CHAPTER 6: ENVIRONMENTAL MITIGATION MEASURES

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TABLES

6. ENVIRONMENTAL MITIGATION MEASURES[1]

Mitigation measures in this chapter are set out for the Project construction and operations phases with respect to the impacts identified in Chapter 5. The monitoring program presented in Chapter 7 *Environmental Monitoring Plan* and the recommendations in the *Watershed Management Plan* should be read in conjunction with this chapter.

6.1. PROJECT CONSTRUCTION PHASE

The objective of the mitigation recommendations is to:

- minimize environmental impacts, and
- ensure that the Project is compliant with statutory requirements during the construction phase.

Within this report there are three categories of impacts that have mitigation recommendations:

Category 1. On-site impacts: providing recommendations for mitigation measures for direct impacts caused by various construction activities that typify dam construction.

Category 2. Off-sight impacts: providing recommendations for mitigation measures for the indirect impacts caused by activities that occur within a construction site, but affect areas generally well outside a construction area, for example downstream environments.

Category 3. Cumulative impacts: providing recommendations for mitigation measures for indirect impacts that affect the project through construction, but are generated by external parties within the catchments, and or impacts created by the interplay between the Project and external parties.

The operational phase mitigations are treated separately in this chapter.

For each of the three categories above, 16 vulnerable environmental parameters have been identified as requiring mitigations. These are areas of the physical environment that will be impacted by construction works. Each environmental parameter will be affected to varying degrees according to its proximity to works, and the nature of its connectedness. The 16 vulnerable environmental parameters are listed in **Table 6.1**.

6.1.1 Environmental Management and Monitoring Plans

The Xe-Pian Xe-Namnoy Hydroelectric Power Project (the Project) covers a large area. Mitigation measures for some construction impacts, such as sedimentation and erosion, are expected to be implemented early in the construction phase as part of site design. Site design details usually form part of an Environmental Management and Monitoring Plan for the Construction Phase (EMMP-CP). The mitigation recommendations in this chapter are meant to be a guide to assist the development of a more detailed EMMP-CP. The EMMP-CP will then serve as the parent document to site-specific construction management plans (or Sub-Plans). Mitigation recommendations in this chapter are not intended to serve as a replacement for the development of these two types of plans.

[1] Acknowledgement: Some aspects of this chapter of have been drawn from the Draft Nam Ou Cascade HPP ESIA (2011) and the Environmental and Social Management and Monitoring Plan for the NN5 HPP. Both reports where prepared by Earth Systems Lao, in collaboration with Earth Systems Australia.

Table 6.1: Vulnerable Environmental Parameters

1	Water Quality
2	Water Resources (village and camp use)
3	Hydrology (prior to filling, during filling)
4	Soils
5	Land Use / Land Settlement Productivity
6	Air Quality, Noise and Vibration
7	Riverine Habitats and Aquatic Biodiversity
8	Fisheries and Aquatic Resources
9	Fauna and (Illegal) Wildlife Trade
10	Terrestrial Biodiversity
11	Forestry
12	Cultural Heritage and Archeology
13	Wastes- Hazardous and Non Hazardous
14	Accidental Events and Natural Hazard
15	Transport
16	Health and Nutrition

As part of the Project's overall environmental management system, all construction contractors and sub-contractors should be required to develop and implement environmental Sub-Plans for their works (with each independent contractor and each individual site having its own unique plans). The Sub-Plans must be consistent with all the construction management and mitigation measures and other environmental provisions contained in the EMMP-CP and the PNPC ESIA. The Sub-Plans must also include provisions for managing the health and nutrient status of workers and communities in their area of works. **Annex 6.1** contains a summary of contents that would be required in the EMMP-CP.

6.1.1.1 Category 1: On-site (direct) impacts

The construction phase will last for several years beginning with the preparations for construction that include detailed surveys of construction areas, establishing access roads and construction camps, and land clearing for project facilities; and then progressing through the actual construction of project facilities—roads, dams, reservoirs, water channels, tunnels, power plant, power transmission lines, office facilities, etc. The creation and use of construction facilities use will generate environmental impacts.

For the purposes of assigning mitigations, all on-site construction facility types of the Project have been grouped into eleven (11) sub-groups, where it is recognized that the impacts, and therefore subsequent required mitigation measures, are likely to be similar for all sites within each sub-group. Given the scale of the project several facilities of the same type will be required, such as concrete batching plants, and spread out across the project foot print. The 11 broad sub-groups are listed in **Table 6.2**.

Table 6.2: Category 1: Construction site facility type

1	Dam walls, including saddle dams on the Houay Makchan, Xe Pian and Xe Namnoy
2	Administration offices, accommodation, canteens and camps – temporary and permanent.
3	Vehicle and machinery service workshops, including fuel supply depots.
4	Ordnance storage facilities
5	Power Station and Tailrace Outlet Site
6	Water Transfer Conduits (x2 Houay Makchan and Xe Pian)
7	Crusher, separator and concrete batching plants
8	Quarries, borrow areas and spoil dumps
9	Main access road and other internal service roads and tracks.
10	General waste disposal sites (landfill).
11	Transmission Line Corridors.

Table 6.3 presents the construction phase mitigation measures for directly affected environmental parameters. Mitigation measures are not presented for each construction facility type. No attempt has been made to segregate the construction facility type according to the level of probability that an impact will occur, or the type of impact that will occur. Some construction sites, such as the dams, are likely to suffer all or most of the 16 vulnerable environmental parameters listed above, while other facilities, such as transmission line corridors will not have the full range of issues. Where a site is carefully planned and managed the impacts will be lessened. Ad hoc sites without plans are likely to experience more environmental problems.

The construction phase will generate predictable and quantifiable (and manageable) environmental impacts. In terms of on-site impacts at each construction facility, specific environmental impacts have been identified that relate back to the 16 vulnerable environmental parameters. These impacts are presented also in the following table, along with mitigation recommendations. The scale of mitigations to be implemented will be site specific.

Table 6.3: Construction phase mitigation measures for directly affected environmental parameters

