

FACILITATING THE REFURBISHMENT OF RONESS RESERVOIR

Sub-Project ID: 3.4b

INTRODUCTION



Deliverables	<ul style="list-style-type: none">• Remove vegetation• Ground investigation and engineer’s inspection to inform refurbishment design• Full redesign of dam• Construction of fully refurbished dam to engineer’s design
Beneficiaries	24,470
Budget	US\$ 1,304,000
Location	Protects Kep, Angkaol and Pong Teuk Communes

Problem statement

Of the ten reservoirs in Kep Province Roness is one of the highest and largest. As such, it is easier for downstream communities to obtain water from Roness and the area reliant on the reservoir for water is approximately 22 km². It can also provide additional water supply to downstream reservoirs such as O Thmar through connecting channels in the low-lying agricultural area of Pong Teuk commune. Unfortunately, the dam is dilapidated and, as it was constructed during the Khmer Rouge regime (1975-1979) it was not built to modern engineering standards. Therefore, the reservoir is currently maintained with a very low water level and impounds at most 1m depth of water rather than the theoretical maximum 3.5m. If it is possible to refurbish the reservoir to retain closer to the original intended capacity this would provide much greater water security for the entire province and improve crop yields during the dry season.

This investment provides sufficient budget for a complete investigation, detailed design and refurbishment of the dam, based on the information gathered across three extensive consultations and field visits. The construction costs presented are based on these consultations and site visits. The detailed inspection and design may uncover the need for further works as a 'phase 2' beyond the life of the present project. These will not, however, compromise the effectiveness or safety of the works proposed here, but will propose further enhancements to the dam in the future.

Given that the western area of the Roness dam impounds a small body of water relative to the length of dam wall there may be opportunities during the detail design phase to realign the dam wall to reduce construction costs with minimal impacts to water storage capacity.

Location

The existing Roness Dam is located approximately in the centre of Pong Teuk Commune, immediately upstream of the Phnom Penh to Sihanoukville railway line. The location is shown on the map below.

