Department of
Livestock and Fisheries
Fisheries Division

# Provincial Aquaculture Development Project

# LAO/97/007

## Government Fish Fry Production Facilities in Lao P.D.R.
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**by**

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## *Overview*

The demand for fish fry in Lao P.D. R. is estimated at 60 million pieces annually. Actual production is unknown, but probably does not exceed 10 million pieces per year. Expansion of the aquaculture sector in Lao P.D.R. can only be achieved if this fry shortage can be resolved.

Fish fry are currently supplied by both government and private sector hatcheries. The production from the government own ed hatcheries is generally low and could be improved. The cost of the fish fry produced by the hatcheries is high, which limits the availability of the fry to low income farmers. The high price of the fry reflects the low efficiency of production from the hatcheries. Transportation of fry between hatcheries and farmers is also a constraint to aquaculture. An unknown quantity of fry is imported from China, Vietnam and Thailand into provinces that share borders with these countries.

Production efficiency is related to a range of factors at the hatcheries that can broadly be divided into:

- Unsuitable location/environmental conditions
- Hatchery design
- Inadequate supply of broodstock
- Management constraints
- Marketing

The first four problems are technical in natur e and can be resolved to some extent by modification/redesign of the hatcheries and training assistance during production (it is proposed that the UNV's and the ADA perform this role together with assistance from the more successful hatchery operations).

The proposed hatchery site improvements are intended to be relatively low cost but should result in increased fry production. It must be emphasised that the goal is to improve production from existing facilities by modifying water flow, water quality and management techniques. In some cases (Sayaboury, Khammouan) the maximum production level will be constrained by site location/water supply and therefore significant alteration/expansion of the facilities is not advised. If future increases in production ar e required in these areas alternative hatchery locations are recommended.
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The mass production design that is used in all hatcheries in Lao P.D.R. is not intended for a 1 - 2 tank system. the mass culture system relies on large numbers of tanks that have r elatively low survival, but production is sustained due to continuous throughput. In Lao P.D.R. the adoption of this system is flawed since it relies on placing all the fish eggs in one tank for hatching and then all the fry that are produced in one tank f or ongrowing. The result is that any problem at any stage of the operation results in the complete mortality of the whole stock.

The technical constraints to adequate fry production are as follows:

- Poor broodstock quality - inadequate nutrition , stress and poor rearing environment give low egg production/fertilization success

- Poor fertilization conditions - overstocking of spawning tanks, incorrect hormone dosages and poor water flow/water quality - limit the success of egg fertilization and release
- Wet fertilization method - may have limited spawning/fertilization success (as above) but also physical damage to eggs and poor water quality causing egg mortality
- Egg collection by drainage method causes physical damage and includes wastes from the spawning tanks (faeces, unfertilized eggs, mucus, silt etc.)
- Mass hatching tanks of Vietnamese design have inadequate water flow and poor water quality (suspended solids, low oxygen concentration, high nutrients). Eggs are not suspended properly and may be dama ged. Large size of hatching tanks requires mass spawnings and these are wasteful of broodstock.
- Newly hatched fry are transferred to nursery ponds too quickly. Inadequate food in the ponds results in high mortality. In some cases nursery ponds contain predators. Low flow rates in the ponds may also result in stressful oxygen conditions and this will also affect the small fish fry.

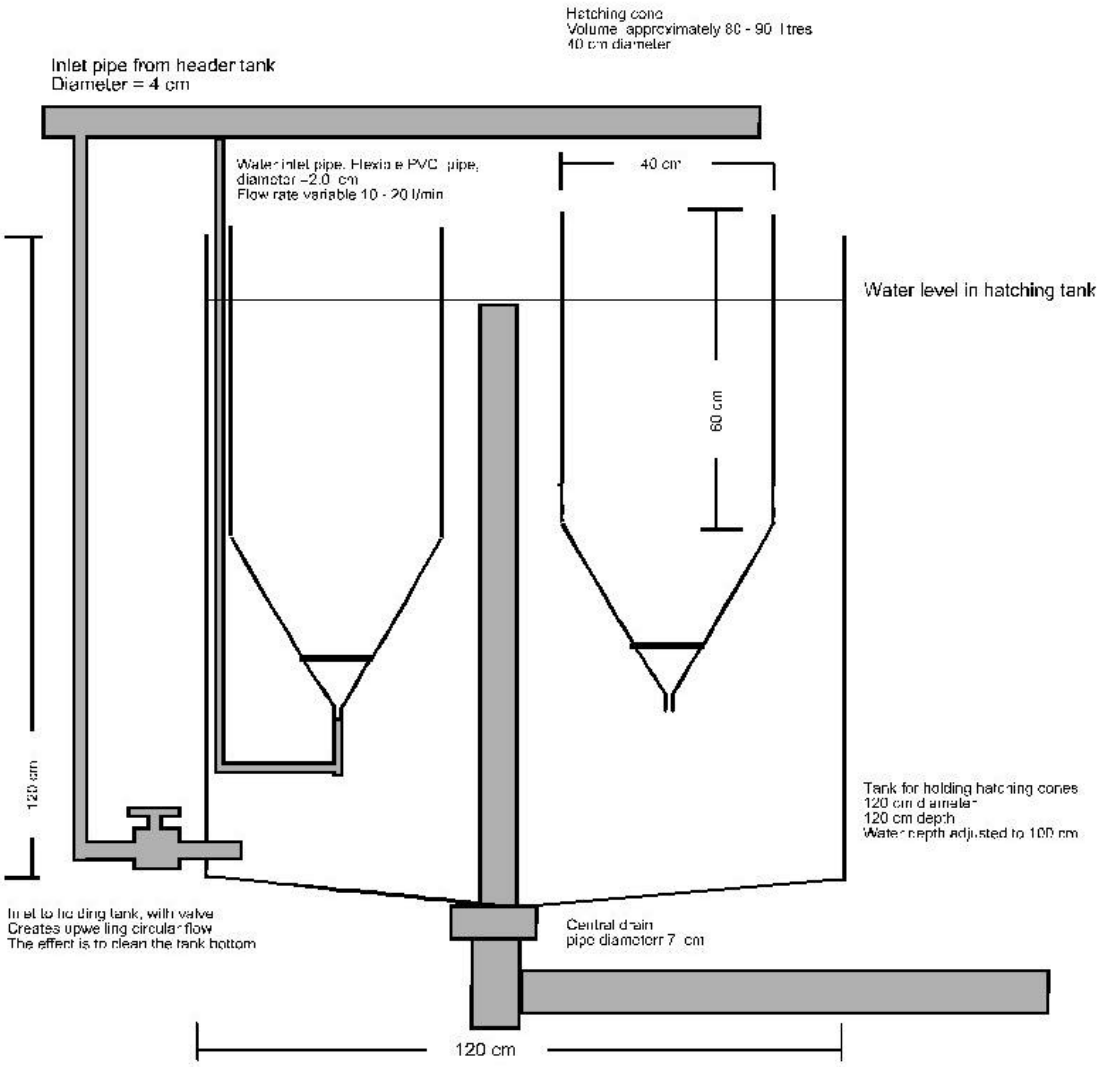
***Recommended improvements include:***

Specific design problems are considered on an individual basis. General management and technical improvements that should be applied to all hatcheries if possible are as follows