Category 1 Construction Sites – Direct Impacts			
Vulnerable Environmental Parameter	**Project Activities**	**Potential Impacts**	**Mitigation Measures**
Water Quality	Release of untreated sewage; poor sanitary and hygiene conditions	Fecal coliform bacteria and pathogen contamination of waterways	Install a wastewater treatment system at each camp site to collect and treat raw sewage from various sources including toilets, showers, basins and kitchen facilities. The treatment system may need to incorporate a chlorine disinfection process to reduce pathogens from the wastewater to suitable levels that will minimize adverse impacts on the environment and water resource uses downstream from the construction area. As a minimum requirement, discharge from the treatment system would need to meet relevant ambient surface water quality guidelines downstream from the site (total coliform bacteria 5,000/100 ml; fecal coliform bacteria 1,000/100 ml; PM-WREA, 2009).
		Nutrification	Provide sufficient latrine facilities available at the construction site. (as above)
	Vegetation clearance; excavation; quarrying; spoil disposal; In-stream construction	Sedimentation (elevated TDS, TSS, Turbidity) of waterways	Encase all spoil dumps with sediment fencing and terracing if necessary.
		Algal development on substrate	Construction waste water to be directed to a sediment pond prior to discharge.
		Nutrification	Install sediment basins or sediment collection devices downstream from dam construction areas.
		Excessive plant growth in waterways	Install silt-curtains to protect against sediment transport.
		Changes to chemical and physical properties of water.	Carry out in stream works during the dry season or low-flow conditions.
			Install silt fences on cleared slopes where possible.
			Progressively replant all cleared areas.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Water Quality (continued)	Storage, use and handling of oils and hydrocarbons	Hydrocarbon leachate to soil and waterways	Store containers of liquid hazardous materials such as fuels, oils and lubricants in leak-proof containers.
			Store oils and hydrocarbons in covered, bunded areas with an impermeable base that are designed to hold 110% of the stored volume.
			As a precaution, a stockpile of loose absorbent material such as sawdust should be stored on site at all times during the construction works
			Store hydrocarbon spill response kits (e.g. *Sorbex*) on site to respond to spills that occur outside the bunded areas.
			As a precaution, deploy absorbent floating booms in the river throughout the construction phase in case of spills that occur during in-stream construction activities.
			Regularly maintain vehicles and equipment to prevent hydrocarbon (oil, grease) leaks
			Conduct vehicle and equipment maintenance in designated areas where contaminated runoff can be contained.
			Park vehicles and equipment on sealed surfaces where contaminated runoff can be contained.
			Document management procedures for oil or hydrocarbon spills in an *Emergency Response Plan* for the Project.
			Ensure heavy equipment used in or adjacent to the river is completely clean of hydrocarbon residue.
			Ensure water levels remain below the gearboxes and axles of any vehicles or mechanical equipment in use.
			Seal all lubricants and fuel tanks so that inundation in water will not result in leaks
	Concrete batching / concreting	Run-off of high pH solution	Directed the run-off from concrete batching plants to a sediment pond prior to discharge
			Construction of a sediment pond downstream of run-off from construction sites.
			Prevent washing of excess concrete and cement from vehicles or equipment adjacent to or in streams.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Water Quality (continued)	Disposal of solid waste	Contamination of groundwater systems from leachates.	Segregate solid waste for reuse and recycling in preference to on site disposal. To prevent contamination of surface runoff and groundwater, disposed of all remaining waste (that cannot be reused or recycled) appropriately in designated waste management facilities. Locate waste management facilities away from natural drainage lines, above the groundwater table, and on low permeability soils.
Groundwater	Various	Contamination of groundwater systems from leachates.	Monitor groundwater monthly at Ban Nong Phanouan (2 km from the Xe Pian dam) and Ban E-Oy (3.7 km from the Houay Makchan Gnai) during the entire construction period.
Water Resources (villages and camps)	General construction activities	Reduced water quality and quantity – surface and ground water	Identify all potentially impacted water sources. Establish catchment protection areas that limit pollution potential activities, and prepare water source management plans using participatory land use planning (PLUP) with villages. Implement water protection education program for workers as a part of induction processes. Monitor sites.
Hydrology	i) Diversions to allow dry areas for construction activities ii) filling reservoirs	Dewatering of river reaches	Regularly monitor flow rates and water levels at key locations downstream of the dam sites to confirm the extent of hydrological impacts and implement suitable management responses.
			Facilitate alternative means of navigation around construction sites.
	Wetland Systems	Dewatering of river reaches will affect various wetland systems along the conduit corridors as well as downstream from the Houay Liang	Map and quantify hydrological requirements of key wetlands systems required for habitats as well as sustaining villager livelihoods. Identify and design means for providing water through construction and operations. Monitor wetland health and productivity.
Soils	Storage, use and handling of oils and hydrocarbons and concrete	Elevated toxicity from hydrocarbon leachates.	Store oils and hydrocarbons in covered, bunded areas with an impermeable base; design the bunded area to contain at least 110% of the stored volumes.
	Topsoil stripping	Loss of valuable resource for rehabilitation work.	Stockpile topsoil in appropriately contoured stockpiles for use in rehabilitation work.
	Compaction	Difficult re-vegetation and rehabilitation.	Following construction work, rip areas that have been compacted and cover with topsoil prior to rehabilitation.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Soils (continued)	Site clearing and preparation	Erosion and Sediment Transport	Minimize the area of land cleared for Project construction work, and retain vegetation in suitable locations to maximize filtration of sediment from turbid runoff, during and post construction.
			Develop temporary and permanent stockpiles of excavated soil and rock according to criteria that maximize landform stability and minimize the potential for sediment release.
			Install drainage control structures at suitable locations to divert clean runoff away from disturbed land surfaces, and to allow for frequent and safe discharge where runoff is concentrated, but without creating deeply incised scour paths.
			Install erosion and sediment control structures such as silt fences and sediment ponds at suitable locations to filter or collect eroded sediments from turbid runoff, where necessary.
			Where removal of riparian vegetation is required, ensure that vegetation is cut off no lower than ground level to promote rapid re-growth. Protect cleared riparian land with a sufficient layer of clean rock to prevent damage to the underlying soil and root structure
			Progressively re-vegetate cleared riverbanks and other disturbed land surfaces at the Project sites as soon as practicable, to facilitate long-term stabilization.
			Re-vegetate road batters and other disturbed land surfaces as soon as practicable, to facilitate long term stabilization.
			Install suitable road drainage infrastructure, such as culverts, where road alignments cross natural drainage lines.
			Progressively rehabilitate quarries and borrow areas.
			Where excavation is required, use material handling techniques that minimize TSS (e.g. use large excavator buckets in preference to small ones; use dozers for backfilling in preference to backhoes).
			Isolate turbid water from the surrounding river flows (e.g. using high durability sediment curtains).
			Dewater construction areas (e.g. using sheet pile enclosures, water-filled geotextiles, gravel berms with impermeable membranes, gravel bags, coffer dams).
			Temporarily suspend construction activities to promote settlement or dispersion of disturbed sediments during extreme turbidity events with high total suspended solids (TSS).

