparation of the post-construction environmental audit report prior to demobilization.
- (xxviii) Implement post-construction rehabilitation and restoration works prior to demobilization.
- (xxix) Submit monthly progress reports on SSEMP implementation to PIU.

F. Details of the Environmental Management Plan

266. This EMP is part of the IEE, which must also be thoroughly understood by the contractor. It is essential that the contractor recognizes the EMP not as a standalone document, but as part of the overall environmental due diligence process embedded in the IEE.

267. The development of this EMP is grounded in a comprehensive assessment of environmental impacts as discussed in the IEE. This evaluation considers the duration, magnitude, and scale of each impact to accurately determine the rating of severity. Such an approach ensures that mitigation measures are appropriately tailored to the specific risks identified throughout the project lifecycle.

268. The requirements set forth in the EMP are uniformly applicable to all contractors, subcontractors, and entities directly engaged in project activities, irrespective of the project phase or contractual arrangements.

269.

270. Upon mobilization before construction including site clearance:

- (i) Contractors must submit a pre-works site conditions report, Site-Specific Environmental Management Plan (SSEMP) and a Site-Specific Health and Safety Management Plan (SSHSMP) to the **PMU/PIU**, through the PMCSC, for verification and approval before commencing any construction activities, including site clearing and preparation. These plans must align with the EMP, and comply with requirements set forth in the bidding and contract documents, and applicable national laws.
- (ii) To ensure comprehensive management of environmental and health and safety risks, contractors are required to consult with the PIUs on the planning and timing of construction activities, including the selection of locations for worker accommodations, laydown yards, workshops, and fabrication sites.
- (iii) Secure all necessary permits and approvals related to environmental and health and safety regulations.
- (iv) In collaboration with the PIUs, must undertake consultations with affected people and communities in and adjacent to the project sites to disseminate information about the details of the works.

271. During construction:

- (i) Implement the approved Site-Specific Environmental Management Plan (SSEMP) and ensure that all site personnel are briefed on its requirements.
- (ii) Coordinate with the Employer and relevant authorities for regular site monitoring and reporting of environmental performance.
- (iii) Install and maintain erosion and sediment control measures to prevent contamination of water bodies.
- (iv) Manage and properly dispose of construction waste, hazardous materials, and spoil in accordance with the EMP and local regulations.
- (v) Adopt dust suppression techniques, such as regular watering of exposed surfaces and covering of transported materials.
- (vi) Control noise and vibration through the use of appropriate equipment and scheduling of high-noise activities during permitted hours.
- (vii) Implement traffic and access management plans to minimize disruption and ensure safety of workers and the public.

- (viii) Protect existing utilities, vegetation, and properties from damage during construction activities.
- (ix) Monitor and address occupational health and safety (OHS) risks, including providing personal protective equipment (PPE) and conducting safety briefings.
- (x) Respond promptly to any environmental incidents or complaints, taking corrective actions as necessary.
- (xi) Maintain clear records of all environmental management activities, inspections, incidents, and corrective actions.

272. After construction prior to demobilization:

- (i) Conduct thorough site cleanup, including removal of all construction debris, waste materials, and temporary structures.
- (ii) Restore disturbed areas to their original or designated condition, such as regrading soil, replanting vegetation, and stabilizing exposed surfaces to prevent erosion.
- (iii) Remove all erosion and sediment control measures only after confirming site stabilization and as approved by relevant authorities.
- (iv) Inspect and repair any damages to existing utilities, infrastructure, or adjacent properties caused by construction activities.
- (v) Ensure all hazardous materials and chemicals are safely removed from the site and disposed of in accordance with local regulations and the Environmental Management Plan (EMP).
- (vi) Conduct a final environmental inspection and address any outstanding corrective actions or non-compliances identified during the project.
- (vii) Submit all required documentation, including environmental monitoring records, inspection reports, and site restoration evidence, to the Employer for approval.
- (viii) Coordinate with stakeholders and local authorities for final site handover and obtain necessary clearances or completion certificates.

273. The following table provides the environmental impacts that have been identified during the IEE study, and the recommended mitigation measures. The table will be the basis for the contractor's SSEMP and SHSMP. If the SSEMP is found to be insufficient in fully mitigating the identified environmental impacts, additional mitigation measures outlined in the EMP will be required to ensure compliance and effective protection of the environment. The contractor must implement these supplemental measures as directed by the Employer.

274. If the contractor fails to comply with the EMP and safeguard requirements, the Employer will seek corrective measures and work with the contractor to bring it back into compliance. If the contractor fails to reestablish compliance, then the Employer may exercise legal remedies, including suspension or cancellation of the contract.

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
Design Phase / Pre-construction Phase				
Natural Hazards	Unprecedented flooding and other natural catastrophic events due to climate change could destroy the project infrastructures.	• Ensure design is based on the basic hydraulic principles of designing the rehabilitation works on canals, taking into consideration the impact of climate change over the long term. This includes proper estimation of volumetric flows during various seasons that will accommodate the expected throughput, and other hydrologic and hydraulic design requirements; • Use of construction materials that could withstand potential stresses during extreme events, temperatures, pressures, etc.; and • The structural designs of the infrastructures shall be able to withstand possible seismic events that may happen in the future.	RID	RID
Loss of vegetation or trees	Prior to any dredging or piling activities, the project will need to clear the vicinity of the work areas, which could lead to loss of vegetation or trees.	• Avoid removal of vegetations to extent possible. If unavoidable, ensure to conduct pre-works survey to record vegetations that will be removed. Plan translocation of trees or vegetations, if possible. • If the tree cutting is extensive for the entire project, develop and implement a tree plantation program that could replace all trees that will be cut.	Contractor	PIU, PMCSC
Conflict of land use	The implementation of the project could lead to conflict on land use associated with the development of new access roads and the surrounding lands.	• Select road alignments that avoid ecologically sensitive areas, densely populated zones, and culturally significant lands. • Coordinate with local authorities to align road development with existing land use plans and avoid overlapping or incompatible uses. • Establish green belts or buffer zones between roads and residential/agricultural areas to reduce noise, pollution, and encroachment. • Conduct early and continuous engagement with affected communities to understand land use patterns and concerns. • Involve local stakeholders in decisions about land access, compensation, and resettlement.	Contractor	PIU, PMCSC
Disposal Sites	The project is expected to generate significant amounts of dredged materials and waste vegetations during construction phase due to dredging and clearing activities. Assuming no other uses for excess spoils, their indiscriminate or unmanaged disposal will negatively impact the environment, such as siltation and clogging of canals, damage to paved roads, and safety to pedestrians and community as a whole. The same fate could happen to the waste vegetations if not managed properly at the sites.	• Immediately after award of contract and prior to any civil works, contractor will identify a location for the temporary disposal of dredged materials that will be generated during the construction phase. This temporary storage area needs to be approved by the PIU. No civil works shall commence until the temporary disposal location is identified and any relevant clearance required is obtained. • Based on the results of sampling of excavated soil, identify the permanent disposal site following the requirements of the sediment management plan developed under the project.	Contractor	PIU, PMCSC
Source of Materials	Extraction of construction materials that will be used for the project (cement, sand, aggregates) can disrupt natural land contours and vegetation at the source sites resulting in accelerated erosion, disturbance in natural drainage patterns, ponding and water logging, and water pollution.	PMU and PIU will guide the contractor in minimizing the use of non-renewable resources and rock-based materials. The contractor will be responsible for: • Sourcing construction materials, including aggregates, etc., from legitimate suppliers authorized by the government; • Avoiding any form of quarrying activities; and • Maintain a construction material register at the site.	Contractor	PMU, PIU, PMCSC
Shifting of Utilities	Disturbance of services due to shifting of utilities (electric poles, wires, water pipes, etc.). In some alignments, utilities such as electric poles, electrical wires, water pipes, etc. may be disturbed or damaged during the construction works. Any	• PMU to ensure all planning and design interventions and decisions are made in consultation with local communities and reflecting inputs from public consultation and disclosures • With approval from PIU, contractor shall liaise with each of the agencies responsible for the maintenance of utilities that are to be crossed, temporarily diverted or otherwise affected by the works as to the timing and nature of any disruption of service. Where required, the responsible agency shall be requested by PIU to carry out the necessary works at the time required and at PIU cost. The tender documents shall	PIU, Contractor	PIU, PMCSC

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
	damage to these utilities will disrupt the daily lives and livelihood activities of the people affected.	contain sufficient information on utilities at the sites to permit the Contractor to include the cost of the works for which it is responsible in the bid.		
Physical Cultural Resources	The alignments of the project pass through near or adjacent locally important cultural heritage site and structures such as temples (Wat), other religious places, spirit houses, etc. Damage to these physical cultural resources (PCRs) could create conflict with the local people and the government as a whole.	• Avoid construction activities in or near PCRs. If cannot be avoided, consult with relevant authorities such as the National Office of Buddhism, the Abbot and local communities surrounding or hosting the PCR. • In unavoidable cases, and in consultation with the relevant authorities, conduct assessment if deemed warranted depending on the scale or scope of project activities and sensitivity of PCRs. Engage the support of PMCSC PCR experts if necessary to execute the assessment. • Develop “chance find” procedures that include a pre-approved management and conservation approach for materials that may be discovered.	PMCSC	PMU
Asbestos-Containing Materials	During site visits on sample project alignments, it was determined that there will be structures with asbestos-containing materials, such as asbestos roofings, that will be demolished in order to implement the project. Thus, during the demolition works, there may be instances that these will be dismantled improperly. Handling asbestos-containing materials may result to the generation of asbestos dust and fibers, which could go airborne and harm the workers and the public. When inhaled, asbestos fibers may cause long term health issues such as asbestosis and other lung inflammation and diseases including cancer.	PIU will ensure the following: • Close coordination with the project social safeguards team and demolition contractor (or equivalent) to ensure demolished or recovered materials during project implementation period, which contain ACMs such as asbestos cement roofings shall not be included in the salvageable materials by affected households. • Develop and implement an ACM Management Plan (AMP) that includes identification of hazards, the use of proper safety gear, and disposal methods, among others, for all ACMs recovered during the project implementation period. • Conduct awareness program on safety during the construction work. • Contractor to undertake construction work stretch-wise to control the volume of ACMs recovered, handled and disposed at a given time. This will ensure that all precautionary measures on the proper handling, transport and disposal of ACMs as provided in this EARF and in the AMP are complied with. • Contractor to follow and adhere to appropriate actions as defined in the AMP. • Contractor to maintain records of ACMs per the AMP. • Contractor to refer to the instructions in the AMP, or by the Asbestos Expert.	PMCSC	PMU
Social Conflicts	The implementation of the project may lead to various social conflicts arising from displacement of communities, including impacts on poor, women and children, Indigenous Peoples or other vulnerable groups.	• Avoid land acquisition to maximum extent possible. For potential involuntary resettlement impacts, implement the Resettlement Plan developed under the project following ADB SPS requirements. • Identify vulnerable groups early and ensure their meaningful participation in consultations and decision-making. • Use local languages, visual aids, and gender-sensitive formats to ensure understanding and inclusion. • Provide income-generating support, skills training, and access to credit for displaced or economically affected groups.	PMCSC	PMU
Vibration	Piling works will be undertaken in some areas with surrounding communities and infrastructures, which include houses, commercial buildings, septic tanks, common community properties, temples, and other structures. Potential damage to structures due to vibration may occur.	• Structural survey and documentation (photo-video documentation) along the alignments to document that integrity and pre-project conditions of structures that will likely be impacted by the excavation and piling activities. • Monitor these structures on a regular basis, and document the same in the presence of the owners or caretakers of structures; and • Compensate owners of structures should damage occurs due to the construction activities. Any valid claim for compensation shall be paid by the contractor.	Contractor	PIU, PMCSC
Construction Camps or Workers' Accommodation	There may be instances that workers will need to stay within or near the construction sites. Contractors would normally provide construction camps or accommodation at these sites.	• The Contractor will need to ensure that the camps or accommodations be provided with sanitary amenities at designated areas. In addition to any local regulations, Contractor will need to follow the standards for workers accommodation pertaining to “Workers’ accommodation: processes and standards. A guidance note by IFC and the EBRD” 2009.²⁶ This shall include the development of a Sewage Management Plan to manage effluents from construction camps and Contractor’s offices, which should be incorporated in the facility designs.	Contractor	PIU, PMCSC

²⁶ https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_gpn_workersaccommodation

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
	However, the haphazard construction of these camps without basic amenities could result in social stress and eventual degradation of the local environment.	Contractor may also follow the International Labor Organization's Workers' Housing Standards,²⁷		
Storage Areas, Laydown Areas, and other Temporary Facilities	Improper siting and construction of project temporary facilities may damage or degrade the immediate environment.	- Ensure sites for temporary facilities are approved by the PIU, in close consultation with local government entities. - Avoid locating in sensitive zones, near water bodies, wetlands, or in areas that disrupt natural drainage. - Ensure sites are clearly marked and confine storage (materials, waste, fuels) to specific, agreed-upon zones, keeping them separate from walkways and emergency routes. - Ensure to minimize footprint. Keep bare soil exposure to a minimum and plan deliveries to reduce on-site clutter. - Ensure site designs and layouts integrate environmental safeguard elements such as, but not limited to, avoidance or prevention of pollution to ambient air quality, noise level, surface water and groundwater quality; and avoidance or minimization of nuisance to communities.	Contractor	PIU, PMCSC
Construction Phase				
Noise Pollution	Elevated noise level at construction sites is a common issue for piling works and other civil works such as site clearing, dredging, including operation of other stationary machines, movement of vehicles for transportation of construction material, and hauling of dredged materials from the construction site. These noise will disturb the communities nearby.	- Provide prior information of the scheduled works, particularly to residents in the nearby communities; - In residential areas and other areas of night time-sensitive institutions such as hospitals, schedule noisy or otherwise invasive activities during periods of the day which will result in least disturbance; - In areas near schools or other areas of daytime-sensitive institutions such as temples and churches, schedule noisy or invasive activities during night time or holidays; - Use of high noise generating equipment shall be stopped during night time; - In unavoidable case of night works (due to local rules) provide prior information to public on work schedule, noisy activities and need to conduct the works at night. Use best construction methods to minimize noise to possible extent; - Vehicle horns should not be used unless necessary to avoid untoward incidents or accidents; - All vehicles and equipment to be used in construction shall be fitted with exhaust silencers; - If it is not practicable to reduce noise levels to or below noise exposure limits, post warning signs in the noise hazard areas. Maintain maximum of noise level of 45 dB(A) at the nearest residence relative to the specific worksite; - Conduct noise level monitoring. Ensure to conduct monitoring when construction activities are at peak. Important areas to test are at locations nearest the community residents and construction camp, if any; - If using generators, use generator set with capacity just enough for the electricity needs at night; - Ensure generator set complies with the noise standards; and - Ensure generator set has acoustic enclosure and silencer (if necessary) in the exhaust muffler.	Contractor	PIU, PMCSC
Vibration	Piling works and the passage of construction heavy equipment are the primary sources of vibration from the project. The vibration will have the tendency to affect nearby structures depending on their integrity.	- Employment of piling techniques with minimum vibration impacts; - Based on the results of pre-works survey, identify all locations with structures that may be structurally weak and monitor all piling works in these locations. Avoid use of pneumatic drills or operating heavy equipment near structures surveyed to be fragile to withstand heavy vibration. Complete work in these areas quickly; - Monitor these structures on a regular basis, and document the same in the presence of the owners or caretakers of structures; and - Compensate owners of structures should damage occurs due to the piling and other activities. Any valid claim for compensation shall be paid by the contractor, or as may be agreed between contractor and PIU and clarified in contract documents.	Contractor	PIU, PMCSC
Access to Establishments	Construction activities could lead to interference with other utilities and blocking of access to residential establishments and/or commercial buildings.	- Identify all critical access points to establishments, if any, prior to executing works; - Schedule works in short segments to maintain access to at least one side of the establishment at all times; and - Design and communicate temporary detours or bypasses for vehicles and pedestrians.	Contractor	PIU, PMCSC

²⁷ <https://www.ilo.org/publications/workers-housing>

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
Dislocation or involuntary resettlement of people	During the construction, there may still be possibilities of dislocation or involuntary resettlement of people that were not identified during the social safeguards survey and planning.	• Develop and implement a resettlement plan (or update an existing resettlement plan) in compliance with ADB SPS requirements.	PMU, PMCSC	PMU, PMCSC
Air Pollution	Construction activities could cause air pollution in the area due to dust generation and vehicle emissions at the construction sites.	• Use dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles; • Use of water suppression for control of loose materials on paved or unpaved road surfaces. Ensure unpaved surfaces used for haulage of materials within settlements are dust-free; • Proper covering (e.g. tarpaulin) of hauling equipment such as dump trucks during transport of construction materials or dredged materials; • Provide temporary barriers or covers around active excavation or dredging sites; • Limit vehicles speed at work site to minimize dust being airborne; • Prohibit idling of heavy equipment or vehicles for a long time; • Regular maintenance of heavy equipment and vehicles to ensure compliance with national vehicle emissions standards; • Use modern vehicles and machinery with the requisite adaptations to limit noise and exhaust emissions and ensure that these are maintained to manufacturers' specifications at all times; • Use of older vehicles or equipment should ensure that these have valid permits at all times (permits are assumed to ensure the vehicles or machines are in compliance with the relevant vehicle emission standards); • Prohibit burning of any liquid or solid wastes; • Ensure all generator sets and ventilation systems installed at work sites are functioning efficiently. Undertake daily inspection of components when possible and institute immediate repairs for either minor or major issues; • Conduct regular visual inspections to identify and address other potential sources of dust emissions; and • Conduct ambient air quality monitoring at strategic locations. Ensure that sampling locations are based on the wind and dust/smoke dispersion direction at the site. Should results of sampling show values exceeding the required limits, ensure that all mitigation measures are in place and effectively implemented. Frequency of implementing dust suppression measures should also be intensified.	Contractor	PIU, PMCSC
Soil Erosion/Landslide and Silt Runoff	Road blocking and temporary flooding due to excavation during rainy season, resulting to continuing soil erosion/silt runoff in or near construction sites.	• As much as possible, conduct of excavation, dredging and piling activities during dry season; • Measures to minimize soil erosion/silt runoff to be incorporated when conducting earthworks during monsoon season; • Bioengineering will be carried out in disturbed areas especially in project access roads; • Disposal sites will be compacted and consistent with the relevant requirements in the sediment management plan developed for the project; and • Appropriate drain structures and slope protection structures such as revetment walls, retaining walls benches or terraces, riprap and spurs will be made to retain unstable soil masses.	Contractor	PIU, PMCSC
Surface Water Pollution	Construction activities could lead to contamination of surface water bodies due to release of silts and chemicals, such as fuels and lubricants, from sites.	• Prioritize re-use of excess spoils and materials in construction activities, provided that these do not contain hazardous substances beyond the standards. Take all precautions to prevent entering of wastes into streams, watercourses, fisheries ponds or irrigation systems; • Manage solid waste according to the following preferred hierarchy: reuse, recycling and disposal to designated areas; • Provide drainage systems around excavation areas to prevent soil erosion and siltation into the canals; • Water from excavation activities should be pumped and drained towards settling ponds and drained through overspill to ensure settling of sediments. • Minimize civil works activities during monsoon season; • Stop excavation activities during sudden heavy downpour or rains, especially for works adjacent the canals; • Store excavated soils/spoils at least 100 meters from the edge of the river or any receiving body of water. If this distance cannot be met due to unavailability, any storage area for spoils should ensure all design	Contractor	PIU, PMCSC

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
		and engineering measures are in place to prevent soil erosion. However, selected sites should not be disturbing or blocking the natural flow of any waterbody; • Store fuel, oil and other chemicals in secure, managed areas with lined impervious floors and bunded with 110% volume. • Allow refueling at designated areas only, which should be situated at least 100 meters from residential areas and edge of any receiving body of water. If this distance cannot be met due to unavailability, designated area should have appropriate design and engineering measures to prevent seepage and runoff to the receiving body of water; • Provide adequate facilities at construction camps to ensure no indiscriminate dumping of liquid and solid wastes happens; • Institute good housekeeping practices at work sites and construction camp sites; • Conduct water quality monitoring at the upstream and downstream portions of affected receiving bodies of water, in accordance with the monitoring plan; and • Compact and stabilize disturbed areas as soon as works are completed in such areas. For the construction of new roads, compact and stabilize the alignment as soon as final grading is completed.		
Land, soil and groundwater pollution	Leakages from the storage and handling of fuel, oil, and other chemicals at construction sites and domestic wastes at the construction camps could pollute the land, soil and groundwater.	• Store fuel, oil and other chemicals in secure, managed areas with lined impervious floors and bunded with 110% volume; • Ensure refueling area has lining to avoid seepage of unavoidable spills during refueling. Ensure to clean up spills immediately and all used cleaning materials are disposed properly; and • Ensure to provide appropriately designed temporary toilets with septic tanks in construction camps.	Contractor	PIU, PMCSC
Traffic	Vehicle movements due to the project activities will increased road traffic and and may require road closures at times around the project sites. This will create traffic congestions in the area.	• Prepare traffic management plan. • Communicate the traffic management plan to the public (road users) and communities. • Ensure contractors have the obligation to restore damaged roads. Contracts should have sufficient financial provisions for road restoration.	Contractor	PIU, PMCSC
Social Conflicts	During construction period, social conflicts may arise between construction workers from other areas and community workers.	• Employ labor force from local communities to maximum extent possible Restrict activities and movement of staff and workers only within designated construction areas.	Contractor	PIU, PMCSC
Community Health and Safety	Numerous threats could be encountered in the vicinities of the projects, including storage camps or yards and workers' camps. Easy access by pedestrians, animals, and other community people to the sites could expose them to these threats, such as the dangers due to moving heavy equipment or electrocution at the sites. There may also be risk of accidental fall of these community people or animals in excavated areas. There may also be serious threat of spreading communicable diseases in the communities surrounding the project sites.	Contractor will need to implement the following measures: • Appoint full time EHS officer per contract requirement; • Install signages, warning signs, warning tapes, hard barricades, and notices around the work site perimeter to avoid unauthorized entry. For excavated sections that cannot be isolated or enclosed due to access issues for the community or residents, ensure to cover these with steel planks or durable wood planks during off-work hours. If during work hours that these excavated sections, especially the deep trenches, cannot be covered entirely, provide steel planks or durable wood planks with handrails that can be used by pedestrians; • Install sturdy fence around storage camps or yards and workers' camps; • Assign guards around the project sites, including storage camps or yards and workers' camps, on a 24/7 basis; • Provide lighting all around the project site, including storage camps or yards and workers' camps, to ensure the perimeter is well-lit at nighttime; • Follow a code of construction practice, which should include restricting workers in designated areas, no open defecation, no littering, no firewood collection, no setting of fire except when needed but in designated places, no trespassing, no unauthorized overstaying at construction sites, and no obligation to undertake potentially dangerous work without the use of proper personal protective equipment, among others;	Contractor	PIU, PMCSC

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
		- Follow international best practices on community health and safety such as those in Section 4.3 of World Bank EHS Guidelines on Construction and Decommissioning Activities;²⁸ The community health and safety plan shall ensure the following: - implement risk management strategies to protect the community from physical, chemical, or other hazards associated with sites under construction and decommissioning; - restricting access to the site, through a combination of institutional and administrative controls, with a focus on high risk structures or areas depending on site-specific situations, including fencing, signage, and communication of risks to the local community; - removing hazardous conditions on construction sites that cannot be controlled affectively with site access restrictions, such as covering openings to small confined spaces, ensuring means of escape for larger openings such as trenches or excavations, or locked storage of hazardous materials; and - implement measure to prevent proliferation of vectors of diseases at work sites; - adequate space and lighting, temporary fences, shining barriers and signage at active work sites; - contractor's preparedness in emergency response; - adequate dissemination of GRM and contractor's observance and implementation of GRM; and - upon availability, local people should be given an opportunity for work in the project activities; - Follow international best practices on traffic safety such as those in Section 3.4 of the World Bank Environmental Health and Safety (EHS) Guidelines on Community Health and Safety;²⁹ The community health and safety plan should include the following: - Adoption of best transport safety practices across all aspects of project operations with the goal of preventing traffic accidents and minimizing injuries suffered by project personnel and the public. Measures should include: - Emphasizing safety aspects among drivers; - Improving driving skills and requiring licensing of drivers; - Adopting limits for trip duration and arranging driver rosters to avoid overtiredness; - Avoiding dangerous routes and times of day to reduce the risk of accidents; - Use of speed control devices (governors) on trucks, and remote monitoring of driver actions; - Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure. Where the project may contribute to a significant increase in traffic along existing roads, or where road transport is a significant component of a project, recommended measures include: - Minimizing pedestrian interaction with construction vehicles; - Collaboration with local communities and responsible authorities to improve signage, visibility and overall safety of roads, particularly along stretches located near schools or other locations where children may be present. Collaborating with local communities on education about traffic and pedestrian safety (e.g. school education campaigns); - Coordination with emergency responders to ensure that appropriate first aid is provided in the event of accidents; - Using locally sourced materials, whenever possible, to minimize transport distances. Locating associated facilities such as worker camps close to project sites and arranging worker bus transport to minimizing external traffic; and - Employing safe traffic control measures, including road signs and flag persons to warn of dangerous conditions. - Follow the established community and occupational health and safety protocol on emerging infectious diseases; - Maintain a complaint logbook at the site and take action promptly of complaints; - Schedule transport and hauling activities by avoiding peak traffic periods; - Clean wheels and undercarriage of haul trucks prior to leaving construction sites; - Educate drivers and advice to limit speed between 20-25 km/h while traversing settlement areas and avoid use of horn unless necessary to prevent accidents; and		

