Annex L: Pest Management Plan

Activities associated with the Project may lead to an increase in pest populations and subsequently an increase in the usage of synthetic chemicals to control these pests in the region affected by the Project. Any increases in the current pest population may be detrimental to agricultural productivity or human health. Any subsequent increase in the use of synthetic chemicals, which can be toxic, has the potential to cause harm to users, to the public and to the environment. This annex presents the Pest Management Plan (PMP), which has been developed to manage potential pest problems that may develop and help ensure that the use of all pesticides, herbicides, fertilizer and other synthetic chemicals associated with the Project will be handled properly and in accordance with World Bank Operational Policy OP 4.09, Pest Management. The PMP is based on the Integrated Pest Management (IPM) approach, which promotes good agricultural practice through the use of responsible and sustainable activities that will result in a reduction in pesticide use and ensure better compliance with OP 4.09.

The annex begins with an outline of current pest problems and pest management activities carried out in the Project area. This is followed by the identification of the potential impacts of the Project in terms of increased prevalence of pest and the identification of the type and degree of potential impacts resulting from pest management activities. The third section presents an evaluation and recommendation of management and mitigation measures; including steps to promote the use of non-chemical pest management techniques. Impacts and mitigation measures are considered by geographical location (NNT NBCA, Nakai Plateau, Xe Bang Fai and Construction Lands) within each of which consideration is given to three sectors (Agriculture, Public Health and Vegetation Clearance and Control for construction and operation activities). Finally, a pest management plan is outlined for three sectors: i) agriculture; ii) public health; and iii) construction. Budgeting and scheduling requirements are included in these separate plans. Finally, the annex discusses monitoring and capacity building needs.

In the context of this annex, a pest may be defined as any organism whose presence causes economic loss or otherwise detracts from human welfare. The term covers a broad range of organisms (plants, animals and micro-organisms) that reduce the productivity of agriculture, destroy goods or render them unfit for human use, or transmit diseases and debilitating conditions. IPM based pest management is a mix of farmer-driven, ecologically based pest control practices that seeks to reduce reliance on synthetic chemical pesticides. It involves: i) managing pests (keeping them below economically damaging levels) rather than seeking to eradicate them; ii) relying, to the extent possible, on non-chemical measures to keep pest populations low; and iii) selecting and applying pesticides, when they have to be used, in a way that minimizes adverse effects on beneficial organisms, humans, and the environment (World Bank Pest Management Guidebook).

Applicable Laws, Regulations & Policies

The relevant GOL regulations that have been identified are:

- Regulation No. 886/AF (10 March, 2000) regarding the management and use of pesticides; and
- Regulation No. 1503/AF (29 November, 2000) regarding the management and use of fertilizers;

There are two routes for the registration of pesticides in Lao PDR dependant on the intended usage. For agricultural use application must be made to the Department of Agriculture and for public health and household use to the Ministry of Health.

For agricultural pesticides there has been a registration procedure in Lao PDR since June 1998. It is based upon FAO Guidelines and under it 46 products have been registered to date. There are 31 active ingredients represented in these products (Table L.1). Some of the active ingredients registered in Lao PDR are listed as Category I (WHO).

There is presently no formal system for registering public health and household pesticides.

Current Pest & Pest Management Activities

This section presents the current pest and management activities in Lao PDR and, more specifically, in the Project area.

Agriculture

In general, pest attack on agricultural crops is low in Lao PDR. Although there is a range of pests mentioned both by farmers, offi-

Table L.1: Active ingredients registered in Lao PDR

Insecticides	Fungicides	Herbicides	Plant Growth Regulators	Rodenticides
Alpha-cypermethrin	Carbendazim	Butachlor + propanil	AlphaNAA + betaNOAA	Coumatetralyl
Carbofuran	Metalaxyl + mancozeb	Glyphosate	BetaNOAA	Salmonella
Acephate	Isoprothiolane + iprobenfos	2, 4-D	Butralin	Zinc phosphide
BPMC (fenobucarb)	Kasugamycin +		Gibberellic acid	
Cyfluthrin	Copper oxychloride			
Cartap	Validamycin			
Cypermethrin	Zineb			
Deltamethrin				
Diazinon				
Dimethoate				
Fenvalerate				

Table L.2: Pests of rice in the Project area (Morton, 2003)

Pest	NNT NBCA	Plateau	XBF
Yellow & striped stem borers: *Scirpophaga incertulas; Chilo suppressalis* (DS)	√	√	√
Rice bug: *Leptocorisa oratorius* (WS, DS)	?	√	√
Gall midge: *Orseolia oryzae* (WS)	?	√	√ *
Brown plant hopper: *Nilaparvata lugens* (DS)			√
Armyworm: *Mythimna spp.*	?	√	√
Golden apple snail: *Pomacia spp.*	?	√	√
Rats	√	√	√
Bacanae: *Gibberella fujikoroi*	?	√	√
Bacterial leaf blight: *Xanthomonas oryzae p.v. oryzae*			√
Rice blast: *Magnaporthe grisea*	?	?	√
Brown spot: *Cochliobolus miyabeanus* (alt. *Helminthosporium oryzae*)	?	√	√ *
Weeds, especially *Cyperus spp.*	?	√	√
Mimosa pigra control		?	

Notes:
WS = wet season; DS = dry season.
"√" = present; "?" = unknown; "*" = main pest.

cials and in the literature, these are rarely of economic importance, except perhaps in some cases for vegetables.

Pests of Rice

There is a rich arthropod fauna in the rice crop in Lao PDR – probably the richest in the world. Table L.2 summarizes the current agricultural pests for rice present or suspected to be present in four Project areas; NNT NBCA, Nakai Plateau, Xe Bang Fai and Construction Lands. The current impact from these pests is low. Insects that have the potential to be pests and indeed are in neighboring countries are not pests in Lao PDR, being kept at low levels by the rich biodiversity of predators and parasites. There appears to be a stable ecological balance in the crop. The main insect pests reported are:

- The brown plant hopper, *Nilaparvata lugens*, is possibly the most widespread dry season pest but only when there is an outbreak. The last significant outbreak occurred in 1990/91 when more than 40% of the irrigated crop was damaged;
- The stemborer, mainly *Scirpophaga incertulas*, occurs in the dry season irrigated crop but rarely cause economically important damage (IRRI, 1998);
- The gall midge, *Orseolia oryzae* occurs in the wet season lowland crop. Lao-IRRI has confirmed that the gall midge can cause severe yield losses, with total crop loss sometimes being reported. The worst affected areas are the Phalanxay District of Savannakhet Province and, to a lesser degree, Phiang District of Sayabouly Province;
- The rice bug, *Leptocorisa oratorius* occurs in both wet and dry season lowland crops. In general, the rice bug does not reach economically important levels, but in the Mekong Valley it appears to be of increasing importance. Its presence has been indicated in the Xe Bang Fai area (Morton, 2003) and on the Nakai Plateau (*T. Taipangnavong*, pers. comm. in Morton, 2003);
- An armyworm, probably *Spodoptera mauritia acronyctoides*, occurs in flood prone areas including parts of Khammouane Province;
- The golden apple snail first became a problem on dry season rice in Vientiane Province in 1992 and it has now spread to seven provinces;
- Rats are reported to be a significant problem in some areas, particularly in upland rice. A CARE survey reported rats a "problem" in the NTT NBCA watershed area (Chamberlain *et al.*, 1996). Supported by the government of Australia, a program to evaluate this problem started in 2000;
- The only rice disease reported by officials and farmers in the Xe Bang Fai region is brown spot disease, *Cochliobolus miyabeanus*, alt. *Helminthosporium oryzae*, especially in conditions of water stress. This disease is associated with soil conditions of induced or real potassium (K) deficiency, or when inappropriate varieties are used or when chemical fertilizers without a K component are used; and

Table L.3: Pests of vegetables in the Project area

Pest	NNT NBCA	Plateau	XBF
Diamond back moth, *Plutella xylostella* on cruciferae	√	√	√
Bacterial wilt on tomato			√

- Another rice disease mentioned by Xe Bang Fai farmers is "jumping spot" – a leaf spot disease that spreads within a few days over an entire paddy. The identity of this disease has not been ascertained.

Current Pest Management for Rice

Pesticides

Across the country there is very little pesticide use per unit area of rice. A recent survey indicated that in Savannakhet 50% of farmers sprayed rice one or more times per year, with 25% sprayed once and 25% sprayed more than once (Heong *et al.*, 2001).

Heong *et al.* (2001) suggested that insecticide use is more prevalent in the Xe Bang Fai plain, where the influence of farming practice in Thailand and the intensity of rice production is greater than further upstream in Mahaxai and Gnommalat Districts. However, in the Xe Bang Fai plain usage is nevertheless still low, with some blanket spraying against brown plant hopper in the dry season but generally being restricted to spot sprays of particularly severe infestations, of for example rice bug, *Leptocorisa oratorius*. Stocks of pesticide do not appear to be kept on the farm (nor in local dealers) as the products are easily accessed from Thailand. As the distance from the Mekong River increases so the awareness and use of pesticides declines. In Mahaxai no farmers reported using them.