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Soils (continued)	Site clearing and preparation	Erosion and Sediment Transport	Locate spoil disposal areas away from flood zones.
			Maximize re-use of spoil in construction activities.
Land Use	Various construction activities	Loss of future options to land use	Clearly identify and mark construction site perimeters. Areas demarcated will include only the area required for construction. Buffer zones will be minimized as much as possible.
			Locate Project infrastructure to minimize permanent impacts on agricultural and productive land where possible.
			Provide proper and timely compensation for land affected. In consultation with affected households and local government authorities, PNPC will develop a compensation matrix with agreed upon rates (replacement costs) for different land types affected. Cash compensation will be the primary form of compensation if land loss represents less than 20% of a household's total productive land cultivated. If the land lost represents more than 20% of the total land cultivated, then identification and preparation of replacement land will be the preferred compensation approach.
			Affected community land will be compensated with community development initiatives.
			Inform affected households of the detailed schedule of construction activities well in advance of implementation. This will allow residence to plan land use and preparation activities.
			Conduct strict survey and monitoring of construction activities to ensure that they remain within the identified perimeter.
			Progressively rehabilitate buffer areas and completed construction sites.
			Implement appropriate erosion control and drainage management measures to minimize the potential land and water quality impacts associated with land clearance.
			Implement a Grievance Procedure to ensure that unanticipated impacts on land can be identified and resolved in a timely manner.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Land Settlements and Productivity	Various construction activities	Loss of productivity in settled land	Locate Project infrastructure to minimize permanent impacts on current agricultural land where possible.
			Restrict clearance of land to only the land required for Project components. Minimize the clearance of buffer zones around Project infrastructure.
			Undertake a comprehensive land and asset survey (detailed measurement survey) after finalizing project design and infrastructure sites, and identify the ownership of any productive land that will be temporarily or permanently lost to the Project to the household level.
			Provide compensation for any productive land that will be lost to the Project. Lost community land assets (including fallow land and forests) will also need to be compensated for at the village level.
			Depending on the level of impact and the preference of the affected persons, compensation can be either cash or in the form of replacement land. As the areas of land affected are fairly small, cash compensation is likely to be the preferred compensation method. The land affected, however, may represent a significant percentage of an individual household's rice paddy land, and in that case, replacement land (identified, purchased and prepared with the assistance of the Project) is most likely the preferred route of compensation.
			Assistance from agricultural extension services in establishing new fields.
			Undertake regular public consultation to ensure the effectiveness of management and mitigation strategies.
			Through community development funding, support activities aimed at managing remaining forest and grazing land areas.
			Establish official land compensation committees at the Provincial, District and Village Levels according to the law and international best practices.
			Engage a livestock and NTFP specialist to evaluate the value of livestock grazing and gathering activities affected.
Air quality	Windblown dust from cleared areas; heavy vehicle and equipment use; excavation	Nuisance dust and decreased visibility leading to safety hazards	Suppress dust by continued watering
			Avoid activities such as loading and dumping topsoil and spoil during high winds; but if this is not possible, apply water during topsoil stripping and other activities.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Air quality (continued)	Windblown dust from cleared areas; heavy vehicle and equipment use; excavation	Nuisance dust and decreased visibility leading to safety hazards	Water all dirt roads and tracks using water carts to minimize dust generation. Rip up and re-vegetate obsolete roads, unless they are made available for community use.
			Re-vegetate long term topsoil stockpiles that have not been used for more than 6 months.
			Contour and re-vegetate spoil disposal areas to minimize erosion of exposed surface areas.
			Progressively rehabilitate cleared sites.
Noise and Vibration	Use of heavy equipment, blasting and general construction activities	Nuisance noise	Provide Project staff and workers with personal protection equipment according to OHS policies.
			Limit construction activities within 500 m of a village to day time and evening hours between 6:00 a.m. and 10:00 p.m. In accordance with the Project facilities design and layout, minimize noise near villages and households by routing traffic along more re mote access routes where and when possible, and install noise barriers to protect villages and households if required. Undertake regular monitoring of noise near villages, constructions sites and camps, and limit noise near dwellings not owned by the Project to no more than 125 dBL.
Riverine Habitats and Aquatic Biodiversity	In-stream construction; excavation; quarrying; spoil disposal	Reduced water quality	Refer to the water quality, soil and land use mitigation measures presented above. Implement the recommended environmental release programs for the dams.
		Colmation resulting in habitat degradation	
		Loss of aquatic vegetation and benthic populations	
		Permanent change in riverine habitat	
Fisheries and Aquatic Resources	In-stream construction; excavation; quarrying; spoil disposal	Loss of downstream and upstream fisheries	Compensate downstream and upstream villagers for lost fisheries.
			Develop alternative fisheries for villagers, such as stocking programs or aquaculture programs.
			Implement the water quality mitigation measures presented above.
			Implement the recommended environmental release programs for the dams.
			Implement mitigation measures for land use and soil management.
			Plan for irrigation schemes to accommodate fish rearing in rice paddies.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Terrestrial Biodiversity	Presence of the construction workforce.	Increased hunting and harvesting of wild animals and plants	Prohibit staff from hunting and exploiting local wildlife, and implement the biodiversity and wildlife protection education program for Project workers as a part of induction processes. Include clauses in staff contracts to prohibit illegal trade in wildlife and timber.
			Conduct environmental education and awareness programs for Project staff and in local villages.
	Extensive modification of the natural environment.	Loss of habitat and/or migration corridors	Minimize vegetation clearance to the area required for construction works, and minimized cleared buffer zones around Project infrastructure.
			Clearly mark and prohibit entry into designated sensitive habitats near construction areas.
			Implement measures to reduce the potential for the introduction of invasive and non-native plant species due to Project activities. Use wash-down procedures for vehicles entering construction areas to limit accidental introduction of exotic species.
			Progressively re-vegetate and rehabilitate cleared areas throughout the Project construction phase to minimize the impacts of land clearance. Use local plant species for re-vegetation wherever possible, including plants rescued from land clearance areas.
	Land clearing	Destruction or damage to Payung trees – *Dalbergia cochinensis*, a threatened species, and their habitat.	It is recommended that Payung seeds be collected and propagated in the PNPC plant nursery and then used in reforestation programs.
	Land clearing and facilities construction	Interference with seasonal migratory routes and loss of habitat for wildlife including elephants, tigers, and other large animals	Some elephants, tigers and other large mammals spend the dry season on the plains below and to the west of the Bolaven Plateau, and migrate onto the Plateau in the vicinity of the Xe Pian gorge for varying periods during the wet season. It is expected that wild animals will generally avoid the construction sites and other areas frequented by Project staff and construction workers. All Project staff and construction workers must be informed to strictly avoid contact with all wild animals that may approach the construction sites, and of the complete prohibition against hunting or otherwise taking or interfering with all wild animals. Restrictions on blasting and other noise generating activities at night will minimize adverse effects on wildlife.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Forests	Various construction activities	Reduced forest cover and habitat quality	To minimize loss of forested areas that are used for NTFP and timber collection, restrict land clearance to only the land required for Project activities.
			Identify important NTFP and timber production forests through participatory land use planning (PLUP) exercises with the local villagers; and clearly mark and designate them as prohibited areas for Project staff and workers.
			Prohibit Project staff and contractors from collecting NTFPs and other forest resources (including wild animals), and educate them to improve their understanding of the importance of forest resources to local communities, and the value of biodiversity conservation.
			Ensure that all labor camps are provided with kerosene or gas for cooking to minimize the collection and use of fuel-wood.
			Adopt appropriate measures to minimize Project related in-migration (e.g. appropriate employment policies) to minimize increasing population pressure on forest resources.
			In consultation with local residents and the Ministry of Agriculture and Forestry (MAF), ensure that local residents and/or GOL have the opportunity to remove commercially valuable timber and NTFPs from lands to be cleared for project activities.
			Monitor the removal of commercially valuable timber from Project areas to ensure that logs are not harvested from nearby areas that will not be disturbed by the Project
			Compensate villagers for any detrimental impacts on their livelihoods and food security associated with the loss of community forest resources due to vegetation clearance, and the potential loss of access to forested areas resulting from Project activities.
			Develop Project policies to specifically avoid detrimental impacts on women, the poor, ethnic minorities and other vulnerable groups, especially regarding the collection and use of forest resources. As forest resource collection, use and sale is undertaken primarily by women, impacts on these resources will tend to affect women disproportionately, it is therefore especially important that this potential gender disparity should be considered in the planning and implementation of management measures.
			Wherever possible, locate Project facilities (including access roads and transmission lines) away from areas of high value to local villagers for timber and NTFP collection.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Wildlife	Construction activities resulting in significant modifications to local environments, and noise and vibration.	Loss of habitat and/or migration corridors	Maintain records of all important animal species spotted at each Project site, and record any wildlife mortalities associated with Project construction activity, including photographs of the animals, their location when observed (GPS coordinates), and anecdotal evidence from workers.
			No noise mitigation is required as sensitive species will migrate away from the affected areas.
	Presence of the construction workforce.	Increased hunting and exploitation	Prohibit staff from hunting and exploiting local wildlife, and implement the biodiversity and wildlife protection education program for Project workers as a part of induction processes. Include clauses in staff contracts to prohibit illegal trade in wildlife and timber.
Cultural Heritage and Archeology	Various construction activities	Loss, damage or destruction of sites and artifacts	Use PLUP to identify all cultural heritage and archeological sites and artifacts of significance.
			Clearly mark construction sites and design construction activities to avoid cultural heritage and archeological sites as much as possible.
			Where direct impacts on cultural heritage and archeological sites are unavoidable, engage a Lao cultural anthropologist to (i) carry out consultations with village authorities to determine whether or not relocation and/or compensation payments are necessary; and (ii) supervise all relocation activities as required for cemeteries or other cultural artifacts, and oversee appeasement ceremonies where necessary.
			Train all Project staff and workers on Chance Find Procedures as part of the induction program.
General and Non-Hazardous Wastes	Storage and handling of general waste (litter and food waste, etc.)	Soil contamination	Install waste bins at the construction sites.
		Water contamination	Maximize recycling and reuse of materials, and provide a separate storage facility for materials that will be reused.
		Nuisance odors	Arrange for the regular collection and sanitary disposal of waste from waste bins.
		Attraction of rodents and other disease vectors.	Conduct regular site clean-ups as required.
		Decreased visual amenity	Dispose of general wastes at an appropriate central facility (refer to the mitigation measures for 'General Waste Dumps (landfill)'.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Hazardous Wastes	Storage and handling of hazardous wastes	Soil contamination	Implement the mitigation measures for soil contamination presented above, as appropriate.
		Water contamination	Implement the mitigation measures for water contamination presented above, as appropriate.
		Animal and human toxicity.	Clearly label all hazardous materials, hazardous materials storage facilities, and hazardous waste storage areas with appropriate signs in English and in Lao, and additional languages as required doe the labor force.
			Create and maintain an updated register of all hazardous materials and chemicals on site, including an inventory of all of the categories of hazardous wastes.
			Design and construct hazardous material storage facilities according to the World Bank and GOL standards.
			Establish protocols for the handling, storage, transport and use of hazardous material within the work sites.
			Develop and implement a hazardous waste collection and disposal program for all Project sites.
			Develop and implement permanent waste disposal protocols.
			Refer to IFC standards for managing hazardous materials, as presented in Annex 6.3.
Accidents and Natural Hazards	General Accidents and Natural Hazards	Fire and Explosion	Provide appropriate firefighting equipment (e.g. fire extinguishers, sand, etc.) adequate for the level of risk identified for the various faculties, and regularly test and maintain them to ensure that they always are in good working order.
			Store and handle all substances under conditions to minimize the risk of fire or explosion.
			Locate the explosives storage at least 300 m away from all infrastructures, and ensure that it is properly enclosed by a protective bund or other structure.
			Develop an *Environmental Emergency Response Plan* and train Project staff in implementation procedures.
		Spills of oil and hazardous materials	Refer to Water Quality and Soils mitigation measures above.
			Develop an *Environmental Emergency Response Plan*, and include disaster risk reduction (DRR) plans for villages within the Project footprint.
		Seismic risk	The Project area is in a low risk seismic area, but seismic risk responses should be factored into the development of the *Environmental Emergency Response Plan*.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Accidents and Natural Hazards	General Accidents and Natural Hazards	Flood	Long term monitoring of meteorological and hydrological conditions will be essential for the successful management and mitigation of daily flow peaks and extreme flood events. Monitoring parameters should include rainfall, river flow rates, water levels and visual observations (aquatic vegetation, fauna, channel morphology and sediment composition, etc.).
			Develop the *Environmental Emergency Response Plan*.
		UXO	The risk of unexploded ordnance (UXO) in the Project area is considered high. PNPC should seek the services of a qualified UXO clearance organization in advance of any land and river ground preparation, regardless of the scale of the works.
			Blasting programs, in particular, must consider the possible presence of UXO, as blasting may cause inadvertent UXO detonations.
Transportation	Various project activities	Impede and or obstruct access to transport routes	The construction of the dams and weir on the Xe Pian, Xe Namnoy, Houay Makchan Gnai and Houay Liang, and the power plant will not block any public roads. In general, the constraints on key land transportation corridors can be addressed through the provision of alternative routes detouring around construction sites. The location of alternative road corridors should be planned to compliment future developments in the area and the operational requirements of the Project.
			The Xe Pian, Xe Namnoy, Houay Makchan Gnai and Houay Liang are not navigable rivers, and the construction of the Project's dams and weir will not impede waterborne transport on the Bolaven Plateau. The Sekong between the upstream confluence of the Xe Namnoy and the downstream confluence of the Xe Pian is a navigable river for most of the year; but the Project construction and operations activities will have no significant effect on river transport.
		Accidents and increased harm to local populations and site workers caused by project traffic movement	Minimize construction vehicles passing through residential areas, and prepare traffic management plans where necessary.
			Require all vehicles to have visual labels that identify them with the Project.
			Prepare a traffic management plan for all project construction areas.
			Require that all Project drivers have valid operator's licenses for all vehicles and equipment that they are required to operate as part of their Project duties. Require that all Project drivers passing a driver safety course as part of their induction, and that they comply with local traffic laws and safety requirements according to road conditions.