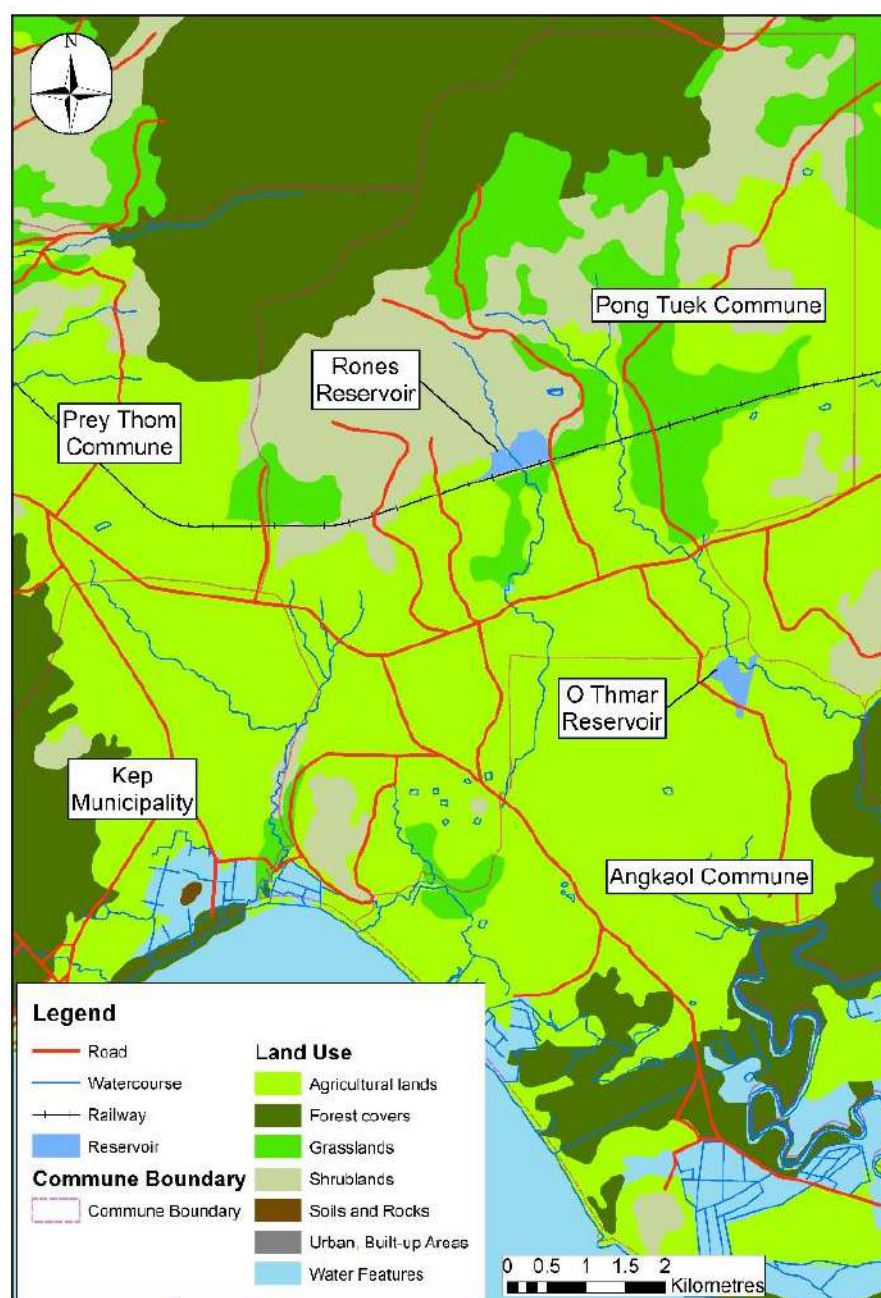


Figure 1 *Map 1 – Location of Rones Reservoir*

Beneficiaries

Roness reservoir provides a water supply for Pong Teuk and Angkaol Communes and Kep Province. The collective population of these three settlements is 24,470. While Roness is not the only supply reservoir for these communes the availability of additional water supply through the dry season would certainly be of benefit to the entire neighbourhood as it would provide additional water security and improve the prospects for double or even triple cropping. It would also improve the prospects for increased local tourism, both through improved water supply and through the potential for recreational activity such as boating, water sports and freshwater fishing.

A complication does exist at Roness as, since the impounded water has been maintained at its current low level due to the state of the embankment, some local villagers have begun to cultivate areas within the footprint of the reservoir. If the embankment is upgraded and the reservoir restored to hold more water than at present this will cause detriment to those people farming within the reservoir extent. However, there is the potential for these people to adapt to alternative livelihoods supporting the additional economic activities that a restored reservoir could attract (e.g. farming goats to graze the embankment to keep it clear of large vegetation; freshwater fishing; providing boating for visitors). There would not be any requirement for resettlement as the local villagers live in a small community just to the east of the reservoir, outside the embankment. The full refurbishment of the reservoir would improve safety for the community by reducing the risk of dam failure.

BUDGET

Investigation, development of design and estimate of construction for Dam Embankment

DESCRIPTION	QUANTITY	UNIT PRICE	COST
Vegetation clearance / management on embankment (1.4 km x 5m)	7,000 m2	\$ 9	\$ 63,000
Ground Investigation (20 boreholes to 15m depth, 5 boreholes to 25m depth, 30 boreholes to 10m depth and conversion of 8 boreholes to monitoring wells to 10m depth), including field engineer supervision	725m	\$ 120	\$ 87,000
Ground investigation – testing and analysis of samples (as detailed in implementation section below)			\$ 45,000
Monitoring wells – recording of data on a weekly basis (done by existing reservoir maintenance staff on site)			\$ 0
International consultancy support / supervision	160 individual work hours	\$ 250	\$ 40,000
Dams Supervising Engineer – supervision and review of inspection, design (assume 4 weeks)	100 individual work days	\$ 500	\$ 50,000
Design support team – hydrology, hydraulic engineer, geologist, structural engineer (average unit rate, national engineer)	600 individual work days	\$ 300	\$ 180,000
QA	4 individual work days	\$ 300	\$ 1,200
Additional material required to widen and improve safety of the dam (estimated – based on additional average dam cross-section of 35m2 over 1.4km length)	50,000 m3	\$ 8	\$ 400,000
Polythene liner embedded in dam upstream face and keyed into bed of reservoir (1.4 km x 18m)	25,200 m2	\$ 4	\$ 100,800
Additional concrete works (spillway, apron, gate housings)	250 m3	\$ 145	\$ 36,250
Spillway surface reinforcement			\$ 150,000
Labour (skilled) (15 skilled operatives for 5 months)	2,500 individual work days	\$ 30	\$ 75,000
Labour (unskilled) (workforce of 50 working 8 hour days for 5 months)	5,050 individual work days	\$ 15	\$ 75,750
		TOTAL	\$1,304,000