However, the situation is changing and the amount of insecticide use in rice has increased in the last five years, possibly doubled (Heong *et al.*, 2001). Such a situation is in accord with expectation. Lao PDR government policy has been effective in increasing the area and intensity of rice production in the lowlands during the last five years. It has been observed in many countries that increasing insecticidal input occurs, partly to protect the extra investment in the dry season irrigated crop, but partly because double cropping leads to an increase in the number and intensity of pests attacking the crop. It is thus very likely from circumstantial evidence that insecticide use, though still relatively light, is increasing year by year.

Other Pest Management Activities

Communities have adopted methods other than the use of synthetic chemicals to manage the presence of pest in their rice crop. Current non-chemical pest management activities conducted in the Project area can be summarized as:

- **Golden apple snail:** there is some pesticide use, though in the area influenced by the Project farmers and officials report that snails are collected for human consumption. All farmers knew that letting the paddy dry out can drastically reduce the population;
- **Rats:** although there have been two human mortalities reported from the accidental ingestion of rodenticidal baits, anecdotal evidence and observation of dead rats for sale at the road side on the Nakai Plateau suggests some people consider them as food and actively trap with snares rather than use chemicals;
- **Rice diseases** are rarely treated with chemicals. Officials and farmers in the Xe Bang Fai did not report any fungicide treatment of rice disease; and
- **Weed** control with herbicides is very rare but there are some farmers using them. One farmer near Nongbok, lower Xe Bang Fai, reported spot spraying in some years on the paddy field before transplanting.

Pests of Vegetables

Morton (2003) identified the main vegetable pests and diseases in the Project area. These are presented in Table L.3. A more comprehensive description of the pests and diseases of vegetables in Lao PDR is presented at the end of the annex (Table L.11).

As in most of S.E Asia the most problematic pest is the diamond back moth, *Plutella xylostella*, on cabbages, other cruciferae, and some other plants.

Current Pest Management for Vegetables

In Lao PDR there is believed to be significant use of pesticides on vegetables. Most pesticide use is insecticides and most of this occurs in districts along the Mekong and also around the capital Vientiane and other major towns. A baseline survey for the Vegetable IPM program which investigated the spray frequency (Kumar, 2001) indicated that Khammouane Province does not have the most intensive pesticide use in Lao PDR (Table L.4).

The number of treatments applied in Khammouane Province is not excessive, but suggests that every farmer treats his vegetables, with insecticides being the predominant treatment. The villages on which the survey was based were almost entirely in Thakhek District, but the information is likely to apply to all of the Xe Bang Fai plain. It is likely that in the less intensive agriculture around Mahaxai and Gnommalat little is applied. In general where produce is grown for the use of the farmer's family little or no treatments are made; where it is destined for trade, such as in the Xe Bang Fai plain, it receives some treatment.

There has been no analysis of pesticide residues in fresh produce in Lao PDR. There are no facilities for this.

Intensive preventative treatment of vegetables can sometimes lead to pests developing resistance mechanisms, which in turn can leads to further treatment and unacceptable residues in the produce. This level of treatment has not yet occurred in Lao PDR and the approaches being developed to avoid it include the use of "softer" pesticides such as *Bacillus thuringiensis*, a clear awareness of pest identity, the tolerance of the crop to pest attack, and biological control.

National IPM Program

From 1996 to 2002, IPM was promoted in Lao PDR through Lao-IRRI and the FAO Regional Community IPM Program. The Program was initiated for vegetables but immediately locally re-ori-

Table L.4: Insecticide treatments in Khammouane Province (Kumar, 2001)

Crop	Insecticide Sprays Per Crop
Cabbage – Dry Season	3 to 5
Tomato – Dry Season	3 to 5
Cucumber – Dry Season	3 to 9
Yard long bean – Dry Season	3 to 6
Chinese Kale – Dry Season	1 to 4
Cauliflower – Dry Season	2 to 6
Hot Pepper – Wet & Dry Season	3 to 7

entated to rice. Basic research was carried out mainly by Lao-IRRI, and the extension of IPM to farms was carried out by the National Agricultural and Forestry Extension Service (NAFES). This was backed by FAO expertise for six years, funded through the governments of the Netherlands and Norway, and terminated in 2002. Funding for a renewed vegetable IPM program through FAO, this time orientated to vegetables, has recently come from the Swiss Government.

IPM is taught through hands-on experience within villages with three core activities:

1. Training of Trainer Courses – 12-16 week course for agricultural extension workers to learn skill to be applied to farmer field schools that they will organize;
2. Farmers Field Schools (FFS) – 20-30 farmers learn aspects of IPM and crop production on a weekly basis; and
3. Field Studies – The IPM Program supports studies by farmers, trainers, researchers and others into all aspects of crop production. The results are fed back into the FFS curricula thus acting to continually strengthen their applicability and appropriateness.

IPM appears to be strongly embedded institutionally in the operations and planning of the MAF. There are IPM specialists in nine provinces, including Khammouane Province, and there are 100 District IPM trainers throughout these provinces.

There is a natural reluctance to use pesticides among farmers and so the attitudinal baseline onto which IMP is launched is sympathetic. The training of farmers is through the medium of the FFS, but in the areas specific to the possible impact of the Project there has been very little influence of the program. Only 17 FFFs have been carried out and discussion with the District IPM coordinator for Khammouane Province suggests in fact only four may be relevant (Morton, 2003).

Since the end of 2002 no more FFSs have been held due to lack of funding. The new funding is for vegetable IPM and this will be orientated to the more intensive area of the Xe Bang Fai plain. It will have no relevance to farms east of Road 13 and probably minimal influence on rice production in the areas of the (vegetable) FFSs in the plain.

With the lack of funding of the IPM program in the last two years it seems that some momentum in the program has been lost. Unless funds are found to continue with rice IPM training the momentum gained in the last few years will be lost, and the effect of the FFSs so far held will fade. The institutional structures are there but no funds for running costs.

Inorganic & Organic Fertilizers

Inorganic fertilizers are used in the more permanent agricultural areas of Gnommalat, Mahaxai and Xe Bang Fai Districts, but not at all in the shifting cultivation agricultural practices of the Nakai Plateau and NNT NBCA.

Where used it is predominately on the dry season rice crop, but in the Xe Bang Fai it is also used in the wet season. The type of usage varies according to the recommendations of MAF extension workers and availability locally. Farmers mentioned using an NPK 16-20-0 compound fertilizer to "prime" the land at around 200-350kg/ha followed by urea 46-0-0 at around 50kg/ha. These fertilizers contains no K, making the rice susceptible to diseases such as brown spot disease in K deficient conditions.

Farmers and officials in the Xe Bang Fai plain indicated that inorganic fertilizer use appears to follow no particular guidelines with respect to soil analyses or the analysis and usefulness of organic fertilizer (Morton, 2003). Some inorganic compound fertilizers appear to be available in a locality on the basis of availability from donors rather than local need.

Organic fertilizers, commercially available or made on the farm, that are available in the Xe Bang Fai area do not appear to have been analyzed. This may be an over simplification of the position, nevertheless the true need for organic fertilizer does not seem to be understood by farmers on the Xe Bang Fai. In Xe Bang Fai plain organic fertilizer, mainly manure, is used with inorganic fertilizer at around 250 kg/ha; a relative low rate, but beneficial if applied annually.

Public Health

Table L.5 summarizes the current disease and their vectors that are present in the Project area and the specific diseases are discussed below.

Dengue

Dengue fever is recorded throughout Lao PDR, including the three Provinces within the Project area.

Education programs have been instituted to promote the need to minimize standing water, the habitat preferred by the larval stage of the *Aedes aegypti* mosquito vector, which is the most effective method to control infection levels.

Larvicidal chemicals to control the vector mosquito such as temephos (Abate insecticide) are added to standing water around the farm, and adulticidal sprays of malathion or a synthetic pyrethroid, are applied in houses. However, these rely on a level of technical awareness and finance for the inputs that is normally only present when the authorities implement control schemes.

Some biological control practices have also been implemented in Lao PDR. The predaceous copepods, *Mesocyclops* sp., feed on *Aedes* larvae and breed locally on farms and although there is no cost there remains the need by householders to continually undertake monitoring and augmentation of colonies to ensure their effectiveness.

Malaria

The level of Plasmodium infected mosquito, *Anopheles dirus*, *A. minimus* and *A. nivipes*, in the entire Project area is not known but must also be low. Current levels of human infection are very low on the Nakai Plateau (< 0.6% Khammouane Province, Dept. of Health) and also in the Gnommalat, Mahaxai, and Xe Bang Fai Districts.