Parameter	Project Activities	Potential Impacts	Mitigation Measures
Transportation	Various project activities	Accidents and increased harm to local populations and site workers caused by project traffic movement	The Project is to prepare and practice an emergency response plan for vehicle accident victims within the project area, or in circumstances where project vehicles are involved outside the project area. This should form part of standard Project OH&S operational procedures.
			Implement all relevant road safety measures during the construction phase (e.g. a zero tolerance drunk driving policy, enforced speed limits on Project roads, etc.).
Health and Nutrition	Minimize negative Project health and nutrition impacts	Construction related activities	PNPC must develop health management policies and strategies, and programs to prevent the introduction and spread of STDs, and especially HIV/AIDS, while ensuring that prevention and control programs are sensitive to cultural practices and taboos.
			The community development funding associated with the Project will support improvements in health care facilities and health education campaigns available to the general population.
			PNPC must provide health care services for its employees in a manner that does not undermine existing health services (e.g. have site staff provide training to local health service providers).
			In cooperation with the Ministry of Health and the Provincial and District Departments of Health, the Project will invest in improvements to existing health care services and facilities.
			Implement the water quality monitoring program to ensure the maintenance of downstream water quality.
			Implement the recommended dust and noise mitigation and traffic safety measures.
			Apply all mitigation measures that relate to the management of hazardous and non-hazardous materials and wastes.
		Minimize the risk of malaria and dengue (and the presence of other water-borne disease vectors)	Minimize areas of standing water by providing effective drainage of active Project areas.
			Treat sewage from construction and operator's camps prior to discharge to the environment.
			Provide assistance and support to the District Health Offices' 'Malaria Control Program' and/or 'Dengue Control Program' to minimize and prevent the occurrence of these diseases in the local communities within the Project area.