DATA COLLECTION

Inputs

This study has been informed by data provided by the Ministry of the Environment, Kep Provincial Department of Water Resources and Meteorology, Kep Provincial Department of the Environment and Pong Teuk Commune. Costings data has been provided by Arcadis and by the UN Habitat Programme Manager for Cambodia. Mapping has used Google Earth satellite imagery and openly available GIS data including geology, land use and watercourses. Advice on the necessary site investigations and hydrological / hydraulic studies has been provided by dams and geotechnical specialists within Arcadis and a site visit has informed the understanding of the dam condition and situation.

Consultations

Consultation has been carried out with the Ministry of the Environment, Kep Provincial Department of Meteorology and Water Resources, Kep Provincial Department of the Environment and Pong Teuk Commune.

Site Records

The site visits to Roness Reservoir included a site visit to the main south-facing dam that runs parallel to and 30m north of the railway line. The embankment has approximately 1:1 side slopes of a fairly sandy material although seemingly containing cohesive material and well-compacted. The downslope side is mostly heavily vegetated with a number of large holes where root boles have been pulled out with fallen trees (Figure 1). There are sporadic trees on the upstream face of the dam as well, and during the visit a branch fell from one of these trees into the water (Figure 3). A small mechanical excavator was present for undertaking some limited vegetation clearance from and repairs to the dam crest but the angle of slope limited the ability to clear a lot of the vegetation. There was no spillway. We observed two manual sluice water gates (one had a damaged spindle but appeared to be still operable), and noted that there is a maintenance engineer retained on site to operate these in the event of a flood to prevent water building up behind the dam. The crest was approx 4m wide, which enabled vehicle access along the top. According to GIS data and Google Maps the crest along the east-facing section of the embankment forms a public road, although like many rural roads here this is unsurfaced. Outflow channels to the south passed under the railway line in culverts (Figure 5) and then ran through the adjacent agricultural land serving irrigation channels. The culverts under the railway did not appear adequate to accommodate a significant outflow from the reservoir if all the sluice gates were fully opened in a flood event. We were advised that the railway had only recently been renovated and the track appeared in a very good condition. Water marks on the concrete of the sluice gate housings showed the level water had formerly been maintained at, which is approx. 3.5m from assumed bed level (assuming the bed of the reservoir is at the same level as ground on the downstream side of the embankment). On the same assumption current water level was maintained at no more than 1m from bed. There were observed to be established woodlands within the footprint of the reservoir and appeared also to be some cultivated areas, which are more apparent from Google Earth satellite imagery dated 07/02/2018. We observed several people within the wooded areas.

IMPLEMENTATION

Design

To safely and effectively complete the refurbishment of the dam at Roness Reservoir, a full investigation and redesign of the dam to include a spillway and other modern safety features which are not currently present is required.

While the consultations and site visits conducted initial investigations and allowed for a concept design to be developed. The detailed site investigation inclusive of geotechnical testing and the detailed design of the dam are to occur in the next phase of works - cost and time implications precluded these works from taking place prior to the submission of the proposal. Any additional construction activities identified during the detailed design phase will be put forward in a proposal for phase 2 works to be implemented in the future to guarantee enhanced functionality in the context of reducing rainfall and a growing population.

An assessment of the Roness dam western wall alignment is to be investigated during the detailed design phase. As the western wall impounds a small body of water relative to its length there are opportunities to reduce construction costs with minimal impacts to overall water storage capacity.

Vegetation Clearance

Firstly, the extent of vegetation along the embankment is both a source of weakness (there is a risk of piping along tree roots, and the root boles of fallen trees cause large-scale physical damage to the embankment) and inhibits the ability to inspect the dam for leaks and other damage. The dam should be inspected by a qualified dams engineer who can instruct on the removal or management of vegetation to minimise disruption to the embankment (felling of established trees may cause more problems with leakage pathways as the roots rot). Any damage from trees that have already fallen, or where tree boles need to be removed, should be repaired before proceeding to the second stage of work. Subject to instructions by the qualified dams engineer, the ground surface on the downstream slope should then be maintained as far as possible as simply grass cover – to enable this it is recommended the area is fenced in and grazed by goats (cattle would be too heavy and could over-graze and damage the slope).