A Lao-EC project in the last few years until 2002, has covered seven Provinces in Lao PDR including Khammouane and the Districts of Nakai, Gnommalat, Mahaxai and Thakhek. The prime means of controlling malaria in Lao PDR is the use of bed nets. Levels of human infection have dropped dramatically since treated bed nets (IBN) were introduced in 1998 along with a campaign for early diagnosis and treatment. They are outstandingly effective in bringing infection levels down when regularly used and when the nets are re-treated with insecticide at appropriate intervals. The latter is one of the most difficult things to ensure happens – unless there are repeated campaigns to remind people to maintain the effectiveness of their nets they will not be treated. The current recommendation of the MOH is an annual treatment with the synthetic pyrethroid insecticide, deltamethrin. The IBN campaign sells treated nets at a subsidized price of about US$ 1.60 or treatment tablets of deltamethrin for US$ 0.20 each.

All districts in the seven provinces were covered through distribution of chloroquine in 1999, 2000 and 2001 and the "SP" combination in 2001 and 2002 (a combination of sulfadoxin and pyrimethamine) to health centers and voluntary health workers.

Table L.5: Diseases and their vectors in the Project area

Disease & Vector	NNT NBCA	Plateau	XBF	Construction Lands
Dengue fever: *Aedes aegypti*, clean standing water	√	√	√	√
Malaria: *Anopheles dirus* in wet season, *A minimus* post rainfall	√	√	√	√
Japanese encephalitis: *Culex mansonii*, *C. tritaeniorhynchus* wet season, animal reservoir pigs	?	?	√	?
Opisthorchiasis, trematode: interm host *Bythynia* genus snails, cyprinoid fish, vertebrate host cats	–	–	√	–
Schistosomiasis: interm host *Neotrichula* genus snails, vertebrate host dogs	–	–	–	–

Notes:
"√" = present; "?" = unknown; "–" = not present.

From the agricultural perspective, where there is no dry season irrigation there is some seasonality to infection rates as a result of the decline in availability of vector mosquito breeding sites. In areas where such irrigation exists, for example the Xe Bang Fai plain, the strategy for monitoring by clinics etc. for outbreaks of malaria has been adjusted accordingly. The government has introduced into many areas, dry season irrigation for rice cultivation and is in the process of introducing "off-season" irrigated crops in the Xe Bang Fai plain. This may well adversely affect control measures in certain areas by providing suitable vector breeding conditions all year round. However, it should be said that infection levels now in the Xe Bang Fai plain are only classified as "low".

Japanese Encephalitis

Japanese encephalitis is endemic in most rural areas of Asia, particularly where there is paddy rice and irrigated agriculture, and its presence has bee indicated in Khammouane Province, however, the extent is not known (Vongsay *et al.*, 1994). Although the main vector mosquito, *Culex tritaeniorhynchus*, is common only a small fraction are infected. The level of infection is higher where domestic pigs are common as they act as a permanent reservoir of infection.

There is no specific treatment for infected individuals but general viral vaccines give short-lived protection. Preventing mosquito bites around dawn and dusk is effective in avoiding the disease.

Opisthorchiasis

This liver fluke, *Opisthorchis viverrini*, is picked up through eating infected raw fish and the residents of Gnommalat and Mahaxai commonly are infected. The intermediate host is the snail *Bithynia siamensis goniomphalus*, and a survey has identified infected snails in the area to be affected by the Project, specifically in the Gnommalat District (Lohachit, 1997). The fluke can be found in a commonly eaten raw fish sauce, "padek".

Schistosomiasis

Schistosoma mekongi, a blood fluke, is only recorded around Kong Island in the south of Lao PDR. The intermediate host is the snail *Neotrichula aperta* gamma race and a survey has identified this snail in the area affected by the Project area, specifically in Ban Nakio and Ban Mahaxai. However these individuals were not infected (Lohachit, 1997).

Vegetation Clearance

The area for the Pilot village and the Demonstration farm have already been cleared and only physical means have been used.

Potential Impacts from Pest & Management Activities

Identifying prior to construction the possible impacts that may occur is important so that mitigations measures are already in place to eliminate or reduce the impact as much as possible. This section identifies impacts from pest and pest management activities that may result from the Project.

Agriculture

The agricultural pests currently present in the Project area, indicated in Table L.2, have the potential to make an impact. The extent and plausibility of the impacts from agricultural pest is discussed below.

NNT NBCA

Improved access to the NNT NBCA and improved infrastructure will improve access for traders of synthetic chemicals, and an increased human population would result in increased pressure on the limited agricultural lands. There is no reason to suppose that the consequences of improved access and increased population will result in more pesticide use than currently exists; for example, in the more densely populated Mahaxai District pesticide use is still currently low. Any increases that may result from the improved access to low priced, generic pesticides will be managed by the WMPA.

Inorganic fertilizer use is unlikely to develop considerably though use is possible and the WMPA needs to be aware of this.

Nakai Plateau

The resettled villages are to adopt a settled agriculture system with access to irrigated water to grow rice and other crops. Through analysis of indicative livelihood patterns and financial assessment of the profitability of crops, a variety of crops (rice, maize, vegetables, melons, forage legumes, field crop legumes and fruit trees) have been identified to integrate into the resettlers agricultural systems.

Given the variety of crops and pests, the specific consequence for each individual pesticide use in the long term is therefore impossible to predict. Overall, in the long term, the intensification of vegetable production will tend to result in a general increase in the use of pesticides. In the first few years after re-settlement, however there could be sporadic pest outbreaks, especially of insects and diseases not normally considered pests, as the ecology of the new crops and resident insect/pathogen population find a balance. The rotation and juxtaposition of crops are important influences on pest and disease attack and these will need to be monitored. If outbreaks on a particular crop occur repeatedly the best solution may be to avoid cultivating it.

The poor state of the soil on the Nakai Plateau is the major physical factor in the agricultural development of the re-settlement area. Applications of fertilizer, both organic and inorganic, will be required. Uncontrolled application of fertilizers could lead to the contamination of not only the land but also the reservoir and surrounding water bodies.

Colonization of *Mimosa pigra* in the reservoir draw down zone is a serious potential problem. The weed has become a serious problem in many countries, colonizing large areas of land and making others inaccessible. In Thailand it has infested rice paddy bunds and roadsides and is registered as a Noxious Weed requiring it to be killed wherever found.

Xe Bang Fai

The greatest possibility for increased agricultural pesticide and inorganic fertilizer use is in the Xe Bang Fai area. The increased flow of water from the Nakai Reservoir into the Xe Bang Fai will result in two possible new scenarios that could result in a pest or pest management impact:

Increase in Dry Season Irrigation

The increased flow of water in the Xe Bang Fai will provide a water resource and reduce pumping costs in areas, such as the upper Xe Bang Fai, where the dry season river flow is currently low, and insufficient for large scale irrigation. If indeed more irrigated rice is introduced it will be based on more intensive production than in the wet season, requiring improved varieties, fertilization and crop protection. The potential impact will be as follows:

- Stem borers, gall midge, brown plant hopper and armyworm could all increase but the result should not be more insecticide application than currently exists in the Xe Bang Fai Plain, with about half the farmers applying only one or more sprays per season;
- Golden apple snail will increase and whilst it is accepted that snails may be eaten for food there is a clear danger of it becoming a serious pest and pesticides will be used. There are specific molluscicides that are not toxic to fish but they are relatively expensive and their application may require an improved level of paddy management. Broad spectrum, cheap alternative insecticides, such as endosulfan, therefore tend to be used which can be toxic to other freshwater life, which presents a real threat to the consumption of fish of rice farmers;
- Rice diseases are unimportant at present but, because of the increased cost base of irrigated rice, farmers will be more inclined to apply a fungicide to protect their investment. Bacanae, blast and bacterial leaf blight could increase if two rice crops per year are grown but introduced improved varieties, commonly used for irrigated rice, are bred for blast and bacterial leaf blight resistance and the seed is heat treated to kill bacanae. There is no reason to believe that fungicide use will be greater than the very low levels that already exists in the Xe Bang Fai plain;
- The same consideration applies to weeds as to diseases. Although readily available in Thailand there appears to be very little herbicide use on the irrigated crop in the Xe Bang Fai;
- Inorganic fertilizer use will increase as has happened in the Xe Bang Fai plain.

Increased Duration of Wet Season Flooding

The potential increase in the duration of wet season flooding has yet to be verified. The Xe Bang Fai plain is an area where current flooding frequently causes the loss of significant areas of paddy rice. In this and other similar areas the Lao government has instituted a program of investigation, in collaboration with Vietnam, to ascertain the practicality of planting at the end of the wet season in a drying out environment, but before the beginning of the dry season proper – an off-season crop. Such a crop would benefit or indeed require irrigation throughout the dry season. The increase in flow from the Project may or may not have an effect given the currently large variability in the matrix of factors that govern whether flooding occurs. Off-season rice production is likely to result in higher levels of pests as detailed above.

Construction Lands

During construction, food requirements will be substantial and undoubtedly many local farms will arise to grow vegetables. Pest attack will be inevitable and there is the very clear likelihood of pesticides being used to ensure good quality produce. Without management this could lead to excessive pesticide residue in produce, a hazard to spray operators, and a possible source of pollution for the environment. Similarly, production will be relatively intensive and inorganic fertilizers will need to be applied.