***Use of upwelling hatching cones (Diagram 1)***

- For small scale production, smaller subdivided tanks are required and the use of the hatching cone system is recommended.
- The hatching cones have a small volume (< 100 l ) and several cones are required for the eggs from one fish.
- The advantage is that eggs from different fish can be separated and therefore spawning of broodstock fish can be performed over consecutive day s.
- This improves fertilization efficiency, removes the requirement for mass spawning, allows better control of hatching conditions and enables the use of the dry fertilization method.

Diagram 1 : tank design for upwelling egg hatching cones



***Broodstock species rationalized***

- Most hatcheries are attempting to hold too many species. The result is inadequate numbers of broodstock of the same species for spawning operations
- Different species can be used to take advantage of seasonal spawning times, but the numbers of species should be reduced until a successful hatchery operation is established.
- In most of the hatcheries the recommended species for production should include common carp and/or *Puntius spp* due to their high fecundity and ease of spawning (single injection hypophysation). The market acceptability of these two species is also high making them easier to market to farmers.

***Hormone supplies for hypophysation***

- The project should intervene in the purchase and storage of hormones for broodstock hypophysation.
- In many cases the dosages used appear to be inadequate due to hatchery operators attempting to save money. In some cases this will result in poor spawning success rates.
- The hatcheries should estimate their hormone requirements prior to the start of the hatchery cycle and request supply from the project.
- The Outreach project in Savannakhet is using the livestock department vaccine distribution cold chain to distribute pre-mixed hormone doses for fish hypophysation. This concept should be extended to other provinces to supply small hatchery entrepreneurs when they become established.

***Use of dry fertilization method***

- Dry fertilization is the injection of hormones to the broodstock fish followed by the stripping of the eggs and milt into a bowl to ensure good fertilization.
- This method does not leave fertilization to the random behaviour of the broodstock fish and ensures that the eggs collected are clean and free of fouling that often accompanies eggs produced in spawning tanks.
- The eggs are also not physically damaged by the poor environmental conditions in the spawning tanks.

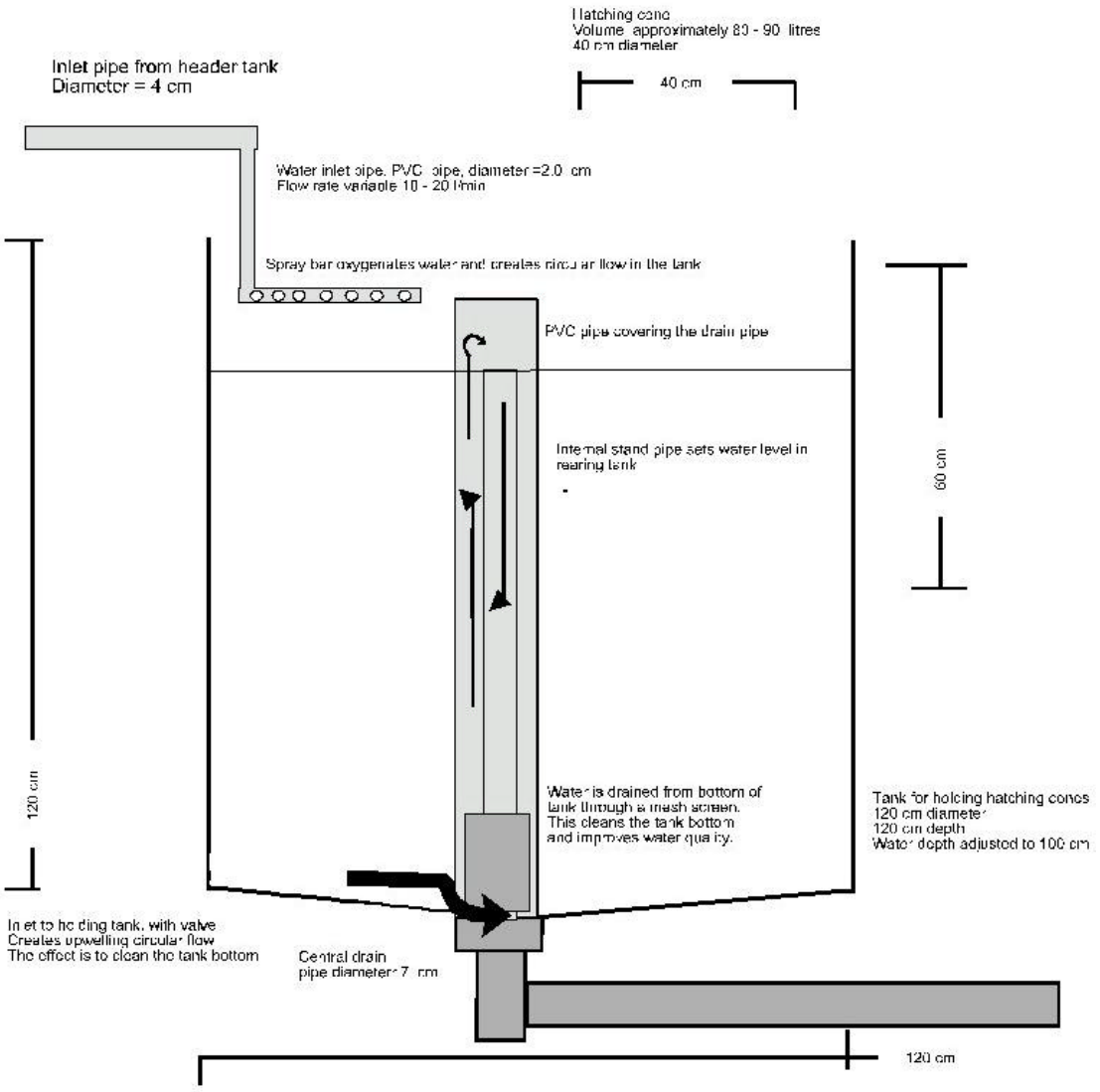
This method is labour intensive and not suitable for very large hatcheries - it is extremely suitable for small hatcheries such as those in Lao P.D.R.