²⁸ IFC World Bank Group. 2007. <https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-construction-and-decommissioning-en.pdf>

²⁹ IFC World Bank Group. 2007. <https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-community-health-and-safety-en.pdf>

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
		Earmark parking place for construction equipment and vehicles when idling; no parking shall be allowed on the roads, that may disturb the traffic movement.		
Occupational Health and Safety	Health risks and safety problems for workers are concerns in all construction projects. Safety risks and health issues arise from storage, handling and transport of hazardous construction material. Health hazard is also significant due to exposure of workers to drainage silts or soils that could be contaminated with hazardous elements such as heavy metals and pathogens. Construction workers are also at risk of accidents due to moving vehicles, and other construction related activities. Workers are also exposed to high level of pollution from dust, exhaust of vehicles and machinery, and noise. Further, extended working hours of workers could lead to risk of accidents due to fatigue. Clustering and gathering of workers can also trigger spread of diseases.	Contractor shall implement the following mitigation measures: - Appoint full time EHS officer per contract requirement; - All relevant provisions of the local labor laws and relevant WHO guidelines will be adhered to, concerning the provision of adequate measures to avoid contracting and/or spreading diseases during construction phase; - Follow international best practices on occupational health and safety such as those in Section 4.2 of World Bank EHS Guidelines on Construction and Decommissioning Activities,³⁰ which include the following elements, whichever are applicable: a. Communication and Training - i Training of all workers on occupational health and safety prior to construction works; - ii Conduct of orientation to visitors on health and safety procedures at work site; - iii Signages strategically installed to identify all areas at work site, including hazard or danger areas; - iv Proper labeling of equipment and containers at construction and storage sites; and - v Suitable arrangements to cater for emergencies, including: first aid equipment; personnel trained to administer first aid; communication with, and transport to, the nearest hospital with an accident / emergency department; monitoring equipment; rescue equipment; firefighting equipment; and - vi communication with nearest fire brigade station; b. Physical Hazards i. Use of personal protective equipment (PPE) by all workers such as earplugs, safety shoes, hard hats, masks, goggles, etc. as applicable, including specific use of appropriate gumboots, gloves and other PPEs when handling and transporting silts and soils excavated from canals, and ensure these are used properly; ii. Avoidance of slips and falls through good house-keeping practices, such as the sorting and placing loose construction materials or demolition debris in established areas away from foot paths, cleaning up excessive waste debris and liquid spills regularly, locating electrical cords and ropes in common areas and marked corridors, and use of slip retardant footwear; iii. Use of bracing or trench shoring on deep excavation works; iv. Adequate lighting in dark working areas and areas with night works; v. Rotating and moving equipment inspected and tested prior to use during construction works. These shall be parked at designated areas and operated by qualified and trained operators only; vi. Specific site traffic rules and routes in place and known to all personnel, workers, drivers, and equipment operators; and vii. Use of air pollution source equipment and vehicles that are well maintained and with valid permits; c. General Facility Design and Operation i. Regular checking of integrity of workplace structures to avoid collapse or failure; ii. Ensuring workplace can withstand severe weather conditions; iii. Enough work spaces available for workers, including exit routes during emergencies; iv. Fire precautions and firefighting equipment installed; v. First aid stations and kits are available. Trained personnel should always be available who can provide first aid measures to victims of accidents; vi. Secured storage areas for chemicals and other hazardous and flammable substances are installed and ensure access is limited to authorized personnel only; vii. Good working environment temperature maintained;	Contractor	PIU, PMCSC

³⁰ IFC World Bank Group. 2007. *Environmental, Health, and Safety (EHS) Guidelines – General EHS Guidelines: Construction and Decommissioning*.

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
		viii. Worker camps and work sites provided with housekeeping facilities, such as separate toilets for male and female workers, drinking water supply, wash and bathing water, rest areas, and other lavatory and worker welfare facilities; and ix. Maintain records and make reports concerning health, safety and welfare of persons, and damage to property. Take remedial action to prevent a recurrence of any accidents that may occur. - Follow established occupational health and safety protocol on emerging infectious diseases; - Provide regular health check-ups, sanitation and hygiene, health care, and control of diseases for the workforce; - Provide at cost all labor and materials and construct/install and maintain site safety, hard barricading, flexible green net, signboards, and lightings throughout the construction site; - Launch awareness programs concerning human trafficking and the possibility of spread of sexually transmitted diseases (STDs) and HIV/AIDS using brochures, posters, and signboards; - Make available ambulance facility at the construction site and camp site, if any; - Compensation for the loss of life (a zero tolerance to loss of life policy should be developed and implemented) or for any type of injuries; and - Provide insurance to the workers. Health and safety training for all site personnel is very important and must be mandatory.		
Terrestrial Flora and Fauna Resources	While the critical habitat screening and results of site visits show no likely presence of endangered and critically endangered species per IUCN Red List, the construction phase of the project may pose impact to other flora and fauna resources in the immediate vicinity of the sites. Vegetations found along the alignments were determined to be common and abundant species found elsewhere in Thailand.	The Contractor will ensure that awareness training on environmental safeguards is provided to all construction workers, which will include the following reminders that need to be observed and complied with during the construction period: - Avoid any cutting of trees and shrubs at the construction site. The spaces are wide enough for any activities without cutting any of the trees or locally important plants, if any; - Prohibit use of wood as fuel at construction camp sites, if any; - Provide LPG/kerosene to workforce staying at the construction camp sites; and - Prohibit the harvest and trade of any plants or poaching of animals found in the area.	Contractor	PIU, PMCSC
Socio-economic Resources	Construction works may result in temporary loss of livelihoods and interruption of social and economic activities in some alignments. In areas where there are shops or other commercial activities, these could lose some business if access is difficult for customers.	The Contractor will ensure the following: - Adopt the GRM of the project, and respond to grievances; - The construction works do not interfere with the convenience of the public or access to, use, and occupation of public or private roads, or any other access to properties, whether public or private. - If needed for the convenience of the public, temporary access to properties adjacent to the construction site will be provided through the construction of ramps. Handrails may be provided to ramps or planks depending on the width of excavations; - In critical areas such as institutions, operating hours are factored into work schedules and workforce is increased for speedy completion; - Advance information on works to be undertaken including appropriate signage is provided; and - The diversion is done in coordination with the traffic police for necessary rerouting of traffic and traffic management.	Contractor	PIU, PMCSC
Post-Construction Phase				
Abandonment and Restoration	The dismantling and abandonment of temporary sites such as construction camps, storage facilities and work areas could lead to deteriorated environmental conditions and nuisance to the people living in nearby communities.	Contractors to: - Develop and implement a post-construction rehabilitation and restoration plan to ensure sites are restored to pre-project conditions or better. - Implement an environmentally suitable waste management and disposal for all wastes and debris left at the sites. - If necessary, landscaping and revegetation will be undertaken. Any damages to roads caused by the project will be rehabilitated and restored to at least their pre-project conditions as well.	Contractor / DSC	PIU, PMCSC
Operation Phase				
Operation of the Flood Control System	During the operation phase or when the project is already fully	Implement relevant procedures following schedules and in timely manner. This will ensure all facilities are working properly even during the occurrence of extreme weather events such as heavy rainfall.	RID	RID

Project Activity / Field	Impacts	Avoidance/Mitigation and Compensatory Measures	Institution/Stakeholder Responsible	
			Implementation	Monitoring
	implemented and the flood control system is already completed, there may always be maintenance works to ensure the system functions effectively and efficiently. During these works, risks to the health and safety RID workers and community people will be present.	• Develop and implement an emergency response procedure that need to be followed before, during and after extreme weather events. • Formalize and implement existing practice of informing affected communities prior to release of irrigation water in the downstream areas. • Continue the conduct of meaningful consultations with the affected communities all throughout the O&M period. • Implement the GRM of the project, and ensure that concerns of stakeholders are addressed early and properly taking into account the welfare of these stakeholders. • Ensure that all site personnel have a basic level of health and safety training and protective equipment.		

G. Environmental Monitoring

275. The contractor will be required to monitor environmental conditions at and near to work sites and along main construction routes on the public highway. The minimum required monitoring is set out in the following table.

Table 40: Environmental Monitoring Requirements

Monitoring Required	Location	Duration	Frequency	Equipment Required
Sampling of water in canals and irrigation systems in accordance with protocols set out in Sediment Management Plan		Throughout project works	As per protocol	Sampling equipment and qualified laboratory
Pre-construction Assessment - Locate all agricultural related infrastructure, below and above ground	As required	As required	As required	Visual assessment
Visual checks to ensure requirement for no idling of machinery or vehicles is adhered to	At all works sites	Throughout construction period	Daily and as required	Recording form
As required by national standard for emissions testing of vehicles	At site or testing centre as appropriate	As required under law	As required under law	Technical emissions equipment
Fence line monitoring of key parameters to include dust (PM10 and 2.5) and gaseous pollutants depending upon site activities and fuels used	At fence line of relative facilities	Throughout use of facility	Monthly	Air quality monitoring equipment to align with good international standards of monitoring
Fenceline monitoring for dust including PM10 and 2.5, Nox and SOx	Permanent work sites	Throughout use of sites		Ambient air quality monitoring equipment aligned with Good International Practice
Air quality to be monitored at fence line of work site locations, visual for dust emissions and measuring of criteria pollutants where relevant	All active work sites, workers camps, storage areas etc	Throughout active work stages	Daily visual checks, weekly monitoring as agreed in final EMP	Visual, appropriate technology available in Thailand - to be agreed as part of final

Monitoring Required	Location	Duration	Frequency	Equipment Required
				contractors EMP
Registration and investigation of any complaints from local residents and users in accordance with approved GRM	n/a	Throughout project implementation phase	As required	None
Roadside monitoring of air quality using integrated units such as Traffic Master roadside AQ monitors	As required	Throughout periods of use of public highways near to residential areas	Continuous	Automated continuous monitoring equipment
Visual and Record Keeping Audits Check that vehicles are road worthy Check drivers credentials Random checks on signage on vehicles Random checks on driving Recording and dealing with complaints in accordance with the GSM	N/A	Throughout Project Implementation Phase	Continuous	None
Visual and record keeping. PMCSC will check demolition activities and clean dirty side compliance. PMCSC will review and confirm audit trail of disposal of asbestos containing materials	As required	Throughout demolition activities on structures containing Asbestos containing materials	Weekly	None
Visual checks for present of water hyacinth - and other Invasive Alien Species	As required	Throughout construction phase	Daily/Ad hoc	Binoculars
Sea water sampling, in-situ testing and laboratory analysis - testing for heavy metals, TDS and turbidity, BOD, COD, bacteria and nutrients	At location of pumping outfall	for initial three year period	Monthly	Sampling, appropriate meters
Sound level monitoring at sensitive receptors during work hours along highway routes used by construction traffic	As required	Throughout period of construction traffic	As required but at least monthly	Sound level meter for environmental noise - Class 1 type and tripod

Monitoring Required	Location	Duration	Frequency	Equipment Required
Fence line noise monitoring - 24 hour values	As required	Throughout use of sites	Weekly	Environmental Sound level meter - class 1 type
Conduct vibration monitoring at sensitive receptors at location of piling activities. Assess risk to buildings and humans at start of project	As required	At start of piling in any location and as required throughout piling activities	As required	Geophones, Metter etc in accordance with Good International Practice
Contractor to monitor local road condition in line with pre-construction survey of road condition	As required on network	Throughout period of active use of local highways	Quarterly	Visual only
Contractor shall maintain record of accidents and near misses in accordance with Good International Practices for measuring accident statistics. All incidents shall be fully investigated using root cause analysis and measures put in place to reduce future risks	N/A	Throughout project implementation	As required	None
Accident and near statistics shall be included within environmental and social monthly reports and shall form part of project weekly meeting agenda	N/A	Throughout project construction period	Weekly for Project meetings, Monthly for Reporting and Six monthly for ADB required Bi-annual reports	None

IX. MONITORING AND REPORTING

276. RID through the PMU and PIU will monitor the progress of EMP implementation. The PMU and PIU, with support from PMCSC, will undertake site inspections and document review to verify compliance with the EMP and progress toward the final outcome. The Contractor will conduct day to day implementation of the SSEMPs.

277. The Contractor will submit monthly reports to the PIU. The monthly reports will include compilation of copies of monitoring sheets accomplished and duly signed by the Contractor's EHS manager (or equivalent) on a daily basis. A sample daily monitoring sheet which can be used by the Contractor is in Appendix 10 of the EARF. This monitoring sheet is indicative which can be further enhanced depending on the actual situations at construction sites.

278. PMU and PIU, with support from PMCSC, shall also conduct their own monitoring activities consistent with the indicators in the EMP to confirm that all environmental safeguard measures are properly implemented at the project sites, including in the surrounding communities. A sample monitoring sheet which can be used by PMU or PIU is in Appendix 11 of the EARF. Similarly, this monitoring sheet is indicative which can be further enhanced depending on the actual situations and other needs of information during the implementation phase.

279. PIU, with support from PMCSC, shall consolidated its own findings with the reports from the contractors. Based on consolidated information, PIU shall submit quarterly reports to PMU. Subsequently, PMU, with support from PMCSC, shall consolidate its own findings, if any, together with the reports from PIU and accomplish the required semi-annual environmental monitoring reports (SEMRs), which shall be submitted to ADB for review and disclosure on ADB website. Submission of SEMR will continue until ADB issues a Project Completion Report. The suggested outline is available in the EARF.

280. ADB will carry out the following monitoring actions to supervise the project:

- (i) On a need basis, conduct visits when potential adverse environmental or social impact exists;
- (ii) Conduct supervision missions with detailed review by ADB's environment/social safeguard specialists and/or officers and/or consultants for components with adverse environmental and social impacts;
- (iii) Review the SEMRs submitted by PMU to ensure that adverse impacts and risks are mitigated as planned in the EMP;
- (iv) Work with PMU to rectify to the extent possible any failures to comply with its environmental safeguard commitments, as covenanted in the loan agreement and elaborated in all environmental safeguard documents; and formulate and implement a corrective action plan to re-establish compliance as appropriate; and
- (v) Prepare a project completion report that assesses whether the objective and desired outcomes of the safeguard plans have been achieved, taking into account the baseline conditions and the results of monitoring.

281. ADB's monitoring and supervision activities are carried out on an on-going basis until a project completion report is issued. ADB issues completion report within 1-2 years after the project is physically completed and in operation.

X. CONCLUSION AND RECOMMENDATION

282. **Conclusion.** This IEE report of the project has been prepared based on preliminary information, including the indicative procurement plan for the entire MFF. This IEE report has also been prepared based on available draft bidding documents, and primary and secondary information of the project sites and their surroundings.

283. The findings of this IEE study have determined the likely nature and extent of environmental impacts and identified the environmental control measures for incorporation into the design and implementation of the proposed project to ensure compliance with environmental legislation and standards during construction and operation phases.

284. The key environmental outcomes accrued from the environmental considerations and analysis during the IEE study and the implementation of environmental control measures of the project have been adequately explained in this report. The extent of adverse impacts is expected to be local, confined within the project's main areas of influence. With mitigation measures in place, the potential adverse impacts during construction would be site-specific. This study has predicted that with implementation of the recommended mitigation measures, the project would be environmentally acceptable to the surrounding population and receptors. Planning principles and design considerations have been reviewed and will be incorporated into the site planning process whenever possible; thus, environmental impacts as being due to the project design or location were not considered critical.

285. Mitigation measures have been developed to avoid or reduce all negative impacts to acceptable levels. Mitigation will be assured by a program of environmental monitoring to ensure that all measures are implemented, and will determine whether the environment is protected as intended. It will include observations on- and off-site, document checks, and interviews with workers and communities. Any requirements for corrective action will be reported to the ADB.

286. The stakeholders were involved in developing the IEE through discussions on-site and off-site in public consultation, after which views expressed were incorporated into the IEE and in the planning and development of the project. The IEE will be made available at public locations in the project area and will be disclosed to a wider audience via the ADB and RID websites. The consultation process will be continued and expanded during project implementation to ensure that stakeholders are fully engaged in the project and have the opportunity to participate in its development and implementation. A grievance redress mechanism is described within the IEE to ensure any public grievances are addressed quickly. The PMU and PIU will be responsible for monitoring with the support of PMCSC. The PMU will prepare and submit required SEMRs to ADB. PMU and ADB will post the SEMRs on their respective websites.

287. The primary beneficiaries of this project will be the residents of the Chao Phraya river basin. By enhancing water conveyance channels, the project will strengthen the flood control system and improve overall environmental conditions. Additionally, it will decrease vulnerability to extreme climate events. Upgraded drainage infrastructure is expected to lessen the frequency and severity of flooding, thereby reducing financial losses from property damage and alleviating economic burdens for both the government and local communities in flood-prone areas. Residents will likely spend less on healthcare and experience fewer lost workdays due to flood-related issues, minimizing disruptions to daily life and employment. As a result, the project is not expected to generate significant adverse impacts, and the overall environmental and health outcomes for the people of Thailand are anticipated to be beneficial.

288. Based on the findings of the IEE, there are no significant impacts and the classification of the project as Category "B" is confirmed.

289. **Recommendations.** Below table summarizes the indicative activities to be completed at different stages of implementation.

Table 41: Summary of Indicative Activities to be Completed

Phase	Activity	Responsibility
Bidding and Contract Award	Inclusion of the IEE in the bid document as Appendix to Section 6: Employer's Requirements.	PMU, PMCSC
	Inclusion of safeguards (environment, health and safety) requirements in the bidders meeting.	PMU, PMCSC
	Submission of requirements including but not limited to personnel qualifications, safeguard qualifications, and environment, health and safety management plan (EHSMP).	Bidders
	Evaluation of safeguard-related submission of bidders.	PMU, PMCSC
	Confirm that contract documents of winning bidder include provision on compliance on all environmental requirements for contractor	PMU, PMCSC
Pre-construction Phase	Induction on safeguards to Contractor.	PIU, PMCSC
	Ensure Contractor appoints a qualified environment, health and safety (EHS) officer.	Contractor
	Preparation of SSEMP based on EMP.	Contractor
	Approval of SSEMP	PIU, PMCSC
	Instrumental monitoring for baseline environmental conditions per IEE.	PMCSC
	Pre-works photo-documentation of sites, access roads, existing structures, etc.	Contractor
	Obtain all statutory clearances, permits, no objection certificates (or equivalent) required under the project.	PIU/PMCSC, Contractor
	Continuing consultations with stakeholders, including the private sector, NGOs and civil society organizations	PMU and PIU, with support of PMCSC
After six months from effectivity of the loan	Submission of first semi-annual monitoring report (SEMR) to ADB	PMU
Construction Phase	Implementation of EMP and SSEMP	Contractor
	Monthly submission of report to PIU	Contractor
	Quarterly submission of report to PMU	PIU
	Semi-annual submission of SEMR to ADB, not later than 31 July (for period covering January to June) and not later than 31 January (for period covering July to December)	PMU
	Preparation of corrective actions for non-compliances and non-conformances, if required for any reporting period.	PIU / PMCSC / Contractor
	Implementation of GRM	PMU, PIU
	Information disclosure and stakeholder engagement	PMU, PIU
	Preparation and delivery of safeguards capacity building plan (excluding those that are internally covered by the Contractor)	PMCSC
	Continuing consultations with stakeholders, including the private sector, NGOs and civil society organizations	PMU, PIU with support of PMCSC
	Updating of IEE for Tranche 2 and Tranche 3, if required	PMU, PMCSC
Post-construction Phase	Preparation and implementation of reinstatement and rehabilitation plan, which includes	Contractor

	rehabilitation of disturbed areas/properties and revegetation/tree-planting.	
	Preparation of post-construction environmental audit report	
	Validation and approval of post-construction environmental audit report	PIU with support of PMCSC
Operation Phase	Implementation of EMP (Operation Phase)	PMU, PIU
	Continuing consultations with stakeholders, including the private sector, NGOs and civil society organizations	PMU, PMU
	Submission of SEMR to ADB, not later than 31 July (for period covering January to June) and not later than 31 January (for period covering July to December) until Project Completion Report is issued by ADB.	PMU

Appendix 1: Sample of Existing Site conditions, Receptors, Land Use and Proposed Construction Work

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Tranche 1				
	Pikka Canal (9.4 km)	-	Aquaculture : 2.1 km² (67 %) Village : 0.9 km² (30 %) Abandoned : 0.06 km² (2 %) Other Agriculture : 0.03 km² (1 %)	The improvement of Pikka Canal covers a total length of 9.4 km. The works involve reshaping the canal through earth excavation along the entire length. Associated hydraulic structures are included. This improvement increases the canal's discharge capacity from 5 cubic meters per second to 16 cubic meters per second.	  There is mostly limited road access.
	Raphiphat Canal (32.3 km)	Wat Statue, left side	Village: 3.2 km² (40%) Paddy Field: 2.0 km² (25%) Roads: 1.4 km² (17%) Industrial Land: 0.7 km² (9%)	The improvement of Raphiphat Canal covers a length of 32.3 km and involves reshaping the canal using a vertical wall design with driven concrete sheet piles reinforced with steel, along the entire 32.3 kilometers. The project includes associated structures and will increase the water	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
			Other Agriculture: 0.2 km ² (3%) Abandoned: 0.4 km ² (5%)	discharge capacity from 210 cubic meters per second to 400 cubic meters per second.	 The road access for both the left and east banks is facilitated by two lanes, each approximately 7 m wide.
	Raphiphat Yaek Tok Canal (36.7 km)	Kum Hak Health Promoting Hospital, left side Nong Rong Health Promoting Hospital, left side Wang Chula Health Promoting Hospital, left side Phayom Health Promoting Hospital, left side	Village : 6.4 km ² (56%) Paddy Field : 1.3 km ² (12%) Roads : 1.1 km ² (10%) Other Agriculture : 1.1 km ² (9%) Abandoned : 0.7 km ² (6%) Industrial Land : 0.3 km ² (3%) Aquaculture : 0.3 km ² (2%) Golf course : 0.2 km ² (1%)	The improvement of Raphiphat Yaek Tok Canal spans a total length of 36.7 km. The work consists of two main components: approximately 0.3 km of reinforced concrete corrugated sheet pile vertical wall construction in selected sections, and 36.4 km of canal reshaping through earth excavation. The project also includes the construction of associated hydraulic structures. The project is divided into two sections. Part 1 extends from the downstream side of the Phra Sri Sin Regulator to the junction with Hok Wa Sai Bon	  The road access for both the left and east banks is facilitated by

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
				Canal (Canal 10). In this part, the water discharge capacity will be increased from 85 cubic meters per second to 100 cubic meters per second. Section 2 continues from the junction with Hok Wa Sai Bon Canal(Canal 10) to the Phra In Racha siphon. In this part, the discharge capacity will be enhanced from 40 cubic meters per second to 60 cubic meters per second at the upstream part, and to 45 cubic meters per second at the downstream part.	two lanes, each approximately 6-7 m wide.
	Rangsit Prayunsak Canal (30.3 km)	Thanya Witthaya kindergarten, left side Thanya Witthaya foundation school, left side Thanyaburi hospital, right side Provincial administration college, right side Wat Muljindararam, left side Wat Kienket, right side	Village : 2.0 km ² (56%) Roads : 0.7 km ² (19%) Other Agriculture : 0.6 km ² (17%) Abandoned : 0.2 km ² (4%) Paddy Field : 0.1 km ² (3%)	The improvement of Rangsit Prayunsak Canal (Part 1) covers a total length of 30.3 km. It includes 21.0 km of canal reshaping through earth excavation, combined with 1.4 km of reinforced concrete corrugated sheet pile wall on the left canal bank. In addition, stability enhancement of the earth canal banks using concrete corrugated sheet pile (CCSP) sheet piles is implemented along 7.4 km on the left bank and 8.8 km on the right bank. This section	 

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
		Fa Sirin kindergarten, left side Chumchon Prachathipat Witthayakhan school, right side Siri Sueksa school, left side P. Phibunsongkhram bunker, left side Wat Thian Thawai, left side Wat Talat Nuea, left side Wat Pa Klang Thung, left side Wat Chinwararam Worawihan, right side		extends from the junction with Canal 1 to Canal 13 and allows a discharge capacity of 55.0 cubic meters per second.	The road access for both the left banks is approximately 10 m. For the right bank, access is intermediate, with a width of approximately 6 m.
	Dan Canal (10.6 km)	Ban Bang Phriang, left side Dan Canal Sub-district Health Promoting Hospital, Village No. 13, Samut Prakan Province, right side	Village : 1.9 km ² (51 %) Aquaculture : 1.5 km ² (39 %) Abandoned : 0.2 km ² (5 %) Industrial Land : 0.1 km ² (3 %) Roads : 0.04 km ² (1 %)	The improvement of Dan Canal, with a reported length of 10.6 km, involves reshaping the canal using vertical wall structures made of driven reinforced concrete sheet piles along the entire length. Associated hydraulic structures are included. This improvement increases the	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
			Other Agriculture : 0.02 km ² (1 %)	canal's discharge capacity from 30 cubic meters per second to 108 cubic meters per second.	 There is mostly limited road access.
	Ta lam Canal (8.0 km)		Aquaculture: 1.4 km ² (54%) Village: 1.2 km ² (43%) Abandoned Land: 0.1 km ² (3%)	The improvement work on Ta lam Canal , with a total length of 8.0 kilometers, involves reshaping the canal using vertically reinforced concrete wall structures with pre-cast sheet piles along the entire length. The project also includes the construction of associated hydraulic structures. This intervention increases the canal's discharge capacity from 3 cubic meters per second to 8 cubic meters per second.	  There is mostly limited road access.
	Samrong Canal	Wat Sukanthasilaram (Hom Sin), left side	Village : 2.830 km ² (64%)	The second part covers a length of 12.1 km, with 1.6 km undergoing similar structural	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	(Part 2) (12.1 km)	Tha Sa An Health Promoting Hospital Chachoengsao Province, left side	Aquaculture : 1.238 km ² (28%) Abandoned : 0.221 km ² (5%) Roads : 0.051 km ² (1%) Other Agriculture : 0.045 km ² (1%) Other : 0.032 km ² (1%)	upgrades. This section also includes related structures and enhances the discharge capacity from 8 cubic meters per second to 20 cubic meters per second.	  There is mostly limited road access.
	Raphiphat Yaek Tai Canal (27.9 km)	No historical or cultural sites listed by the Department of Fine Arts within 1 km from either side of the canal Single houses along sections on both sides of the canal College Nongkhae, left side,	Sections with single trees along both sides of the canal (canal side) Banks covered with grass and shrubs Village : 3.6 km ² (44 %)	Improving the canal cross-section using vertical retaining walls made of CCSP, with a total length of 27.9 km.	