6.1.1.2 Category 2 and Category 3: off-site and cumulative impacts mitigations for construction (and operations) phase

The Project construction phase will last for several years, beginning with preparations that include detailed surveys of construction areas, establishing access roads and construction camps, land clearing for project facilities; and then progressing through the actual construction of project facilities—roads, dams, reservoirs, water channels, tunnels, power plant, power transmission lines, office facilities, etc.

The creation and use of construction facilities will generate off-site environmental impacts. Careful management of water, soils, vegetation cover and wastes on-site will reduce the severity of impacts off-site. Strictly controlled on-site mitigations in addition to the operation mitigations—both presented in tables in this section—are essential to minimize environmental degradation in non-Project areas. The impacts off-site and the cumulative impacts can be further managed by the development of various catchment plans and strategies with the involvement of key stakeholders. Of particular importance is the development of Catchment Management Plans that form part of the overall Watershed Management Plan which is summarized below.

Watershed Management Plan

It is recommended that a Watershed Management Plan (WMP) be formulated as part of the main response to managing off-site and cumulative impacts through the construction phase and into the operations phase. The WMP should contain the following features.

- Work plans and schedules for the progressive rehabilitation of any temporarily disturbed forest areas, including temporary access roads and camps.
- The allocation of a portion of revenue from the Project to establish an Environment Protection Fund for the watersheds, and through this fund provision of support for the management and expansion of local forests and protection of waterways.
- Detailed Catchment Management Plans for rehabilitation of the catchments in priority areas, such as the Houay Makchan Gnai, upper Xe Pian and Xe Namnoy. Plans can include zoning and prescribing permissible land and forest use activities.
- Details of the support to the GOL and local communities for protecting remaining vegetation in riparian areas following construction activities and reservoir impoundment. Other forms of assistance can be used to increase the capacity of law enforcement for critical issues to the Project, such as illegal logging.
- Details on the mechanisms to offset all permanent losses of natural terrestrial habitats. It should consider funding and implementing effective conservation management in nearby protected areas of similar habitat and at least equivalent conservation importance.
- Details on the environmental flow release program to sustain the ecological functions of streams and rivers in the sections immediately downstream from the dams and weir.
- Details on reservoir management and development (e.g. tourism) options.
- Consultation and multi-stakeholder land and water use planning initiatives in the reservoir catchments, including the hydropower, mining and agriculture sectors, and GOL and local communities.
- Details on land use planning strategies between PNPC and local communities, e.g. participatory land use planning (PLUP) to achieve sustainable livelihoods within a new landscape.

Monitoring

Having comprehensive monitoring systems in place in upstream river reaches, in the reservoirs and downstream river reaches that include real-time stream flow characteristics (quality and quantity), along with a network of automated meteorology stations, are among the most important aspects of being able to mitigate environmental degradation off-site. **Chapter 7** identifies a range of appropriate monitoring activities and locations within and outside the project area.

The PNPC environmental monitoring program may include up to five (5) main categories of monitoring as outlined below.

Discharge monitoring: monitoring contaminants being discharged or emitted from Project sites to the environment; this is usually carried out at the point of discharge or within the local catchment area. Discharge monitoring provides direct information associated with the concentrations and loads of contaminants being discharged. It also acts as a link between ambient monitoring results and the Project itself. Typical discharge monitoring locations should include various sites within and in the vicinity of the Project area to monitor discharges to water and noise and possibly air emissions.

Ambient monitoring: monitoring the background conditions and the receiving environments that could be affected by Project activities (i.e. air, water, soil, flora, fauna, etc.). It is useful in determining the effects of emissions or discharges from the project on the receiving environment, in contrast to discharge monitoring which identifies their occurrence. Typical ambient monitoring locations should include upstream and downstream locations for surface waters, as well as nearby sensitive receptors for noise and possibly air quality. Ambient monitoring of aquatic and terrestrial biodiversity, meteorology and rehabilitation activities should also be conducted. Ambient monitoring should be undertaken during the construction and operations phases, and is in addition to the collection of baseline data. When compiled with baseline data, this would establish long-term trends and detect any variations within environmental parameters over time.

Validation monitoring: monitoring Project activities to identify deviations from the expected impacts and to verify the degree of accuracy of the EIA predictions.

Compliance monitoring: monitoring the implementation of the management measures and the EMMP as a whole, to ensure that the EMMP is being implemented as required and that the appropriate regulatory requirements and standards have been met.

Effectiveness monitoring: monitoring the effectiveness of the environmental management and mitigation measures to ensure that the desired objectives are being achieved.

A sixth category, **investigation monitoring,** should also be undertaken as and when required, to determine the occurrence, nature and extent of possible impacts following an environmental incident (e.g. oil spills, unauthorized discharges, etc.) or to verify or refute third-party claims of environmental impacts. For example, investigation monitoring may be undertaken upstream from a routine monitoring point to identify a source of contamination.

When, for example, accidental spills occur or significant sediment releases from sites occur (e.g. sediment flushing), their extent and severity are dependent on a number of factors such as flow conditions, toxicity level, dilution capability, particular environmental parameter sensitivities, intervention response time lapse and the quality of (emergency) responses. The availability of current data on local environmental parameters obtained from comprehensive monitoring systems will prove the most valuable to manage spills or contamination events.

Some environmental impacts can be much slower to manifest and can remain unnoticed and unmanaged until a critical level is reached if proper monitoring is not available.

Operations Phase

This section covers mitigation measures for the environmental impacts from Project operations. The assessment extends outside the immediate project areas and includes impacts on nearby villages, water and environments of the broader catchment. These mitigations should be coupled with those itemized in Categories 1, 2 and 3.

The objectives of the mitigation recommendations are to:

- minimize environmental impacts, and
- ensure that the Project is compliant with statutory requirements during operation phase.