- The dry method is not widely practiced in the Lao P.D.R. hatcheries principally due to labour requirements and the need for large scale spawnings to fill the large Vietnamese design spawning tanks.

***Use of improved nurseries***

- The nursing of fry in earthen ponds is a low cost method that can be successful. However, if ponds are poorly managed then survivals form the system can be extremely low.
- Improved methods for fry nursing include the holding of fry within net cages (happas) so that water quality and feeding can be better controlled. The net cage system also allows the exclusion of predators.
- Rearing fry in circular fibreglass tanks can also improve survival in the initial stages by ensuring good water quality (high oxygen concentration and high rate of water exchange). ***(Diagram 2)***

Diagram 2 : holding tank design for upwelling egg hatching cones



- The tank system is relatively inexpensiv e but does required a pressurized water supply system to operate effectively. This is usually achieved by supplying water to the tank via pipework (not open channels) from a header tank or elevated reservoir.
- Supply of young fry to secondary nurseries away from the hatchery site should be encouraged following the model of the Outreach project 'nursing network'. This reduces the holding time of fry within the hatchery and enables more intensive fry production to be performed.

***Problems with markets***

The iss ue of marketing causes management difficulties at the hatcheries due to the requirement to hold fish fry for longer than necessary. If fry are not sold soon after production, they must be held at the hatchery site. This leads to increasing mortalities and price increase. The increased price makes these larger fry less desirable to farmers and therefore less likely to be purchased.

The goal of the hatcheries should be to mass produce fry that can be moved to nursery sites as soon as possible. This should broadly follow the model established by the Outreach project in Savannakhet. This reduces pressure on water resources at the hatchery sites, reduces mortality in the nursery ponds and allows the hatchery staff to concentrate on the spawning and production of more fry.

The economics of a fry nursing operation must be attractive to ensure take -up by private sector operators; this requires several factors to be resolved:

- The supply of fry must be adequate and coincide with seasonal demands so that the nursing operation is guaranteed a good market
- The price of the fry supplied must be low to ensure profitability to the nursing operation (allowing for relatively high mortality in their operation)
- Appropriate conditions must be available at the nursery site (i. e. adequate water supply/water quality, and pond/happa construction).
- Appropriate training and on-going support must be provided initially
- Nursery operators may require assistance in obtaining credit for their activities

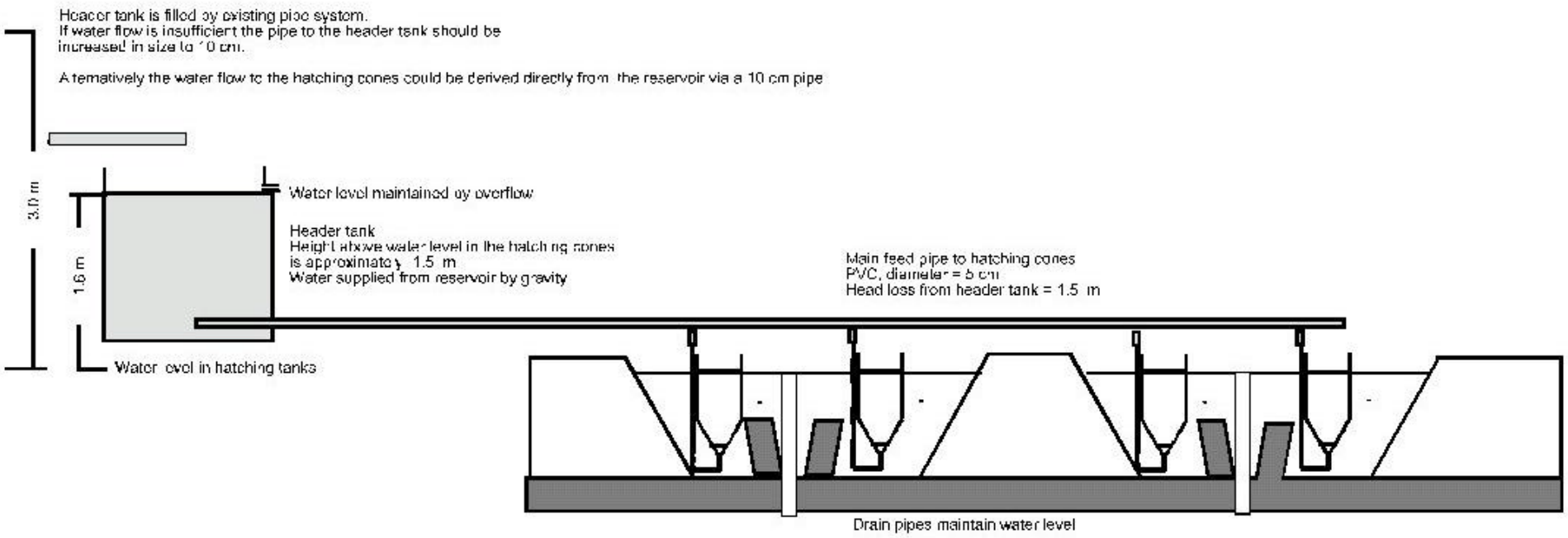
## *Xiang Khouang Province (Diagram 3)*

The Xiang Khouang hatchery is producing Chinese carp (Grass carp, 800,000 during 1997) for sale to farmers. The low level of production is principally due to the hatchery design and insufficient water/poor water quality. Management techniques to increas e the efficiency of fertilization and egg survival could also be improved.

It is recommended that the following changes are made at the hatchery at Xiang Khouang:

- The reservoir needs to be restructured - deepened and the overall area increased
- A concrete sluice should be constructed to divert water from the supply stream to the reservoir. This is also to prevent the erosion of the reservoir walls by high water flow in the rainy season
- The hatchery building should be improved to exclude dust and insects fr om the egg hatching tanks
- The hatching tanks are too large for individual fish spawnings and an upwelling hatching cone (jooay) method is recommended
- The use of individual hatching cones will allow fish to be spawned over successive days and improve the ef ficiency of the spawning and hatching operation
- Fish that are to be spawned should be stripped for dry fertilization. the method currently used is inefficient and results in high levels of egg wastage (due to non - fertilization and physical damage).
- The dos age rate for broodstock fish and injection methods should be adjusted.
- There are currently no fry nursing tanks at the site. Fibreglass tanks (500 - 1000 l) could be installed to hold newly hatched fry until first feeding.
- If nursing tanks are not feasible then newly hatched fry should be maintained in nursery ponds in net cages (happas) and fed appropriately.
- After the fry commence feeding it is recommended that they are transported for nursing outside of the hatchery unit (within 5 days). This will allow the facilities at the hatchery to produced continuously without overloading the pond holding capacity for fry.
- Suitable fry nursing sites (an operators) should be identified and appropriate training given.
- The species produced should be common carp ( *Cyprinus carpio*), and Chinese carp. The local cyprinid 'Pa Fek' may be an alternative.