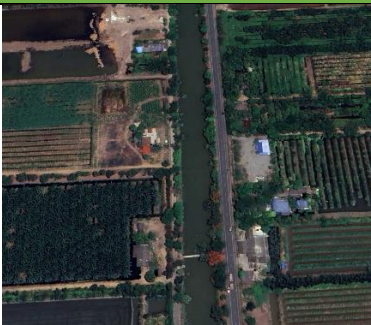
Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
		Wat Sang Boon School, left side 3 schools Wat Si Pathum, left side Wat Mai Thepnimit, left side Darul Muhayrin Mosque, right side Wat Thammarat Charoenphol, left side Pre-cast concrete production plant, left side	Other Agriculture : 1.3 km ² (16 %) Roads: 0.8 km ² (10 %) Paddy Field : 0.8 km ² (10 %) Aquaculture : 0.8 km ² (9 %) Abandoned : 0.7 km ² (8 %)		 The road access for both the left and east banks is facilitated by two lanes, each approximately 7-10 m wide.
	Canal 13 (Part1) (13.0 km)	Piyarat Kindergarten Debsirin Khlong Sip Sam Pathum Thani School, right side, Prathip Kindergarten, left side, Phluea Udom Health Promoting Hospital, left side	Village: 1.5 km ² (41%) Other Agriculture: 0.8 km ² (21%) Paddy Field: 0.5 km ² (14%) Roads: 0.4 km ² (11%) Abandoned: 0.2 km ² (6%) Industrial Land: 0.2 km ² (4%) Aquaculture: 0.1 km ² (4%)	The improvement of Canal 13 (Part 1), with a length of 13.0 km, involves improving the canal profile. This includes constructing vertically retaining walls along the left bank over 12.2 km and dredging to reshape the canal as an earthen canal with slope stabilisation using corrugated prestressed concrete sheet piles (CCSP) along 0.8 km of the left bank. The right bank will be dredged and widened as an earthen canal, with slope stabilising using CCSP along the full 13.0 km. The	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
				works include associated structures.	 The road access for both the left and east banks is facilitated by two lanes, each approximately 7 m wide.
	Canal 13 (Part2) (10.2 km)	Surao Ban Ko School, right side Atdinunnasiha School, right side	Village : 2.0 km ² (63 %) Paddy Field : 0.6 km ² (18 %) Roads : 0.2 km ² (6 %) Abandoned : 0.1 km ² (5 %) Other Agriculture : 0.1 km ² (5 %) Aquaculture : 0.1 km ² (3 %)	The improvement of Canal 13 (Part 2), with a total length of 10.2 km, consists of improving the canal into a vertical wall profile using corrugated prestressed concrete sheet piles (CCSP) along the entire length, including associated structures.	 The road access for both the left and right banks is facilitated by two lanes, each approximately 7 m wide.

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Canal 14 (Part 1) (14.1 km)		Village : 1.3 km² (33%) Other Agriculture : 1.0 km² (24%) Abandoned : 0.7 km² (16%) Paddy Field : 0.6 km² (15%) Aquaculture : 0.2 km² (5%) Roads : 0.2 km² (5%) Golf course : 0.1 km² (1%)	The improvement of Canal 14 (Part 1) covers a total length of 14.1 km. This includes 13.8 km of canal reshaping through earth excavation, combined with 0.2 km of reinforced concrete sheet pile wall (cast-in-place) on the left bank. To enhance stability, 13.8 km of CCSP are installed on the left bank and 0.5 km on the right bank. The section extends from the outer river boundary to Rangsit Prayunsak Canal, with associated hydraulic structures. The discharge capacity is increased from 30.0 cubic meters per second to 50.0 cubic meters per second.	  The road access is available only for the left banks, which is approximately 7 m wide. However, the right bank is difficult to access, with a width of only approximately 3 m.

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Canal 14 (Part 3) (12.6 km)	Wat Mai Charoen Rat School, left side	Village : 2.6 km ² (58%) Paddy Field : 1.6 km ² (36%) Other Agriculture : 0.1 km ² (2%) Abandoned : 0.07 km ² (2%) Aquaculture : 0.03 km ² (1%) Golf course : 0.02 km ² (1%) Industrial Land : 0.02 km ² (1%)	The improvement of Canal 14 (Section 3) covers a total length of 12.6 km. It involves reshaping the canal into a vertical wall structure using reinforced concrete sheet piles along the entire section. The works also include associated hydraulic structures. This improvement increases the discharge capacity from 20 cubic meters per second to 50 cubic meters per second.	  There is mostly limited road access.
	Phra Ong Chaianuchit Canal (Pilot) (850 m)		Village : 0.166 km ² (44%) Industrial Land : 0.090 km ² (24%) Paddy Field : 0.085 km ² (22%) Other Agriculture : 0.024 km ² (6%)	850 m CODI Pilot Project	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
			Roads : 0.016 km ² (4%)		 There is mostly limited road access.
	Canal 15 (Part 1) (14.2 km)		Village : 2.6 km ² (54%) Paddy Field : 1.3 km ² (27%) Abandoned : 0.4 km ² (8%) Other Agriculture : 0.3 km ² (6%) Aquaculture : 0.09 km ² (2%) Industrial Land : 0.06 km ² (1%) Roads : 0.04 km ² (1%)	The improvement of Canal 15 (Section 1) covers a total length of 14.2 km. It involves reshaping the canal using CCSP along the entire section. The works include associated hydraulic structures. This improvement increases the discharge capacity from 28 cubic meters per second to 55 cubic meters per second.	  There is mostly limited road access.
	Tranche 2				

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Canal 10 (21.4 km)	Nong Suea Hospital, right side	Village : 2.9 km² (47%) Other Agriculture : 1.5 km² (23%) Paddy Field : 0.7 km² (11%) Roads : 0.5 km² (7%) Abandoned : 0.4 km² (7%) Industrial Land : 0.2 km² (3%) Aquaculture : 0.1 km² (1%)	The improvement of Canal 10 covers a length of 21.4 kilometers and involves reshaping the canal through earth excavation. The works include associated hydraulic structures and extend from the junction with Raphiphat Yaek Tok Canal to Rangsit Prayunsak Canal. As a result of the improvement, the canal's discharge capacity will increase from 27 cubic meters per second to 40 cubic meters per second.	  The road access for both the east banks is approximately 7 m. For the left bank, access is intermediate, with a width of approximately 5 m.
	Nakhon Nueng Khet Canal (8.6 km)	Ninlarat Uppatham School, left side Sawang Arom Temple, right side Nakhon Nueng Khet Health Promoting Hospital Chachoengsao Province, right side	Village : 6.0 km² (63%) Abandoned : 1.2 km² (12%) Paddy Field : 1.0 km² (10%) Industrial Land : 0.6 km² (6%) Aquaculture : 0.4 km² (4%)	The improvement of Nakhon Nueng Khet Canal (Section 1), with a total length of 8.6 km, involves reshaping the canal using vertical retaining walls made of corrugated prestressed concrete sheet piles (CCSP) 6.4 km along the left bank and 2.7 km along the right bank. Additionally,	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
		Wat Chana Songsarn, left side Wat Nakhon Nueng Khet (Wat Ton Tan), left side	Other Agriculture : 0.3 km ² (4%)	dredging over 2.3 km and slope stabilization along 2.1 km, along with associated structures.	 There is limited road access to the main canal, with only a few roads available.
	Phra Ong Chaianuchit Canal (Part 2) (14.2 km)	Khlong Luang Phaeng Health Promoting Hospital, left side	Village : 2.78 km ² (62%) Paddy Field : 0.75 km ² (17%) Aquaculture : 0.54 km ² (12%) Abandoned : 0.23 km ² (5%) Roads : 0.10 km ² (2%)	The improvement works on Phra Ong Chaianuchit Canal (Part 2), with a total length of 14.2 km, involve reshaping the canal using vertical retaining walls constructed with pre-cast reinforced concrete sheet piles along the entire section, together with associated hydraulic structures. This upgrade increases the canal's drainage capacity from the original 50 cubic meters per second to 120 cubic meters per second.	  There is mostly limited road access.

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Canal 14 (Part 2) (13.6 km)		Village : 1.8 km ² (40 %) Paddy Field : 1.1 km ² (25 %) Abandoned : 0.7 km ² (16 %) Other Agriculture : 0.6 km ² (12 %) Industrial Land : 0.2 km ² (4 %) Aquaculture : 0.07 km ² (2 %) Roads : 0.06 km ² (1 %)	The improvement of Canal 14 (Part 2) covers a total length of 13.6 km. This involves reshaping the canal using reinforced concrete sheet piles along the entire section, with associated hydraulic structures. The upgrade increases the canal's discharge capacity from 30.0 to 50.0 cubic meters per second.	  There is mostly limited road access.
	Hok Wa Sai Lang Canal (9.2 km)		Village : 5.4 km ² (70 %) Paddy Field : 1.0 km ² (13 %) Abandoned : 0.8 km ² (10 %) Other Agriculture : 0.2 km ² (3 %) Aquaculture : 0.2 km ² (2 %)	The improvement of Hok Wa Sai Lang Canal covers a total length of 9.2 km. The project involves reshaping the canal with 9.2 km of reinforced concrete sheet pile retaining walls. A 0.50-km section, which serves as a connecting vertical canal, will not be improved. The works include the construction of associated	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
			Industrial Land : 0.1 km ² (2 %) Roads : 0.06 km ² (1 %)	structures and are designed to enhance the canal's discharge capacity to 60, 65, 80, and 95 cubic meters per second, depending on the specific segments of the canal.	 There is mostly limited road access.
	Phra Ong Chaianuchit Canal (Part 1) (4.5 km)		Village : 0.99 km ² (64%) Paddy Field : 0.27 km ² (17%) Abandoned : 0.20 km ² (13%) Other Agriculture : 0.05 km ² (3%) Aquaculture : 0.03 km ² (2%)	Improvement works on Phra Ong Chaianuchit Canal (Part 1), with a total length of 4.5 km, involve reshaping the canal using vertical retaining walls constructed with pre-cast reinforced concrete sheet piles along its entire length, including associated hydraulic structures. This enhancement increases the canal's drainage capacity from the original 30–71 cubic meters per second to 125 cubic meters per second.	  There is mostly limited road access.

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Udom Chonlajorn Canal (15.0 km)		Village : 3.2 km ² (62%) Aquaculture : 0.9 km ² (17%) Abandoned : 0.5 km ² (9%) Paddy Field : 0.4 km ² (7%) Industrial Land : 0.2 km ² (3%) Other Agriculture : 0.09 km ² (2%)	The improvement of Udom Chonlajorn Canal involves upgrading to a total length of 15 km. The work includes reshaping the canal using a vertical wall design with prestressed CCSP along the entire length. Accompanying structures will also be constructed. This enhancement will increase the canal's discharge capacity from the original 14 cubic meters per second to 30 cubic meters per second.	  There is mostly limited road access.
	Canal 15 (Part 2) (13.4 km)	Bueng Nam Rak Health Promoting Hospital, right side	Village : 3.4 km ² (74 %) Paddy Field : 0.9 km ² (20 %) Other Agriculture : 0.1 km ² (3 %) Abandoned : 0.1 km ² (2 %) Aquaculture : 0.05 km ² (1 %)	The improvement of Canal 15 (Part 2) covers a total length of 13.4 km, involving canal widening using reinforced CCSP walls along the entire section. The works include associated hydraulic structures. This improvement increases the discharge capacity from 20 cubic meters	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
				per second to 40 cubic meters per second.	 There is mostly limited road access.
	Tranche 3				
	Samrong Canal (Part 1) (1.63 km)		Village : 0.46 km ² (89%) Aquaculture : 0.04 km ² (8%) Industrial Land : 0.01 km ² (2%) Roads : 0.00 km ² (1%)	The improvement of Samrong Canal (Part 1), with a total length of 1.63 km, involves reshaping the canal into a vertical wall section using pre-cast reinforced concrete sheet piles along the entire stretch. The works also include associated hydraulic structures. This upgrade increases the canal's discharge capacity from 50 cubic meters per second to 108 cubic meters per second.	  There is mostly limited road access.

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Phra Ong Chaianuchit Canal (Part 3) (14.0 km)	Sala Daeng Health Promoting Hospital, Left Side Khleng Luang Phaeng Health Promoting Hospital, Left Side Preng Health Promoting Hospital, Left Side Talat Pak Khleng Chao School, Right Side Wat Sukhanthawat School, Right Side	Village : 6.0 km ² (59%) Aquaculture : 1.5 km ² (15%) Paddy Field : 1.1 km ² (11%) Roads : 0.2 km ² (2%) Abandoned : 0.6 km ² (6%) Industrial Land : 0.2 km ² (2%) Golf course : 0.2 km ² (2%) Other Agriculture : 0.1 km ² (1%)	The improvement works on Phra Ong Chaianuchit Canal involve vertical wall reshaping using pre-cast reinforced concrete sheet piles along a total length of 14.0 kilometers. The project includes the construction of associated hydraulic structures to enhance canal functionality. As a result of these upgrades, the canal's discharge capacity has been significantly increased—from the original range of 30–71 cubic meters per second to 125 cubic meters per second in one section, and from 50.0 to 120.0 cubic meters per second in another.addition of hydraulic structures, the drainage capacity increased from 50 cubic meters per second to 120 cubic meters per second.	  Access to the canal is challenging due to the presence of only one road, with households obstructing further access.

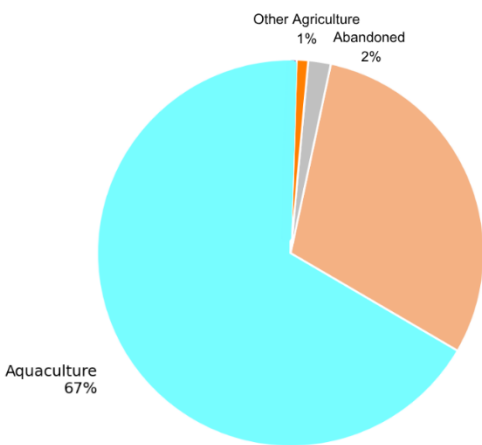
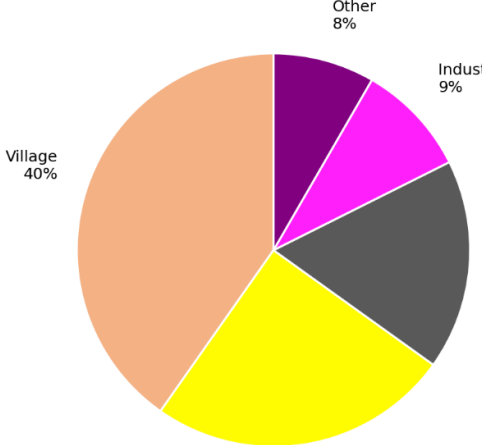
Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Canal 16 (Part 1) (14.8 km)		Village : 3.1 km ² (67%) Paddy Field : 0.8 km ² (17%) Abandoned : 0.5 km ² (11%) Other Agriculture : 0.1 km ² (3%) Roads : 0.06 km ² (1%) Aquaculture : 0.03 km ² (1%)	The improvement work for Canal 16 (Section 1) covers a total length of 14.8 km. The canal will be reshaped using a vertical retaining wall structure with pre-cast reinforced concrete sheet piles over a length of 15.8 km, along with the construction of associated structures. This improvement will increase the water discharge capacity from 35 cubic meters per second to 55 cubic meters per second.	  There is mostly limited road access.
	Canal 16 (Part 2) (14.4 km)		Village : 3.2 km ² (63 %) Paddy Field : 0.9 km ² (18 %) Abandoned : 0.6 km ² (12 %) Aquaculture : 0.3 km ² (5 %) Other Agriculture : 0.08 km ² (1 %)	The Improvement works for Canal 16 (Part 2), with a total length of 14.4 km, involves reshaping the canal using vertical retaining walls constructed with reinforced concrete sheet piles. The work includes related structures and is expected to increase the discharge capacity from 30 cubic meters per second to 40 cubic meters per second.	

Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
					 There is mostly limited road access.
	Canal 17 (14.7 km)		Village: 3.6 km ² (75%) Paddy Field: 0.5 km ² (12%) Abandoned: 0.4 km ² (8%) Aquaculture: 0.1 km ² (3%) Other Agriculture: 0.08 km ² (2%) Industrial Land: 0.06 km ² (1%)	The Improvement works for Canal 17 , with a total length of 14.7 kilometers, involve reshaping the canal using vertical retaining walls constructed with corrugated prestressed concrete sheet piles (CCSP). The work includes associated structures and is expected to increase the discharge capacity from 40 cubic meters per second to 80 cubic meters per second.	  There is mostly limited road access.

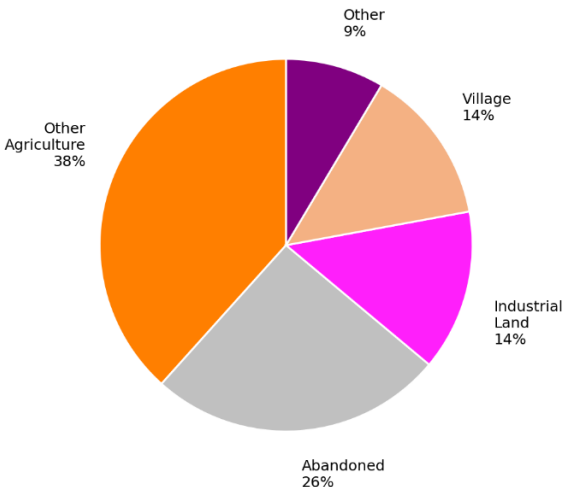
Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
	Nakhon Nueng Khet Canal (19.1 km) (Part 2)	Ninlarat Uppatham School, on the left side Sawang Arom Temple, right side Nakhon Nueng Khet Health Promoting Hospital Chachoengsao Province, right side Wat Chana Songsarn, left side Wat Nakhon Nueng Khet (Wat Ton Tan), left side	Village : 6.0 km ² (63%) Abandoned : 1.2 km ² (12%) Paddy Field : 1.0 km ² (10%) Industrial Land : 0.6 km ² (6%) Aquaculture : 0.4 km ² (4%) Other Agriculture : 0.3 km ² (4%)	Improvement works on Khlong Nakhon Nueng Khet (Part 2), with a total length of 19.1 km, involve reshaping the canal using vertically reinforced CCSP along its entire length, including associated hydraulic structures. This enhancement increases the canal's drainage capacity from the original 12 cubic meters per second to 24 cubic meters per second.	  There is limited road access to the main canal, with only a few roads available.
	Prawet Burirom Canal (23.3 km)	Talat Pak Khlong Chao School, right side Khlong Preng Health Promoting Hospital Chachoengsao Province, left side Wat Mai Prawet School (Si Pracha Bamrung), right side	Village : 5.2 km ² (65 %) Aquaculture : 1.1 km ² (14 %) Abandoned : 0.5 km ² (6 %) Other Agriculture : 0.4 km ² (6 %) Paddy Field : 0.4 km ² (5 %) Industrial Land : 0.3 km ² (4 %)	The improvement of Prawet Burirom Canal covers a total length of 23.3 km. The project involves reshaping the canal into a vertical wall structure using driven reinforced concrete sheet piles along the entire length. Accompanying structures will also be constructed. This upgrade will increase the water discharge capacity from the original 7–27 cubic meters per second to	

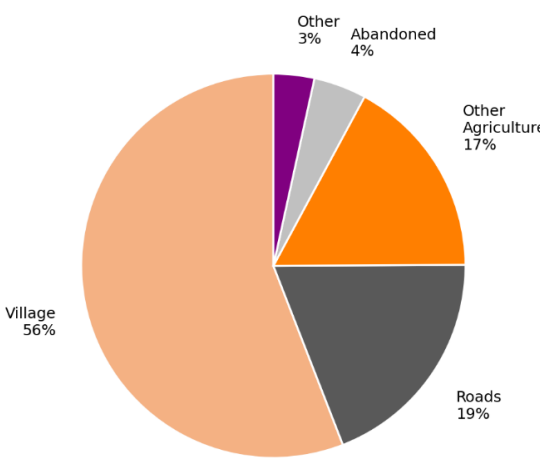
Code	Project Component	Socio-Economic & Cultural Receptors	Land Use within 100 m wide zone	Construction Work	Road Access
				30–60 cubic meters per second.	 There is mostly limited road access.