Geotechnical Investigation

The second element of work will be to undertake geotechnical investigation to establish the quality of the material the dam is built from and the material it is built on. It is not believed that there are any design drawings or specifications dating from the dam construction, and so it is proposed that a series of boreholes are advanced along the dam crest, the upstream and downstream toes, and at the locations of the proposed outlet works and spillway(s) to sample and test existing embankment and foundation soils. If, during the drilling of the boreholes, it is apparent that the material in or under the dam changes between two boreholes, additional ones should be drilled between the two that show differences to determine where an underlying change occurs.

The purpose of the geotechnical investigation is to determine the quality of the soil in the dam and the sub-soil conditions including ground water levels. The Length of the dam is approximately 1400 m.

Site investigation:

- Approximately 25 borings along the dam crest spaced approximately every 70 m including continuous Standard Penetration Tests (SPTs), and (un)disturbed sampling. Five borings would be advanced to top of rock or a maximum depth of 25 m. The remaining 20 would be advanced to a depth of approximately 15 m from the crest of the dam (up to at least 10 m into the original sub-soil).
- Approximately 30 borings along the dam's upstream and downstream toes and at the location of the spillway(s) and outlet works advanced to an average depth of 10 m into natural ground
- Convert 8 borings along 4 cross-sections, spaced at approximately 500m into monitoring wells (approximately 10 m deep) to determine the piezometric level.

At the discretion of the qualified dams engineer, some borings could be replaced by Cone Penetration Testing (CPT's). It is assumed that drilling through the dam material and sub-soil can be executed by percussion boring or an equal system. In case hard soil (rock) is encountered then drilling using the rotary coring technique will be necessary.

Laboratory testing (it is assumed no rock material will be encountered) to be conducted on existing embankment soils and foundation soils.

Non-cohesive soils

The following tests are required on non-cohesive soil samples:

- Particle size analysis (classes/sieve dimensions);
- Hydrometer tests on selected samples;
- Triaxial tests (consolidated drained, minimum/maximum density).

Cohesive soils

The following tests are required on cohesive soil samples:

- Atterberg limits;
- Moisture content;
- In situ density (by undisturbed samples);
- Un-drained shear strength (pocket penetrometer and/or torvane in field);
- Triaxial tests (consolidated undrained with pore pressure measurements);
- Particle size analysis (classes/sieve dimensions);
- Hydrometer tests on selected samples;
- Consolidation test.
- Dispersion tests

For the Roness dam this will to the following amount of site investigation and laboratory testing:

- 20 borings including SPT's and (un)disturbed sampling up to depth of 15 m;
- 5 borings including SPT's and (un)disturbed sampling up to depth of 25 m;
- 30 borings to a depth of 10 m
- 8 monitoring wells including monitoring every week (to be done by existing on-site maintenance operatives following training);
- Continuous SPTs
- 15 determination of undrained shear strength (pocket penetrometer and/or torvane in field).
- 15 disturbed samples (short borings)
- 30 disturbed samples (long borings: dam material and sub-soil)
- 15 undisturbed samples (sub soil)

Approximate amount of tests (non-cohesive)

- 20 Particle size analysis (5 including hydrometer tests);
- 10 Triaxial tests of 9 samples each (each with 3 confining pressures) for all soils – existing embankment and foundation soils

Approximate amount of tests (cohesive):

- 25 Atterberg limits;
- 15 organic content;
- 250 water content;
- 10 particle size analysis incl. hydrometer tests;
- 15 in-situ density;
- 5 triaxial tests of 9 samples each (each with 3 confining pressures) for all soils – existing embankment, foundation soils;
- 5 consolidation tests.

Detailed Inspection and Design Report

Third, the qualified dams engineer should carry out a thorough inspection of the dam and the reservoir. Then, with support from specialist hydrological and hydraulic engineers, and including analysis of the geotechnical investigation, the dams engineer should produce a report detailing the works required to bring the dam up to modern safety standards. This report should include:

- A study of the local geological and hydrological conditions;
- A site visit;
- Determine and collect basic assumptions for the design of the dam, e.g. earthquake loads, spillway requirements and ancillary objects etc.;
- Planning, execution and supervision of the site investigation specified above;
- Design of the dam: determination of dam height or maximum water level, dam dimensions, spillway, channel design incl. revetments, design culverts including foundation of these objects;
- Design drawings and contract, bill of quantities etc.