# Diagram 3: Side view of the proposed hatchery at Xiang Khouang




Existing concrete mass production hatching tanks

## *Oudomxay Province (Diagram 4 & 5)*

This site has recently been constructed and has not yet commenced production. The style of the hatchery is based on the Vietnamese mas s production system and is similar to the hatchery at Xiang Khouang.

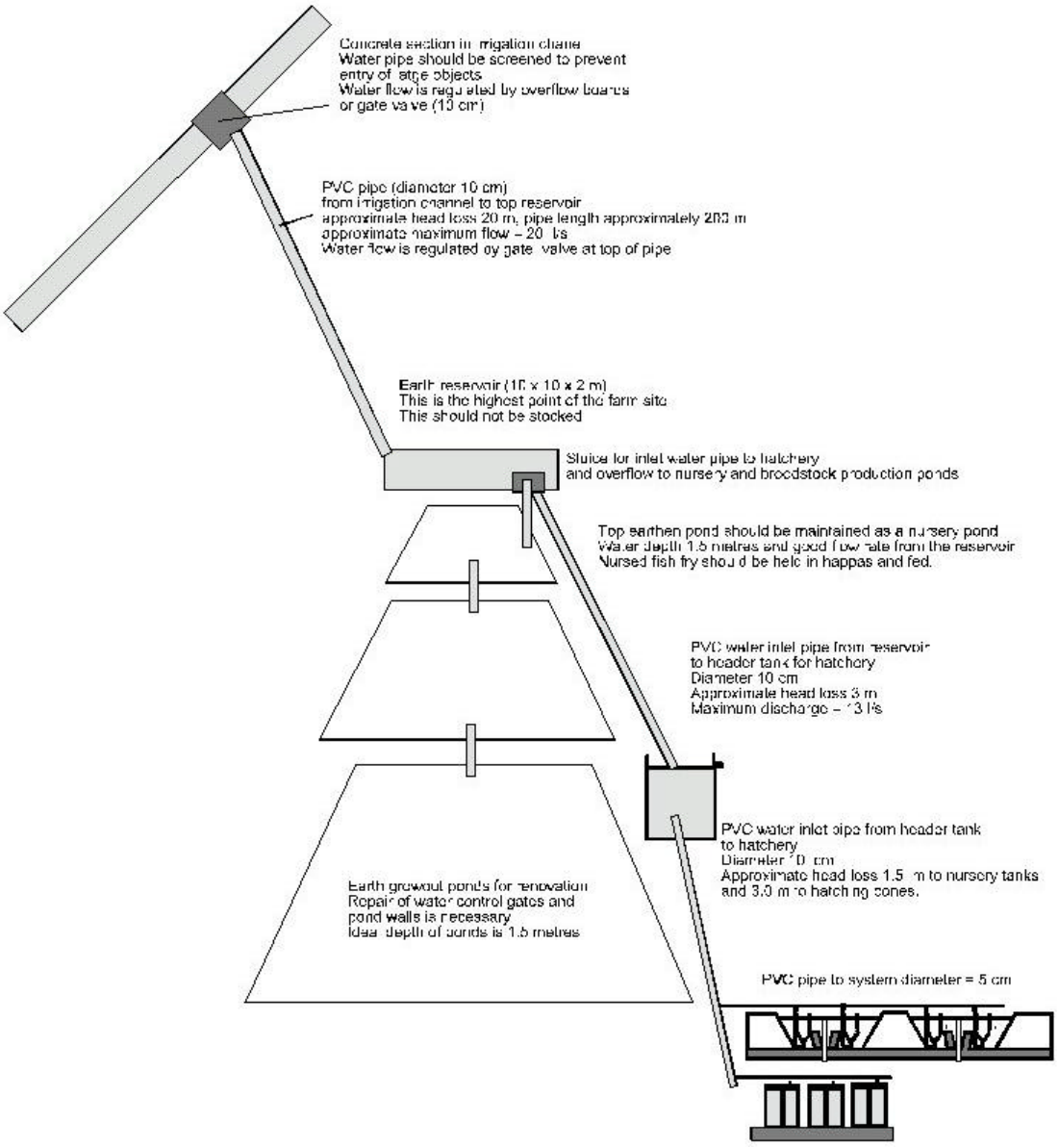
The hatchery is supplied water via a small earth channel which is fed from an irrigation canal (about 200 metres distant). The size of the channel is inadequate to supply sufficient wat er to the hatchery. The earth channel could also be easily blocked/damaged resulting in water shortages at the hatchery.

The hatchery site also has several large earthen ponds. These ponds are in poor condition and need to be renovated.