Dams also have predictable and manageable environmental impacts during the Project operations phase. The key hydrological issues in the reservoirs during operations will be the large seasonal variations in the reservoir water level, and smaller fluctuations in the water level due to the variable refilling rates that depend on the rainfall patterns, the environmental release schedules, and daily fluctuations in flow rates downstream from the power plant due to the variable daily operation schedules of the turbines for both EGAT and EdL.

For the larger Xe Namnoy reservoir (about 50.6 km^2), there is the potential for stratification when the reservoir is full, and therefore the discharge of anoxic water through the power plant and into the tailrace and the Sekong; but that is not an issue for the smaller Xe Pian reservoir (about 3 km^2). It is not anticipated that there will be agricultural activities in the seasonal drawdown zones of the reservoir shores, but there may be some fishing and/or aquaculture activities, and boating activities, that could result in a minor increase the erosion of the reservoir shores. If motorboats will be allowed to operate on the reservoirs, then low speed limits would mitigate against increased erosion from wakes.

Because the recommended environmental release schedules from the reservoirs are much smaller than the normal flows in the river sections below the dams, even the occasional high releases to mimic flood events are not expected to cause increased erosion of the river banks, and mitigation measures against erosion should not be needed.

The dams will be effective barriers to upstream fish migrations, but some fish may pass over the dams to downstream areas with the environmental releases into the downstream river channels. This is important if exotic fish species will be introduced into the reservoirs either to establish fisheries or for aquaculture, as they would be likely to find their way into the river sections below the dams, and possibly nearby wetlands. Prohibiting the introduction of exotic fish and other aquatic species into the reservoirs from outside the Lower Mekong Basin would mitigate against detrimental effects on aquatic biodiversity.

The Xe Pian and Xe Namnoy in the vicinity of the dams are not navigable for most of the year due to either very low flows of a few cubic meters per second or less during most of the dry season, and dangerous high flows, rapids and waterfalls during heavy rains in the wet season, so the impacts on navigation on the Bolaven Plateau are insignificant. However, the lower Xe Pian and Xe Namnoy on the plains below the plateau are navigable, and the Sekong into which they flow is a navigable river. The navigable section of the lower Xe Namnoy is relatively short, and the falls near the confluence with the Sekong limit navigation from the Sekong into the Xe Namnoy except when high flows during the wet season completely inundate the falls, so the Project effects on navigation in the lower Xe Namnoy would be minor. The navigable section of the lower Xe Pian is relatively long, and the Project

will have only a very minor effect on navigation because the diversion from the upper Xe Pian amounts to only about 7% of the average annual flow in the lower Xe Pian. The diversion from the upper Xe Namnoy will result in about a 10% reduction in the average annual flow in the Sekong from the confluence with the Xe Namnoy to the Power Plant tailrace, and a marginal increase in the average annual flow from the tailrace to the confluence with the Xe Pian, and the negative impact on navigation is expected to be very minor or negligible, with some positive impact downstream from the tailrace the during the dry season. Mitigation measures for Project effects on navigation should not be required.

Following construction, there is likely to be a net outward migration, as construction laborers leave to seek employment with other projects or return home. Many camp followers will also leave following the construction phase. Still, however, the economic development of the area is likely to result in some in-migration issues, but at a largely reduced scale, as much smaller workforce is required during the Operation Phase.

Areas cleared to make way for infrastructure such as constructions sites, ROW and road access will begin to stabilize reducing sediment mobilization. Areas and facilities no longer needed through operations would have been have been progressively decommissioned and rehabilitated. As population levels become reduced, stabilization of natural resources (biodiversity, forests, wildlife, timber, NTFP, etc) is expected to follow if catchment plans are developed and implemented. Livelihood restoration activities and programs would have been implemented over the past years of construction and the capacity of local villages to manage their resources sustainably should be evident.

Table 6.4 provides a list of likely impacts that will affect each of the environmental parameters during the Project operations phase. The actual extent (coverage) and severity of the impacts will depend on many factors, but each impact will require careful monitoring over the Project life. Long term monitoring will be essential for the successful management and mitigation of Project impacts. A detailed monitoring program needs to be established for the operations phase, to enable comparison with baseline data and monitoring data collected during the construction phase, to determine the actual Project impacts.

Table 6.4: Operations Phase Environmental Mitigation Measures by Environmental Parameter.

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Water Quality	The inundation of residual biomass in the Xe Pian and Xe Namnoy reservoirs during operations is likely to result in some reduction in water quality. The Houay Makchan Gnai weir will impound a relatively small pool of water with a short retention time and little residual biomass, so impacts on water quality are unlikely to be significant	The recommendation is to install an environmental release system in the Xe Namnoy reservoir that will continually draw the best quality water from just below the surface layer. The bottom water will be high in biological oxygen demand BOD if and when seasonal stratification occurs, which can be mitigated through the use of aerators at the power plant discharge, and baffles in the tailrace to increase turbulence.	Design
	There may be localized increases in total suspended solids (TSS) and turbidity in the vicinity of the reservoir banks, where erosion and landslides may become an issue.	Implement the soils mitigation measures described in this table.	Construction
	There may be an increase in the incidence of waterborne and vector-borne diseases, such as malaria, due to the increase in standing water environments.	Wastewater treatment systems need to be installed at each campsite to collect and treat raw sewage from sources including toilets, showers, basins and kitchen facilities. These systems will need to be maintained throughout the operations phase.	Construction and Operations
Groundwater	Contamination from leaks and spills of oil, hazardous wastes, sewage and wastewater. Villages relying on groundwater near the dams are Ban Nong Phanouan (2 km from the Xe Pian dam) and Ban E-Oy (3.7 km from the Houay Makchan Gnai).	Monitor the groundwater monthly at Ban Nong Phanouan and Ban E-Oy during the entire construction period, and prepare a monitoring program during operations based on the construction phase monitoring results.	Construction and Operations
Village Water Resources	Reduced water quality and quantity – surface and ground water	Identify all potentially affected water sources. Establish water catchment protection areas that limit potential polluting activities, and prepare water source management plans through participatory land use planning (PLUP) with villages. Monitor sites.	Construction and Operations
Hydrology	Annual filling of the Xe Namnoy reservoir (maximum surface area 50.6 km^2) and the Xe Pian reservoir (maximum surface area of 3km^2).	No specific avoidance, mitigation and management measures are proposed to change the hydrological conditions of the reservoirs during operations. Implement the recommended environmental release program and monitor.	Operations
		Provide appropriate compensation to villagers whose land, assets and/or livelihoods may be adversely affected by the creation of the reservoirs.	Operations