- This report will involve input from specialist teams in the following areas:
- Hydrologic & hydraulic analysis and hydraulic design of outlet works and spillway(s)
- Geotechnical analysis and design for embankment design, seepage controls, foundation treatment
- Structural design of outlet works and spillway(s)
- Civil design and preparation of drawings and technical specifications

The following assumptions have been made in determining the extent of work on the Rones Dam.

- 1) Numbers and depths of borings are estimates required to facilitate design of a fully refurbished embankment. If the intent of this document is to only provide the program and cost for a preliminary geotechnical investigation, then the program can be cut back. See comments in the text.
- 2) Dam foundation consists of alluvial sediments with unknown depth to rock (but assumed at no more than 25 m).
- 3) Dam is 1400 m long and up to 4 m high
- 4) Outlet work to be designed consists of tower and conduit
- 5) Spillway(s) to be designed consist of open channel structure(s) on one of the abutments.
- 6) Assumptions for foundation conditions:
 - a. Rock is deep and will not factor into the foundation analysis or require special evaluation or treatment.
 - b. There will be suitable low-permeability soil stratum within 10-12 m of the natural ground surface.
- 7) Terrain is relatively flat.
- 8) There are no property or other restrictions for locating spillway(s) and outlet works.
- 9) Assumes no time for environmental assessments or permitting
- 10) Does not include any bidding or procurement assistance or construction phase services.
- 11) Assumes 8 to 12-month design period following the geotechnical investigation.

The above reconstruction procedure at this stage assumes:

- 1) Suitability of the existing material from the dam for the refurbish the dam wall with minimal need to augment this material by mixing in externally sourced soils. Additional material outside the site boundaries can be sourced if necessary.
- 2) If there are limitations to the availability of locally sourced clay, as an alternative to a clay blanket and clay key, the dam's impermeable lining will be constructed using embedded HDPE sheeting. The HDPE sheet would be tied into the bed at the upstream toe of the embankment and provided with a suitable protective cover. The HDPE sheeting is to be safely treated to ensure that sheet degradation from rodents is mitigated.
- 3) Construction of a new spillway and the refurbishment of the existing outfall structures
- 4) Use of locally sourced materials to widen and strengthen the dam

Community Engagement

Roness reservoir is well-positioned to provide a water supply to much of Pong Teuk, Kep, Angkaol and Prey Thom Communes and as such the majority of the communities will have a stake in its refurbishment and will be supportive of any works. As identified above, there is a small community of approximately 50 people living in a village immediately to the east of Roness Dam, some of whom currently cultivate land within the reservoir footprint. It will be necessary to engage with these people to ensure they are able to effectively adapt to any change in the reservoir water level that occurs at a later date following completion of the investigation and design proposed in this investment.

Construction

The existing dam material will be re-used and strengthened as much as possible. Other details of the physical works are as above.

Contractor Requirements

The geotechnical investigation should be carried out under the instruction of a qualified dams engineer to advise on the specific placing of boreholes and monitoring wells.

Key Risks & Safeguarding Issues

§ Environmental

The works will require drilling and construction machinery and materials to be brought to site, and the existing road may require modification to enable access. Any disruption as a result of the road works should be kept to a minimum.

§ Social Safeguards

Full engagement should take place with the neighbouring community and training put in place with the workforce to ensure good working relations are maintained throughout the works.

§ Gender/Youth (if applicable)

No safeguarding issues identified

For more details, see screening, below and Part II, Section K of the proposal.