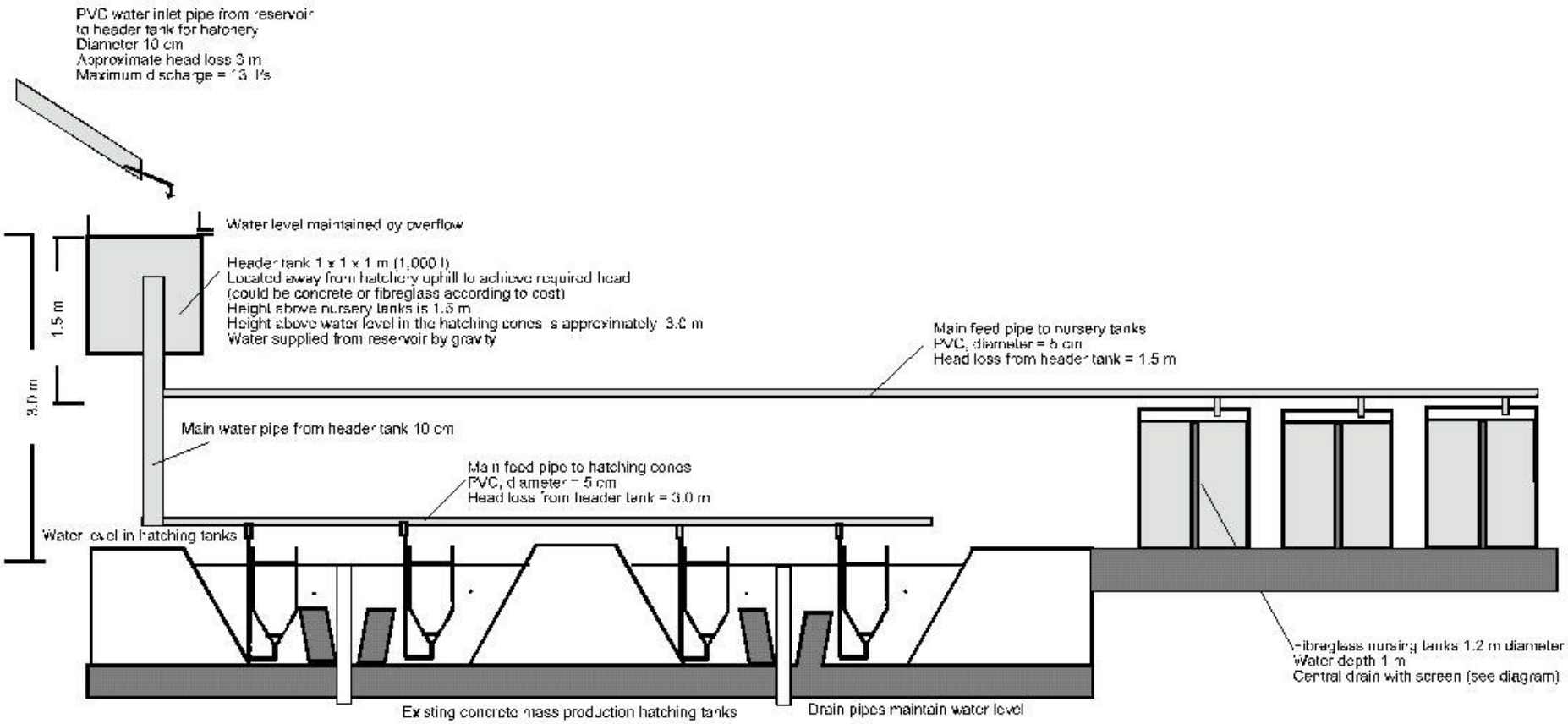
It is recommended that the following changes are made at the hatchery at Oudomxay:

- The water supply to the hatchery should be improved by the use of a PVC pipe (10 cm) connected to the irrigation canal.
- The water supply pipe should discharge into a small reservoir at the top of the site (approximately 3 - 4 metres above the height of the hatchery).
- From the reservoir a concrete sluice will supply another PVC (10 cm) pipe to the hatchery header tank.
- The concrete sluice will also overflow to supply water to the earthen pond s on the site.
- The header tank at the hatchery will supply water to the hatching tanks which should employ the hatching cone method for hatching eggs.
- It is recommended that dry fertilization method is used.
- There are no fry nursing tanks at the site, the refore fibreglass tanks could be employed.
- If fry nursing tanks are not used, then the top earthen pond should be used as a fry nursery. Fry should be held in net cages (happas) until 5 -7 days post first feeding.
- Fry should be removed from the site within 5 -7 days for nursing.
- Suitable nursery ponds and operators should be identified.
- The species produced should be common carp ( *Cyprinus carpio*), and barbs (*Puntius spp.*)

Diagram 4: Side view of the proposed hatchery at Oudomxay (NOT TO SCALE)



# Diagram 5: Side view of the proposed hatchery at Oudomxay



## *Sayaboury Province (Diagram 6)*

The fry production station in Sayaboury province is located within the Nam Tan irrigation project. Water for the hatchery is supplied via a secondary irrigation canal. Water is not supplied continuously through this canal and the quantity supplied is uncertain. Water is not supplied during the periods Ap ril-May and September - October to allow the rice fields to dry off prior to harvest.

Production times of fish fry varies according to climate and species produced but the period April-May is likely to coincide with an optimal production time for fish fr y. The lack of water during this period is a major constraint to fry production.

Due to the shallow nature and shallow slope of the secondary irrigation canal water flow is expected to be inadequate for effective fry production.

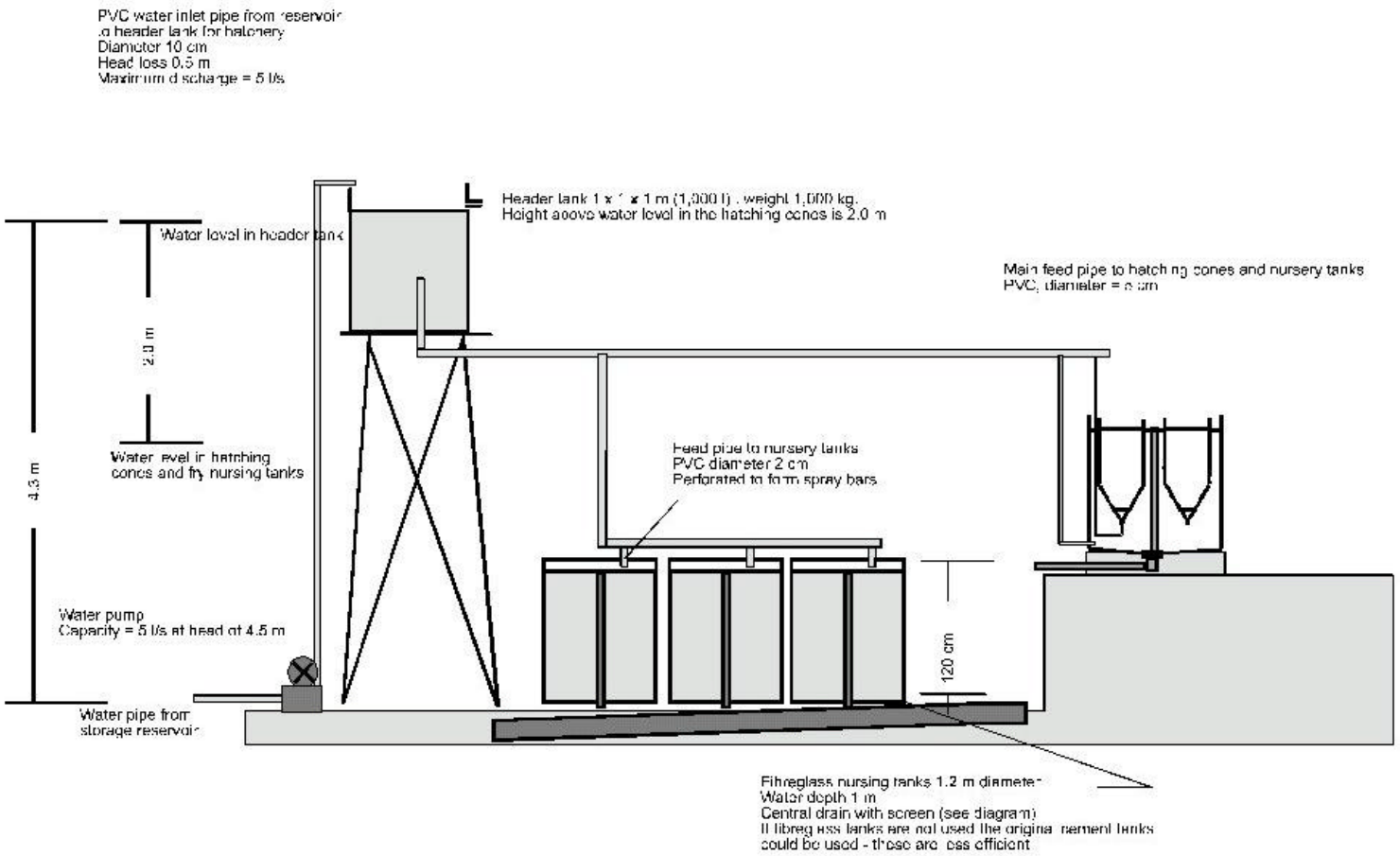
The hatchery design uti lizes an open channel system to supply water to the production tanks. the lack of pressure in the system almost certainly results in inadequate water flow to both hatching and rearing tanks.