Public Health

In June 2003, a Task Force to provide a Health Impact Assessment of the Project was established by the MOH, but will not report for some time. The Task Force will undoubtedly be aware of the need to consider all possible medico-sociological effects to ensure that diseases that currently are of relatively rare incidence or those well contained in the existing population do not increase.

NNT NBCA

In terms of pests and pest management the Project is not expected to have any impact on public health in the NNT NBCA. In summary:

- **Malaria:** the Project should have no significant impact on the vector nor the existing prevalence of this disease;
- **Dengue:** the Project should have no significant impact on the vector nor the existing prevalence of this disease;
- **Opisthorchiasis:** this disease is not recorded and the snail vector is not found in this area;
- **Schistosomiasis:** this disease is not recorded and the snail vector is not found in this area; and
- **Japanese encephalitis:** occurrence not recorded and unlikely in this area.

Nakai Plateau

There is not expected to be any significant pest or pest management impacts resulting from the Project on the Nakai Plateau. In summary:

- **Malaria:** the Project should have no significant impact on the prevalence of this disease among the re-settled villagers as long as normal current preventative measures against the vector mosquitoes are adopted. There is the possibility of an increase in breeding sites for the mosquito vectors resulting from irrigation carried out by the re-settled villagers, and possibly from the reservoir itself;
- **Dengue:** the Project should have no significant impact on the prevalence of this disease as long as normal current preventative measures to remove the breeding sites of the vector mosquito are adopted. These measures would also need to be adopted by new itinerant people attracted to the area;
- **Opisthorchiasis:** this disease is not recorded and the snail vector is not found in this area. Raw fish sauce "padek", may contain the disease and the local community could be at risk from infection if they consume it – though this is no different from the current position;
- **Schistosomiasis:** this disease is not recorded and the snail vector is not found in this area; and

- **Japanese encephalitis:** occurrence not recorded and unlikely in this area.

Xe Bang Fai

The Project is not expected to have any significant impact on the prevalence of malaria, dengue, Opisthorchiasis and Schistosomiasis in the Xe Bang Fai area:

- **Malaria:** there is the possibility of an increase in breeding sites for the vector mosquito in the dry season if and when more dry season irrigation is adopted. However preventative measures are already being implemented by the MOH throughout these areas in the form of insecticide treated bed nets and the population should suffer no noticeable increase in risk. As part of the Project's compensation package for communities in the Xe Bang Fai, aquaculture and rice-cum-fish practices may be strengthened. The production of insectivorous fish, such as the mosquito fish (*Gamgusia affinis*) and the common guppy (*Poecilia reticulate*), may encourage the biological control of the aquatic larval stage of the mosquito. A review of the local aquatic ecology and the implication of such encouragement shall be first carried out by a specialist;
- **Dengue:** the Project should have no significant impact on the prevalence of this disease, nor of the vector;
- **Opisthorchiasis:** the Project should have no significant impact on the existing prevalence of this disease;
- **Schistosomiasis:** disease not recorded but the snail vector has been found in the area. The nearest place the disease has been recorded is Kong Island in the south of Lao PDR. In the opinion of local specialists there is no reason to believe the Project will have any impact in the spread of this disease; and
- **Japanese encephalitis:** dry season irrigation could augment the population of the vector mosquito in the Xe Bang Fai valley east of Road 13 by providing more breeding sites in irrigated fields and surrounds.

Construction Lands

Providing the construction workforce follows the correct personal preventative measures there should be no impact from malaria, dengue, Opisthorchiasis, Schistosomiasis or Japanese encephalitis:

- **Malaria:** the Project should have no significant impact on the prevalence of this disease, subject to all site staff and others associated with the Project abiding by the same precautions as are recommended to the present Lao population. Certain amounts of pesticide to treat the bed nets will need to be purchased, but the insecticides in use (synthetic pyrethroids) are of very low mammalian toxicity and there should be no danger to human heath;
- **Dengue:** the presence of new habitations and living areas will result in the inevitable presence of small pools of standing clear water. These provide the breeding site for the dengue vector mosquito, *Aedes aegypti*, who's larvae inhabits clear water in artificial and isolated cavities. Dengue fever could increase if these sites of breeding are not eliminated;
- **Opisthorchiasis:** there is no reason to believe construction lands will lead to any changes that will cause an increase in this disease;
- **Schistosomiasis:** disease not recorded but the snail vector has been found in the area. The nearest place the disease has been recorded is Kong Island in the south of Lao PDR. In the opinion of local specialists there is no reason to believe the Project will have any impact in the spread of this disease; and
- **Japanese encephalitis:** not relevant to the construction lands.

Vegetation Clearance

In the construction phase large areas of land will be cleared to facilitate living areas for staff, yards for equipment, workshops, offices, bulk materials storage, and all the normal requirements of large civil construction projects. The Concession Agreement stipulates that land clearance must be through physical means.

NNT NBCA

There is no requirement for vegetation clearing activities within the NNT NBCA.

Nakai Plateau

Resettlement area land is to be used for agriculture and so the soil should be disturbed as little as possible by the application of herbicides for land clearance. Primary tree clearance must be carried out by felling. Because the resettlers will participate in the preparation of their own land, clearing of small trees and undergrowth will be in a manner that the local people are used to – manually. No chemical use is permitted nor the need envisaged. There is predicted to be no impact from the use of chemicals to clear vegetation.

Xe Bang Fai

Transmission Lines

For initial construction this land will be cleared using only physical means. It is important for maintenance and safety that the land underneath power lines is accessible. Maintenance of land under power lines in a similar, existing hydroelectric scheme, the Theun-Hinboun scheme, is through the use of labour and the Project will no doubt be the same. Certain situations may dictate occasional use of a herbicide and to prepare for this appropriate herbicides may be identified beforehand.

Downstream Channel

Appropriate management is required to prevent shrubby colonization of the banks of the Downstream Channel, especially by such noxious weeds as *Mimosa pigra*. The use of herbicides to control woody stemmed weeds may be necessary. Encouragement of herbaceous growth as opposed to woody may also be desirable, and if so a shrub killer may need to be applied in the first year. The criteria for selecting a suitable herbicide are provided later in this annex. Both these situations may be successfully managed through the use of local labour.

Mitigation Measures

All mitigation measures are outlined as part of the three specific Pest Management Plans detailed later in this Annex. Some of the main mitigation measures are discussed in more detail below.

Integrated Pest Management

NAFES IPM FFSs

The objective of this PMP is that pesticide use is minimized or avoided where possible and that any use is an intelligent and considered part of an IPM approach. This has indeed also been the policy of NAFES since 1994, therefore it is proposed to mitigate agricultural impacts, resulting from an increase in or inappropriate use of synthetic chemicals, by supporting NAFES to implement a program of IPM training in geographical areas relevant to the Project.

It is proposed that GOL undertake FFSs, mainly in the upper and middle Xe Bang Fai, prior to Commercial Operating Date (COD), with a prerequisite of NTPC to support a specialist to first assess

the success of NAFES run IPM FFSs and to strengthen the curriculum and teaching methodology before the start of the program.

Farmers will be trained, when the use of pesticides is necessary, to use only the correct pesticides, at the appropriate dose, at the right time, and not to pose a hazard to themselves, others or the environment. Each FFS accommodates up to 30 farmer families, and so villages larger than this will have untrained families unless some information trickles down from the trained families to others. If necessary, since the impacts in terms of pest management will only materialize in the years following COD, there is time to continue the IPM program.

The effectiveness of FFSs as a method of education and/or changing farmer practice has been discussed among aid workers for many years by sociologists, agriculturalists and others, but for the last two decades it has been the generally accepted method and the best one to provide a sustainable result.

Pest Management Specialist

NTPC will employ a Pest Management Specialist (PMS) to provide IPM training needs for the resettlers, and to authorize capacity of pesticide use. The PMS will be trained in IPM to be able to strengthen the capacity of the NAFES run IPM FFSs, as outlined above.

Promotion of Organic Fertilizer

The desirability of using organic fertilizer has been well established throughout the area of the Project as is evident from the establishment by NTPC of an organic fertilizer factory on the Nakai Plateau to supply the resettlement villages. Regardless of the desirability of using inorganic fertilizers in their own right it is highly desirable that organic matter be introduced to the soil. This factor is of prime importance and makes the use of inorganic fertilizers of secondary importance. As the soil survey has shown however, although of secondary importance to organic fertilizers, careful choice and planned use of the correct inorganic fertilizers will be also be essential for successful settled agriculture on the Plateau. Analysis of the organic fertilizer and soil will be conducted.

Pesticides Acceptable to NTPC

Given pesticide availability is limited by the size of the market in Lao PDR, pesticides used by farmers within the Project area will be those registered in neighboring Thailand and Vietnam, and may or may not be registered in Lao PDR. Both neighboring countries have effective and up to date registration and regulatory systems.

Thus pesticides acceptable for use in areas where NTPC has influence over selection must satisfy the following criteria:

- Registered in Lao PDR for the use in question and not on the Category I (WHO) list; and/or
- Registered in Thailand for the use in question; and/or
- Registered in Vietnam for the use in question; and
- Not banned in Lao PDR.