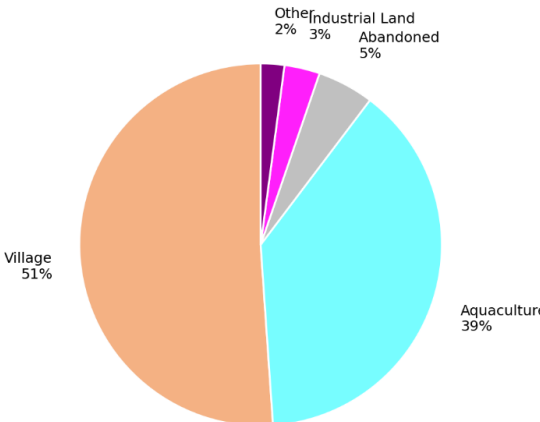
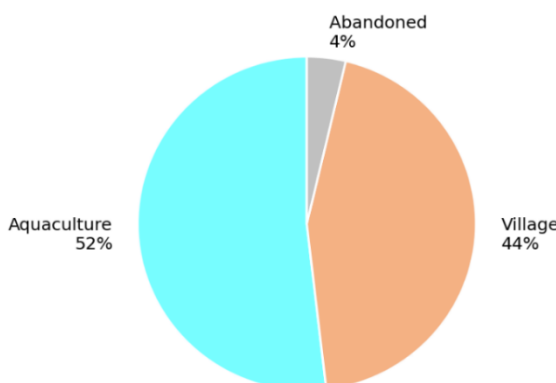
Appendix 2: Land Use Statistics

Appendix 2: Land Use Statistics																
Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
Tranche 1																
	Pikka Canal (9.4 km)	No roads	 <table><tr><th>Land Use</th><th>Percentage</th></tr><tr><td>Aquaculture</td><td>67%</td></tr><tr><td>Village</td><td>30%</td></tr><tr><td>Abandoned</td><td>2%</td></tr><tr><td>Other Agriculture</td><td>1%</td></tr></table>	Land Use	Percentage	Aquaculture	67%	Village	30%	Abandoned	2%	Other Agriculture	1%	9.4 km improvement of Pikka Canal Full-length canal reshaping by earth excavation Associated hydraulic structures Capacity increased from 5.0 m³/s to 16.0 m³/s		
Land Use	Percentage															
Aquaculture	67%															
Village	30%															
Abandoned	2%															
Other Agriculture	1%															
	Raphiphat Canal (32.3 km)	Wat Satue, left side 7 m wide road on both sides	 <table><tr><th>Land Use</th><th>Percentage</th></tr><tr><td>Village</td><td>40%</td></tr><tr><td>Paddy Field</td><td>25%</td></tr><tr><td>Roads</td><td>17%</td></tr><tr><td>Industrial Land</td><td>9%</td></tr><tr><td>Other</td><td>8%</td></tr></table>	Land Use	Percentage	Village	40%	Paddy Field	25%	Roads	17%	Industrial Land	9%	Other	8%	32.3 km concrete sheet piles Associated structures increase capacity from 210 m³/s to 400 m³/s
Land Use	Percentage															
Village	40%															
Paddy Field	25%															
Roads	17%															
Industrial Land	9%															
Other	8%															

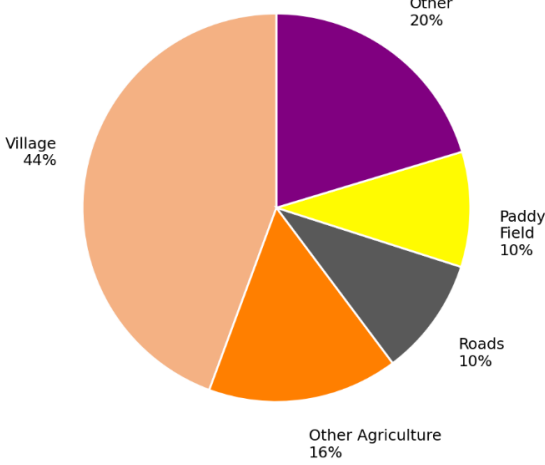
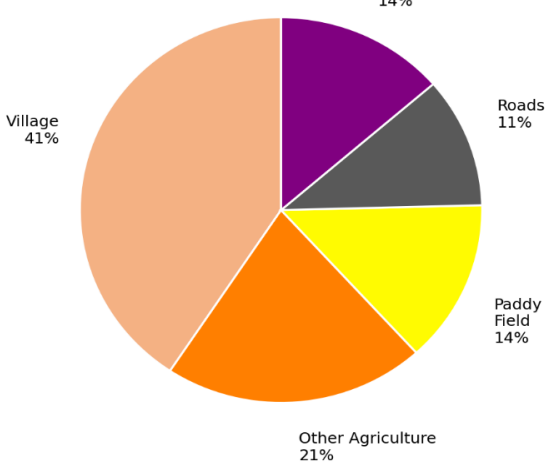
31 The types and extent of different land uses along each canal are presented as the percent of a 100 m wide area along each side of the canal that is occupied by a particular land use. These percentages have been calculated based on detailed land use maps (2021) obtained from the Department of Land

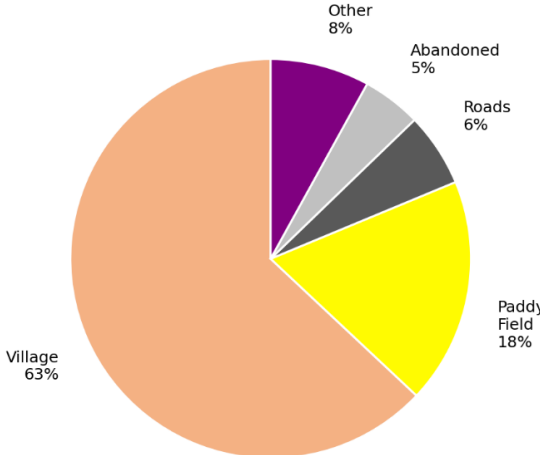
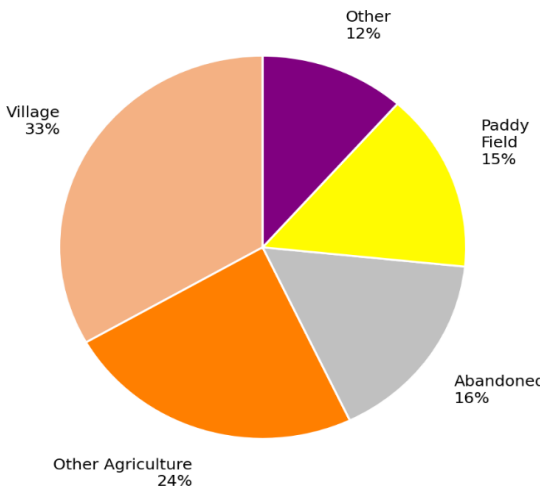
Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
	Raphiphat Yaek Tok Canal (36.7 km)	Kum Hak Health Promoting Hospital, left side Nong Rong Health Promoting Hospital, left side Wang Chula Health Promoting Hospital, left side Phayom Health Promoting Hospital, left side 7 m wide road on both sides	 <table border="1"> <caption>Land Use and Cover Data</caption> <thead> <tr> <th>Category</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Other Agriculture</td> <td>38%</td> </tr> <tr> <td>Abandoned</td> <td>26%</td> </tr> <tr> <td>Industrial Land</td> <td>14%</td> </tr> <tr> <td>Village</td> <td>14%</td> </tr> <tr> <td>Other</td> <td>9%</td> </tr> </tbody> </table>	Category	Percentage	Other Agriculture	38%	Abandoned	26%	Industrial Land	14%	Village	14%	Other	9%	36.7 km improvement of Raphiphat Yaek Tok Canal 0.3 km of CCSP vertical retaining wall and 36.4 km of canal reshaping by earth excavation Associated hydraulic structures Part 1: Phra Sri Sin Regulator to Hok Wa Sai Bon Canal (Canal 10) — capacity increased from 85 m³/s to 100 m³/s Part 2: Hok Wa Sai Bon Canal (Canal 10) to Phra In Racha siphon — capacity increased from 40 m³/s to 60 m³/s (upstream), and to 45 m³/s
Category	Percentage															
Other Agriculture	38%															
Abandoned	26%															
Industrial Land	14%															
Village	14%															
Other	9%															

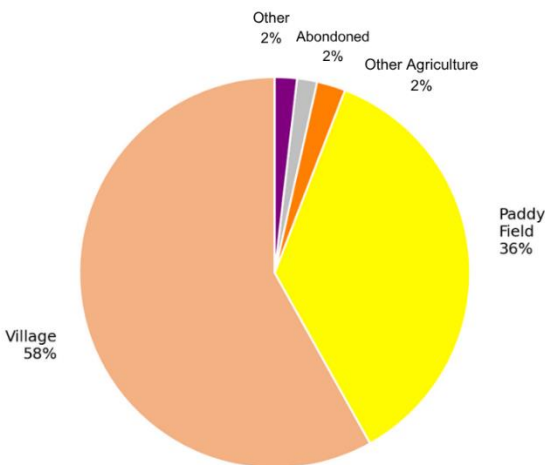
Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
				(downstre am)												
	Rangsit Prayunsa k Canal (30.3 km)	Thanya Witthaya kindergarten, left side Thanya Witthaya foundation school, left side Thanyaburi hospital, right side Provincial administration college, right side Wat Muljindararam , left side Wat Kienket, right side Fa Sirin kindergarten, left side Chumchon Prachathipat Witthayakhan school, right side Siri Sueksa school, left side P. Phibunsongkh ram bunker, left side Wat Thian Thawai, left side Wat Talat Nuea, left side Wat Pa Klang Thung, left side	 <table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Village</td><td>56%</td></tr><tr><td>Roads</td><td>19%</td></tr><tr><td>Other Agriculture</td><td>17%</td></tr><tr><td>Abandoned</td><td>4%</td></tr><tr><td>Other</td><td>3%</td></tr></table>	Land Use and Cover	Percentage	Village	56%	Roads	19%	Other Agriculture	17%	Abandoned	4%	Other	3%	30.3 km improvem ent of Rangsit Prayunsak Canal (Part 1) Bank stability improvem ent using CCSP: 7.4 km (left), 8.8 km (right) From Canal 1 to Canal 13 Capacity: 55.0 m³/s
Land Use and Cover	Percentage															
Village	56%															
Roads	19%															
Other Agriculture	17%															
Abandoned	4%															
Other	3%															

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
		Wat Chinwararam Worawihan, right side 6 lane expressway on northern side 7 m wide road on southern side														
	Dan Canal (10.6 km)	Ban Bang Phriang, left side Klong Dan Sub-district Health Promoting Hospital, Village No. 13, Samut Prakan Province, right side No roads Boardwalk on right bank	 <table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Village</td><td>51%</td></tr><tr><td>Aquaculture</td><td>39%</td></tr><tr><td>Abandoned</td><td>5%</td></tr><tr><td>Industrial Land</td><td>3%</td></tr><tr><td>Other</td><td>2%</td></tr></table>	Land Use and Cover	Percentage	Village	51%	Aquaculture	39%	Abandoned	5%	Industrial Land	3%	Other	2%	10.6 km improvement of Dan Canal Full-length vertical wall reshaping using driven reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 30.0 m³/s to 108.0 m³/s
Land Use and Cover	Percentage															
Village	51%															
Aquaculture	39%															
Abandoned	5%															
Industrial Land	3%															
Other	2%															
	Ta lam Canal (8.0 km)		 <table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Aquaculture</td><td>52%</td></tr><tr><td>Village</td><td>44%</td></tr><tr><td>Abandoned</td><td>4%</td></tr></table>	Land Use and Cover	Percentage	Aquaculture	52%	Village	44%	Abandoned	4%	8.0 km improvement of Ta lam Canal Full-length vertical wall reshaping using pre-cast reinforced concrete sheet piles				
Land Use and Cover	Percentage															
Aquaculture	52%															
Village	44%															
Abandoned	4%															

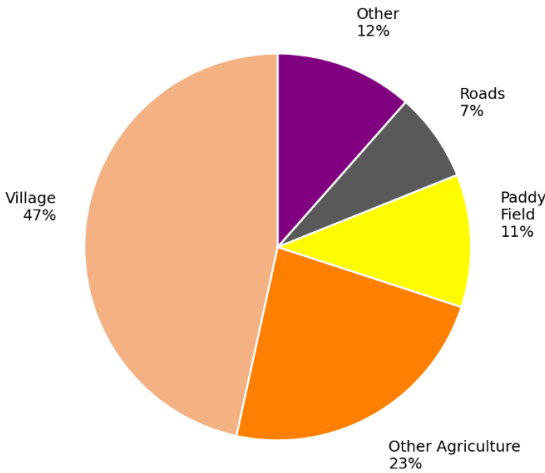
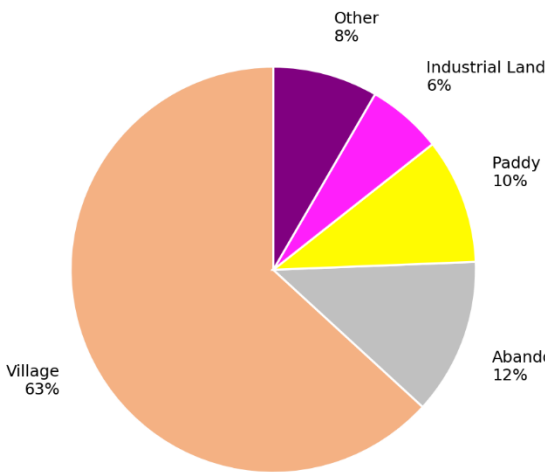
Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work														
				Associated hydraulic structures Capacity increased from 3.0 m³/s to 8.0 m³/s														
	Samrong Canal (Part 2) (12.1 km)	Wat Sukanthasilar am (Hom Sin), left side Tha Sa An Health Promoting Hospital Chachoengsa o Province, left side No road	<table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Village</td><td>64%</td></tr><tr><td>Aquaculture</td><td>28%</td></tr><tr><td>Abandoned</td><td>5%</td></tr><tr><td>Roads</td><td>1%</td></tr><tr><td>Other Agriculture</td><td>1%</td></tr><tr><td>Other</td><td>1%</td></tr></table>	Land Use and Cover	Percentage	Village	64%	Aquaculture	28%	Abandoned	5%	Roads	1%	Other Agriculture	1%	Other	1%	12.1 km improvement of Samrong Canal (divided into two parts) Part 2: 12.1 km section, with 1.6 km structurally upgraded using similar methods Associated hydraulic structures Capacity increased from 8.0 m³/s to 20.0 m³/s
Land Use and Cover	Percentage																	
Village	64%																	
Aquaculture	28%																	
Abandoned	5%																	
Roads	1%																	
Other Agriculture	1%																	
Other	1%																	

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
	Raphiphat Yaek Tai Canal (27.9 km)	College Nongkhae, left side, Wat Sang Boon School, left side 3 schools Wat Si Pathum, left side Wat Mai Thepnimit, left side Darul Muhayrin Mosque, right side Wat Thammarat Charoenphol, left side Pre-cast concrete production plant, left side 7 m wide road on both sides	 <table><caption>Land Use and Cover Data for Raphiphat Yaek Tai Canal</caption><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>44%</td></tr><tr><td>Other</td><td>20%</td></tr><tr><td>Paddy Field</td><td>10%</td></tr><tr><td>Roads</td><td>10%</td></tr><tr><td>Other Agriculture</td><td>16%</td></tr></tbody></table>	Category	Percentage	Village	44%	Other	20%	Paddy Field	10%	Roads	10%	Other Agriculture	16%	27.9 km of corrugated prestressed concrete sheet piles (CCSP) Associated structures
Category	Percentage															
Village	44%															
Other	20%															
Paddy Field	10%															
Roads	10%															
Other Agriculture	16%															
	Canal 13 (Part1) (13.0 km)	Piyarat Kindergarten Debsirin Khlong Sip Sam Pathum Thani School, right side, Prathip Kindergarten, left side, Phluea Udom Health Promoting Hospital, left side 7 m wide road on both sides	 <table><caption>Land Use and Cover Data for Canal 13 (Part1)</caption><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>41%</td></tr><tr><td>Other</td><td>14%</td></tr><tr><td>Roads</td><td>11%</td></tr><tr><td>Paddy Field</td><td>14%</td></tr><tr><td>Other Agriculture</td><td>21%</td></tr></tbody></table>	Category	Percentage	Village	41%	Other	14%	Roads	11%	Paddy Field	14%	Other Agriculture	21%	13.0 km improvement of Canal 13 (Part 1) 12.2 km of vertical retaining wall on the left bank 0.8 km of slope stabilisation (left bank) using CCSP 13.0 km of slope stabilisation
Category	Percentage															
Village	41%															
Other	14%															
Roads	11%															
Paddy Field	14%															
Other Agriculture	21%															

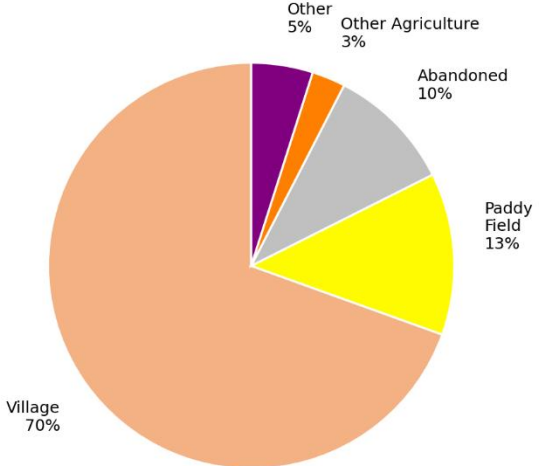
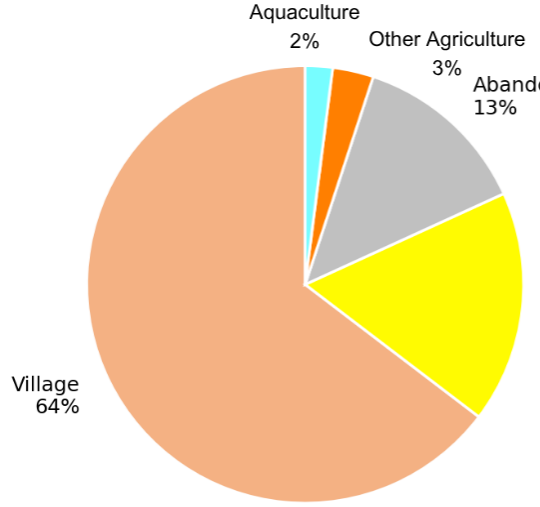
Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
				n (right bank) using CCSP and canal widening Associated hydraulic structures												
	Canal 13 (Part2) (10.2 km)	Surao Ban Ko School, right side Atdinunnasiha School, right side 7 m wide road on both sides	 <table> <tr> <th>Category</th> <th>Percentage</th> </tr> <tr> <td>Village</td> <td>63%</td> </tr> <tr> <td>Paddy Field</td> <td>18%</td> </tr> <tr> <td>Roads</td> <td>6%</td> </tr> <tr> <td>Abandoned</td> <td>5%</td> </tr> <tr> <td>Other</td> <td>8%</td> </tr> </table>	Category	Percentage	Village	63%	Paddy Field	18%	Roads	6%	Abandoned	5%	Other	8%	10.2 km improvement of Canal 13 (Part 2) Full-length vertical wall profile using CCSP Associated hydraulic structures
Category	Percentage															
Village	63%															
Paddy Field	18%															
Roads	6%															
Abandoned	5%															
Other	8%															
	Canal 14 (Part 1) (14.1 km)	Road on right bank	 <table> <tr> <th>Category</th> <th>Percentage</th> </tr> <tr> <td>Village</td> <td>33%</td> </tr> <tr> <td>Other Agriculture</td> <td>24%</td> </tr> <tr> <td>Abandoned</td> <td>16%</td> </tr> <tr> <td>Paddy Field</td> <td>15%</td> </tr> <tr> <td>Other</td> <td>12%</td> </tr> </table>	Category	Percentage	Village	33%	Other Agriculture	24%	Abandoned	16%	Paddy Field	15%	Other	12%	14.1 km improvement of Canal 14 (Part 1) 13.8 km of canal reshaping by earth excavation 0.2 km cast-in-place concrete sheet pile wall (left bank) Stability enhancement using CCSP:
Category	Percentage															
Village	33%															
Other Agriculture	24%															
Abandoned	16%															
Paddy Field	15%															
Other	12%															

Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
				13.8 km (left bank), 0.5 km (right bank) From the outer river boundary to Rangsit Prayunsak Canal Associated hydraulic structures Capacity increased from 30.0 m³/s to 50.0 m³/s												
	Canal 14 (Part 3) (12.6 km)	Wat Charoen School, side Mai Rat left	 <table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Village</td><td>58%</td></tr><tr><td>Paddy Field</td><td>36%</td></tr><tr><td>Other Agriculture</td><td>2%</td></tr><tr><td>Abandoned</td><td>2%</td></tr><tr><td>Other</td><td>2%</td></tr></table>	Land Use and Cover	Percentage	Village	58%	Paddy Field	36%	Other Agriculture	2%	Abandoned	2%	Other	2%	12.6 km improvement of Canal 14 (Section 3) Full-length vertical wall profile using reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 20.0 m³/s to 50.0 m³/s
Land Use and Cover	Percentage															
Village	58%															
Paddy Field	36%															
Other Agriculture	2%															
Abandoned	2%															
Other	2%															

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work
	Phra Ong Chaianuchit Canal (Pilot) (850 m)		Village 44% Industrial Land 24% Paddy Field 22% Other Agriculture 6% Roads 4%	850 m CODI Pilot Project
	Canal 15 (Part 1) (14.2 km)	No road	Village 54% Paddy Field 27% Abandoned 8% Other Agriculture 6% Other 4%	14.2 km improvement of Canal 15 (Part 1) Full-length canal reshaping using CCSP Associated hydraulic structures Capacity increased from 28.0 m³/s to 55.0 m³/s
TRaNCHE 2				

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
	Canal 10 (21.4 km)	Nong Suea Hospital, right side	 <table><caption>Land Use and Cover Data for Canal 10</caption><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>47%</td></tr><tr><td>Other Agriculture</td><td>23%</td></tr><tr><td>Paddy Field</td><td>11%</td></tr><tr><td>Other</td><td>12%</td></tr><tr><td>Roads</td><td>7%</td></tr></tbody></table>	Category	Percentage	Village	47%	Other Agriculture	23%	Paddy Field	11%	Other	12%	Roads	7%	21.4 km improvement of Canal 10 Canal reshaping by earth excavation Associated hydraulic structures From Raphiphat Yaek Tok Canal to Rangsit Prayunsak Canal Capacity increased from 27 m³/s to 40 m³/s
Category	Percentage															
Village	47%															
Other Agriculture	23%															
Paddy Field	11%															
Other	12%															
Roads	7%															
	Nakhon Nueng Khet Canal (8.6 km)	Ninlarat Uppatham School, on the left side Sawang Arom Temple, right side Nakhon Nueng Khet Health Promoting Hospital Chachoengsao Province, right side Wat Chana Songsarn, left side Wat Nakhon Nueng Khet (Wat Ton Tan), left side	 <table><caption>Land Use and Cover Data for Nakhon Nueng Khet Canal</caption><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>63%</td></tr><tr><td>Abandoned</td><td>12%</td></tr><tr><td>Paddy Field</td><td>10%</td></tr><tr><td>Other</td><td>8%</td></tr><tr><td>Industrial Land</td><td>6%</td></tr></tbody></table>	Category	Percentage	Village	63%	Abandoned	12%	Paddy Field	10%	Other	8%	Industrial Land	6%	8.6 km improvement of Nakhon Nueng Khet Canal (Part 1) CCSP vertical retaining walls: 6.4 km (left bank), 2.7 km (right bank) 2.3 km of dredging 2.1 km of slope stabilisation Associated hydraulic structures
Category	Percentage															
Village	63%															
Abandoned	12%															
Paddy Field	10%															
Other	8%															
Industrial Land	6%															

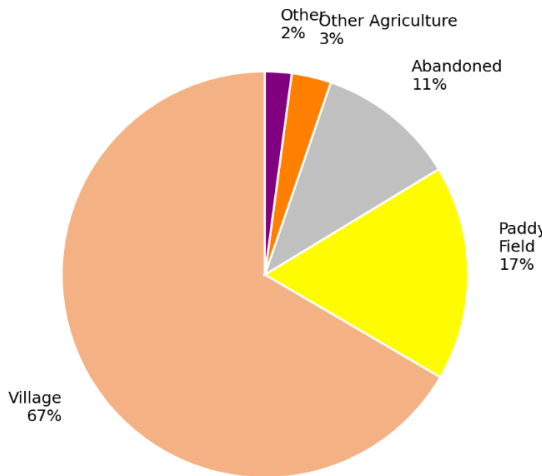
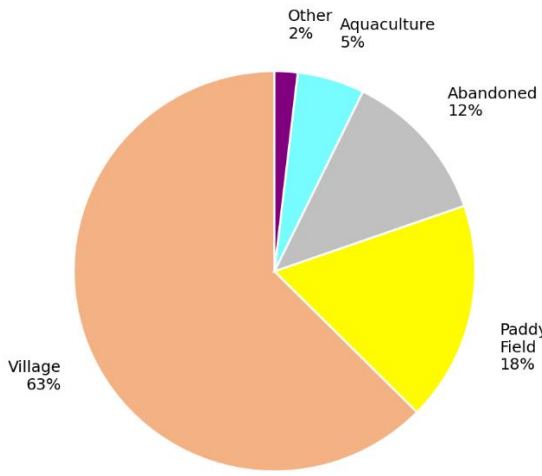
Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work
	Phra Ong Chaianu chit Canal (Part 2) (14.2 km)	Khlong Luang Phaeng Health Promoting Hospital, left side	Village 62% Paddy 17% Aquacult 12% Abandoned 5% Road 2% Other 2%	14.2 km improvem ent of Khlong Phra Ong Chaianu chit (Part 2) Vertical retaining walls with pre-cast reinforced concrete sheet piles: 14.2 km (both banks) Associated hydraulic structures Increases drainage capacity from 50 m ³ /s to 120 m ³ /s
	Canal 14 (Part 2) (13.6 km)		Village 40% Paddy Field 25% Other Agric 12% Aba 16% Other 7%	13.6 km improvem ent of Canal 14 (Part 2) Full-length reshaping using reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 30.0 m ³ /s to 50.0 m ³ /s