It is recommended that the following changes are made at the hat chery at Sayaboury:

- A large water storage reservoir is constructed at the site (50 x 50 x 2 m deep). the top of the reservoir must be at the same level as the water level in the irrigation canal. this will require that the pond is excavated to the depth r equired.
- The water reservoir would ensure water supply during the months when the canal supply ceases. water quality (temperature, suspended solids, nutrients) would be stabilized by storage in the reservoir.
- Floating aquatic plants could be placed in the reservoir to shade the water and control water colouration.
- Fish should not be stocked into the reservoir and the water intake to the pump should be screened to 500 microns if possible . This could be achieved by the use of a sand/gravel box filter.
- A pump and header tank system should be installed to supply pressurized water to the hatchery. The header tank should be 2.0 m above the water level in the hatching tank (see diagram).
- The maximum flow rate and head required for the pump is: 5 l/s at 4.5 m hea d.
- The dry fertilization method should be employed
- Broodstock should be held in the nursery ponds next to the hatchery during hypophysation and stripping. these nursery ponds are too shallow and should be deepened. the broodstock should be held in coarse n et happas and aerated water should be supplied whilst the fish are being held.
- The spawning tank should be used for hatching of eggs in hatching cones.
- The fry holding tanks could be used if pressurized water is supplied to the tanks to increase water flow and aeration.
- An alternative to using the concrete fry tanks (which are difficult to clean ) is the use of circular fibreglass tanks. These could be placed on top of the existing concrete tanks.
- Fry should be removed from the site within 5 -7 days for nursing.
- Suitable nursery ponds and operators should be identified.

- The species produced should be common carp ( *Cyprinus carpio*), and barbs (*Puntius spp.*

# Diagram 6: Side view of the proposed hatchery at Sayaboury



## *Khammouan Province*

The hatchery at Khammouan is similar in design to the Sayaboury site. There is n o water supply to the hatchery site which is a major constraint. There are two large rain fed ponds at the farm site which are used to supply water to the hatchery. These reservoir ponds are also stocked with fish and possibly fed/fertilized. The water t hat is supplied to the hatchery from these ponds can be expected to be poor quality and result in poor egg/fry production.

The broodstock species held at the site are claimed to be: Barbs (Pa Pak, Pa Pak Tong Leuang), Common carp, tilapia, Indian carp (M rigal) and Chinese carp (bighead). Local species include (*Puntius* - Pa Pak Tong Leuang, *Osphoronemus* gouramy - Pa men and Pa Pia).

The wide range of species held is not reflected in the fry production from the site. The estimated production from the site was 190,000 in 1997. It is recommended that a maximum of 3 species are held at the farm and these broodstock are then held in sufficient numbers to ensure increased egg production. If egg numbers can be increased, overall fry production should improve

The farm staff identify the nursery phase as the time of highest mortality. It is unclear whether the mortalities are due to poor feeding, poor water quality or predation - but it is likely that all of these factors have some influence. The lack of water sup ply to the site is a serious constraint to the operation of the nursery and therefore this time should be minimized at the farm site.

It is recommended that the following changes are made at the hatchery at Khammouan:

- All fish should be netted from the reservoirs and the reservoirs should not be fed/fertilized. these ponds must act as reservoirs not reservoir/production ponds.
- Water drawn from the reservoirs should be filtered/screened.
- A header tank should be constructed to pressurize water to the hatch ery.
- The circular spawning tank should be converted to the use of hatching cones.
- Spawning should utilize the dry fertilization method ***(Diagram 1)***
- Circular fibreglass tanks (500 - 1,000 l) could be used to hold fry until 3 days after first feeding (***Diagram 2)***
- Fry should be transferred to net happas in a nursery ponds.
- The nursery ponds do not have a flowing water supply, therefore ideally fry should be transferred to an alternative location as soon as possible.
- Suitable fry nursing sites and operators sho uld be identified.
- The production from this site cannot be expected to be high, due to the constraint of water supply. It is not recommended that the capacity of the site is increased since the demand for water would exceed the water storage capacity of th e reservoirs.

## *Savannakhet Province (Diagram 7)*

This is fed by water pumped from the Mekhong river. The quality of the river water is poor due to the very high suspended solids loading. Suspended solids affect the production of eggs and fry in two major ways:

- The suspended solids adhere to the surface of the eggs and the gills of the hatched fry. This limits the transfer of oxygen and results in egg/fry mortality through suffocation.
- Suspended solids often have high organic and bacterial loadings assoc iated and these conditions are stressful to fish fry and eggs. The result of high bacterial loadings can lead to infections and mortalities.