A list of active ingredients that have been registered in Lao PDR and who's appropriate use, with the exception of Category I (WHO) listed active ingredients, is acceptable to NTPC was presented in Table L.1.

Although regulatory and pesticide registration systems of Vietnam and Thailand have been adopted, both countries have serious problems with cheap generic pesticides. Pesticides will therefore be checked to avoid the use of these problematic generic pesticides.

In situations where an internationally approved pesticide is proposed to be used but does not fulfill the criteria outlined above then, after approval by the PMS, NTPC may apply for registration with the MAF. There is currently no charge levied by GOL for this registration.

In addition, for use on vegetables grown for the Project workforce, there will be a CODEX Alimentarius MRLs (Maximum Residue Level) for the active ingredient on that vegetable to allow meaningful assessment of residue levels.

The decision process on which active ingredient is most appropriate will consider:

- Low or zero toxicity to fish and aquatic life;
- Short soil persistence;
- Inability to leach from soil;
- Low hazard to the user;
- Rapid degradation (for vegetable use); and
- Narrow spectrum of activity in IPM use.

Pesticides Not Acceptable to NTPC

Approximately sixty pesticides have been banned or have been subject to restricted registration throughout the world. These pesticides are not banned in Lao PDR, and there is no suggestion here that they need to be. Table L.6 indicates active ingredients with restrictions in Asia/Pacific countries as well as those banned in Lao PDR. The use of these active ingredients will not be acceptable to NTPC.

Three pesticide not acceptable to NTPC of interest are:

- **Endosulfan** is one of the most highly toxic insecticides to aquatic life. It's use to control a pest of increasing importance in Lao PDR, the golden apple snail, has been noted and will certainly increase, so endangering fish. In Thailand endosulfan is not registered for snail control but is used for that purpose, being readily available on the farm because it is registered for other uses. Fish kill in areas where it has become carelessly used is of great concern. This insecticide should definitely not be used nor stored or transported in any area relating to the Project, and for the general good should immediately be banned in Lao PDR;
- **Methamidophos** was banned in Thailand in April 2003. The hasty nature of the banning demanded the immediate removal of stocks from distributors shelves. This may be unenforceable however. Its use in Lao PDR may thus be expected for a further two or three years, as will also occur in Thailand, as stocks in the Thai distribution channel are used up. Its listing in PIC relates to liquid formulations of 60% or higher; and
- **Monocrotophos** was banned in Thailand in 1999; any usage in Lao PDR since then is the result of stocks in the long distribution channel. PIC listing relates to liquid formulations of 60% or higher.

Procedures for Pesticide Management

There exists the danger that if pesticides need to be used by farmers there may be no advice readily available or training in safe use. Farmers and all personnel in contact with pesticides shall adhere to accepted international guidelines and procedures. The main international agencies publishing these are the FAO and the GCPF (Global Crop Protection Federation).

Part of the support given by GOL to NAFES is to ensure that NAFES is properly equipped to train farmers and give such advice on pesticide use as part of the FFS education process. It should be ascertained that NAFES has the capability to give such advice as part of the FFS education process.

Specific pesticide procedure have not been submitted as part of the PMP and therefore can not be included in this draft.

Table L.6: Active ingedients not acceptable to NTPC

Active Ingredients with Restriction in Asia/Pacific Countries		Active Ingredients Banned In Lao PDR		Active Ingredients on the PIC List But Not Banned in Lao PDR	
Active Ingredient	Country placing a restriction	Active Ingredient	Status	Active Ingredient	Status
Aramite	Thailand	2,4,5-T	X	DNOC	(X) Scheduled for PIC review
Azinphos-ethyl	Thailand	Aldrin	X	Methamidophos	Xf
Azinphos-methyl	Thailand	Binapacryl	X	Pentachlorophenol	X
Calcium arsenate	Thailand	Captafol	X	Phosphamidon	Xf
Chlordecone	Thailand	Chlordane	X	Benomyl	powder formulations >7% scheduled for PIC review
Chlorthiophos	Thailand	Chlordimeform	X	Carbofuran	powder formulations >10% scheduled for PIC review
Cycloheximide	Thailand	Chlorobenzilate	X	Thiram	powder formulations >15% scheduled for PIC review
Dichlorophen	Thailand	Cyhexatin	!		
Demefox	Thailand	Daminozide	!		
Demephion	Thailand	DDT	X		
Dinoterb	Thailand	Dieldrin	X		
Disulfoton	Thailand	Dinoseb	X		
DNOC	Thailand	Endrin	X		
Endosulfan	Thailand	Ethylene Dibromide	X		
Fensulfothion	Thailand	Ethylene Dichloride	X		
Folpet	Malaysia	Ethylene Oxide	X		
Fonofos	Thailand	Fluoroacetamide	X		
MCPA	Thailand	Gamma HCH	X		
MCPB	Thailand	Heptachlor	X		
Mecoprop	Thailand	Hexachlorobenzene	X		
Mephospholan	Thailand	Leptophos	!		
Methamidophos	Thailand	MEMC	?		
Methazole	Australia	Methyl Bromide	!		
Mevinphos	Thailand	Monocrotophos	Xf		
Mirex	Thailand and others	Parathion	Xf		
Paraquat	Malaysia	Parathion Methyl	Xf		
Paris Green	Thailand	Sodium Arsenate	X		
Phorate	Thailand	Sodium Chlorate	!		
Phosphamidon	Thailand	Sodium Fluuroacetate	!		
Prothoate	Thailand	TEPP	!		
Schradan	Thailand	Toxaphene	X		
Sulfotep	Thailand				
Tribufos	Australia				

Notes:

"X" = not registered in OECD countries and on the FAO/UNDP Prior Informed Consent (PIC) List.
"Xf" = formulations subject to restriction and not the active ingredient.
"?" = banned but with unknown PIC status.
"!" = poses risk to handlers, environment, in the treated produce and is subject to regulatory restriction in some countries.

NTPC support for the Ministry of Health

Through its resettlers health program and regional health program, NTPC will support the local clinics and small hospital on the Nakai Plateau and Xe Bang Fai area to educate the population in prevention of malaria and dengue. Such support and reinforcement of local medical facilities to provide preventative measures has been found to be lacking in schemes elsewhere in the world, and is now considered an essential prerequisite to international funding, (Hunter J.M., in Sharp D., 2003).

Institutional Capacity & Strengthening

Implementation of mitigation measures depends not only on the ability of the NTPC to plan and control its own activities but also on the capacity of governmental departments to fulfill their commitments in these areas. The institutional capacity and strengthening needs and means for the MAF and the MOH are outlined below.

Ministry of Agriculture & Forestry

NAFES – IPM Training

With the exception of the IPM program on vegetables, NAFES is no longer organising IPM training in the country, and particularly for rice integrated pest management through FFSs, which is considered to be the best method to train farmers in pest management. The best option to train farmers in the areas affected by the Project will be that GOL revive such FFSs. The PMS and the agronomist will assist with the review of the curriculum content training methods, resources available at NAFES to ensure adequate training in the appropriate use of pesticide and IPM techniques.

Analysis of Pesticide Residues in Vegetables

No facilities exist in Lao PDR to carry out pesticide analyses on fresh or processed food. There is much anecdotal evidence and some quantitative data to suggest that significant pesticide use occurs in areas where vegetables are intensively grown. NTPC needs to ensure that the vegetables grown for the workforce do not contain pesticide residues or where they do that they are in accord with levels accepted in Thailand or elsewhere. There are three options as means to achieve this:

1. Establish own laboratories;
2. Support the purchase of additional equipment for existing laboratory in the MOH, Food and Drug Quality Control Centre (FADQCC), Vientiane; and
3. Send samples away (to Thailand) for analysis.

Option 1 has merit only if there is to be built a specialist laboratory for the MAF for other purposes into which the equipment necessary for pesticide analyses can be installed and run. The establishment of such a laboratory is, on a strict basis of need, unwarranted.

Option 2 seems suitable in the long term if GOL authorities wish to regularly monitor residue levels in other produce. The FADQCC already has equipment for analyzing medical drugs and one member of staff has in fact been trained in Sweden in pesticide analysis. It has long term support from the USA Pharmacopaeia via WHO, training assistance from the US CDC, and current support from the Wellcome Trust (UK) for malarial and HIV medicine analysis. It does not have the equipment for analyzing foodstuffs for pesticide residues. A joint MOH and MAF initiative would be called for.

Until recently Option 3 looked unreliable, frozen samples having to make the journey to Vientiane and then (by air) to the nearest laboratory in Thailand – probably Bangkok, however in July 2003 the Thai authorities decided to establish by 2004 a network of eight regional residue analysis laboratories, one of these being in Ubon Ratchathani – only 170km by road from Savannakhet, and another in Khon Kaen. Initial informal soundings in the Thai Department of Agriculture suggest there would be no barrier to NTPC using the service of these laboratories and this option should therefore be adopted for monitoring residues in the vegetables supplied to the workforce.