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
	Hok Wa Sai Lang Canal (9.2 km)		 <table><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>70%</td></tr><tr><td>Paddy Field</td><td>13%</td></tr><tr><td>Abandoned</td><td>10%</td></tr><tr><td>Other Agriculture</td><td>3%</td></tr><tr><td>Other</td><td>5%</td></tr></tbody></table>	Category	Percentage	Village	70%	Paddy Field	13%	Abandoned	10%	Other Agriculture	3%	Other	5%	9.2 km improvement of Hok Wa Sai Lang Canal 9.2 km of reinforced concrete sheet pile retaining walls Associated hydraulic structures Capacity increased to 60, 65, 80, and 95 m³/s, depending on canal segments
Category	Percentage															
Village	70%															
Paddy Field	13%															
Abandoned	10%															
Other Agriculture	3%															
Other	5%															
	Phra Ong Chaianuchit Canal (Part 1) (4.5 km)		 <table><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>64%</td></tr><tr><td>Paddy Field</td><td>17%</td></tr><tr><td>Abandoned</td><td>13%</td></tr><tr><td>Other Agriculture</td><td>3%</td></tr><tr><td>Aquaculture</td><td>2%</td></tr></tbody></table>	Category	Percentage	Village	64%	Paddy Field	17%	Abandoned	13%	Other Agriculture	3%	Aquaculture	2%	4.5 km improvement of Khlong Phra Ong Chaianuchit (Part 1) Vertical retaining walls with pre-cast reinforced concrete sheet piles : 4.5 km (both banks) Associated hydraulic structures Increases drainage capacity from 30–
Category	Percentage															
Village	64%															
Paddy Field	17%															
Abandoned	13%															
Other Agriculture	3%															
Aquaculture	2%															

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
				71 m³/s to 125 m³/s												
	Udom Chonlajor n Canal (15.0 km)		<table border="1"><thead><tr><th>Land Use and Cover</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>62%</td></tr><tr><td>Aquaculture</td><td>17%</td></tr><tr><td>Abandoned</td><td>9%</td></tr><tr><td>Paddy Field</td><td>7%</td></tr><tr><td>Other</td><td>5%</td></tr></tbody></table>	Land Use and Cover	Percentage	Village	62%	Aquaculture	17%	Abandoned	9%	Paddy Field	7%	Other	5%	15.0 km improvem ent of Udom Chonlajor n Canal Full-length vertical wall reshaping using CCSP Associated hydraulic structures Capacity increased from 14.0 m³/s to 30.0 m³/s
Land Use and Cover	Percentage															
Village	62%															
Aquaculture	17%															
Abandoned	9%															
Paddy Field	7%															
Other	5%															
	Canal 15 (Part 2) (13.4 km)	Bueng Nam Rak Health Promoting Hospital, right side	<table border="1"><thead><tr><th>Land Use and Cover</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>74%</td></tr><tr><td>Paddy Field</td><td>20%</td></tr><tr><td>Other Agriculture</td><td>3%</td></tr><tr><td>Abandoned</td><td>2%</td></tr><tr><td>Other</td><td>2%</td></tr></tbody></table>	Land Use and Cover	Percentage	Village	74%	Paddy Field	20%	Other Agriculture	3%	Abandoned	2%	Other	2%	13.4 km improvem ent of Canal 15 (Part 2) Full-length canal widening using CCSP walls Associated hydraulic structures Capacity increased from 20.0 m³/s to 40.0 m³/s
Land Use and Cover	Percentage															
Village	74%															
Paddy Field	20%															
Other Agriculture	3%															
Abandoned	2%															
Other	2%															
TRaNCHE 3																

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work										
	Samrong Canal (Part 1) (1.63 km)		<table><thead><tr><th>Land Use and Cover</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>89%</td></tr><tr><td>Aquaculture</td><td>8%</td></tr><tr><td>Industrial Land</td><td>2%</td></tr><tr><td>Roads</td><td>1%</td></tr></tbody></table>	Land Use and Cover	Percentage	Village	89%	Aquaculture	8%	Industrial Land	2%	Roads	1%	Vertical wall reshaping using pre-cast reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 50.0 m³/s to 108.0 m³/s 1.63 km improvement of Khlong Samrong (Part 1) Full-length vertical wall reshaping using pre-cast reinforced concrete sheet piles Associated hydraulic structures
Land Use and Cover	Percentage													
Village	89%													
Aquaculture	8%													
Industrial Land	2%													
Roads	1%													

Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal ³¹	Constructi on Work												
	Phra Ong Chaianu chit Canal (Part 3) (14.0 km)	Sala Daeng Health Promoting Hospital, Left Side Klong Luang Phaeng Health Promoting Hospital, Left Side Preng Health Promoting Hospital, Left Side Talat Pak Klong Chao School, Right Side Wat Sukhanthawat School, Right Side	<table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Village</td><td>59%</td></tr><tr><td>Aquaculture</td><td>15%</td></tr><tr><td>Paddy Field</td><td>11%</td></tr><tr><td>Other</td><td>8%</td></tr><tr><td>Abandoned</td><td>6%</td></tr></table>	Land Use and Cover	Percentage	Village	59%	Aquaculture	15%	Paddy Field	11%	Other	8%	Abandoned	6%	Vertical wall reshaping using pre-cast reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 30–71 m ³ /s to 125 m ³ /s 14.0 km improvem ent of Phra Ong Chaianuc hit Canal Full-length vertical wall reshaping using pre-cast reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 50.0 m ³ /s to 120.0 m ³ /s
Land Use and Cover	Percentage															
Village	59%															
Aquaculture	15%															
Paddy Field	11%															
Other	8%															
Abandoned	6%															

Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
	Canal 16 (Part 1) (14.8 km)		 <table><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>67%</td></tr><tr><td>Paddy Field</td><td>17%</td></tr><tr><td>Abandoned</td><td>11%</td></tr><tr><td>Other Agriculture</td><td>3%</td></tr><tr><td>Other</td><td>2%</td></tr></tbody></table>	Category	Percentage	Village	67%	Paddy Field	17%	Abandoned	11%	Other Agriculture	3%	Other	2%	14.8 km improvement of Canal 16 (Part 1) Vertical retaining wall using pre-cast reinforced concrete sheet piles (15.8 km) Associated hydraulic structures Capacity increased from 35.0 m³/s to 55.0 m³/s
Category	Percentage															
Village	67%															
Paddy Field	17%															
Abandoned	11%															
Other Agriculture	3%															
Other	2%															
	Canal 16 (Part 2) (14.4 km)		 <table><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>63%</td></tr><tr><td>Paddy Field</td><td>18%</td></tr><tr><td>Abandoned</td><td>12%</td></tr><tr><td>Aquaculture</td><td>5%</td></tr><tr><td>Other</td><td>2%</td></tr></tbody></table>	Category	Percentage	Village	63%	Paddy Field	18%	Abandoned	12%	Aquaculture	5%	Other	2%	14.4 km improvement of Canal 16 (Part 2) Full-length vertical retaining walls using reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 30.0 m³/s to 40.0 m³/s
Category	Percentage															
Village	63%															
Paddy Field	18%															
Abandoned	12%															
Aquaculture	5%															
Other	2%															

Cod e	Project Compone nt	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal31	Constructi on Work												
	Canal 17 (14.7 km)		<table border="1"><caption>Land Use and Cover Data for Canal 17</caption><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>75%</td></tr><tr><td>Paddy Field</td><td>12%</td></tr><tr><td>Abandoned</td><td>8%</td></tr><tr><td>Aquaculture</td><td>3%</td></tr><tr><td>Other</td><td>3%</td></tr></tbody></table>	Category	Percentage	Village	75%	Paddy Field	12%	Abandoned	8%	Aquaculture	3%	Other	3%	14.7 km improvem ent of Canal 17 Full-length vertical retaining walls using CCSP Associated hydraulic structures Capacity increased from 40.0 m³/s to 80.0 m³/s
Category	Percentage															
Village	75%															
Paddy Field	12%															
Abandoned	8%															
Aquaculture	3%															
Other	3%															
	Nakhon Nueng Khet Canal (19.1 km)	Ninlarat Uppatham School, left side Sawang Arom Temple, right side Nakhon Nueng Khet Health Promoting Hospital Chachoengsa o Province, right side Wat Chana Songsarn, left side Wat Nakhon Nueng Khet (Wat Ton Tan), left side	<table border="1"><caption>Land Use and Cover Data for Nakhon Nueng Khet Canal</caption><thead><tr><th>Category</th><th>Percentage</th></tr></thead><tbody><tr><td>Village</td><td>63%</td></tr><tr><td>Abandoned</td><td>12%</td></tr><tr><td>Paddy Field</td><td>10%</td></tr><tr><td>Other</td><td>8%</td></tr><tr><td>Industrial Land</td><td>6%</td></tr></tbody></table>	Category	Percentage	Village	63%	Abandoned	12%	Paddy Field	10%	Other	8%	Industrial Land	6%	19.1 km improvem ent of Nakhon Nueng Khet Canal (Part 2) CCSP vertical retaining walls: 18.756 km (both banks) Associated hydraulic structures Increases drainage capacity from 12 m³/s to 24 m³/s
Category	Percentage															
Village	63%															
Abandoned	12%															
Paddy Field	10%															
Other	8%															
Industrial Land	6%															

Cod e	Project Component	Socio-Economic & Cultural Receptors	Land Use and Cover / Ecological Receptors within 100 m wide zone on each side of the canal ³¹	Constructi on Work												
	Prawet Burirom Canal (23.3 km)	Talat Pak Khlong Chao School, right side Khlong Preng Health Promoting Hospital Chachoengsa o Province, left side Wat Mai Prawet School (Si Pracha Bamrung), right side	<table><tr><th>Land Use and Cover</th><th>Percentage</th></tr><tr><td>Village</td><td>65%</td></tr><tr><td>Aquaculture</td><td>14%</td></tr><tr><td>Other</td><td>9%</td></tr><tr><td>Other Agriculture</td><td>6%</td></tr><tr><td>Abandoned</td><td>6%</td></tr></table>	Land Use and Cover	Percentage	Village	65%	Aquaculture	14%	Other	9%	Other Agriculture	6%	Abandoned	6%	23.3 km improvement of Prawet Burirom Canal Full-length vertical wall reshaping using driven reinforced concrete sheet piles Associated hydraulic structures Capacity increased from 7–27 m ³ /s to 30–60 m ³ /s
Land Use and Cover	Percentage															
Village	65%															
Aquaculture	14%															
Other	9%															
Other Agriculture	6%															
Abandoned	6%															

Appendix 3: Sediment and Water Quality – Results from Survey

Zone 1 water quality table
Zone 1 water quality graphs
Zone 1 sediment quality table
Zone 1 sediment quality graphs
Zone 2 water quality table
Zone 2 water quality graphs
Zone 2 sediment quality table
Zone 2 sediment quality graphs
Zone 3 water quality table
Zone 3 water quality graphs
Zone 3 sediment quality table
Zone 3 sediment quality graphs

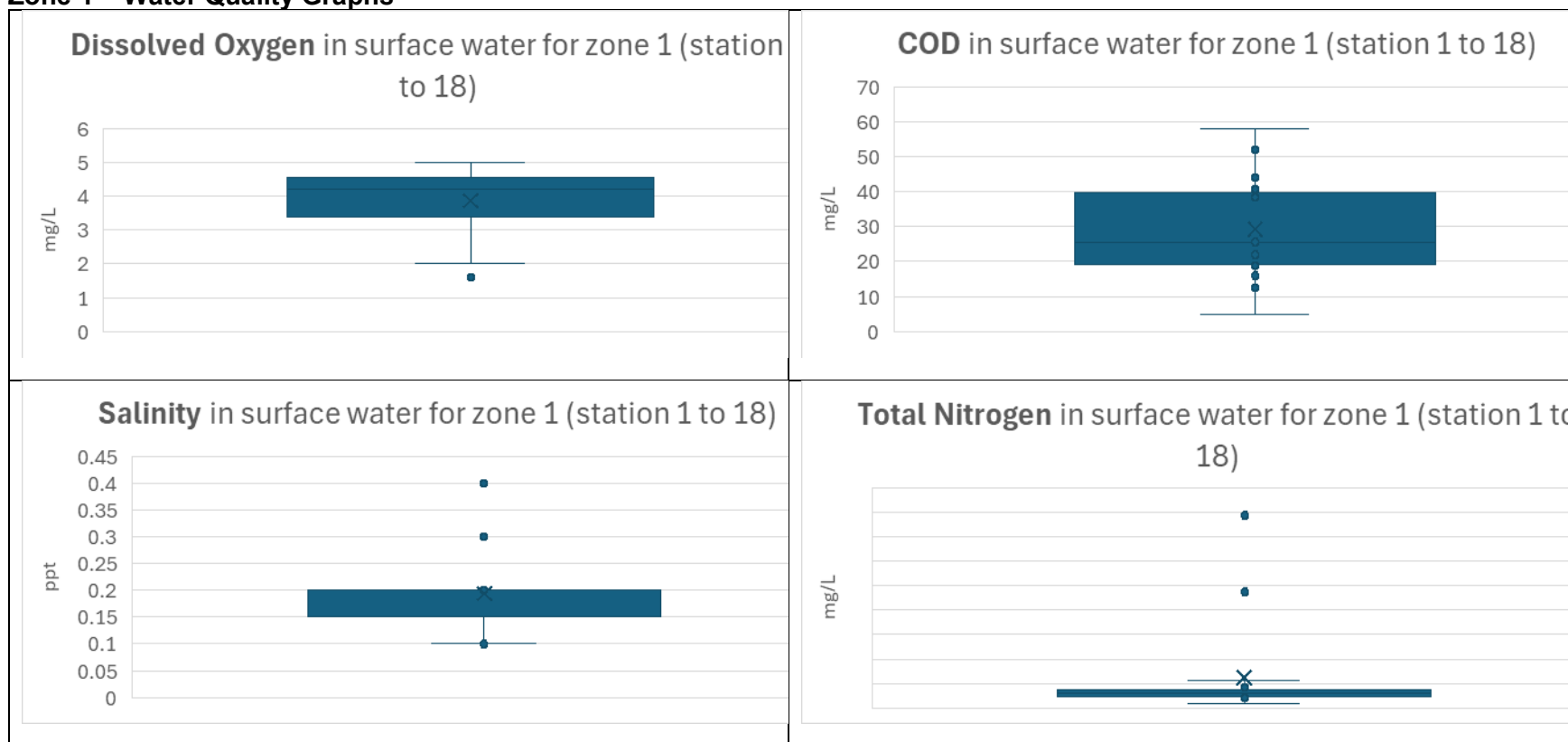
Zone 1 – Water Quality Table

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17
pH		7.7	7.7	8	7.8	7.6	7.7	7.8	7.8	7.1	8.6	7.6	7.1	7.6	7.6	7.5	8	7.2
Temperature	°C	31.8	30.6	31.2	32.1	30.5	29.7	31	32.1	29.9	32.8	33.2	31.6	30.9	31.2	31.6	32.3	31.6
Electrical Conductivity	uS/cm	288	355	347	341	346	341	373	851	644	384	541	549	328	331	421	388	357
Dissolved Oxygen	mg./L.	4.5	4.2	3.5	4.4	3.5	3.3	3.7	3.3	1.6	4.4	4	2	4.3	4.6	4.6	4.8	5
Salinity	ppt	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2
Transparency	m.	0.3	0.3	0.2	0.3	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.4	0.1	0.3	0.3	0.3	0.3
BOD	mg./L.	1.8	1.7	1.1	2.7	0.5	1.2	0.5	12.6	7.3	12	2.9	5.8	1.5	3.2	20.8	18.4	2.3
COD	mg./L.	12.4	19.2	5	22	22.4	19.2	16	52	38.4	44	38.4	38.4	18.8	25.6	58	40.8	26
Total Suspended Solids	mg./L.	40.9	38.5	70.3	68.9	73.7	132	50.9	33.8	12.9	29.1	22.6	21.9	76.2	87.4	19.4	31	24.8
Total Nitrogen	mg./L.	0.55	0.67	0.6	0.71	0.59	0.55	1.11	7.87	0.42	0.48	0.83	4.75	0.59	0.61	0.42	0.43	0.2
Total Phosphorus	mg./L.	0.06	0.07	0.05	0.07	0.05	0.13	0.06	0.33	0.94	0.08	0.09	0.48	0.08	0.07	0.12	0.12	0.07
Ammonia-Nitrogen	mg./L.	0.1	0.1	0.1	0.1	0.1	0.1	0.85	7.22	0.25	0.1	0.57	4.53	0.1	0.1	0.1	0.1	0.1
Nitrate-Nitrogen	mg./L.	0.3	0.39	0.3	0.47	0.3	0.26	0.2	0.05	0.01	0.01	0.14	0.01	0.36	0.33	0.01	0.13	0.01
Phenol	mg./L.	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Coliform Bacteria	MP N/100 ml.	490	490	490	1100	4900	2400	1300	80000	80000	240	1300	35000	1300	1300	330	35000	4900
Faecal Coliform Bacteria	MP N/100 ml.	490	130	110	400	2400	1300	170	80000	80000	130	790	13000	490	790	240	24000	1100

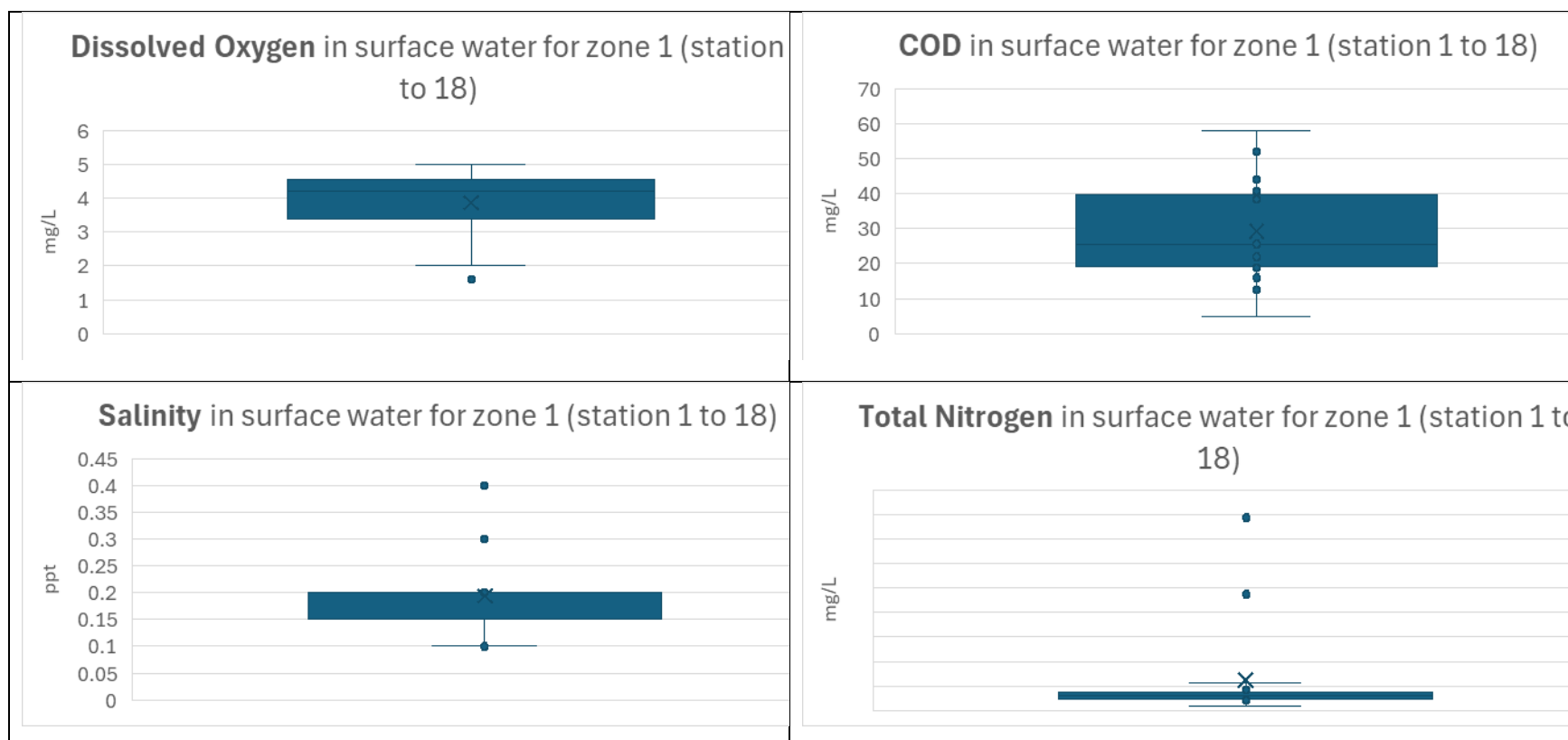
Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17
Aldrin	ug./L.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Diekdin	ug./L.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Endrin	ug./L.	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Heptachlor	ug./L.	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
DDT	ug./L.	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total Organochlorine Pesticides	mg./L.	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
TPH (C5 - C8)	mg./L.	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
TPH (C>8 - C16)	mg./L.	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
TPH (C>16 - C35)	mg./L.	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
Arsenic	mg./L.	0.0014	0.0016	0.0012	0.0012	0.0012	0.0014	0.0013	0.002	0.0017	0.0021	0.0017	0.0015	0.0013	0.0014	0.0005	0.0012	0.0005
Hexavalent Chromium	mg./L.	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Mercury	mg./L.	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05
Cadmium	mg./L.	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Copper	mg./L.	0.002	0.002	0.0125	0.002	0.0125	0.0125	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Lead	mg./L.	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
Nickel	mg./L.	0.0025	0.0025	0.0025	0.0025	0.0025	0.025	0.025	0.025	0.025	0.0025	0.025	0.025	0.025	0.025	0.0025	0.025	0.0025
Zinc	mg./L.	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0125	0.0015	0.0125	0.0125	0.0125	0.0125	0.0015	0.0015	0.0125	0.0125	0.0125

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17
Water Colour /Turbid		Yell ow/T urbi d	Yell ow/ Cle ar	Yell ow/T urbi d	Yell ow/ Clea r	Yello w/Tu rbid	Yell ow/ Clea r	Yello w/Tu rbid	Yello w/Tu rbid	Yell ow/ Clea r	Yello w/Tu rbid	Yello w/Tu rbid	Yello w/Tu rbid	Yello w/Tu rbid	Yello w/Tu rbid	Yello w/Tu rbid	Gre en/T urbi d	Yell ow/ Clea r
Sediment		Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Gree n	Yello w	Bro wn	Bro wn	Bro wn	Gree n	Gre en	Bro wn