PHOTOS

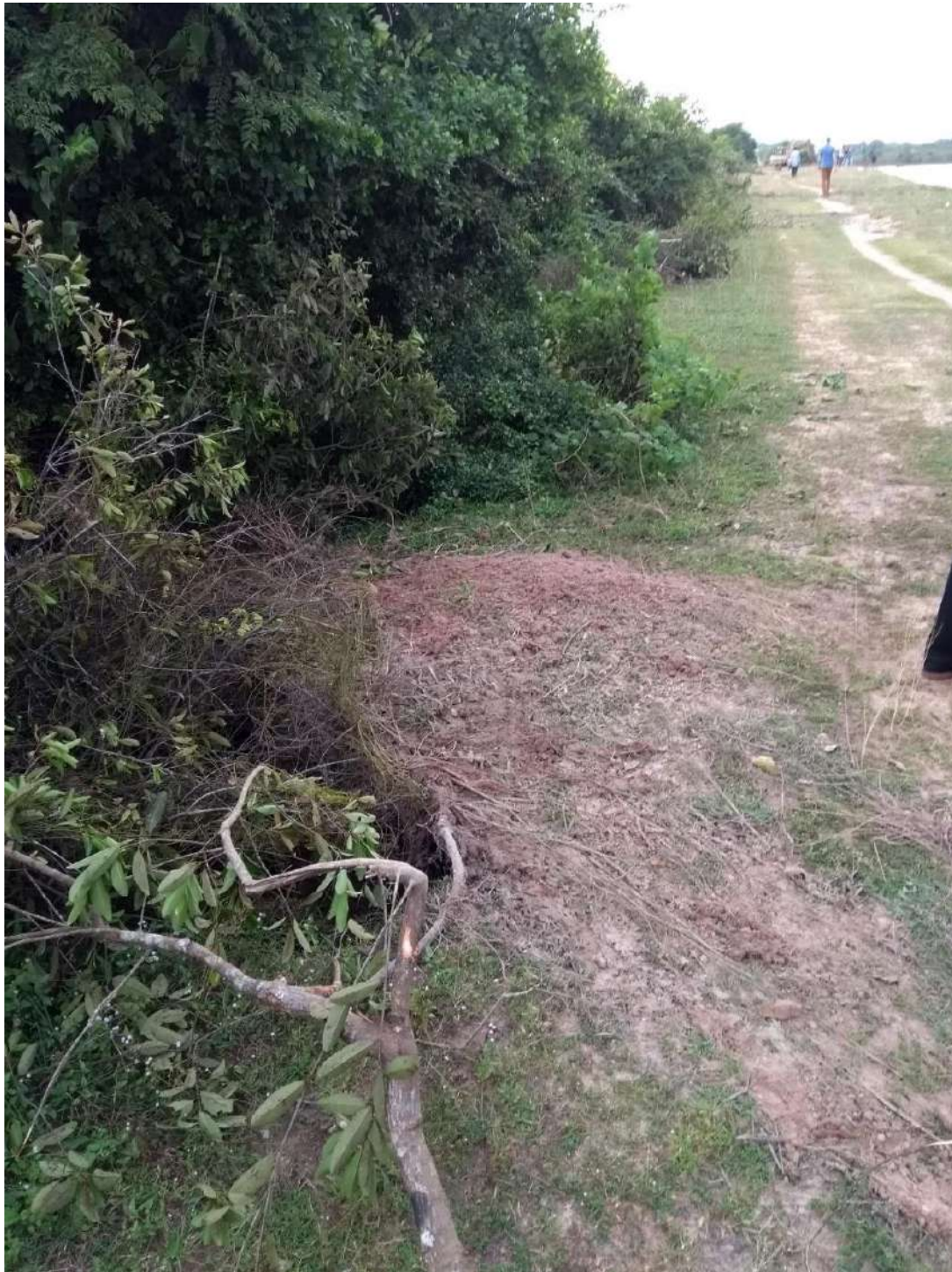


Figure 2 *“Downstream face of the dam with dense vegetation and root bole damage.”*



Figure 3 *“View along the crest of the dam showing eroded embankment face and vegetation on the downside of the dam”*