Ministry of Health

Concerning vector control there is a need for the MOH to provide education concerning malaria and dengue to the workforce villages and the re-settlers. With the assistance of NTPC as proposed, there should no problem with this occurring. The MOH is preparing its own assessment of the impact of the Project and presumably will deploy its resources accordingly. The PMP includes the provision of financial help to the MOH to enable three surveys in the upper Xe Bang Fai to monitor the infection rate in the mosquito vector of Japanese encephalitis.

Pest Management Plan

To help focus the mitigation measures, three User PMPs have been developed, one for each of the sectors of Agriculture, Public Health and Vegetation Clearance.

The Pest Management Plans are designed to avoid the use of, or properly manage synthetic chemical use. The strategy for implementing activities contained in the PMP is therefore to utilize the present institutions in Lao PDR, particularly the National Agriculture and Forestry Extension Service, NAFES – augmenting them where necessary, to use local staff, and to build on existing farmer inclinations of keeping synthetic chemical use to a minimum. For aspects in which expertise has not yet developed the strategy is to utilize Technical Assistance.

Agriculture Pest Management Plan

This PMP (see following Table L.7) deals with the impacts associated with increases in the use of agricultural pesticides and inorganic fertilizers that may result from changes in agricultural practices and intensities. The objective of the plan is to ensure that:

- Any intensification of agricultural practice does not result in any increase in the use of agricultural chemicals;
- The resettlers have support and advice in pest and soil management for coping with their new pattern of agriculture; and
- The supply of food for the constructing and operating work force is safe in terms of pesticide Minimum Residue Levels and has been produced with due attention to human and environmental safety.

Public Health Pest Management Plan

The PMP presented in Table L.8 is concerned only with any impact the Project will have on the distribution and prevalence of disease vectors, and the subsequent control measures. Increases in the prevalence of disease vectors may result directly from increased water on the Plateau or in the Xe Bang Fai, or indirectly through alteration of agricultural practices. The diseases malaria, dengue, Japanese encephalitis, Schistosomiasis and Opisthorchiasis have been discussed in the potential impacts, however, only the first four appear relevant to the Project. Schistosomiasis's snail vector may have more breeding sites but it is not infected by the disease in this area and the nearest place is a couple of hundred kilometres away. There has been plenty of opportunity for the snail to become infected over many years, and there is no current shortage of sites for the snail. It has to be concluded, as do the experts in the MOH, that there is no risk posed by the Construction Lands. The issues are therefore:

- Education in malaria personal prevention measures;
- Education in reducing breeding sites of the dengue mosquito vector;
- Education in Opisthorchiasis personal prevention measures;
- Monitor the mosquito vector of Japanese encephalitis along the upper Xe Bang Fai.

Vegetation Clearance Pest Management Plan

In general, clearance of vegetation using chemicals is unnecessary and is specifically undesirable in the context of geographical location of the Project. The use of chemicals for any vegetation clearance shall be minimized and hand labour opted for. Three areas where the possibility of herbicide use has some justification are:

- Any specific shallow soil areas of the re-settlement area that are destined for agricultural use;
- The area underneath the Transmission Lines, and
- along the banks of the Downstream Channel.

The vegetation clearance PMP is presented in Table L.9.

Monitoring

Monitoring activities and responsible parties are presented in Table L.10, by geographical location.

Pests of Vegetables & Fruit

Table L.11 presents a collection of comments from interviews with officials and farmers and, for vegetables, data from Kumar (2001). It is not by any means a survey of incidence or of economic importance of pests and diseases. This table is included because of the paucity of published information in Lao PDR.

Table L.7: Pest management plan for agriculture

	Possible impact	Activity/Mitigation Measure
	NNT NBCA	
A1	Increased human population in NNT NBCA coupled with use of pesticides or inorganic fertilizers may impact water quality & wildlife conservation.	Regulatory control of agricultural chemical use in the NTT NBCA.
	Nakai Plateau	
A2	Ill-advised pesticide use in re-settlement farms to control sporadic pest outbreaks.	NTPC employ Pest Management Specialist (PMS). A specialist should be employed who has IPM training, but who will have several responsibilities including overseeing pest control at resettlement area, construction lands, & monitoring the effectiveness of the FFSs to be run by NAFES.
A3		IPM education through FFSs. Once the final pattern of cropping has been decided the main pests will become obvious. For rice & many vegetable pests the IPM research base exists. For other crops vigilance will be needed & consult an IPM specialists if necessary.
A4	Unnecessary inorganic fertilizer use.	NTPC employ Agronomist.
A5		Undertake fertilizer trials & nutrient analyses of organic manures & inorganic fertilizers to ascertain need & application rate for inorganic fertilizer. Advise villagers.
A6	Unnecessary use of synthetic pesticides & inorganic fertilizer.	Institute Bye-Law to ban use of pesticides & inorganic fertilizer use without written authority of Nakai District Authorities, delogated to NTPC's PMS. NTPC's PMS & Agronomist will monitor. Usage would require authorization & pesticide choice be limited to pesticides of zero aquatic toxicity, short persistence & poor capacity to leach through soil. A Pesticide Usage Log Book should be instituted.
A7	*Mimosa pigra* may become established in the drawdown zone of the reservoir making movement difficult & rendering areas unusable.	Annual survey by PMS to check for presence. If present, a plan devised to eradicated or controlled this pest; this may require consultancy on invasive plant species. Physical & biological control may need to be tested – a bruchid beetle has been effective in research. Chemical back up may be necessary.
	Xe Bang Fai	
A8	Stem borers, gall midge, brown plant hopper & army-worm could increase to levels found on the XBF plain, if more farmers adopt dry season irrigated rice. Increased pest population could result in increased pesticide usage.	FFSs to train farmers in IPM, & in the correct & safe use of pesticides & fungicides. Examine curriculum of FFS to ensure that it is adequate & monitor performance of NAFES.
	Fungicides are more likely to be applied to control diseases in irrigated rice. This increases the cost of production.	Train farmers in IPM methods of plant disease control. Correct identification of diseases and understanding of their potential for damage. Selecting the correct fungicide if necessary. Ensuring safe and effective use of fungicides. Train IPM trainers & extension staff in fungicide recommendations.
	Inorganic fertilizer will be used on the irrigated crop to maximize yield potential.	Inorganic fertilizer should be used optimally & only on the back of organic so as to improve soil structure. The IPM program of NAFES through FFSs encourages the use of organic fertilizer.
A9	Golden apple snail numbers increase as dry season irrigated crops are adopted. Use of endosulfan to control golden apple snail kills fish & other aquatic life.	Petition to ban endosulfan use in Lao PDR. Educate & encourage farmers in IPM methods of snail control.
	Construction Lands	
A10	Uncontrolled growing of vegetables to supply work force & associated followers will result in significant uncontrolled use of pesticides & of inorganic fertilizers.	Whichever scheme for vegetable supply is adopted there need to be clear guidelines set & enforced for agrochemical selection & usage, as part of Good Agricultural Practice. The PMS referred to for approval or rejection of pesticide on supply farms.
		Random residue analysis of produce will require to be carried out.

	Reason for Mitigation	Benefit	Implementing Agency	Budget Responsibility
		NNT NBCA		
A1	To prevent contamination of wildlife & the reservoir.	Pristine wildlife habitat & clean water in the reservoir.	NTT NBCA WMPA	Included in WMPA scope.
		Nakai Plateau		
A2	To provide NTPC with a source of specialist advice in pest management & pesticides & an authorizing capability in various aspects of the Project.	Prevent water contamination of the reservoir to avoid toxicity to aquatic organisms including fish which are an essential food & livelihood of local people. Protection of resettlers health & creation of sustainable agriculture.	NTPC	Included in RMO scope.
A3	Resettlers are untrained in all aspects of pesticide usage, fertilizer application & IPM. Avoid unnecessary use of synthetic pesticides & inorganic fertilizers. Avoid human hazard from pesticide residues especially in vegetables & during spraying.		NAFES	Included in RMO scope.
A4	Provide capacity & expertise in fertilizer usage, & assist PMS as necessary.	Preserve water quality.	NTPC	Included in RMO scope.
A5	Prevent contamination of reservoir with nitrates. Keep farming costs low & improve soil structure.	Improve the organic matter status of the soil & contribute to sustainable agriculture. Optimize success of resettlers.	NTPC Agronomist.	Included in RMO scope.
A6	Re-settlement is in the watershed of the reservoir & water pollution must be prevented. Resettlers are untrained in all aspects of pesticide usage, fertilizer application & IPM. Avoid human hazard from pesticide residues especially in vegetables & during spraying.	Avoidance of water contamination will provide safety to aquatic organisms including fish, a local source of both nutritional and commercial value. Protection of wildlife. Protection of settlers & creation of sustainable agriculture.	GOL for Bye-Law. NTPC PMS & Agronomist for monitoring.	GOL for Bye-Law. Authorization & monitoring included in PMS & Agronomist scope.
A7	If this thorny weed becomes established it will invade many areas of the Plateau, making movement difficult, & render areas unusable.	Maintain land free for wildlife & human movement.	NTPC PMS for survey & control program. NTPC for specialist (Technical Assistance).	Included in PMS scope. NTPC for TA, if required.
		Xe Bang Fai		
A8	Excessive pesticide use will imbalance the existing natural pest control & will lead to further use. Accidents & improper use will result in human & environmental hazard. The existing resources of NAFES are not adequate enough to train enough farmers before operational phase.	Preserve existing natural pest control agents & train farmers in IPM including safe & informed pesticide use. Provide a low cost & sustainable pest control system using most appropriate product. Avoid accidental environmental & human risks. Increased profit.	NAFES for FFSs. NTPC PMS for examining curriculum & monitoring NAFES.	GOL Included in PMS scope.
	To manage diseases & protect the irrigated crop yield potential but at the same time optimize profitability. To provide an informed position on fungicide use.			
	Inorganic fertilizer increases cost, may lead to soil water contamination, does not improve soil structure & alters freshwater biology.	Provides maximum use of organic & supplementary use of inorganic fertilizer.		
A9	Golden apple snail may increase with increased dry season irrigated rice. Its control using endosulfan must be prevented to avoid inadvertent fish kill.	Conserve fish for human consumption & sale.	DOA for banning endosulfan. NAFES for IPM.	GOL Include in A8 scope.
		Construction Lands		
A10	To avoid the uncontrolled use of pesticides & inorganic fertilizers, in order to prevent excessive residues in vegetables. Prevent environmental contamination from excessive use.	Safe food for the work force. No contamination of the water of the reservoir (fish). No contamination of the environment of the plateau.	HC may decide to control vegetable production with assistance from PMS.	Included in HCC scope.
			PMS to monitor pesticide use.	Included in HCC scope.