Zone 1 – Water Quality Graphs



Zone 1 – Water Quality Graphs



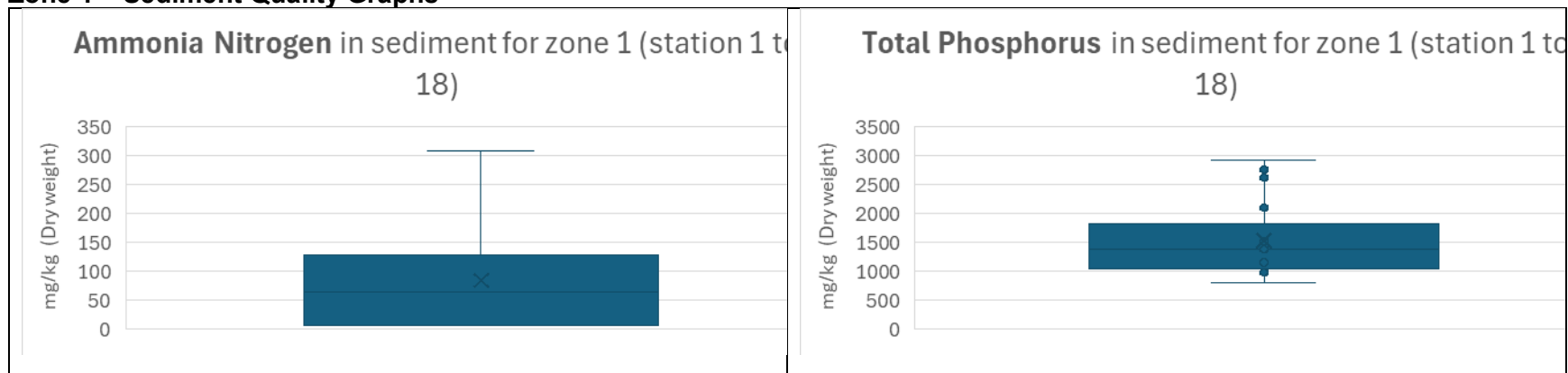
Zone 1 – Sediment Quality Table

Parameter	Unit	S 1	S 2	S 3	S 4	S 5	S 6	S 9	S 11	S 21	S 10	S 15	S 18	S 7	S 12	S 8	S 13	S 14
1. pH (1:1)		7.7	7.5	7.6	7.7	6.8	6.8	7.6	7.7	7.3	7.2	7.3	7.5	7.2	7.4	7.7	7.5	7.2
2. Moisture	%	54.8	51.4	45.3	47.3	67.5	56.3	77.3	69.3	66.6	65.2	75.2	76.4	55.3	66.9	57.2	63.3	81.5
3. Ammonia-Nitrogen	mg/kg(Dry weight)	5	113	5	5	5	5	100	208	41.3	72.4	308	142	35.3	15	70.2	63.2	220
4. Nitrate-Nitrogen	mg/kg(Dry weight)	15	15	5	5	5	5	42.4	54.7	15	15	50.8	84.3	15	15	66.2	34.3	91.4
5. Total Phosphorus	mg/kg(Dry weight)	787	1,053	981	1,385	1,012	1,024	1,415	2,613	1,520	1,142	2,758	2,091	1,207	1,389	1,380	1,163	2,921

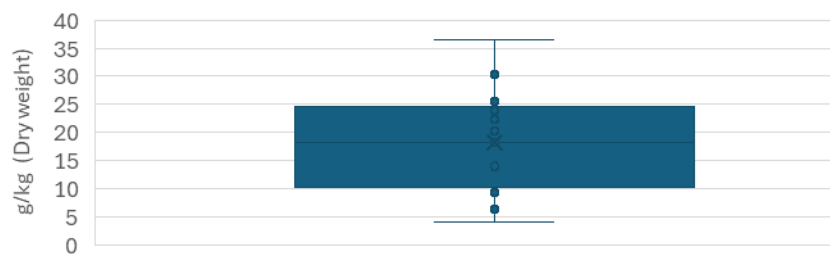
Parameter	Unit	S 1	S 2	S 3	S 4	S 5	S 6	S 9	S 11	S 21	S 10	S 15	S 18	S 7	S 12	S 8	S 13	S 14
6. Total Organic Carbon	g/kg (Dry weight)	6.41	9.74	4.09	9.27	14	10.55	25.51	30.4	36.61	25.11	23.91	20.29	14.46	18.15	23.89	14.62	22.28
7. Azinphos-Ethyl	ug/kg (Dry weight)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
8. Azinphos-Methyl	ug/kg (Dry weight)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
9. Hexachlorobenzene	ug/kg (Dry weight)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
10. Chlordane	ug/kg (Dry weight)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
11. Dieldrin	ug/kg (Dry weight)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
12. Endrin	ug/kg (Dry weight)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
13. Heptachlor	ug/kg (Dry weight)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
14. Heptachlor Epoxide	ug/kg (Dry weight)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
15. Lindane	ug/kg (Dry weight)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
16. Atrazine	ug/kg (Dry weight)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
17. Toxaphene	ug/kg (Dry weight)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
18. SUM DDD	ug/kg (Dry weight)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
19. SUM DDE	ug/kg (Dry weight)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
20. SUM DDT	ug/kg (Dry weight)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
21. Malathion	ug/kg (Dry weight)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
22. Hexachloroethane	ug/kg (Dry weight)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
23. PAHs	ug/kg (Dry weight)	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90

Parameter	Unit	S 1	S 2	S 3	S 4	S 5	S 6	S 9	S 11	S 21	S 10	S 15	S 18	S 7	S 12	S 8	S 13	S 14
24. Arsenic (As)	mg/kg (Dry weight)	4.6 2	5.4 5	1.6 3	3.9 2	4.2 1	2.9 1	4.7 8	7.4 8	6.7 6	4.9 9	5.5 1	6.3 4	5.8 1	5.5	3.4 5	6.6 5	6.9 1
25. Hexavalent Chromium (Cr6+)	mg/kg (Dry weight)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
26. Mercury (Hg)	mg/kg (Dry weight)	0.0 369	0.0 374	0.0 768	0.0 237	0.1 2	0.0 348	0.0 643	0.2 43	0.0 326	0.1 8	0.1 75	0.0 47	0.1 3	0.0 888	0.0 739	0.0 575	0.0 654
27. Cadmium (Cd)	mg/kg (Dry weight)	1.8 5	2.4 3	0.7 15	1.9 5	1.3 6	1.0 1	1.5 2	2.3 9	2.0 8	1.4 1	1.7 8	2.0 3	1.8 6	1.6 3	1.7 1	2.0 1	2.1 1
28. Copper (Cu)	mg/kg (Dry weight)	22. 6	24. 5	9.4	22. 4	16. 4	11. 4	17	54. 4	21. 9	21	33. 3	24. 7	21. 4	19	16. 6	17. 8	22. 9
29. Lead (Pb)	mg/kg (Dry weight)	14. 7	12. 6	2.5	11	11. 3	0.0 75	15. 6	32. 6	18. 9	13. 4	26. 1	23. 7	12. 3	14. 4	17. 3	18. 2	18. 2
30. Nickel (Ni)	mg/kg (Dry weight)	23. 5	22. 6	9.1 2	20. 5	21. 3	12. 2	25. 4	22	25	23. 8	29. 3	38. 1	23. 7	22. 3	26. 6	26. 8	35. 3
31. Zinc (Zn)	mg/kg (Dry weight)	44. 2	46. 9	17. 6	51. 6	44	28. 6	47. 6	201	52. 7	64. 1	126	99. 6	54. 4	47. 1	56. 4	59. 9	123
Sediment		Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bl ack	Bro wn	Bro wn	Gre y	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn	Bro wn

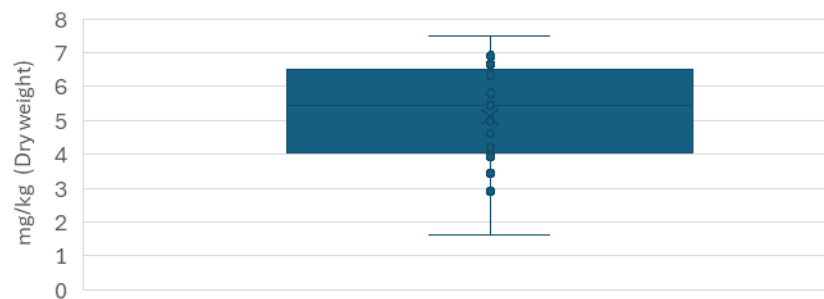
Zone 1 – Sediment Quality Graphs



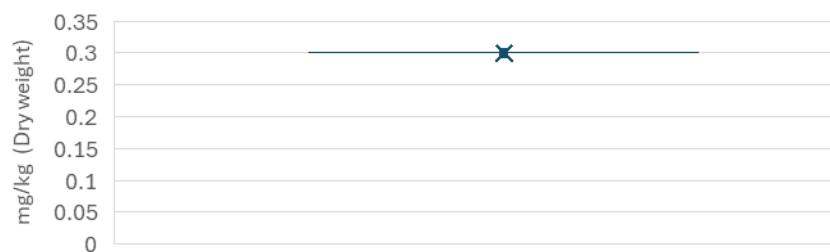
Total Organic Carbon in sediment for zone 1 (station 1 to 18)



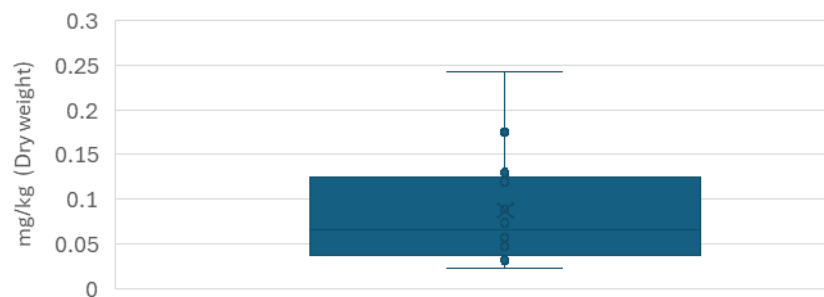
Arsenic (As) in sediment for zone 1 (station 1 to 18)



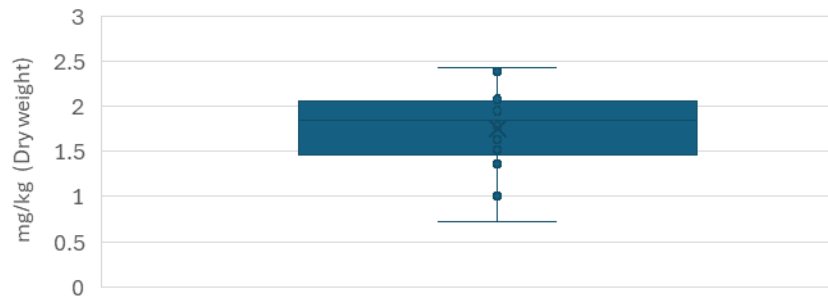
Hexavalent Chromium (Cr6+) in sediment for zone 1 (station 1 to 18)



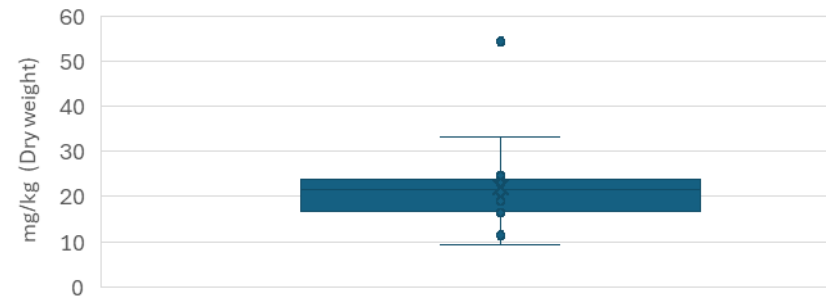
Mercury (Hg) in sediment for zone 1 (station 1 to 18)



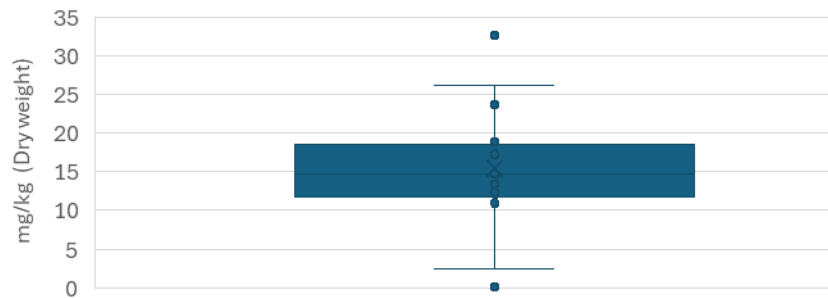
Cadmium (Cd) in sediment for zone 1 (station 1 to 18)



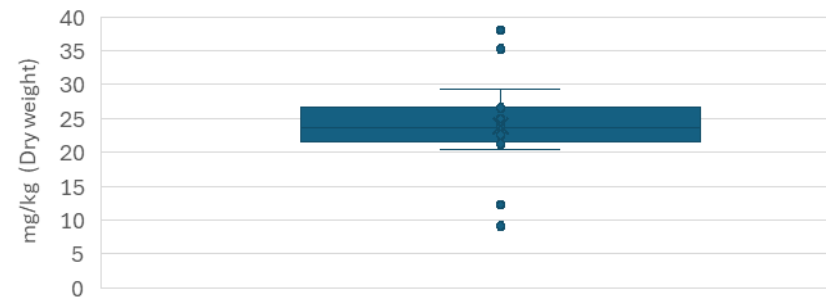
Copper (Cu) in sediment for zone 1 (station 1 to 18)



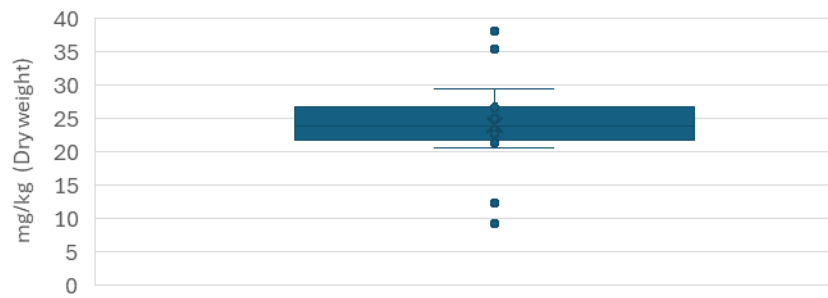
Lead (Pb) in sediment for zone 1 (station 1 to 18)



Nickel (Ni) in sediment for zone 1 (station 1 to 18)



Zinc (Zn) in sediment for zone 1 (station 1 to 18)



Zone 1 – Sediment Quality GraphsZone 2 – Water Quality Table

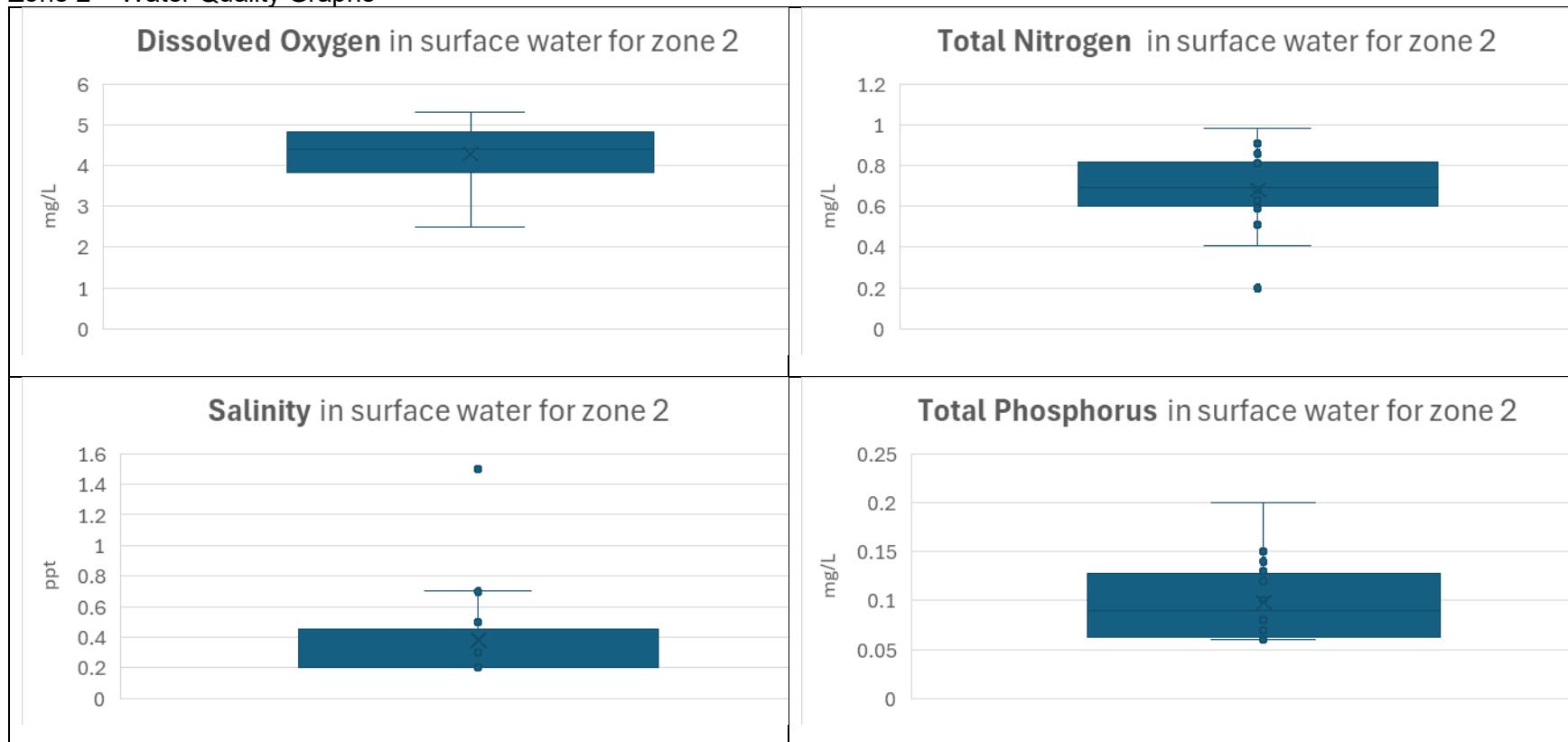
Parameter	Unit	S 19	S 23	S 28	S 16	S 17	S 20	S 22	S 25	S 26	S 24	S 27	S 29	S 30	S 31	S 32	S 36
1. pH		7.6 (31.6)	7.6 (32.8)	7.5 (32.0)	7.1 (32.3)	7.4 (33.8)	6.9 (31.4)	7.1 (32.7)	7.2 (32.2)	7.8 (34.5)	7.4 (33.4)	7.1(3 2.3)	7.4(3 5.5)	7.2 (32.3)	7.3 (32.0)	7.3 (31.6)	7.3 (31.9)
2. Temperature	°C	31.6	32.8	32	32.3	33.8	31.4	32.7	32.2	34.5	33.4	32.3	35.5	32.3	32	31.6	31.9
3. Electrical Conductivity	uS/cm	360	374	362	401	548	1,191	552	615	1,609	623	3,257	673	392	363	542	1,546
4. Dissolved Oxygen	mg/L	4.5	4.4	3.3	2.5	4.9	4.6	4.4	3.7	5.1	4.3	5.1	4.3	4.4	4.2	3.6	5.3
5. Salinity	ppt	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.3	0.7	0.3	1.5	0.3	0.2	0.2	0.2	0.7
6. Transparency	m	0.2	0.2	0.2	0.4	0.2	0.3	0.3	0.1	0.1	0.2	0.5	0.3	0.3	0.2	0.1	0.4
7. BOD	mg/L	2.4	1.5	3.2	2.3	2.8	2.7	2.4	4.5	7.4	4.1	2.4	3.3	2.8	2.4	2.7	6.5
8. COD	mg/L	16	22	35.2	22.4	27.6	37.6	28	35.2	45.6	15.6	39.2	19.2	16	32	22.2	28.4
9. Total Suspended Solids	mg/L	50.9	46.7	37.2	15.1	79.3	25.3	50.9	57.6	16.8	48.1	16.2	27.7	22.7	39.7	57.2	23.9
10. Total Nitrogen	mg/L	0.91	0.81	0.86	0.59	0.68	0.51	0.64	0.82	0.63	0.7	0.41	0.2	0.7	0.82	0.98	0.65
11. Total Phosphorus	mg/L	0.07	0.1	0.15	0.07	0.08	0.1	0.13	0.06	0.07	0.06	0.06	0.06	0.1	0.14	0.12	0.2
12. Ammonia-Nitrogen	mg/L	0.1	0.1	0.1	0.25	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.25	0.1
13. Nitrate-Nitrogen	mg/L	0.38	0.35	0.35	0.05	0.18	0.05	0.29	0.11	0.05	0.15	0.05	0.05	0.23	0.48	0.32	0.14
14. Phenol	mg/L	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
15. Coliform Bacteria	MPN /100 mL	11000	490	4900	13000	24000	4900	1700	1400	1700	4900	240	13000	54000	13000	3300	1300
16. Faecal Coliform Bacteria	MPN /100 mL	700	68	4900	2200	13000	680	93	1100	270	490	240	13000	4900	13000	1700	170

Parameter	Unit	S 19	S 23	S 28	S 16	S 17	S 20	S 22	S 25	S 26	S 24	S 27	S 29	S 30	S 31	S 32	S 36
17. Aldrin	ug/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
18. Dieldrin	ug/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
19. Endrin	ug/L	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
20. Heptachlor	ug/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
21. DDT	ug/L	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
22. Total Organochlorine Pesticides	mg/L	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035
23. TPH (C5 - C8)	mg/L	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
24. TPH (C>8 - C16)	mg/L	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
26. TPH (C>16 - C35)	mg/L	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
26. Arsenic	mg/L	0.0015	0.0015	0.0015	0.0012	0.0005	0.0011	0.0014	0.0019	0.0017	0.0014	0.0005	0.0012	0.0015	0.0014	0.0017	0.0015
27. Hexavalent Chromium	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
28. Mercury	mg/L	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
29. Cadmium	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
30. Copper	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.0125	0.0125	0.0125	0.002	0.002	0.002	0.002
31. Lead	mg/L	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
32. Nickel	mg/L	0.0025	0.0025	0.0025	0.0025	0.0025	0.025	0.0025	0.025	0.0025	0.0025	0.0025	0.025	0.0025	0.0025	0.0025	0.0025
33. Zinc	mg/L	0.0125	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0125	0.0125	0.0015	0.0015	0.0015	0.0015	0.069	0.0015

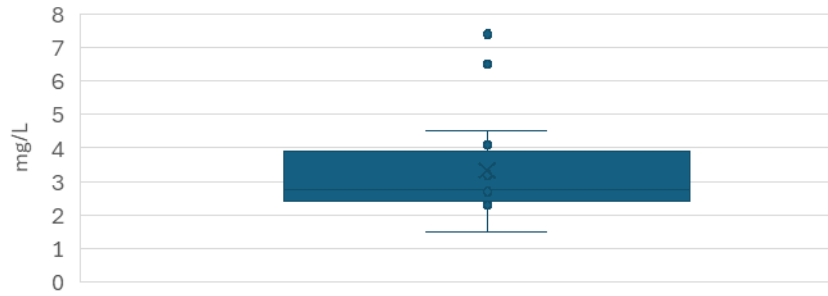
Parameter	Unit	S 19	S 23	S 28	S 16	S 17	S 20	S 22	S 25	S 26	S 24	S 27	S 29	S 30	S 31	S 32	S 36
Water Colour /Turbid		Yell ow Clea r	Yello w Turbi d	Yello w Turbi d	Yell ow Clea r	Yell ow Clea r	Yello w Turbi d	Yello w Turbi d	Yello w Turbi d	Yell ow Clea r	Yello w Turbi d	Yello w Turbi d	Yello w Turbi d	Yello w Turbi d	Yello w Turbi d	Yello w Turbi d	Yell ow Tur bid
Sediment		Bro wn	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n	Brow n

Zone 2 – Water Quality Graphs

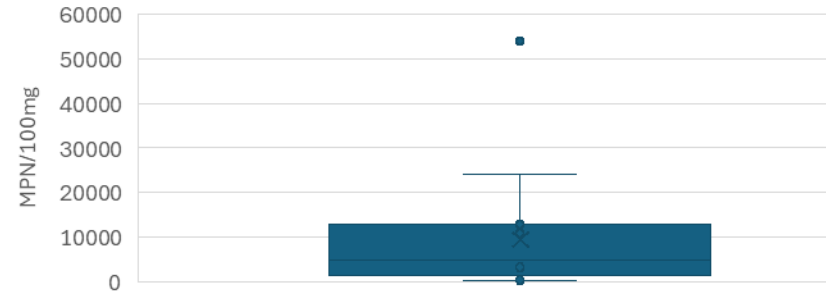
Zone 2 – Water Quality Graphs



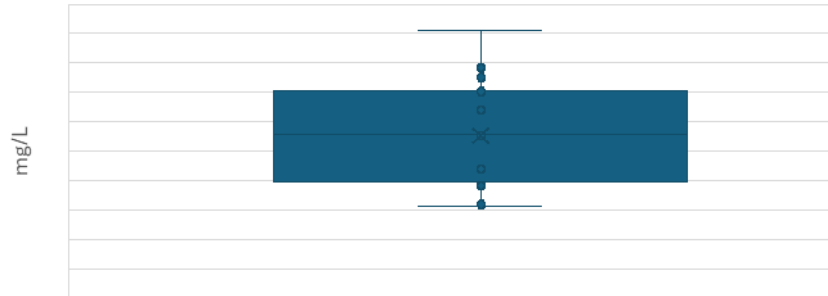
BOD in surface water for zone 2



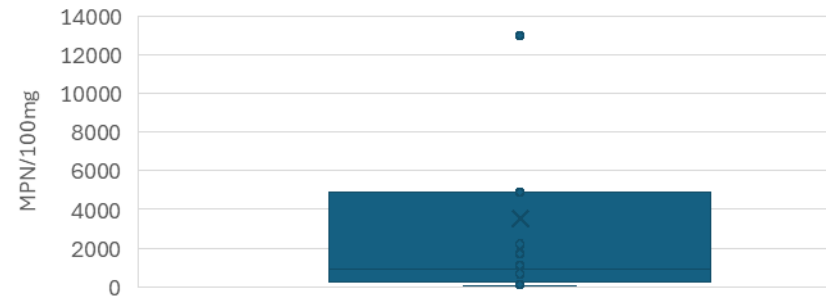
Coliform Bacteria in surface water for zone 2