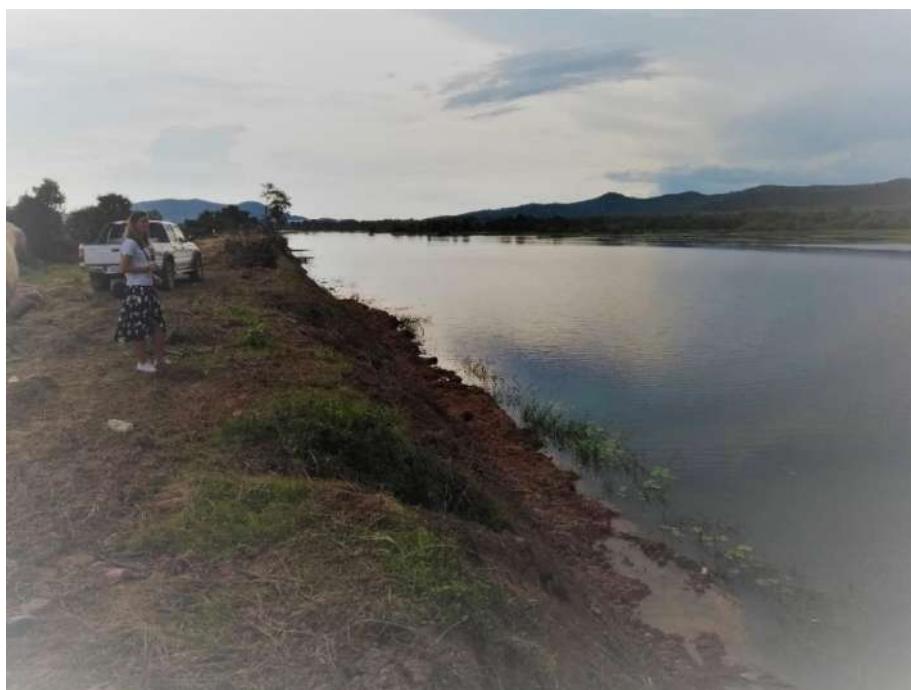


Figure 4 *“View along the upstream face of the dam showing the over-steepened and eroded embankment face.”*



Figure 5 *“View along east side of reservoir, showing upstream face with some vegetation.”*



Figure 6 *“Downstream face showing access road ramp up to crest, dense vegetation and proximity of railway line.”*



Figure 7 *“View downstream from the main outlet sluice showing the apron and the railway culverts.”*

Table 1

ENVIRONMENTAL AND SOCIAL SAFEGUARD PRINCIPLE	RISK MITIGATION ACTIONS INCORPORATED IN THE DESIGN
<p><i>Compliance with the law</i></p> <p>projects/programmes supported by the Fund shall be in compliance with all applicable domestic and international law.</p>	<p>Roness reservoir is classified as state public land and can be accessed by a public road. All actions concerning to rehabilitation of the reservoir have checked and are compliant with relevant national laws, as detailed in the proposal Part II, Section E.</p>
<p><i>Access and Equity</i></p> <p>Projects/programmes supported by the Fund shall provide fair and equitable access to benefits in a manner that is inclusive and does not impede access to basic health services, clean water and sanitation, energy, education, housing, safe and decent working conditions, and land rights. Projects/programmes should not exacerbate existing inequities, particularly with respect to marginalized or vulnerable groups.</p>	<p>This investment will deliver improved access to fresh water for poor surrounding agricultural communities. There is no evidence that the rehabilitation works could prejudice the ability of people to access water.</p>
<p><i>Marginalised and Vulnerable Groups</i></p> <p>Projects/programmes supported by the Fund shall avoid imposing any disproportionate adverse impacts on marginalized and vulnerable groups including children, women and girls, the elderly, indigenous people, tribal groups, displaced people, refugees, people living with disabilities, and people living with HIV/AIDS. In screening any proposed project/programme, the implementing entities shall assess and consider particular impacts on marginalized and vulnerable groups.</p>	<p>The improvements to the reservoir will not marginalise vulnerable groups.</p> <p>The investment is designed to improve water storage capabilities. This will benefit women as they are less likely to have to walk long distances to collect water during the dry season.</p>

Human Rights

Projects/programmes supported by the Fund shall respect and where applicable promote international human rights.

There is no evidence to suggest that human rights will be violated. Rights issues concerning land, women, labour and indigenous people are addressed separately in this sheet.

Gender Equity and Women's Empowerment

Projects/programmes supported by the Fund shall be designed and implemented in such a way that both women and men 1) have equal opportunities to participate as per the Fund gender policy; 2) receive comparable social and economic benefits; and 3) do not suffer disproportionate adverse effects during the development process.

In the poor communities affected by the proposal it was observed that women tend to take more of a household and community management role and therefore they are likely to benefit further from the community's improved crop yield, as they will be likely to take on the role of selling surplus crops.

Men and women will be given equal opportunity to provide their labour to the construction process, under the [People's Process](#) approach. Whenever women provide their labour, the project will ensure that they have access to separate bathrooms and hygienic products.

All labourers (male and female) employed under the project will be given a mandatory briefing on the prevention of sexual harassment and exploitation prior to commencing their work.

Core Labour Rights

Projects/programmes supported by the Fund shall meet the core labour standards as identified by the International Labour Organization.

There are no specific risks to core labour rights resulting from this investment. However, the following safeguard provisions will be made.