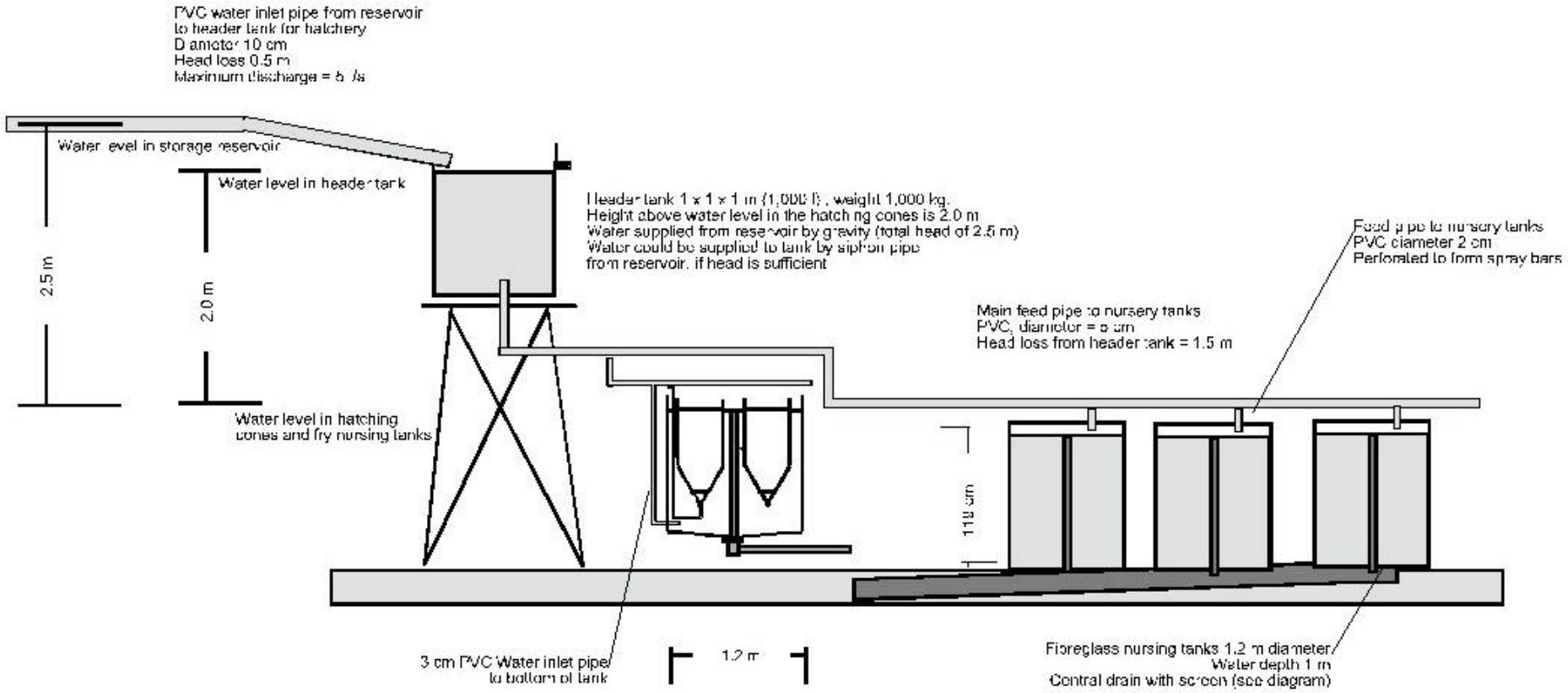
High suspended solids loadings also affect the hatching cone method of egg incubation - the hatching cones become fouled with sediment and water no longer flows through the cloth. This causes overflowing and the loss of eggs.

- The hatchery site does have a solids settlement reservoir (30 x 40 x 2 m) and the inlet and outlet have a gravel/sand screen to filter the wat er. It appears that these screens are not effective (or become rapidly blocked) resulting in high suspended solids loading in the reservoir.

- The solids loading in the reservoir might be improved by the use of large aquatic vegetation plants floating on th e water surface. The species chosen should also have a hanging root system to assist the trapping and/or sedimentation of the suspended solids. If such a system was implemented and proved to be successful the pond would require periodic drainage and cleaning to remove the sedimented solids.

- Filtration of the water is another option but the filter size and area is likely to be large and require very frequent cleaning - this is why an enhanced sedimentation approach is favoured.
- The water flow rate to the ha tchery is low and a larger pipe from the reservoir is required (see diagram 7)
- If the suspended solids loading can be reduced sufficiently the hatching cone method for egg incubation is recommended.
- Header tanks to supply pressurized water to the hatchery system are required. These tanks could be fed by gravity flow from the reservoir and water head should be approximately 2 m (see diagram 7)
- The nursery tanks have inadequate water flow and the shape of the tanks is inefficient for cleaning and feeding the fry. Circular fibreglass tanks (500 - 1,000 l) are preferred for the initial fry holding before introduction to the nursery ponds.
- Fry should be removed from the site within 5 -7 days for nursing.
- Suitable nursery ponds and operators should be identified.
- The species produced should be common carp (*Cyprinus carpio*), and barbs (*Puntius spp.*)

# Diagram 7: Side view of the proposed hatchery at Savannakhet



## *Luang Prabang Province*

- The hatchery at Luang Prabang province appears well maintained but would benefit from improved egg hatching tanks using upwelling pressurized water ***(Diagram 1).***
- Fry are stocked to earthen nursery ponds before sale and highest mortalities occur during this part of the production process. Mortalities are attributed to predation and leech infestation.
- Pre-nursing in fibreglass tanks (500 - 1,000 l) within the nursery building would improve early survival and prevent the losses of small larvae (such as *Puntius*) through the pond gates or to insect predators. The concrete nursery tanks in the hatchery are unsuitable due to their shape and size ***(Diagram 2)***
- Dry fertilization should be encouraged as a standard spawning procedure
- Broodstock of several species are maintained at the station. It is recommended that fewer species (maximum 3) are held and that larger numbers of broodstock are obtained
- Recommended species are common carp, *Puntius spp.* for mass culture.

## *Sekong Province (Diagrams 8 , 9 & 10 )*

This hatchery is under design by ADA/NPD (See plans attached).

There is a large area surrounding the nursery and broodstock ponds which could be used for livestock. The broodstock ponds could also be integrated with duck, chicken or pig pens over the ponds . This would act as a valuable demonstration of integrated fish -livestock culture and would contribute to the livelihood of the hatchery staff in a manner that was both positive and compatible with the hatchery production.

The hatchery design is flexible to allow expansion of the operation in the future if the demand for fish fry increases. Initially the production scale is relatively small to enable the hatchery operators to closely control the system and to learn how the hatchery functions.

There is area at the bottom of the site that could be used for the expansion of broodstock/nursery ponds.

The species to be cultured at the hatchery are intend ed to be local species indigenous to the Sekong river. Initial breeding work should focus on *Puntius spp.* due to their ease of spawning. Exotic species should not be introduced to the station

***Design criteria for the Sekong hatchery (Diagram 8)***

***Abstracted from irrigation canal***

- Delivery to storage reservoir via 10 cm PVC pipe (approximately 100 m with a head loss of 1.5 m).
- Maximum design flow is 8 l/s

***Storage reservoir (size 40 x 40 x 2 m deep).***

- This acts as a water store and also reduces pressure in pipelines form the irrigation canal
- Water storage will allow settlement of the water to improve water quality
- Water plants (aquatic macrophytes) could also be introduced to minimize water colouration and assist in the settlement of fine solids.
- A concrete sluice provides a constant head for the hatchery water supply pipe and the overflow is delivered into the water supply channel for the nursery and broodstock ponds.