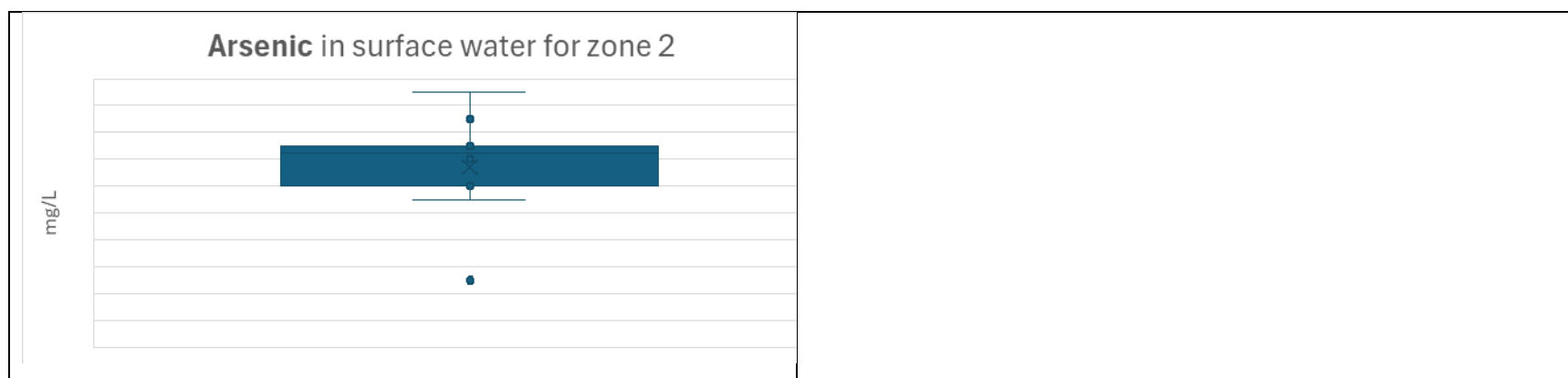


COD in surface water for zone 2



Faecal Coliform Bacteria in surface water for zone 2





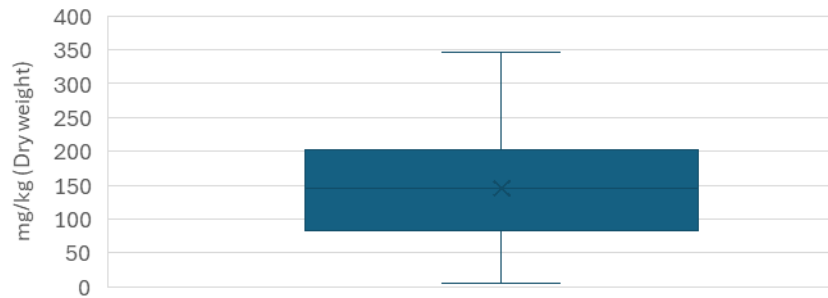
Zone 2 – Sediment Quality Table

Parameter	S 19	S 23	S 28	S 16	S 17	S 20	S 22	S 25	S 26	S 24	S 27	S 29	S 30	S 31	S 32	S 36
1. pH	7.7	7.4	7.1	7.8	7.4	6.8	7.1	7.1	7.8	7.1	7.4	6.9	7.7	7.1	7.7	7.2
2. Moisture	68.9	71.5	65.6	74.4	63.5	51.2	70.6	67.8	54.6	72	72.1	68.5	62.5	60.5	70.1	65.7
3. Ammonia-Nitrogen	70.1	151	194	113	43.6	74.4	134	165	86.1	175	83.9	203	82.1	170	201	140
4. Nitrate-Nitrogen	39.9	76.8	50.6	15	15	44.7	52.4	62.4	15	64.3	15	65.4	35.2	68.1	51.5	93
5. Total Phosphorus	1356	3018	3360	1698	1024	1205	2771	2284	1155	1780	1162	2300	1579	3259	2083	1770
6. Total Organic Carbon	19.3 1	15.8 3	23.2 9	21.3 9	17.7 9	21.2 4	21.1 9	22.5 2	21.6 6	19.5 5	12.8 4	23.6 1	22.6 3	16.6 8	17.7 6	16.4 3
7. Azinphos-Ethyl	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5
8. Azinphos-Methyl	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5
9. Hexachlorobenzene	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
10. Chlordane	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1
11. Dieldrin	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05
12. Endrin	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1

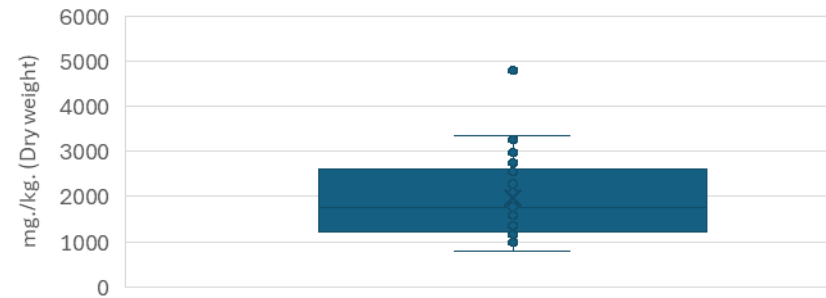
Parameter	S 19	S 23	S 28	S 16	S 17	S 20	S 22	S 25	S 26	S 24	S 27	S 29	S 30	S 31	S 32	S 36
13. Heptachlor	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05
14. Heptachlor Epoxide	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05
15. Lindane	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05
16. Atrazine	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
17. Toxaphene	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05	0.00 05
18. SUM DDD	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1
19. SUM DDE	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1
20. SUM DDT	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1	0.00 1
21. Malathion	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5	0.00 5
22. Hexachloroethane	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
23. PAHs	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
24. Arsenic	4.14	8.96	7.76	4.12	5.01	2.39	6.09	4.41	4.72	4.18	4.95	5.74	6.62	6.25	5.02	5.95
25. Hexavalent Chromium	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
26. Mercury	0.06 56	0.06 91	0.06 22	0.07 89	0.05 86	0.07 48	0.06 6	0.04 69	0.03 55	0.07 64	0.05 52	0.18 9	0.04 67	0.11	0.11 9	0.05 28
27. Cadmium	1.73	2.95	1.85	1.74	1.89	0.91 6	1.81	1.68	1.75	1.56	1.42	2.21	2.27	1.87	1.81	1.96
28. Copper	16.8	32.5	23.5	22.1	16.1	11.1	22	20.9	17.8	18.2	13.5	28.8	18.3	22.6	17.5	17.8
29. Lead	15.9	26.7	20.5	15.3	17.9	11.6	19.1	17.7	18	19.4	13.1	21.3	18.9	19.5	17.3	17.6
30. Nickel	22.5	38.9	25	30.4	31.5	18.5	28.5	29	33	27.4	20.8	34.9	30.9	26.8	22.2	28.4
31. Zinc	47.9	88.4	86.3	70.3	58.9	49.6	74.8	81.7	102	75	47.7	137	65.1	74.2	64	80.8

Zone 2 – Sediment Quality Graphs

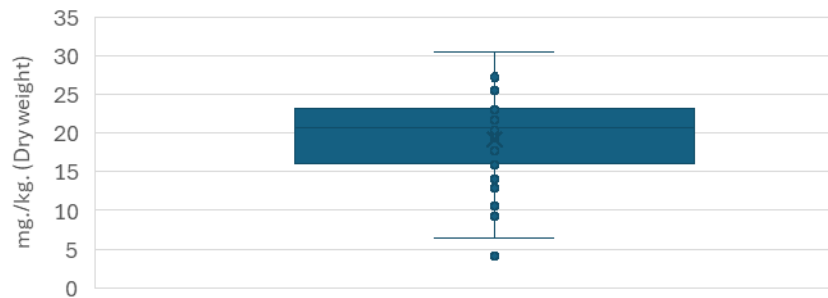
Ammonia Nitrogen in sediment for zone 2



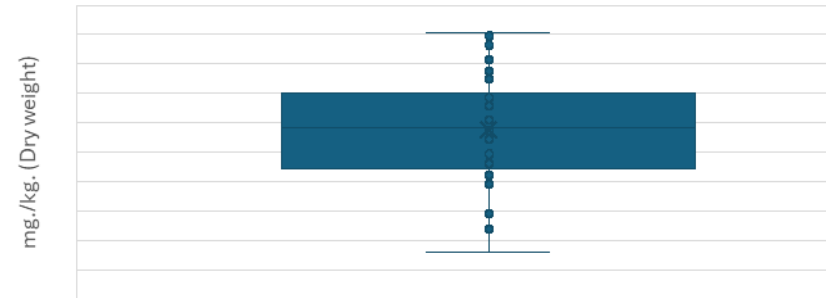
Total Phosphorus in sediment for zone 2



Total Organic Carbon in sediment for zone 2



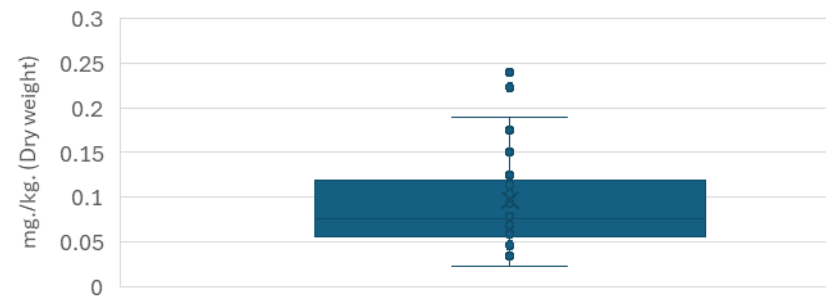
Arsenic (As) in sediment for zone 2

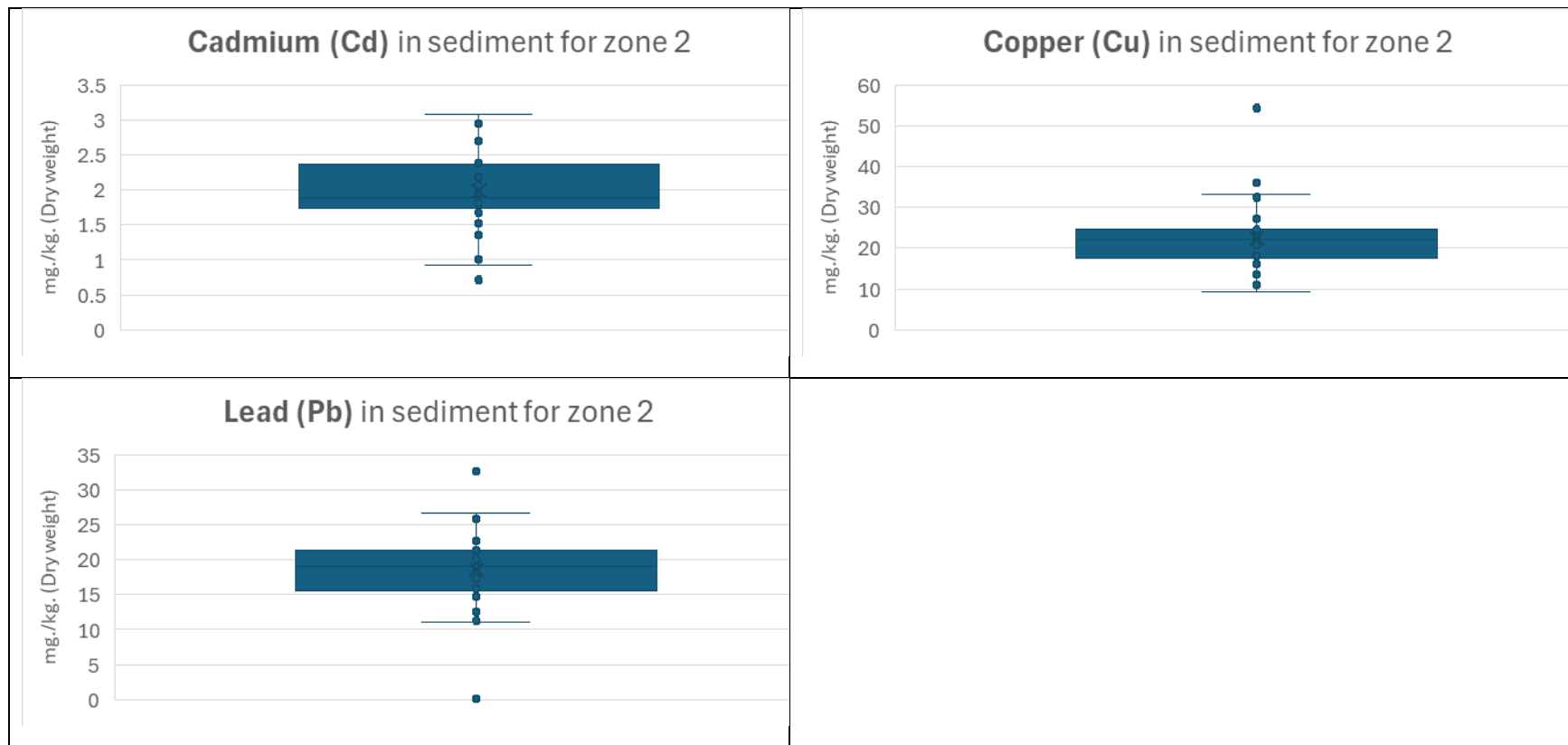


Hexavalent Chromium (Cr6+) in sediment for zone 2



Mercury (Hg) in sediment for zone 2





Zone 3 – Water Quality Table

Para meter	S 33	S 35	S 34	S 37	S 38	S 40	S 39	S 41	S 42	S 43	S 44	S 47	S 48	S 45	S 46
1. pH	7.3	7	7.4	7.4	7.5	8.1	7.5	7.5	8.4	7.6	7.3	8.7	8.3	7.6	7.6
2. Temp eratur e	30.6	30.1	33.6	31.5	31.6	31.8	31.9	30.5	32.5	30.8	30.1	32.5	30.1	31.7	31.9
3. Electri cal	856	1186	839	969	2690	3509	4133	5326	4423	5578	3890	7134	11076	5469	6108

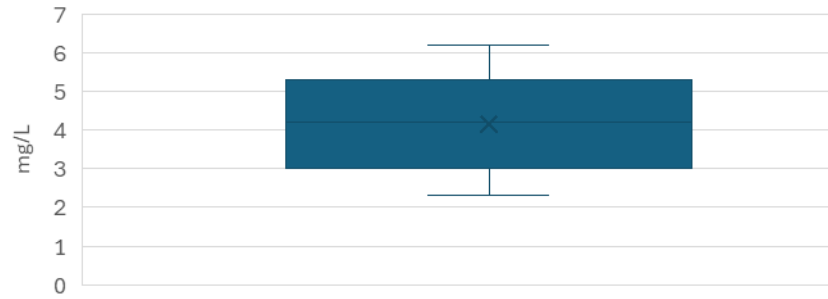
Conductivity															
4. Dissolved Oxygen	2.8	3	5.1	2.8	4.8	5.5	3.7	2.3	4.4	3.3	5.3	6.2	3.1	4.2	5.7
5. Salinity	0.3	0.5	0.3	0.4	1.2	1.6	1.9	2.6	2	2.7	1.9	3.4	5.7	2.6	2.9
6. Transparency	0.3	0.4	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.3
7. BOD	3.4	2.2	4.3	6.7	5.7	7.4	13.1	9.4	20.6	15	20	15.3	11.4	16.4	11.6
8. COD	48	41.6	38.4	56	72	68	88	80	92	80	70	56	116	100	96
9. Total Suspended Solids	34	17.3	30.6	69.3	60.6	34.1	28.8	60.6	39.5	77.3	33.8	25.2	32.5	26.8	16
10. Total Nitrogen	3.04	0.54	0.41	4.29	0.2	0.2	1.13	0.68	0.65	2.31	4.83	0.53	1	8.94	0.41
11. Total Phosphorus	0.14	0.1	0.08	0.11	0.13	0.21	0.7	0.24	0.77	0.62	0.83	0.84	2.14	1.66	1.44
12. Ammonia-Nitrogen	1.77	0.25	0.1	3.57	0.1	0.1	0.95	0.25	0.25	1.92	4.52	0.1	0.89	8.02	0.1
13. Nitrate-	0.59	0.13	0.05	0.49	0.01	0.01	0.13	0.05	0.23	0.17	0.05	0.1	0.01	0.01	0.05

Nitrogen															
14. Phenol	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
15. Coliform Bacteria	7000	1700	3300	4900	460	940	92000	1700	4900	54000	160000	3300	1300	160000	17000
16. Faecal Coliform Bacteria	2300	490	790	1300	460	210	11000	680	490	35000	54000	3300	490	35000	3300
17. Aldrin	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
18. Dieldrin	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
19. Endrin	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
20. Heptachlor	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
21. DDT	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
22. Total Organochlorine Pesticides	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035
23. TPH	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
24. TPH	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008

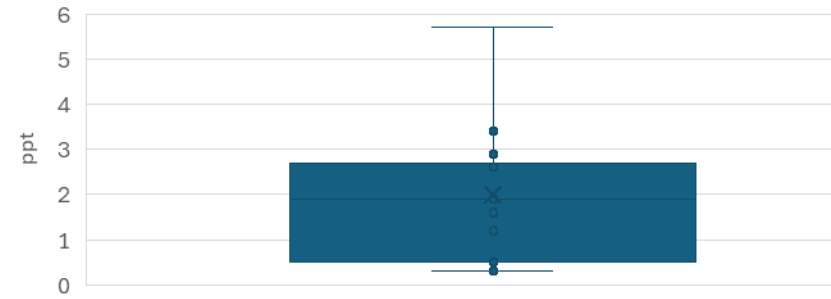
25. TPH	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
26. Arsenic	0.0025	0.0022	0.0026	0.0023	0.0019	0.0023	0.0062	0.0042	0.0058	0.0065	0.0058	0.0081	0.0155	0.0066	0.008
27. Hexavalent Chromium	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
28. Mercury	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	0.00025	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05	0.00025	5.00E-05	0.00025
29. Cadmium	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.002	0.002	0.0005	0.0005	0.0005
30. Copper	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
31. Lead	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
32. Nickel	0.0025	0.0025	0.0025	0.025	0.0025	0.0025	0.025	0.025	0.025	0.025	0.025	0.025	0.0025	0.0025	0.0025
33. Zinc	0.0125	0.0015	0.0015	0.0125	0.0015	0.0015	0.0015	0.0015	0.0125	0.0125	0.0125	0.0015	0.0015	0.0015	0.0015

Zone 3 – Water Quality Graphs

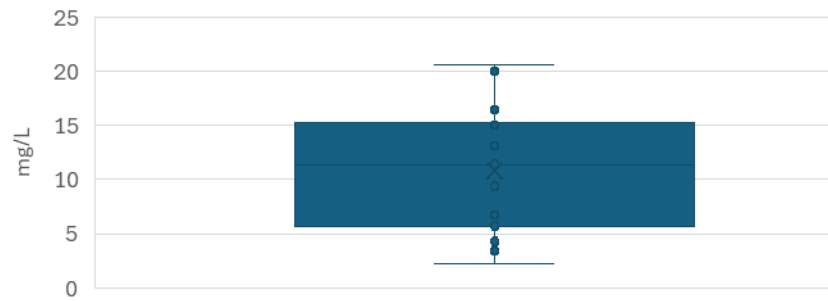
Dissolved Oxygen in Surface Water for zone 3



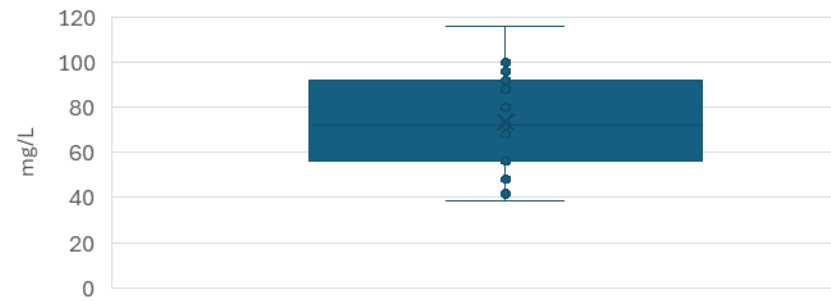
Salinity in Surface Water for zone 3



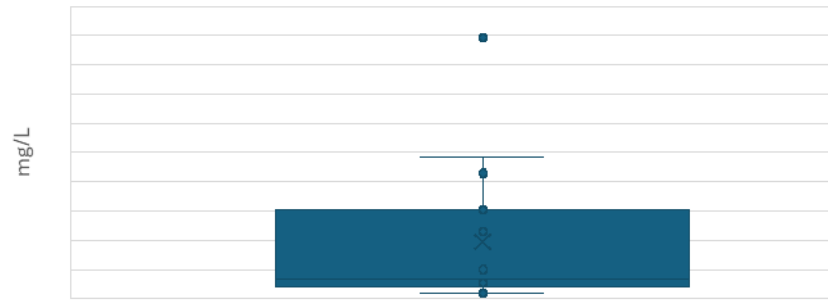
BOD in Surface Water for zone 3



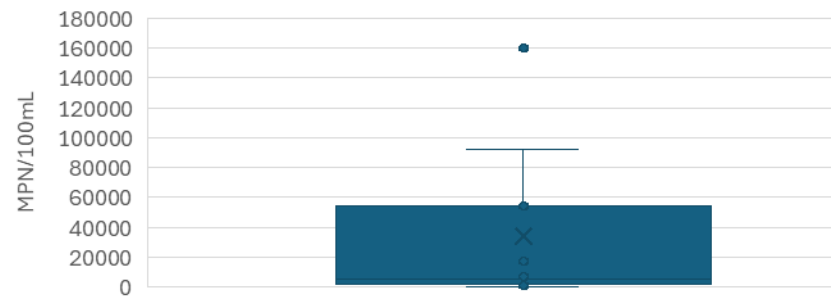
COD in Surface Water for zone 3



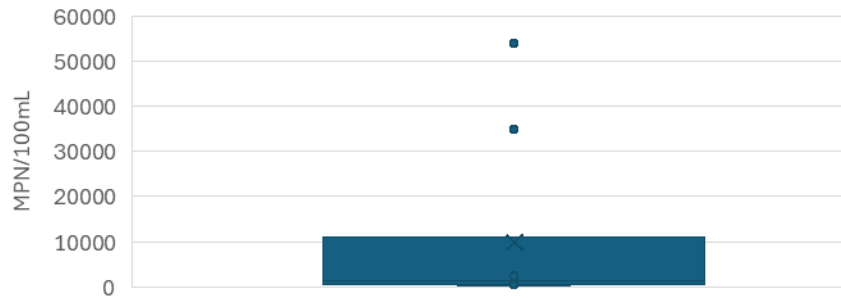
Total Nitrogen in Surface Water for zone 3



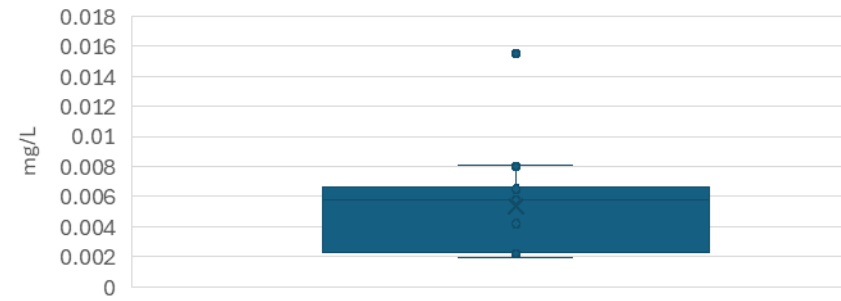
Coliform Bacteria in Surface Water for zone 3