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Soils	Dam and weir operations will contribute to reservoir bank erosion, reservoir sediment accumulation, and downstream riverbank instability. Erosion and landslides could be potential issues in parts of the reservoir drawdown areas. Groundwater levels adjacent to the reservoirs are expected to fluctuate with variations in the reservoir water level, with implications for the long-term stability of the reservoir banks.	Consider the introduction of operational buffer zones around the reservoirs to limit the types of land use along or near the reservoir shoreline. The recommended operational setbacks or buffer zones are 20 m outside the NWL and 10 m outside the FSL. Avoiding rapid drawdown events in the Xe Pian reservoir will minimize the potential for reservoir bank erosion.	Design and Operations
	The accumulation of sediment in the reservoirs will result in decreased sediment loads in the river sections below each dam, which could promote scouring of the river channel and banks.	Areas that are potentially sensitive to erosion, such as road and bridge construction sites adjacent to the river should be periodically surveyed to determine if there is any requirement for stabilization.	Operations
	The sediment yield from access road and transmission line areas could increase during the wet season, but this should not be a significant issue during the operations phase if mitigation measures are implemented effectively.	Progressively re-vegetate cleared and disturbed land surfaces at the Project sites as soon as practicable, to facilitate long-term stabilization, and monitor the process and progress.	Construction and Operations
	Reduced active storage volumes created by elevated sediment levels in the reservoirs	Detailed catchment and watershed management plans will need to be developed through both technical surveys of each of the primary PNPC sub-catchments, to identify issues and erosion hotspots, and through consultation and negotiation with other developers and stakeholders to strengthen soil conservation methods, and enhance the protection of existing forest and vegetation cover. The plans must be able to delineate those areas of the watersheds that require rehabilitation, reforestation, and protection. The studies should consider both the slopes and soils, and the status of the existing vegetation cover, and current and proposed land use practices. Progressively re-vegetate cleared and disturbed land surfaces at the Project sites as soon as practicable, to facilitate long-term stabilization. Monitor.	Construction and Operations
	The contribution of sediment from the three Project Catchments to the Sekong is expected to decrease during the operation phase. The changed sediment transport regime could potentially have an impact on aquatic fauna and fisheries downstream.	The cumulative impact of hydropower dams and other developments in the project area on the Sekong and its tributaries should be considered as part of a detailed Integrated Water Resources Management Plan outlined above.	Construction Operation

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Soils	Sections of the Houay Liang channel will be used as a water transfer channel from the Houay Makchan Gnai to the Xe Pian reservoir.	The morphology of the Houay Liang channel should be regularly monitored , and modifications, upgrades and repairs be undertaken as required.	Operations
Land Use, Resettlement and Productivity	Loss of productivity and/or alienation from settled land	Compensate villages for adversely affected community land with community development initiatives. Implement a Grievance Procedure to ensure that unanticipated impacts on land can be identified and resolved in a timely manner. Provide agricultural extension services when assisting villagers to establish new fields to replace those lost or adversely affected by the Project. Conduct regular public consultation to ensure the effectiveness of management and mitigation strategies. Provide community development funds to support activities aimed at managing the remaining forest and grazing land areas. Establish official land compensation committees at the Provincial, District and Village levels according to the law and international best practices. Engage livestock and NTFP specialists to evaluate the value of livestock grazing and gathering activities affected.	Construction and Operations
Air Quality, Noise and Vibration	Air quality, noise and vibration levels during the operation phase will be significantly less than experienced during construction. Where dam facility maintenance measures are required, impacts are likely to be short-term and localized.	Using mitigations described in earlier section, maintenance works are not likely to be at a level that will cause structural or nuisance impacts. Normal operations are not expected to generate significant noise, dust and vibrations issues. Construct seal roads or regularly water dirt roads using water carts to minimize the generation of dust.	Construction and Operations
Riverine Habitats and Aquatic Biodiversity	Key potential impacts of operations on aquatic biodiversity and habitats are primarily related to(i) the alteration of aquatic habitats, (ii) reservoir water quality and levels, (iii) interruption of fish migrations and biodiversity loss, and (iv) fish mortality.	Implement Environmental Flow Release and monitor – include monitoring benthic organisms. The level of environmental flow requirements is based on the needs of particular ecosystem components downstream. Monitoring will allow for adjustments to the flow conditions to maximize ecosystem production. EFRs should be revised in consultation with local villagers, to ensure that impacts below the dams are minimized.	Operations

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Riverine Habitats and Aquatic Biodiversity		Undertake the following environmental mitigations: • Maintain geomorphic features of the natural channel downstream from the dam where possible; • Where possible, maintain riparian habitats within the reservoir footprint; • Maintain appropriate loading of large woody debris along reservoir shoreline; • Maintain good habitat quality in reservoir tributaries; • Monitor the aquatic ecology of downstream reaches to assess the impact of the water management strategies on the maintenance of downstream habitats. In particular, monitor the maintenance of the habitat heterogeneity of the downstream habitats and the frequency of deep pools, shallow riffles etc. compared to baseline conditions; • Manage and maintain water quality downstream of the dam site to provide some use of the aquatic environment by mainstream species.	Operations
Fish and Aquatic Resources	Key operation activities likely to result in potential FAR impacts include reservoir impoundment, operation of the dam (barrier), flow regulation and sediment flushing. The negative impacts on fish stocks are likely to become evident during the operations phase, but are expected to begin once construction starts. Fish will be affected by the loss of spawning habitat, as well as the loss of food resources.	Effective management and minimization of potential livelihood impacts associated with any loss or decrease of fish and other aquatic resources during operations will be dependent on the successful development and implementation of a compensation and livelihood restoration strategy which aims to support households during a transition period and provide a safety net to ensure their wellbeing does not fall below pre-project levels, while also providing access to opportunities for other forms of livelihood development. Avoiding rapid draw-down events will minimize the potential for bank erosion and exposing eggs laid in fringing macrophytes and shallow inundated areas to desiccation, reducing the spawning success of species that use these habitats as spawning sites.	Construction and Operations

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Fish and Aquatic Resources	Key operation activities likely to result in potential FAR impacts include reservoir impoundment, operation of the dam (barrier), flow regulation and sediment flushing. The negative impacts on fish stocks are likely to become evident during the operations phase, but are expected to begin once construction starts. Fish will be affected by the loss of spawning habitat, as well as the loss of food resources.	Implement recommended environmental release schedules and monitor the results, including benthic organisms. The environmental release schedule is based on the needs of particular ecosystem components downstream. Monitoring will allow for adjustments to the flow conditions to maximize ecosystem production. The environmental release schedule should be revised in consultation with local villagers, to ensure that adverse impacts below the dams are minimized. Implement environmental mitigation measures described in the Riverine Habitats/ Aquatic Biodiversity sections Do not introduce new species into the reservoir during the first 5 years following dam closure to allow local aquatic communities time to stabilize. Introduction of fish species that are endemic to the Lower Mekong Basin and that might be able to utilize the reservoir may be considered, depending on the characteristics of the reservoir. Regularly monitor fish types, populations and productivity to identify of trends, and possibly early warnings of potential impacts. Implement, manage and monitor aquaculture development, and continue aquiculture support programs. Undertake the following environmental mitigations: • Develop and implement a quota system for sensitive fisheries. • Support the DAFO to proactively manage, enforce and expand Fish Conservations Zones. • Conduct education campaigns to educate local villagers regarding fishing technologies appropriate for the reservoirs. • If and when aquaculture is permitted in the reservoirs, establishing a licensing system that restricts the number of cages or pens that can be placed in a certain areas, or can belong to one household should be considered. • If and when fish are introduced into the reservoirs from external sources, establish a quarantine program to minimize the risk of introduction of fish diseases and parasitic infections, and periodically examine harvested fish to determine whether or not any dangerous diseases or parasites are present.	Construction and Operations