Table L.8: Pest management plan for public health

Possible impact		Activity/Mitigation Measure
NNT NBCA		
None		
Nakai Plateau		
PH1	Malaria control.	Malaria control measures that are already being implemented locally as a result of an EU supported malaria control initiative need to be additionally implemented through three groups of people: 1. People being re-settled by NTPC; 2. Itinerant settlers; and 3. Construction workers & eventual operators. Augment current Ministry of Health capabilities through creation of a clinic staffed as appropriate to cope with a population increased by around 20,000 people. The main preventative measure against the vector mosquito, *Anopheles dirus* and *A. maximimus*, insecticide treated bed nets, should be supplied in all NTPC sleeping accommodation, & issued through workers to all family members. Only may be treated with synthetic pyrethroids, permethrin or deltamethrin, as advised by MOH. Re-treatment needed at regular annual intervals, with deltamethrin.
PH2	Dengue Control.	Dengue control measures that are currently being implemented through District clinics etc., which need to be additionally implemented through three new cohorts of people. 1. People being re-settled by NT2; 2. Itinerant settlers; and 3. Construction workers and eventually operators. Education campaign will be required to advise on need to minimise mosquito vector, *Aedes aegyptii*, breeding sites – still clear water.
PH3	Opisthorchiasis control.	Educate the three groups of people not to eat raw fish.
Xe Bang Fai		
	Malaria control	Included in PH1
	Dengue control	Included in PH2
PH4	Japanese encephalitis is endemic in the plain. Any increases in dry season irrigation will provide additional breeding sites for the vector mosquito.	Monitoring for the occurrence of *Culex tritaeniorhynchus*.
	Opisthorchiasis control	Included in PH3
Construction Lands		
PH5	Workforce unprotected against malaria vectors, *Anopheles dirus* & *A. maximumus*.	The workforce must be advised of the normal protection measures applied in the district. Insecticide treated bed nets should be supplied in all NTPC sleeping accommodation, & issued through workers to all family members. Treatment should only be with synthetic pyrethroids, permethrin or deltamethrin, as advised by MOH. Re-treatment is needed at regular intervals.
PH6	Dengue may spread	Education campaign will be required to advise on need to minimize mosquito vector, *Aedes aegyptii*, breeding sites – still clear water.
	Opisthorchiasis control	Included in PH3

	Reason for Mitigation	Benefit	Implementing Agency	Budget Responsibility
NNT NBCA				
None				
Nakai Plateau				
PH1	Avoid the occurrence of malaria & dengue through preventative measures.	Health of the local population & the Project work force.	MOH	Included in Resettlers health program. Included in regional health program. Included in HCC Project staff health program.
PH2	Avoid the occurrence of dengue through preventative measures.	Health of the local population and the project work force.	MOH	Included in Resettlers health program. Included in regional health program. Included in HCC Project staff health program.
PH3	Avoid contracting Opisthorchiasis.	Health of the local population and workforce.	MOH	Included in Resettlers health program. Included in regional health program. Included in HCC Project staff health program.
Xe Bang Fai				
	Included in PH1	Included in PH1	Included in PH1	
	Included in PH2	Included in PH2	Included in PH2	
PH4	Forewarning of possible disease in order to ensure awareness of symptoms & enable supportive care.	Avoid disease in population.	MOH	Included in regional health program.
	Included in PH3	Included in PH3	Included in PH3	
Construction Lands				
PH5	To avoid the workforce contracting malaria.	A healthy workforce.	HC – with advice from MOH, to supply insecticide treated bed nets, facilities to re-treat, & the insecticide.	Included in HCC Project staff health program.
PH6	To avoid the workforce contracting dengue fever.	A healthy workforce.	HC – with MOH advice, for leaflets, etc.	Included in HCC Project staff health program.
	Included in PH3	Included in PH3	Included in PH3	Included in HCC Project staff health program.

Table L.9: Pest management plan for vegetation clearance and control

	Possible impact	Activity/Mitigation Measure
NNT NBCA		
None		
Nakai Plateau		
VC1	Use of herbicides for initial clearance of the resettlement area & construction lands on the Plateau could contaminate soils & result in a hazard for wildlife & humans.	Herbicide use in the watershed is forbidden in the Concession Agreement & no need is envisaged in the re-settlement area nor the construction lands. Monitoring procedures via NTPC's PMS need implementing & authorizing in case there is an unexpected need. Herbicide selection criteria in Sections 5.2 & 5.3. Use of herbicide only if authorized by the PMS, & logged in the Logbook.
VC2	Use of herbicides for initial clearance of undergrowth on shallow soil in areas where cultivation may be practiced. Not believed to be necessary at this point.	
Xe Bang Fai		
None		
Construction Lands		
VC3	Herbicide use for initial clearance for construction of the Transmission Line towers, then routine clearance during Operating Phase.	Herbicide use will be controlled under the PMP & no need is envisaged in the construction lands. Monitoring & authorization procedures need implementing in case there is an unexpected need.
VC4	Control of woody plants on the Downstream Channel banks.	The use of manual labour is planned for the area under power lines. Shrub controlling herbicides may be necessary for preventing the growth of noxious shrubs along the Downstream Channel. Monitoring & authorization procedures need implementing.

	Reason for Mitigation	Benefit	Implementing Agency	Budget Responsibility
NNT NBCA				
None				
Nakai Plateau				
VC1	Prevent contamination of resettlement farm soils & reservoir. To ensure only appropriate herbicide is used.	Optimize the performance of the poor soils of the re-settlement farms.	PMS	Include in PMS scope.
VC2	To prevent the unwanted disturbance of shallow soils on sites for re-settlement farms. To ensure only appropriate herbicide is used.			Include in PMS scope.
Xe Bang Fai				
None				
Construction Lands				
VC3	Allow access for power line maintenance.	Allow routine maintenance of power lines & create safe clearance from the surrounding vegetation.	HC for clearance in Construction Phase. NTPC for monitoring in Construction Phase. NTPC for clearing & monitoring during Operating Phase. PMS for authorization.	Included in the HCC. Included in EMO scope. Included in NTPC operating costs. Included in PMS scope.
VC4	Prevent colonization by woody shrubs along Downstream Channel - outer banks & spoil banks. Allows access for maintenance & movement by local people.	Efficient, locally sensitive & responsible management of impact of peripheral structures.	HC for clearance in Construction Phase. NTPC for monitoring in Construction Phase. NTPC for clearing & monitoring during Operating Phase. PMS for authorization.	Included in the HCC. Included in EMO scope. Included in NTPC operating costs. Included in PMS scope.