Safety equipment will be required for workers on the site and provided for them.

This activity will draw upon unskilled labour from the community. All workers in the project will be informed of their rights to organise, including joining formal labour unions, in accordance with the law. Unskilled labourers will be paid \$300 per month (assuming an 8-hour working day, 5 days per week, this is 50% higher than the national minimum wage).

All workers employed by the project (including under agreement of cooperation) will be aged 18 or over)

	See above provisions for women's labour.
<i>Indigenous People</i> <p>The Fund shall not support projects/programmes that are inconsistent with the rights and responsibilities set forth in the UN Declaration on the Rights of Indigenous Peoples and other applicable international instruments relating to indigenous peoples.</p>	<p>There is no evidence of indigenous people or undocumented migrants in the target area, and consequently there is no risk that the activities will affect indigenous people.</p>
<i>Involuntary Resettlement</i> <p>Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids or minimizes the need for involuntary resettlement. When limited involuntary resettlement is unavoidable, due process should be observed so that displaced persons shall be informed of their rights, consulted on their options, and offered technically, economically, and socially feasible resettlement alternatives or fair and adequate compensation.</p>	<p>The works all involve work on public state-owned land and are accessed by public roads and tracks. There are no dwellings on or immediately adjacent to the reservoir or its access road, and therefore there will be no resettlement required as a result of this investment.</p> <p>However, there is a small risk that the construction work will cause a temporary negative impact to surrounding agricultural land. There will need to be consultation and engagement with the community currently growing crops within the reservoir footprint to identify if alternative livelihoods are required.</p>
<i>Protection of Natural Habitat</i> <p>The Fund shall not support projects/programmes that would involve unjustified conversion or degradation of critical natural habitats, including those that are (a) legally protected; (b) officially proposed for protection; (c) recognized by authoritative sources for their high conservation value, including as critical habitat; or (d) recognized as protected by traditional or indigenous local communities.</p>	<p>Rones is a man-made dam and not a designated habitat or biodiversity area.</p> <p>There is a small risk of temporary disturbance to the natural habitat while the work is being conducted. Contractors will be required to minimise disturbance during the construction period in accordance with guidance from the Ministry of Environment.</p> <p>However, in the long-run, this investment is designed to improve the safety and functionality of the dam. Failure of the dam would cause far greater damage to the natural environment than temporary disruption arising from construction works.</p>

Conservation of Biological Diversity

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids any significant or unjustified reduction or loss of biological diversity or the introduction of known invasive species.

Roness is a man-made dam and not a designated habitat or biodiversity area.

There is no evidence of unique or endangered species in or around the dam.

Climate Change

Projects/programmes supported by the Fund shall not result in any significant or unjustified increase in greenhouse gas emissions or other drivers of climate change.

This investment will help to better understand the local effects of climate change for the poor local communities, and enable more effective adaption. There will be necessary but controlled CO2 emissions associated with the construction period only.

Pollution Prevention and Resource Efficiency

Projects/programmes supported by the Fund shall be designed and implemented in a way that meets applicable international standards for maximizing energy efficiency and minimizing material resource use, the production of wastes, and the release of pollutants.

Environmental safeguards should be applied during the geotechnical investigation and construction works to ensure no oils or cement are allowed into the environment.

Public Health

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids potentially significant negative impacts on public health.

This investment should benefit public health by improving crop production. There are no anticipated negative effects.

The construction will not use any hazardous materials or chemicals that could damage public health.

Physical and Cultural Heritage

Projects/programmes supported by the Fund shall be designed and implemented in a way that avoids the alteration, damage, or removal of any physical cultural resources, cultural sites, and sites with unique natural values recognized as such at the community, national or international level. Projects/programmes should also not permanently interfere with existing access and use of such physical and cultural resources.

The investment activities will not harm physical or cultural heritage. There are no sites of cultural, spiritual or religious heritage in or around the gates or its adjoining canals

Land and Soil Conservation

Projects/programmes supported by the Fund shall be designed and implemented in a way that promotes soil conservation and avoids degradation or conversion of productive lands or land that provides valuable ecosystem services.

This investment will facilitate the longer-term improvement in water supply to the community. This will reduce the instances of soil loss and degradation during the dry season and thereby reduce nutrient loss.

There are no other possible issues with land or soil conservation



UNHABITAT

FACILITATING THE REFURBISHMENT OF RONESS RESERVOIR