Faecal Coliform Bacteria in Surface Water for zone 3



Arsenic in Surface Water for zone 3



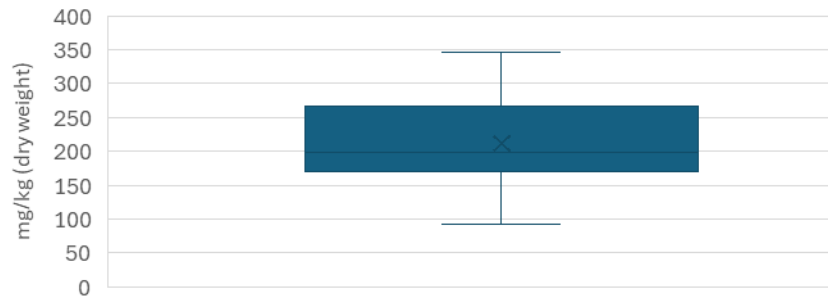
Zone 3 - Sediment Quality Table

Parameter	S33	S35	S34	S37	S38	S40	S39	S41	S42	S43	S44	S47	S48	S45	S46	S49	S50
1. pH (1:1)	7.1	7.2	7.1	7.4	7.3	7.4	7.2	7.2	7.3	7.4	7.3	7.8	7.5	7.4	7.2	7.6	7.8
2. Moisture	73.4	77.1	70	84.2	76.4	76	74.1	79.3	71.6	66.4	69.4	63	64.7	68.2	72.9	70.8	74.1
3. Ammonia-Nitrogen	264	181	138	347	199	141	171	329	266	180	182	93.2	203	207	269	35.3	15
4. Nitrate-Nitrogen	15	15	15	125	15	15	57.9	140	72.2	33	47.4	15	61.5	15	15	15	15
5. Total Phosphorus	2562	2442	1708	2831	2982	2393	1687	2546	1724	1584	1488	1199	1810	2298	4808	2027	2238
6. Total Organic Carbon	23.42	27.04	21.91	25.97	21.04	20.38	23.56	26.05	27.25	22.26	21.59	14.97	19.94	23	19.46	18.87	18.29
7. Azinphos-Ethyl	0.005	0.005	0.005	0.005	5.7	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
8. Azinphos-Methyl	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
9. Hexachlorobenzene	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
10. Chlordane	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
11. Dieldrin	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
12. Endrin	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
13. Heptachlor	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
14. Heptachlor Epoxide	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
15. Lindane	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
16. Atrazine	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
17. Toxaphene	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

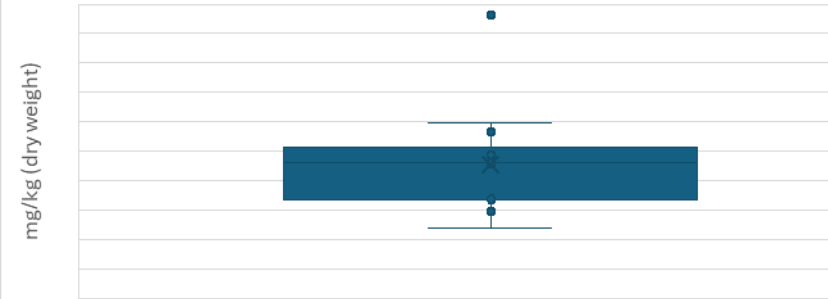
Parameter	S33	S35	S34	S37	S38	S40	S39	S41	S42	S43	S44	S47	S48	S45	S46	S49	S50
18. Sum DDD	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01
19. Sum DDE	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01
20. Sum DDT	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01	0.0 01
21. Malathion	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05	0.0 05
22. Hexachloroethane	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
23. PAHs	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
24. Arsenic	7.6 5	6.7 6	5.4 4	6.6 6	6.8 6	6.1 9	6.8 3	7.0 5	9.0 5	7.5 9	10. 2	8.6 5	8.1 6	6.5 7	7.7 1	1.4 2	2.6
25. Hexavalent Chromium (Cr6+)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
26. Mercury (Hg)	0.1 61	0.1 17	0.0 76	0.2 4	0.1 25	0.0 992	0.0 942	0.1 14	0.1 53	0.1 51	0.0 784	0.1 04	0.0 592	0.1 09	0.2 23	0.2 37	0.2 37
27. Cadmium (Cd)	2.5 9	2.5 3	2.3 1	2.1 5	2.7	2.4 3	2.0 6	1.8 7	2.7 6	2.1 9	3.4	2.7 8	2.8	2.1 4	3.0 8	1.2 6	2.2
28. Copper (Cu)	25. 5	24. 9	21. 2	27. 3	24. 7	22. 9	20. 8	23. 6	25. 2	27. 7	28. 1	22. 6	22. 2	21. 4	36. 1	21. 4	30. 9
29. Lead (Pb)	22. 9	22. 4	18. 1	25. 8	22. 1	19. 5	19. 5	21. 7	25. 9	20. 1	24. 8	20. 7	21. 1	16. 5	22. 7	15. 8	22. 8
30. Nickel (Ni)	34. 8	34. 8	28. 2	35. 4	35. 4	30. 4	33. 3	26. 9	40. 5	31	38. 4	37. 6	36	28. 1	43. 5	21. 4	34. 6
31. Zinc (Zn)	101	135	80. 7	132	110	107	110	93. 7	119	182	136	93. 8	89	97. 8	148	93. 5	154

Zone 3 – Sediment Quality Graph

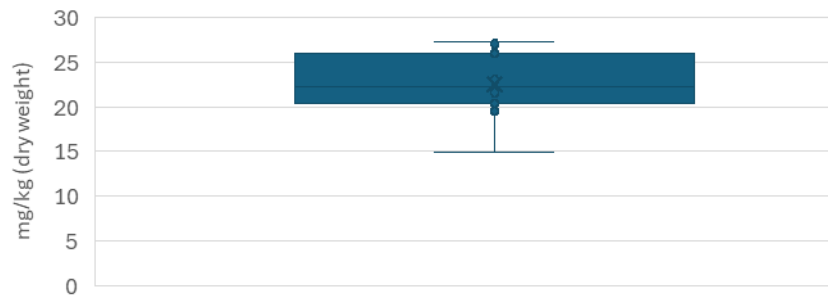
Ammonia Nitrogen in sediment for Zone 3



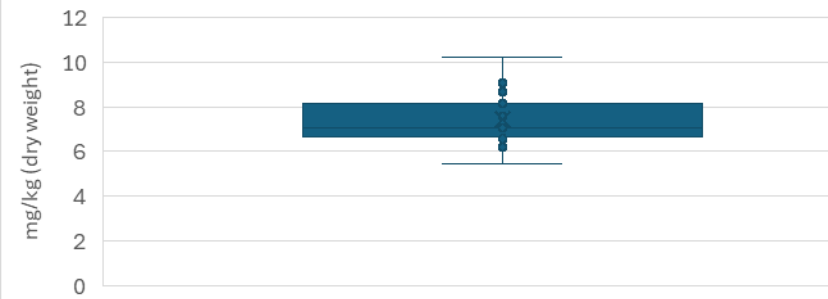
Total Phosphorus in sediment for Zone 3



Total Organic Carbon in sediment for Zone 3



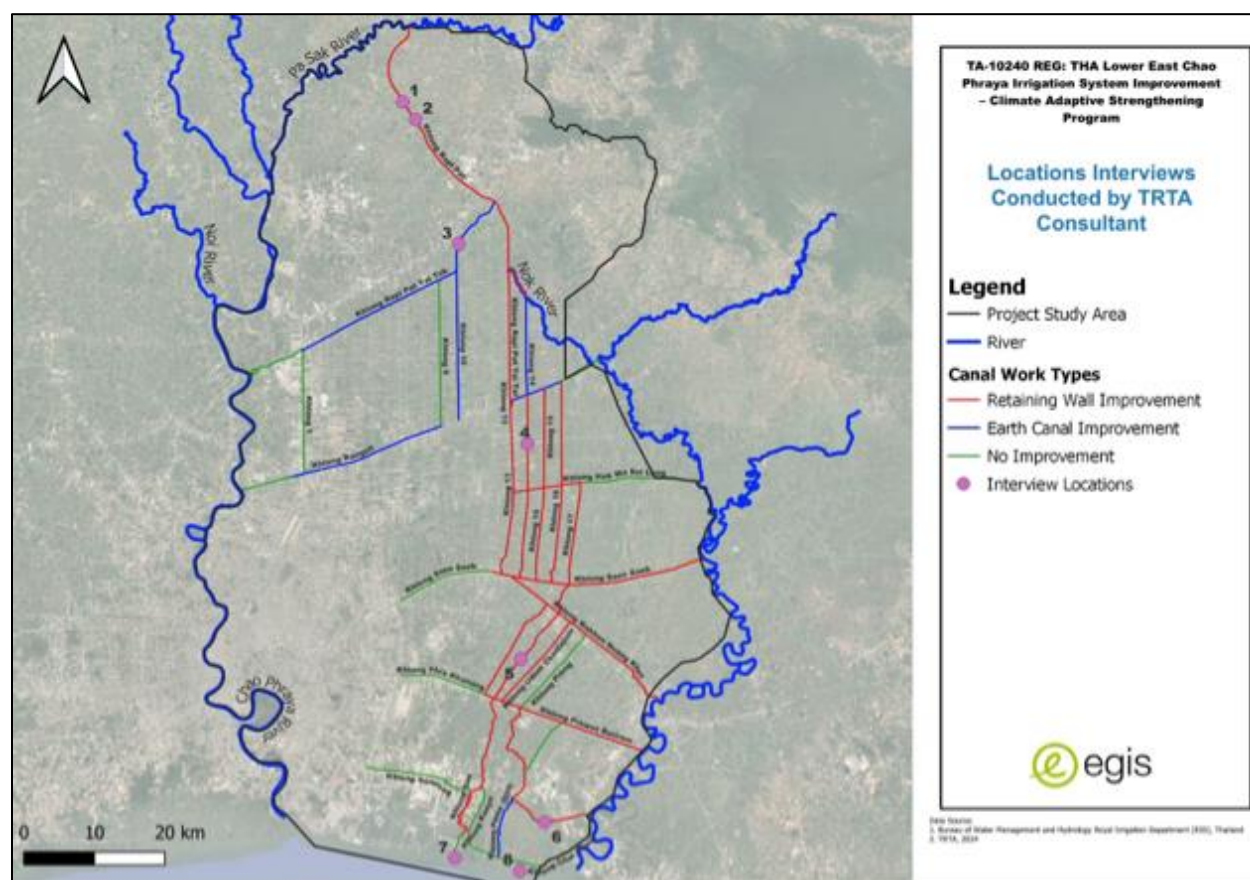
Arsenic (As) in sediment for Zone 3



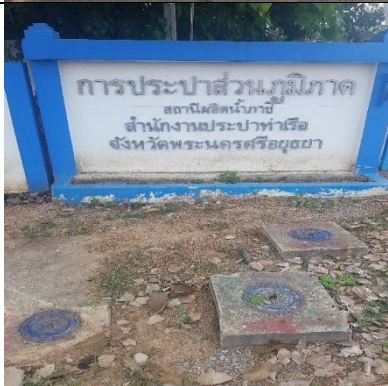
Appendix 4: Critical Habitat Assessment Report

[see separate document]

Appendix 5: Consultation Interviews from 2025

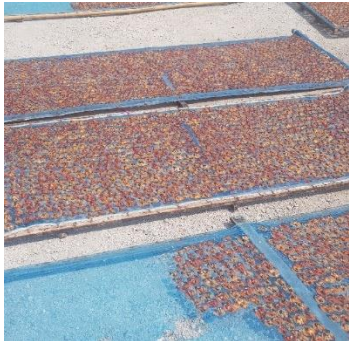


Date	Description	Photos
March 17, 2025	Nong Rong water supply system located adjacent to Station 5 utilises raw water abstracted from the Raphiphat Yaek Tok Canal, with a pumping capacity in the range of 400 to 1,150 litres per minute. The extracted water is treated using conventional water treatment processes to ensure compliance with relevant quality standards for domestic use. Furthermore, multiple community water supply systems within the surrounding area have been observed to similarly source raw water from local canal networks, underscoring the importance of these canals as primary water supply sources for local communities.	

Date	Description	Photos
		
	The Tha Rua Water Treatment Plant in Ayutthaya Province abstracts raw water from the Raphiphat Canal, utilising pumps with a capacity of 140 cubic meters per hour.	
		
	The power plant operated by Gulf Company, identifiable by its two stacks in the background, utilises water from the Raphiphat Canal for its cooling processes.	

Date	Description	Photos
	Water for agricultural purposes is abstracted from canals at various locations throughout the area.	
		
March 18, 2025	The interviewee, an aquaculture operator located adjacent to Station 34, engages in fish and shrimp farming activities. Each production cycle involves approximately eight months of cultivation, followed by a three to four month period during which the pond is drained and dried prior to initiating the next cycle. There is currently no routine analysis of the raw water quality, as no significant water quality issues have been reported by the operator. Wastewater generated from aquaculture operations is discharged back into the Phra Ong Chaiyanuchit Canal. Reported production yields range from 20 to 30 tonnes per 100 rai (equivalent to 160,000 square meters) per cycle.	

Date	Description	Photos
	Salt farming activities observed en route to Station 49 utilise seawater, with operations limited to the dry season. The process involves allowing seawater to evaporate naturally, resulting in no wastewater discharge.	
		
	A fish farming operation observed along the route to Station 46 utilises freshwater sourced from the Samrong Canal, typically supporting one to two production cycles per year. Prior to each harvest, wastewater from the ponds is discharged back into the Samrong Canal.	 

Date	Description	Photos
	Aquaculture activities in the coastal area focus on mussel cultivation. A significant challenge reported by cultivators is the discharge of freshwater into coastal zones, which often results in low or failed production. Despite this, cultivators recognise the necessity of flood protection measures, although they acknowledge that such interventions may further reduce yields.	
		
March 19, 2025	A grass farmer interviewed along the road between the 13th and 14th canals produces turf primarily for golf courses and residential lawns. The crop is harvested every 1 to 1.5 months. Additionally, the farmer reports that water quality is consistently good.	
		

Date	Description	Photos
		

Appendix 6: Environmental Audit Report

Environmental Audit of Existing Facility (Existing Canal Network and Regulators)

I. Introduction

1. In accordance with the Asian Development Bank (ADB) Safeguard Policy Statement (SPS), an environmental audit of the existing facilities is required to ensure that ongoing operations are consistent with applicable safeguard requirements and do not pose undue environmental risks. The audit forms part of the initial environmental examination (IEE) process undertaken by the Royal Irrigation Department (RID) as implementing agency to assess the environmental performance of legacy infrastructure and to identify any gaps between current practices and ADB SPS requirements. This process is essential to establish a baseline of compliance and to determine whether corrective actions are necessary prior to, or in parallel with, project implementation.

2. The audit will evaluate the environmental management systems, operational practices, and maintenance procedures of the existing irrigation and drainage facilities. Findings will be used to determine the safeguard categorization of the project and to identify risks that may affect environmental quality, community health and safety, and long-term sustainability. Where deficiencies are identified, recommendations to improve the system operation will be prepared to specify measures.

II. Objectives of the Audit

3. To establish the baseline environmental performance of the existing flood control system, the audit will examine current maintenance practices related to siltation, aquatic vegetation, and waste management. This audit also identifies potential environmental risks and highlight any compliance gaps, focusing on risks from inadequate management, including impacts on water flow and community health, and assess the extent to which current practices align with best practices.

4. For any identified issue, propose specific corrective actions and preventive strategies aimed at enhancing canal efficiency, and compliance with safeguard requirements. Additionally, propose a comprehensive monitoring and reporting framework that incorporates performance indicators and adaptive management processes to ensure ongoing safeguard compliance, appropriate project categorization, and long-term operational sustainability.

III. Scope of Audit

5. **Coverage of the Audit.** The scope of this audit is limited to existing facilities, specifically the canals and regulators that are scheduled for rehabilitation through ADB funding. Site visits were conducted at selected canal alignments and regulator (flow regulator) locations. Due to time limitations, it was not feasible to inspect every site; therefore, it is assumed that the locations visited are representative of the entire project area.

6. **Main Areas of Emphasis.** Following initial site inspections at several project locations, the audit identified the primary areas that require attention to ensure the existing facilities meet environmental compliance standards and are in alignment with ADB SPS requirements.

- (i) Environmental regulatory compliance;
- (ii) Environmental aspects of the existing facilities, such as management of siltation and aquatic vegetations (e.g. water hyacinths);
- (iii) Vegetation waste disposal practices; and
- (iv) Regulator gate maintenance.

IV. Detailed Findings

A. Environmental Regulatory Compliance

7. The management and operation of the drainage canals and flow control regulators designated for rehabilitation under the ADB-funded initiative fall under the authority of the Royal Irrigation Department (RID). The RID, through its Regional Offices 10 and 11, will facilitate the execution of project activities within their respective areas of responsibility. As these facilities operate within the scope of RID's legally mandated core functions as a government institution, there is no requirement to obtain additional permits or clearances from external government agencies. Consequently, regulatory compliance concerns are not anticipated.

B. Siltation Management

1. Irregular Removal Practices

8. Currently, the removal of silt from the drainage canals is carried out on an irregular basis, primarily in response to visible and significant accumulation. Instead of following a proactive, scheduled maintenance plan, interventions typically occur only when heavy siltation is observed by operational staff or reported by local communities. This reactive approach means that silt is often left to build up over extended periods, potentially creating blockages and diminishing the canals' operational capacity.

2. Monitoring Gaps Along Canal Networks

9. The extensive length of the canal system poses a significant challenge for consistent monitoring. Due to limited resources and manpower, not all sections of the canals are regularly inspected, resulting in incomplete oversight. Consequently, certain stretches are left with residual silt after initial removal efforts, as some problem areas may go undetected for prolonged periods. This gap in monitoring can undermine the effectiveness of maintenance activities and allow siltation issues to persist.

3. Hydrological and Environmental Impacts

10. Stagnant water flow is a direct consequence of silt accumulation in the canals. Blocked or narrowed sections reduce the overall efficiency of irrigation, limiting water delivery to agricultural lands and affecting crop yields. Moreover, stagnant water creates ideal conditions for mosquito breeding, which can increase the risk of vector-borne diseases in surrounding communities. The environmental ramifications also extend to aquatic life, as reduced flow negatively impacts water quality and ecosystem health.

4. Operational and Financial Burdens

11. The lack of a systematic desilting schedule not only affects canal performance but also leads to increased operational costs. Irregular and reactive maintenance requires mobilizing equipment and personnel on short notice, which is often less efficient and more expensive than planned interventions. This unpredictability hampers effective water management and may strain the resources of the responsible agencies. Establishing a proactive maintenance regime could help lower costs and improve resource allocation.

C. Aquatic Vegetation (Water Hyacinth)

12. The canal network faces significant challenges due to the extensive proliferation of water hyacinth, with heavy growth observed in numerous sections that could impede water flow and may contribute to operational inefficiencies. Removal efforts are sporadic and largely insufficient, as most stretches remain unmanaged. While customized water pump boats are employed for mechanical removal in select areas, their coverage is limited and fails to address the widespread nature of the problem. Ecologically, the unchecked growth of water hyacinth exacerbates environmental concerns by reducing dissolved oxygen levels, harming aquatic

biodiversity, and accelerating the process of eutrophication, thereby threatening both the health of the canal ecosystem and the effectiveness of water management operations.

Figure 1: Sample Canals with Water Hyacinth and Mechanical Removal



D. Waste Management

13. Water hyacinth removal efforts are complicated by the presence of plastics and domestic solid waste mixed in with the vegetation, resulting in collected material that is challenging to dispose of responsibly. When this mixed waste is dumped onto canal embankments, it leads to secondary pollution and environmental degradation. Additionally, solid waste accumulates at regulator gates, obstructing water flow and increasing the frequency and difficulty of maintenance. The ongoing entry of household waste into the canals highlights deficiencies in community waste management practices, further exacerbating operational and ecological issues within the canal network.

E. Operation of Regulators and Pump Stations

14. Several regulators situated in the northern part of the canal network require more frequent cleaning and clearing of trapped debris and aquatic vegetation from their gates. Without regular maintenance, these materials can accumulate and obstruct water flow, leading to reduced efficiency and increased risk of localized flooding. Instituting routine cleaning schedules for these northern regulators is essential to maintain optimal water movement and prevent operational disruptions throughout the system.

15. Despite the challenges faced in canal maintenance across the broader network, there are notable positive findings concerning the main regulators situated in the southern area near the Gulf of Thailand. These key structures are extensively manned, ensuring that experienced personnel are always present to oversee operations and respond promptly to any emerging issues. The presence of dedicated staff not only enhances the responsiveness to maintenance

needs but also supports consistent and reliable water regulation, which is vital for the downstream flow into the Gulf.

16. Furthermore, these main regulators benefit from a robust and well-organized monitoring system. Regular inspections and the use of monitoring equipment help maintain optimal operational conditions, significantly reducing the likelihood of blockages or critical failures. The systematic approach to maintenance and oversight in these southern regulators stands in contrast to the more irregular practices observed elsewhere, offering a model for effective canal management. This proactive regime contributes to improved water quality, flood prevention, and overall environmental protection in the region.

Figure 2: Sample Photos of Regulators and Canals Taken During Audit



V. Recommendations

17. To ensure the long-term sustainability and efficiency of the canal network, the following recommendations should be incorporated into the environmental management plan for the entire system during its operational phase. Integrating these measures will help address key ecological and operational challenges, supporting improved water quality, ecosystem health, and effective resource management.

A. Siltation Control

18. Implement a structured desilting program by scheduling annual and seasonal dredging activities. Set clear targets for sediment removal to ensure consistent canal depth and prevent blockages throughout the year.

19. Deploy GIS mapping and conduct regular drone surveys to pinpoint areas with significant silt accumulation. Use the collected data to prioritize intervention and allocate resources efficiently for desilting efforts.

20. Engage local communities by launching monitoring initiatives that empower residents to report silt build-up in their neighborhoods. Facilitate training sessions and provide reporting tools to strengthen grassroots participation in maintaining canal health.

B. Water Hyacinth Management

21. Accelerate the deployment of mechanical removal boats throughout all canal sections to ensure swift and effective extraction of water hyacinths. By scheduling regular patrols and removal operations, canal authorities can prevent dense vegetation from obstructing water flow and mitigate risk of flooding. Equip teams with advanced machinery and provide ongoing training to maximize operational efficiency and minimize environmental disruption.

22. Initiate trials with environment friendly biological control agents to curb water hyacinth regrowth in targeted areas. Collaborate with agricultural experts and local universities to monitor the impact and safety of these agents, ensuring they are introduced in a controlled manner. Document results and refine release strategies to achieve sustainable long-term management of invasive aquatic plants.

23. Encourage community-driven reuse of harvested hyacinths by establishing collection centers and facilitating partnerships with composting, biofuel producers, and local artisans. Organize educational workshops and promotional campaigns to highlight the economic and environmental benefits of transforming hyacinth waste into valuable resources. Support pilot projects that showcase innovative uses, inspiring broader adoption and reducing the burden on landfill sites.

C. Waste Management

24. Set up segregation facilities to efficiently separate plastics from vegetation and other waste streams. This ensures that recyclable materials are diverted from disposal, reducing environmental impact.

25. Designate specific disposal sites for solid waste, placing them away from embankments to prevent contamination of water bodies and maintain canal integrity.

26. Intensify community awareness campaigns to educate residents on the importance of proper waste disposal, fostering positive behavior change and reducing littering.

27. Work closely with local municipalities to enhance solid waste collection systems, ensuring timely removal and appropriate management of waste generated within canal communities.

D. Regulator Maintenance

28. Install floating barriers upstream to capture solid waste before it reaches the regulator gates.

29. Schedule routine inspections and cleaning of regulators to ensure optimal operation.

30. Implement (or operation any existing) automated waste removal systems to minimize manual labor and increase efficiency.

VI. Conclusion

31. The audit reveals that current canal maintenance practices under RID are sufficient in some aspect, but there is still room for improvement. Addressing siltation, aquatic vegetation, and solid waste requires a systematic, integrated approach combining technology, community participation, and institutional reforms. Implementing the recommended strategies will enhance canal efficiency, protect ecosystems, and ensure long-term sustainability of the flood control system.

Appendix 7: Stakeholder Engagement Plan

[see separate document]