Table L.10: Monitoring activities associated with the Pest Management Plan

Monitoring Activity	Why Needed	Benefits/Performance Indicators	Management Responsibility
NNT NBCA			
Ensure no use of pesticides or inorganic fertilizers in the NNT NBCA. Farm visits & checks on retail stores.	Improved access & increasing population pressure may lead to usage of pesticides & inorganic fertilizers in spite of WMPA/NBCA regulations.	Prevent population becoming used to using inappropriate agricultural chemicals. Maintain natural biodiversity & water quality.	WMPA – part of role of "rangers".
Nakai Plateau			
PMS employed by NTPC will advise re-settled villagers in pest control issues, & monitor & authorize use of synthetic pesticides if necessary. A pesticide use log must be maintained.	Regulatory control of chemical use to prevent water contamination & maintain biodiversity. The usage log ensures traceability & provides an administrative tool.	Prevent injudicious use of pesticides. A single point of contact, the PMS, to avoid pesticide residues in vegetables.	NTPC – part of role of PMS.
Monitor use of inorganic fertilizers. The procedure should follow that noted directly above for pesticides.	Some use will be necessary but minimization is important.	Ensure low cost sustainable agricultural production & avoidance of reservoir contamination.	NTPC – part of role of Agronomist.
Monitor *Mimosa pigra* occurrence.	A noxious weed if it becomes established in the drawn down zone of the reservoir.	Keep land free of this noxious weed.	NTPC – monitoring by the PMS & Agronomist.
Monitoring of human disease vector control.		Keep prevalence of diseases low in the population.	MOH
Xe Bang Fai			
Monitor performance of NAFES in conducting FFSs for IPM training. Examination of curriculum. Visit to villages to ascertain impact. In each year five villages after one year & five after two years – ten per year.	Need to ensure that farmers possibly affected by the Project receive good IPM training. It is proposed to support the existing IPM & FFS program of NAFES.	That the NAFES program is properly planned & executed, & farmers effectively trained.	NTPC – PMS & Agronomist. Coordination with NAFES.
Monitor for new pests or any other unexpected agricultural effects of increased water flows from the Project. This should include monitoring in the lower Xe Bang Fai where the GOL is introducing off-season cropping. Monitoring should be a specific activity & recorded as such in separate log books at monthly intervals at least, but not involving biological surveys unless there is a strong indication of some Project prompted change after the Downstream Channel starts to flow. As noted later, monitoring should take place during the FFS assessments.	Be aware of unexpected effects as they occur to enable prompt response & amelioration. To be able to separate any effects of the Project from those independently caused by the introduction of off-season cropping.	Ensures the Project remains a benign & beneficial influence on Xe Bang Fai agriculture. Ensures NTPC can clearly identify its own impact. Monitoring will begin when the Project construction is given the go-ahead, as noted later, & this will provide a base line of about five or six years before water flows in the Downstream Channel.	NTPC – PMS & Agronomist. Coordination with NAFES & other MAF Departments.
Monitor fertilization practice & effectiveness of NAFES extension & FFSs.	Ensure inorganic fertilizers are only used supplementary to basic use of organic fertilizers.	That NAFES program is properly planned & executed, & farmers effectively trained.	NTPC – Agronomist. Liaison with NAFES.
Monitor for increased risk of Japanese encephalitis in upper Xe Bang Fai; monitor for infected *Culex tritaeniorhynchus*. Sponsor three studies – a base line study the year before expected water flows from the Project, a second two years after & a third five years after.	Be forewarned about risk of disease increase.	Population can be educated & treated as appropriate.	NTPC – financial support to MOH.
Construction Lands			
Monitor vegetable supply to the work force & followers. Monitor for adherence to GAP & pest management guidelines. Monitor suppliers for best practice in operator training, pesticide selection, storage & waste disposal. Monitor vegetable produce for pesticide residues. Liaise with Thai consultants as necessary to achieve this.	Maintain focus of vegetable producers on safety of spray operator, consumer & environment. To ensure that vegetable producers are abiding by best practice with regard to IPM & fertilizer use. See Appendix III for details.	Ensures that the sudden demand for fresh produce placed on the locality by the Project is managed with proper regard for the environment, operator safety & workforce consumers. Fosters the introduction of GAP & IPM to commercial vegetable production in Lao PDR.	NTPC – HC PMS & Agronomist.
Vector control monitoring concerning malaria & dengue. Monitor treatment of bed nets. PMS should monitor & be a party to the collaboration between HC & MOH.	To ensure constant implementation of MOH recommended practice.	Ensure MOH has resources & implements training measures. Ensure NTPC controls pesticide for bed net treatment.	NTPC – HC in collaboration with MOH. PMS to be a party to collaboration & monitor activities.
Monitoring & formally controlling herbicide use on construction lands. All use must be logged & approved by the PMS.	Avoid unnecessary pesticide use. Ensure awareness among the fragmented management at all the different sites, as need may be sporadic & varied.	Ensures traceability & a cohesive approach to herbicide use on the sites that managers can easily understand.	NTPC – HC PMS.
Monitoring of possible herbicide use alongside Downstream Channel.	The Downstream Channel is away from the constant preview of company staff, but needs to appear cared for & be well managed with regard to the local community. Avoid unnecessary pesticide use.	Creates a "good neighbor" impression over a significant area, & maintains pride of local community.	NTPC – HC, with logging of actions & approval of PMS.

Table L.11: Pests of vegetables and fruit

Crop	Insects		Diseases	
	Common Name	Scientific Name	Common Name	Scientific Name
Vegetables				
Cruciferae: cabbage, chinese kale, lettuce, etc.				
	Diamond back moth	*Plutella xylostella*	Damping off	*Pythium, Phytophthora*
	Cutworm	*Agrotis ypsilon*	Bacterial soft rot	*Erwinia carotovora*
	Webworm	*Hellula undalis*	Downy mildew	*Peronospora parasitica*
	Armyworm	*Spodoptera exigua, S litura*	Alternaria leaf spot	*Alternasia* sp.
	Flea beetle	*Phyllotrata* sp.	Black rot	*Xanthomonas campestris*
	Cabbage aphid	*Brevicorynae brassicae*	Club root	*Plasmodiophora brassicae*
	Cabbage maggots	*Phyllocnistis* sp.	Powdery mildew	*Erysiphe cichoracearum*
	Looper	*Chrysodeixis chalcites, Plusia signata*		
	Imported cabbage worm	*Pieris rapae*		
	Cabbage shield bug	*Eurydema rugosum*		
	Cluster caterpillar	*Crocidolomia binotalis*		
Solanacae: tomato, potato, tobacco, aubergine, chillies				
Tomato	Serpentine leaf miner	*Liriomyza huidobrensis*	Bacterial wilt	*Ralstonia solanacearum*
Tomato	Nematodes		Alternaria leaf spot	*Alternaria* sp.
Tomato	Fruit worm	*Helicoverpa armigera*		
General	Thrips	*Thrips palmi*	Cercospoa leaf spot	*Cercospora* sp.
General	Leaf folder	*Lamprosema indicata*	Leaf curl virus	
General	Leaf-eating ladybird beetle	*Epilachna vigintioctopunctata*		
Chillies			Tobacco mosaic virus	
Aubergine	Fruit & shoot borer	*Leucinodes orbonalis*		
Potato	Potato tuber moth	*Phthorimaea operculella*	Late blight	*Phytophthora infestans*
			Early blight	*Alternaria solani*
Tobacco	Green tobacco capsid	*Nesidiocoris tenuis*	Tobacco mosaic virus	
Aliacae: onions/garlic				
	Thrips	*Thrips tabaci*	Downy mildew	*Peronospora parasitica*
	Cutworm	*Agrotis ypsilon*	Purple blotch	*Alternaria porri*
Cucurbitacae				
	Cucumber beetle	*Diabrotica speciosa*	Downy mildew	*Peronospora parasitica*
	Red pumpkin beetle	*Aulocophora foviecollis*	Powdery mildew	*Erysiphe cichoracearum*
	Leaf-eating ladybird beetle	*Epilachna vigintioctopunctata*	Cercospora leaf spot	*Cercospora* sp.
	Leaf miner	*Liriomyza* sp.	Alternaria leaf spot	*Alternaria* sp.
	Cotton aphid	*Aphis gossypii*	Mosaic virus	
	Cucumber fruit fly	*Bactrocera cucumis*	Anthracnose	*Colletotrichum orbiculare*
Leguminosae				
Yard long bean	Bean leaf miner	*Japanagromyza inaequalis**	Red rust	*Uromyces* sp.
	Legume pod borer	*Maruca vitrata*	Anthracnose	*Colleotrichum* sp.
	Aphids	*Aphis craccivora, A. fabae*	Cercospora leaf spot	*Cercospora* sp.
Peanuts	Nematodes			
Maize				
	Corn earworm	*Helicoverpa armigera*	Downy mildew	
	Corn borer	*Ostrinia* sp.		
Fruit				
Citrus				
	"Bark boring beetle"			
Pummelo	Leaf miner	*Phyllocnistis citrella?*	Bacterial canker	
Pummelo	"Bark boring beetle"			
Lychee				
	"Eater of young leaves"			
	Aphids			
Mango				
	Oriental fruit fly	*Bactrocera dorsalis*	Anthracnose	*Colletotrichum gloeosporiodes*
	Aphids			
	Mango leaf cutting weevil	*Deporaus marginatus*		
	"Bark boring beetle"			
Avocado				
	Fruit fly			
	"Bark boring beetle"			

Notes:

Nomenclature is indicative only. Species underlined are most important.
"*" = Mentioned in Kumar (2000), however *J. inaequalis* is not otherwise recorded in the nortern hemisphere. Specimen possibly *J. yanoi* or *Ophiomyia* sp.