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Fish and Aquatic Resources	Low water temperatures and DO, and potentially elevated concentration of noxious or toxic elements may develop in the anoxic deep water of the Xe Namnoy reservoir, and cause fish kills if and when the reservoir water turns over. Poor quality water discharged from the power plant into the tailrace may cause fish kills.	Normalize, to the extent possible, water quality during the roughly 8 km passage down the tailrace channel from the power plant to the Sekong. This may require the installation of spray valves at the water discharge from the power plant and/or baffles in the tailrace to create turbulent flow conditions and increase the aeration of the water. Establish a water quality monitoring program focusing primarily on the dry season and the transition periods (December to June) at a series of points along the tailrace. Establish a program to monitor fish migrations up and down the Sekong past the tailrace for several years before the power plant operations begin.	Operations
Wildlife	Increased economic activity and improved access near the Project area may lead to increased wildlife trading.	Undertake situational monitoring of wildlife management activities as part of routine village consultations and PLUP. Conduct wildlife education and management awareness programs for Project staff and local villages. Prohibit staff from hunting or otherwise exploiting local wildlife. Implement biodiversity and wildlife protection education programs for workers as a part of induction their processes during the operations phase Wildlife monitoring will focus on (i) modification of habitats after impoundment and identification of the value of the new reservoir habitats; (ii) observations of wildlife and birds use of the reservoir and the surrounding habitats; (iii) trends and threats to wildlife and the watershed.	Construction and Operations
Terrestrial Biodiversity	Complete modification of the environment, including loss of habitat and/or migration corridors.	In accordance with the National Policy on Environmental and Social Sustainability of the Hydropower Sector in Lao PDR, No. 561/CPI, dated 7 June 2005, offset all permanent losses of natural terrestrial habitat by funding and implementing effective conservation management programs in nearby protected areas of similar habitat and at least equivalent, conservation importance. It is recommended that a detailed plan is prepared for vegetation offsets at the catchment level, as part of the Integrated Watershed Management Plan.	Construction and Operations

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Forests	The physical relocation of communities to new areas, increased access opportunities, and loss of forest resources from construction works will place additional pressure on remaining forest areas.	Effective management and minimization of potential livelihood impacts associated with any loss or decrease of forest resources during operations will depend on the successful development and implementation of compensation and livelihood restoration strategies. Forest loss is expected to be offset by the Project at the catchment scale through reforestation and conservation activities in other areas. Progressive rehabilitation and re-vegetation of cleared areas through construction phase using priority forest species type will help to reduce forest loss impacts during operations. Conduct forest environmental education and awareness programs for Project staff and local villagers.	Construction and Operations
Archeology and Cultural Heritage	Operations may likely cause the flooding of important cultural and archeological sites. This includes important natural sites. It is possible that artifacts can be found during operations	Implement Chance Find Procedures as required. Set up a grievance procedure to ensure that new issues arising from the Project are appropriately managed during the Operations Phase. Train all Project staff on the Chance Find Procedures as part of the induction program.	Construction and Operations
Waste Management	The generation of non-hazardous wastes will be significantly reduced during operations. There is not expected to be the generation of hazardous materials from the operation	Waste management will require the use of several specifically designed facilities (i.e. storage and separation area for recyclables; residue waste landfill for non-recyclables, non-hazardous materials; sewage and grey water treatment plants). Monitor decommissioned sites used to manage (dispose of or store) waste products during through the construction phase for leakage and emissions. It is recommended that sewage and grey water be treated on site before being discharged to the local waterways. Non-hazardous solid waste should not be disposed of together with spoil from excavation activities.	
Accidents and Natural Hazards	The most significant is likely to be flooding but the operations of the dams and weirs will are expected to contribute to attenuating local flooding.	Operational plans for the dams would be required to manage flood surges and prevent flooding beyond NWL.	Construction and Operations

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Accidents and Natural Hazards	There remains a probability of accidental and natural events that lead to environmentally hazardous discharges. During the Operations Phase, the potential for accidental toxic releases is low, as there is no longer expected to be hazardous materials stored on site.	Install a warning system to alet downstream villages and river users in advance of all planned sudden releases from the dams, including the surges in the recommended environmental release program that are designed to flush sediment for deep pools. Development of the *Environmental Emergency Response Plan*. Include disaster risk reduction (DRR) plans in villages within the project footprint.	Construction and Operations
Transport	Road transportation during operations is likely to result in a negligible impact. While the risk of road accidents remains, the proposed management measures will minimize potential impacts on community safety.	All Project vehicles and equipment must have clearly visible labels that identify them with the Project. Require project drivers and equipment operators to strictly adhere to local traffic regulations and show caution in variable driving conditions. All Project drivers must pass a driver safety course as part of their induction and before operating any vehicles or equipment. The Project must prepare and practice an emergency response plan for vehicle accident victims within the Project area, or in circumstances where project vehicles are involved outside the Project area. This should form part of standard Project OH&S operational procedures. Relevant road safety measures implemented during the construction phase (e.g. zero tolerance drunk driving policy, enforced speed limits on Project roads, etc.) will be implemented during operations phase.	Construction and Operations
Health and Nutrition	Minimize negative health and nutrition impacts of the Project through operations.	Monitor and support health management strategies relating to the spread of STIs (especially HIV/AIDS). Ensure on-going prevention and control programs. Continue to support community development associated with improvements in local health care facilities and health education campaigns for the general population In cooperation with the Ministry of Health and the Provincial and District Departments of Health, invest in improvements to existing health care services and facilities. Implement on-going water quality monitoring and reporting to ensure the maintenance of downstream water quality.	

Parameter	Potential Impacts from Project Operations	Mitigation Measures	Phases
Health and Nutrition		Provide on-going assistance and support to the District Health Offices' malaria and/or dengue control programs to minimize and prevent their occurrence in local communities in the Project area.	Operations
Irrigation Schemes	Various impacts are likely to be minor overall. Maximize the opportunities for rice and fish production.	Drainage channels may become key migratory pathways for fish and other aquatic fauna within the irrigated rice field system, as long as channels are designed without fall structures. Maintain lateral connectivity by designing fish-friendly cross-drainage culverts to enhance connectivity. Line new canals with geo-fabric to avoid flow related damage and reduce maintenance costs. Periodically monitor water quality at discharge locations, and stage releases to avoid a pollution spike in the Sekong Water related diseases such as malaria and dengue have been known to increase with expanding irrigation systems that provide habitat for mosquitoes, and diarrheal disease may increase when people dump solid waste or pollutants into the canals. These problems can be mitigated through information dissemination programs and by installing a participatory management system for the irrigation scheme. Maintenance of wetlands along the lower Houay Liang, and the introduction of rice-fish production systems in the irrigated rice paddies may help to improve local diets and livelihoods. Agricultural (irrigation) extension is necessary to curb patterns of chemical misuse and should form part of the overall development of the schemes.	Operations