***Hatchery (Diagram 9)***

- Supplied by PVC pipe from the sluice gate of the storage reservoir.
- Inlet pipe has a diameter of 10 cm and head loss of 1 m
- Length of pipe is between 70 -100 m, maximum design discharge is
- Inlet water is stored in a constant head tank (1.5 x 1.5 x 2.2 m high), water depth is maintained at 2 m by overflow
- Eggs and hatchli ngs are held in fine net hatching cones (see diagram) suspended in a circular fibreglass tank (diameter 1.2 m, height 1.2 metre). Maximum flow

rate is nominally estimated at 1.8 litres/second per tank (two tanks, total requirement = 3.2 l/s). ***(Diagrams 1 & 2).***

- 6 egg hatching cones with nominal volume 80 -90 litres. Stocking density of eggs = 3000/litre, 240,000 - 270,000 eggs per cone. Total eggs = 1.4 - 1.6 million
- 6 hatched fry upwelling cones. Stocking density of hatchlings = max 2000/litre. 160,000 - 180,000 hatchlings per cone. Total hatchlings 960,000 - 1,080,000 (approximately 1 million).
- This is equivalent to a 60% combined hatch and survival rate for one cycle. Even is survival was 30%, two production cycles could produce 1 million first feedi ng fry.

***First feeding fry***

- Yolk sac fry are transferred to square cement tanks (1 x 1 x 0.5) for first feeding and held for 5+ days. These tanks could be constructed of fibreglass (500 - 1000 l)
- 6 tanks 1 x 1 x 0.5 (500 litres), total capacity = 300 litres
- Fry density = 1000 - 1,500 per litre = 300,000 - 450,000
- The expected overall survival to stocking in nursery ponds is approximately 30%. With time this survival rate should be improved

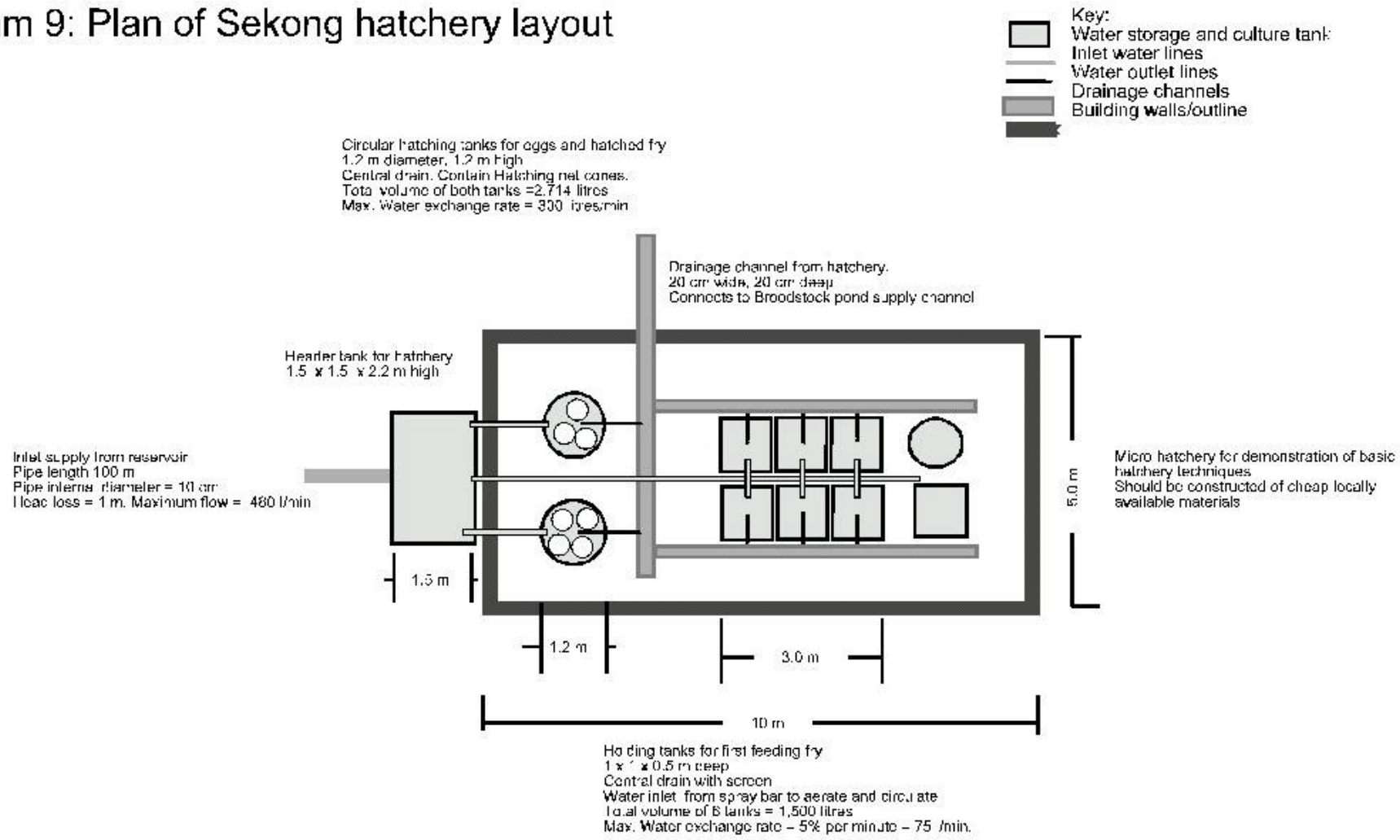
***Nursery ponds***

- 5 days post first feeding , fry are introduced to n ursery pond happas and fed bran / egg suspension
- 5 nursery ponds (5 x 10 x 1 m)
- Nominal water flow rate in nursery pond is (5 - 10 % per day) = 0.03 - 0.06 l/s
- total nursery pond water requirement = 0.15 - 0.3 l/s
- Ready for sale
- Nursery ponds can also be used for holding of broodstock in happas after hypophysation ready for stripping.

***Broodstock holding ponds***

- 10 x 20 x 1.5 m for broodstock holding and feeding
- 4 ponds, maximum possible water exchange 5 -10 % per day = 0.7 - 1.4 l/s
- Broodstock can be fed with locally available feed, but integration of livestock over the ponds is recommended to improve nutrition and fertilization of the ponds.
- The integration of livestock will also act as a demonstration to local farmers of the potential for integrated aqu aculture.

# Diagram 9: Plan of Sekong hatchery layout



# Diagram 10: Side view of the proposed hatchery at Sekong